NFPA-13

STANDARD FOR INSTALLATION OF SPRINKLER SYSTEM

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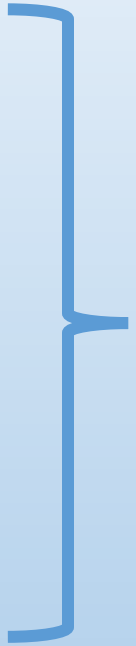

Special Occupancy requirements & Supporting Chapters

CHAPTERS & STRUCTURE

Annexure-A	Explanatory Materials- Not the part of Code
Annexure-B	Miscellaneous Topics
Annexure-C	Explanation of Test Data and Procedures for rack Storage
Annexure-D	Sprinkler system Information from NFPA 101,201 edition.
Annexure-E	Development of Design approach
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SECTION 01

CORE REQUIREMENTS

#1.1 - Scope

1.1.3* This standard is written with the assumption that the sprinkler system shall be designed to protect against a single fire originating within the building.

#4.2#4.3

Classification of Hazard and Role of OC

#4.4 - Standby Hose Stations Connected to Sprinkler Systems

Table 19.3.3.1.2 Hose Stream Allowance and Water Supply Duration Requirements for Hydraulically Calculated Systems

Occupancy	Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	gpm	L/min	gpm	L/min	
Light hazard	0, 50, or 100	0, 190, or 380	100	380	30
Ordinary hazard	0, 50, or 100	0, 190, or 380	250	950	60–90
Extra hazard	0, 50, or 100	0, 190, or 380	500	1900	90–120

What is these hose stream

Are they standpipe demand….?

Standby Hose Stations Connected to Sprinkler Systems

- NFPA 13 allows small (1½ in.) and large (2½ in.) hose connections to be connected to fire sprinkler systems. Such connections are considered a part of the fire sprinkler system, not a standpipe system.
- The purpose of a standby hose connection is to provide the user with some type of fire protection without providing all of the full requirements of a standpipe system. Connecting the standby hose to the fire sprinkler system allows a small amount of water to be available for firefighting (typically 50–250 gpm) without the full water supply of a standpipe system.
- *There are two occupancies where standby hose connections are sometimes found: storage warehouses and assembly occupancies back stage.*

How are these Standby hoses justified in Storage occupancies…?

They were justified in storage warehouses because the ceiling is very high and the fire takes some time to grow large enough to set off sprinklers, which gives the warehouse employees time to try and extinguish the fire.

Standby Hose Stations Connected to Sprinkler Systems

- Many fire protection professionals were concerned with the thought of untrained employees in a warehouse trying to use the hose to fight a fire without any protective clothing or equipment.
- In addition, the Occupational Safety and Health Administration (OSHA) started to express concerns that if the hose was placed in the warehouse for employees to use, the employees needed to be provided with protective clothing, equipment and training
- *In the 2010 edition of NFPA 13, the requirement was changed to only have the hose stations installed when they were specifically required by the Authority Having Jurisdiction.*

NFPA 13 Rule for Such Standby Hoses

The connections are required to be spaced around a building so that all portions of the building can be reached within 100 ft of hose and 30 ft of throw.

The connections are permitted to be made directly to wet pipe sprinkler system piping of the following sizes:

- 2.5 in. piping on a tree sprinkler system (one flow path from the water supply to the connection).
- 2 in. piping on a looped or gridded sprinkler system (more than one flow path from the water supply to the connection).
- For piping serving a single hose connection:

— Minimum 1 in. pipe for horizontal runs up to 20 ft.

— Minimum 1.25 in. pipe for horizontal runs up to 80 ft. Note that the whole run needs to be 1.25 in. pipe. You are not allowed to switch to 1 in. pipe for the last 20 ft.

— Minimum 1.5 in. pipe for horizontal runs over 80 ft. Note that the whole run needs to be 1.5 in. pipe. You are not allowed to switch to smaller pipe sizes towards the end of the run.

— Minimum of 1 in. for vertical runs

For piping serving multiple hose connections, a minimum of 1.5 in. pipe is required

Storage warehouse and Standby hoses

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Storage warehouse and Standby hoses

- The connections need to be made in such a way that the closure of a sprinkler system valve does not take all of the fire protection out of service at the same time

Options – 01

A separate piping system for just the hose stations. This would have its own connection to the water supply with its own control valve and closing any valve on the fire sprinkler system would have no effect on whether water could get to the hose stations

Storage warehouse and Standby hoses

- The connections need to be made in such a way that the closure of a sprinkler system valve does not take all of the fire protection out of service at the same time

Options – 02

A connection to the sprinkler riser upstream of the control valve. This is really the same as option 1 above.

Storage warehouse and Standby hoses

- The connections need to be made in such a way that the closure of a sprinkler system valve does not take all of the fire protection out of service at the same time

Options – 03

Feeding the hose stations in one part of a warehouse with the ceiling sprinkler piping from another part of the warehouse makes sure that when one valve is closed, the protection is not completely eliminated from each area of the building. Closing the valves to the ceiling sprinklers in one area will take out the hose stations in another area, but in that area the ceiling sprinklers should still be active. In the area where the ceiling sprinklers were shut down, the hoses will be fed from a different sprinkler system, so they should still be active..

Storage warehouse and Standby hoses

- The connections need to be made in such a way that the closure of a sprinkler system valve does not take all of the fire protection out of service at the same time

Options – 04

In rack storage warehouses where the decision has been made to install in-rack sprinklers, the hose stations are permitted to be fed from the ceiling sprinklers in the same area as the hose stations as long as the in-rack sprinklers have a completely different control valve. In this way, at least one of the three types of fire protection in an area will be active at all times

Back stage areas of theaters & Standby Hoses

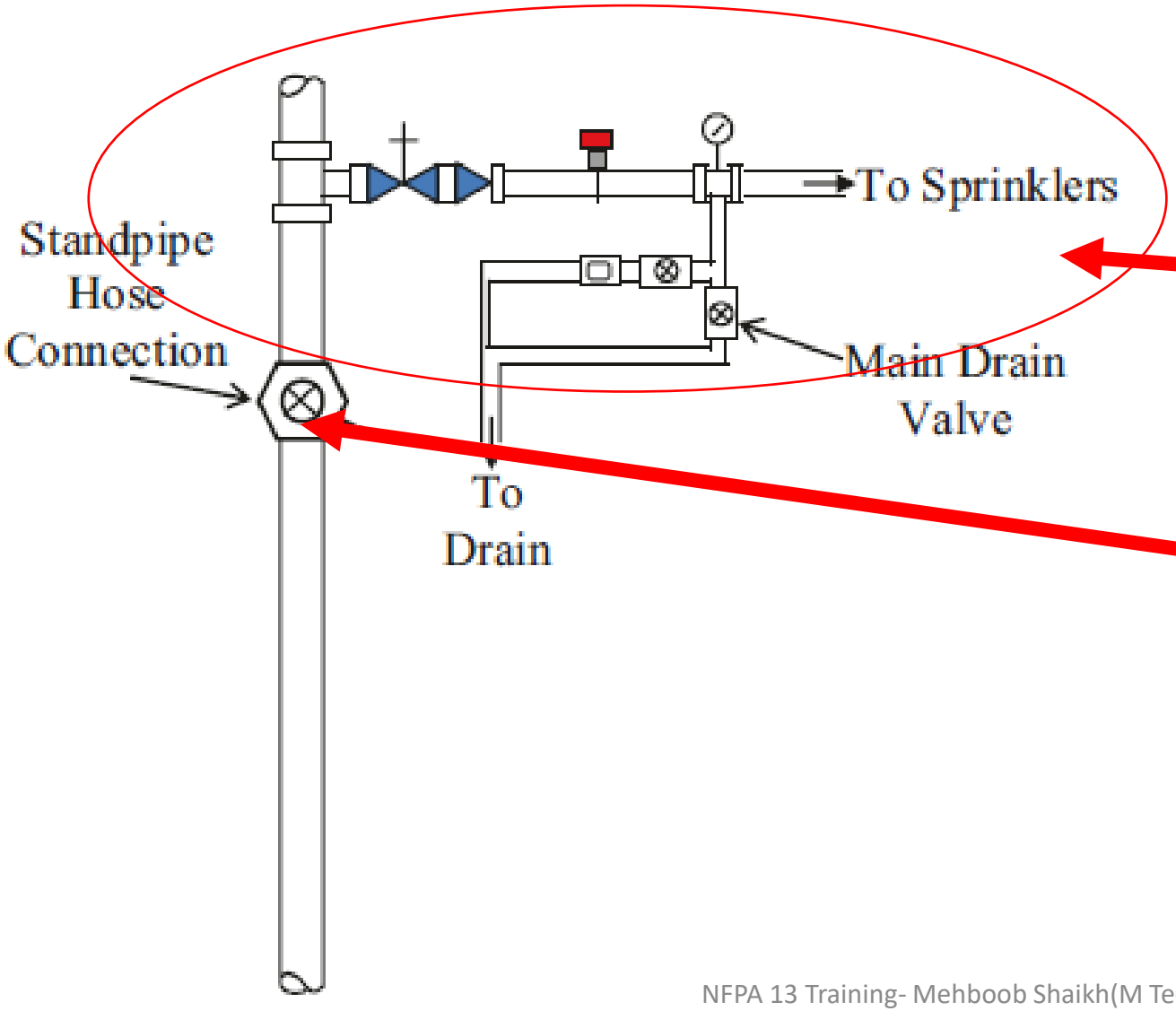
Many building and fire codes require that these areas have 1.5 in. hose stations, but the codes allow them to be directly connected to the sprinkler systems rather than have them installed as separate standpipe systems

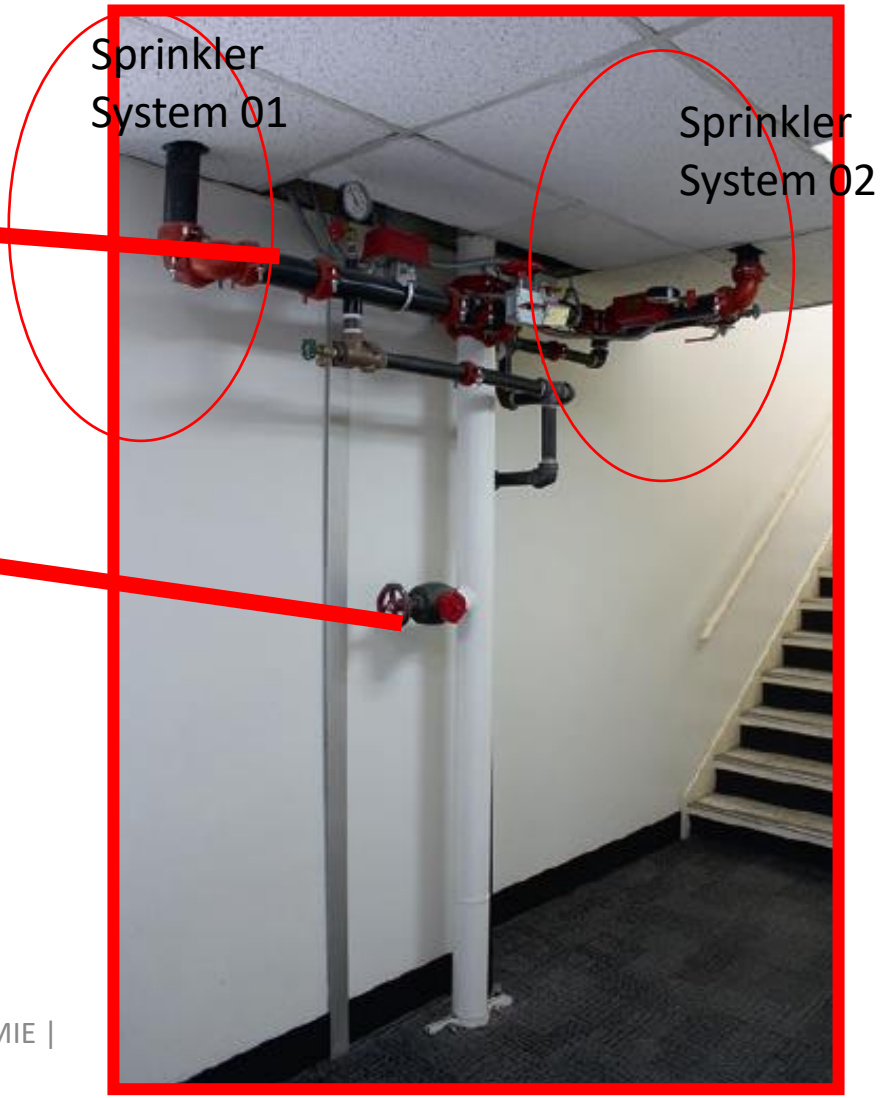
The general rules for the installation of these hose systems is the same as discussed above for warehouses with one exception. The hose stations for non-storage situations are allowed to be directly connected to the ceiling sprinkler system in the same portion of the building as the hose stations

NFPA 13 Rule for Such Standby Hoses

- The flow demand for the inside hose stations takes the place of some of the total hose stream demand
- NFPA 13 requires a total of 100 gpm of hose stream demand for light hazard, 250 gpm for ordinary hazard and 500 gpm for extra hazard
- If there are two or more hose stations in a building, the inside hose stream demand will be 100 gpm and the outside hose stream demand becomes 0 gpm in a light hazard occupancy, 150 gpm in an ordinary hazard occupancy and 400 gpm in the extra hazard occupancy

Combined Sprinkler and Standpipe System





Few Points to Ponder About ….?

For a Sprinkler system we should have to have a Separate Sprinkler Riser !!!!! & Where is the Sprinkler Riser in Combined System…?

Few Points to Ponder About ….?

But the Risers are understood to be the Vertical pipe not the horizontal one isn't it …?

3.3.215 System Riser. The aboveground horizontal or vertical pipe between the water supply and the mains (cross or feed) that contains a control valve (either directly or within its supply pipe), a pressure gauge, a drain, and a waterflow alarm device.

Few Points to Ponder About ….?

Why we have connected two Sprinkler System to this standpipe..?

4.5.1 The maximum floor area on any one floor to be protected by sprinklers supplied by any one sprinkler system riser or combined system riser shall be as follows:

(1) Light hazard — 52,000 ft^2 (4830 m^2)
(2) Ordinary hazard — 52,000 ft^2 (4830 m^2)
(3)* Extra hazard — Hydraulically calculated — 40,000 ft^2 (3720 m^2)
(4) High-piled Storage — High-piled storage (as defined in 3.3.95) and storage covered by other NFPA standards — 40,000 ft^2 (3720 m^2)
(5) In-rack Storage — 40,000 ft^2 (3720 m^2)

Chapter- 5 : Water Supplies

Learning Objectives :

Understanding minimum requirements for the various water supply sources that provide water to sprinkler systems

Types of Water Supply Sources

(1) A connection to an approved public or private waterworks system in accordance with 5.2.2

(2) A connection including a fire pump in accordance with 5.2.3

(3) A connection to a water storage tank at grade or below grade installed in accordance with NFPA 22 and filled from an approved source

(4) A connection to a pressure tank in accordance with 5.2.4 and filled from an approved source

(5) A connection to a gravity tank in accordance with 5.2.5 and filled from an approved source

(8) A penstock, flume, river, lake, pond, or reservoir in accordance with 5.2.8

(8)A source of recycled or reclaimed water where the building owner (or their agent) has analyzed the source of the water and the treatment process (if any) that the water undergoes before being made available to the sprinkler system

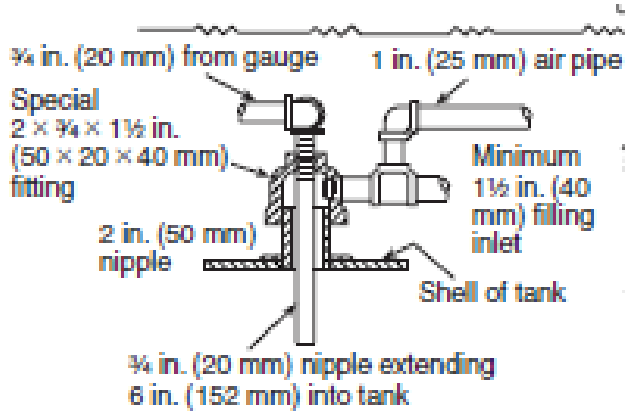
Pressure Tank

- Use in limited private fire protection services, such as sprinkler systems, standpipe and hose systems, and water spray fixed systems.
- Tank capacity should be approved by the authority having jurisdiction (AHJ) and is considered to be the total contents, both air and water in the cylinder.
- The pressure shall be sufficient to push all of the water out of the tank while maintaining the necessary residual pressure required by NFPA 13 at the top of the sprinkler system.
- Most pressure tanks are located above the top level of the sprinklers.
- Subject to the approval of the AHJ, tanks may be located in the basement or elsewhere

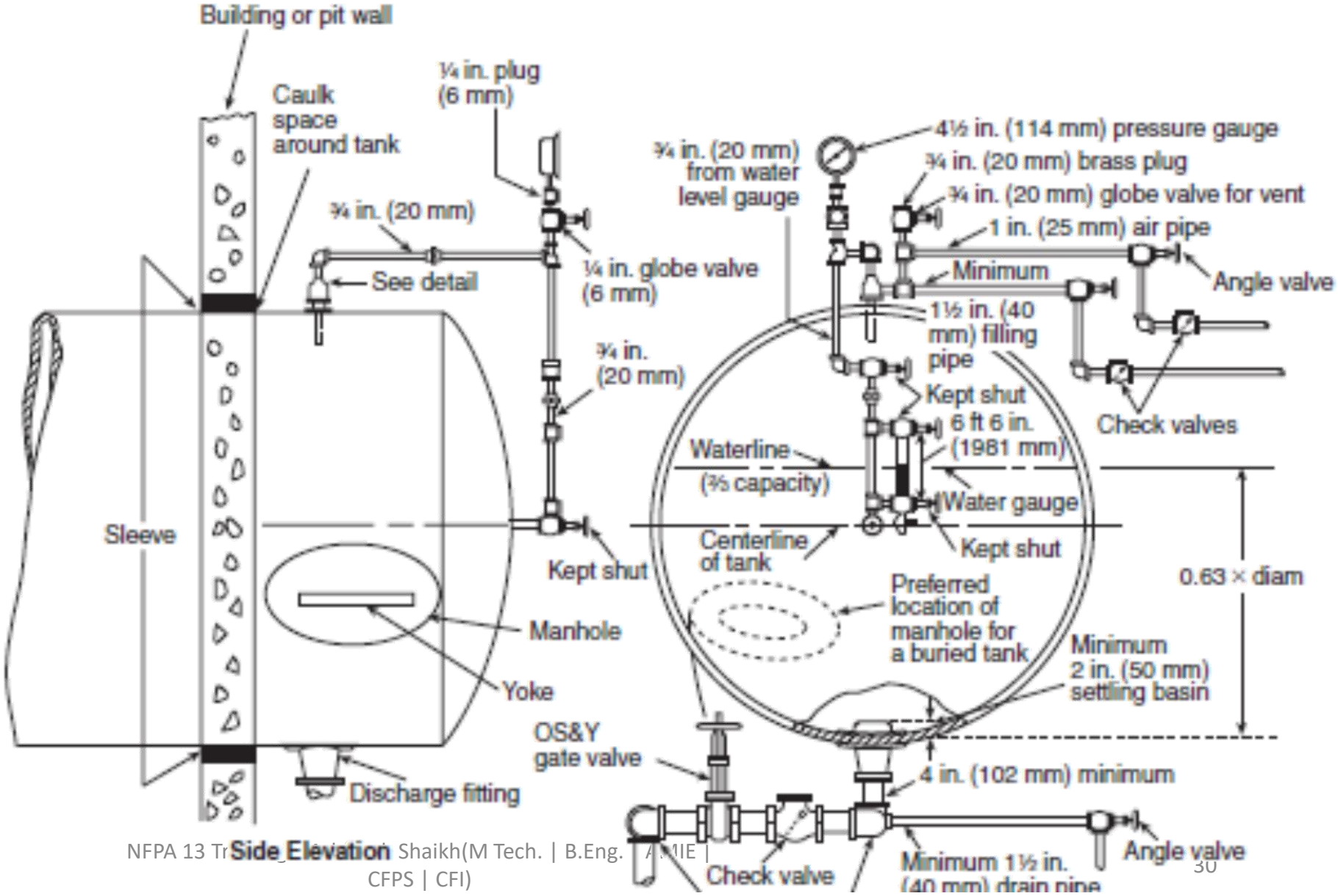
Pressure Tank

- The tank is normally kept two-thirds full of water (a water-level gauge provided and the tank plate marked “2/3 capacity line”) and a gauge pressure of at least 85 psig (518 kPa) is maintained.
- A listed air pressure gauge with a maximum range equivalent to twice the normal working pressure should be installed.
- As the last of the water leaves the pressure tank, the residual pressure shown on the gauge should not be less than zero and should give at least 15 psi (103 kPa) pressure at the highest automatic discharge device under the main roof of the building.
- Air for pressure tanks should be supplied by compressors capable of delivering not less than 18 ft3/min (0.045 m3/min) of free air for tanks of 8500 gal (28.4 m3) total capacity and not less than 20 ft3/min (0.058 m3/min) for larger sizes.

Pressure Tank



Detail of Air and Filling Connections



Side Elevation

Pressure Tank

TABLE 15.1.7 Typical Dimensions of Horizontal Pressure Tanks of Standard Sizes

Approx. Gross Capacity		Approx. Net Cap. 2/3 Full		Inside Diam.		Inside Length		Approx. Wt. of Water 2/3 Full	
gal	*L*	*gal*	*L*	*in.*	*m*	*ft*	*m*	*lbs*	*kg*
3000	11,355	2000	7,570	60	1.5	20.2	6.2	16,670	7,568
3000	11,355	2000	7,570	66	1.7	17.0	5.2	16,670	7,568
3000	11,355	2000	7,570	72	1.8	14.2	4.3	16,670	7,568
4500	17,033	3000	11,355	66	1.7	25.4	7.7	25,000	11,350
4500	17,033	3000	11,355	72	1.8	21.3	6.5	25,000	11,350
4500	17,033	3000	11,355	78	2.0	18.2	5.5	25,000	11,350
6000	22,710	4000	15,140	72	1.8	28.2	8.6	33,340	15,136
6000	22,710	4000	15,140	78	2.0	24.2	7.4	33,340	15,136
6000	22,710	4000	15,140	84	2.1	21.0	6.4	33,340	15,136
7500	28,388	5000	18,925	78	2.0	30.3	9.2	41,670	18,918
7500	28,388	5000	18,925	84	2.1	26.2	8.0	41,670	18,918
7500	28,388	5000	18,925	90	2.3	22.7	6.9	41,670	18,918
9000	34,065	6000	22,710	84	2.1	31.4	9.6	50,000	22,700
9000	34,065	6000	22,710	90	2.3	27.3	8.3	50,000	22,700
9000	34,065	6000	22,710	96	2.4	24.0	7.3	50,000	22,700

Pressure Tank Sizing Example

A Pressure tank is to be used to provide a 30 min water supply to a system with a hydraulically calculated demand of 140 gpm (530 L/min) at a pressure of 118 psi (8.14 bar). Due to nearby component pressure ratings, it is important that air pressure in the tank not exceed 175 psi (12.0 bar). To determine the minimum size tank.

Solution

$$P_i = \frac{P_f + 15}{A} - 15$$

where

P_i = Tank air pressure to be used

P_f = System pressure required per hydraulic calculations

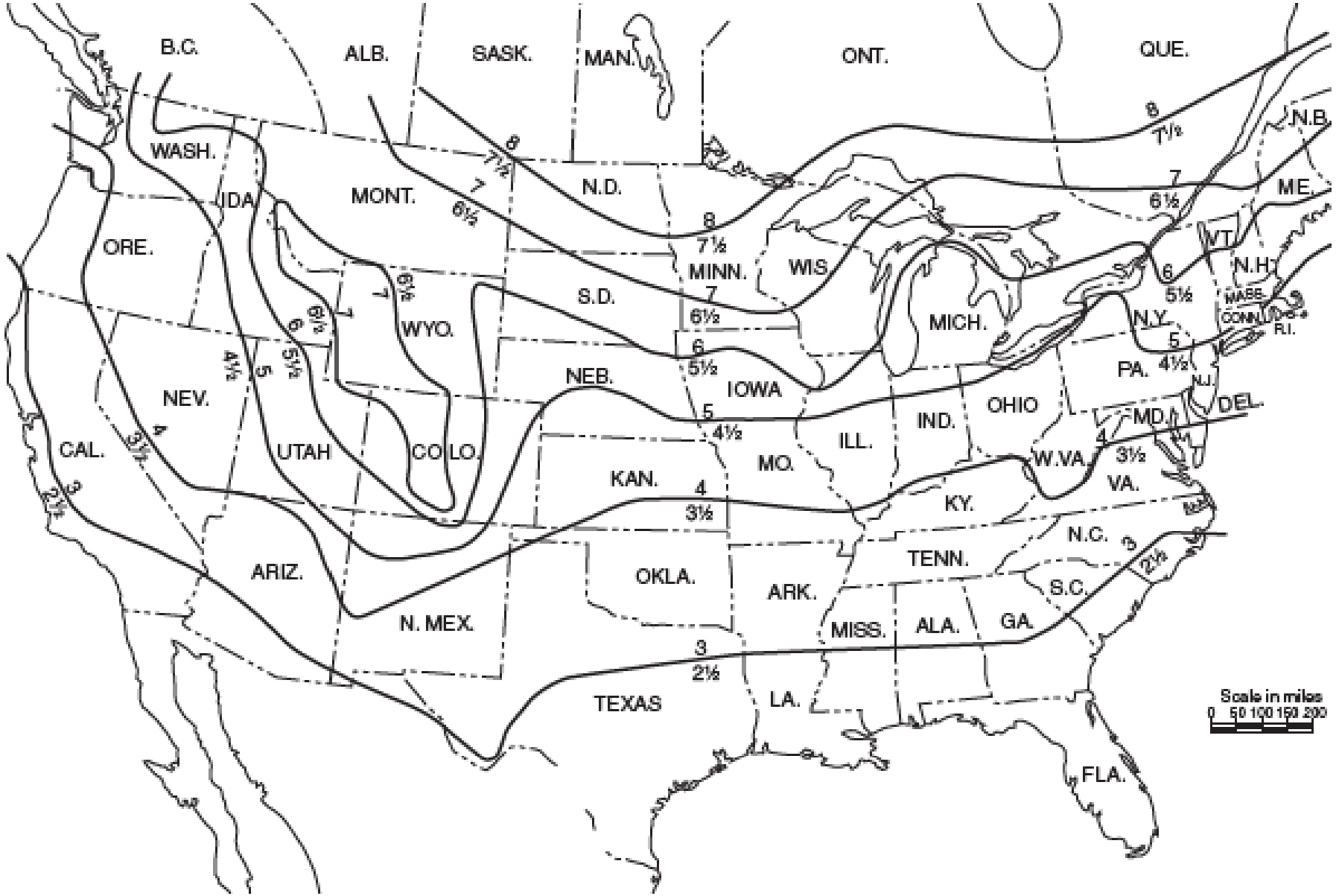
A = Proportion of air in the tank

Chapter- 8 : Installation of Underground Piping

Learning Objectives :

- Understanding minimum requirements for underground piping, including piping materials, fittings, joining of pipe and fittings, depth of cover, protection against freezing, protection against damage, laying of pipe, joint restraint, backfilling, and testing and acceptance.

Protection of Private service Mains



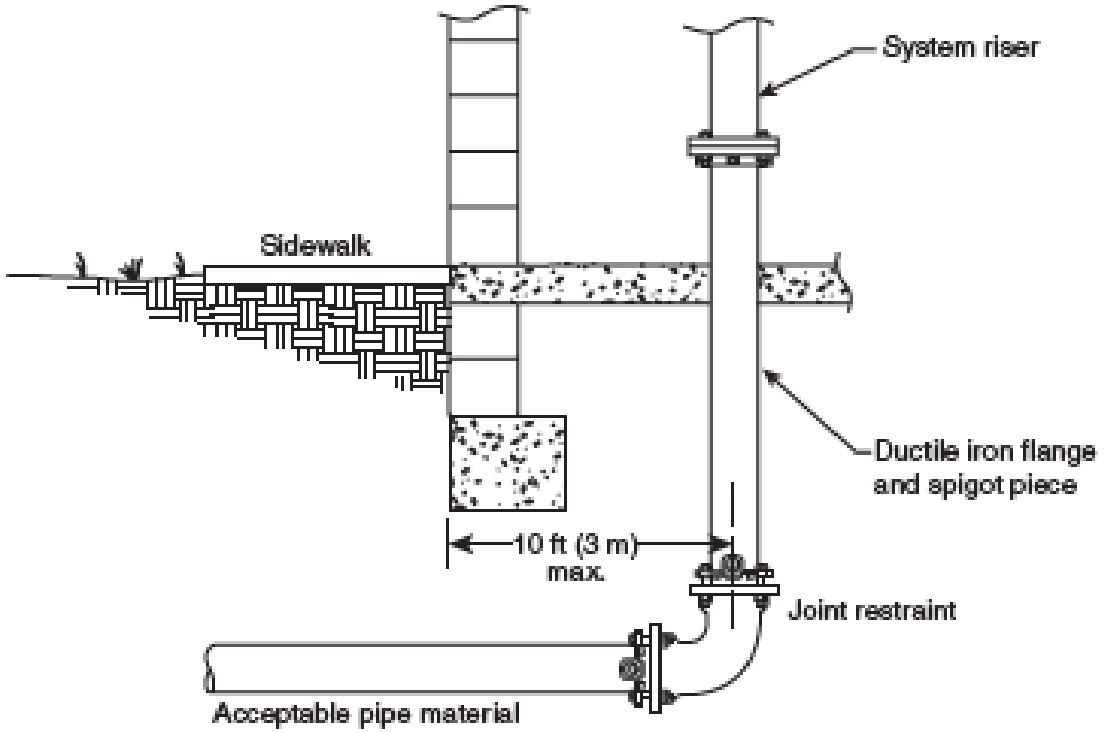
Protection of Private service Mains

Source: Compiled from United States Weather Bureau records.
For SI units, °C = ⅝ (°F −32); 1 mi = 1.609 km.

FIGURE A.6.4.2(b) Isothermal Lines — Lowest One-Day Mean Temperature (°F). [24:Figure A.10.4.2(b)]

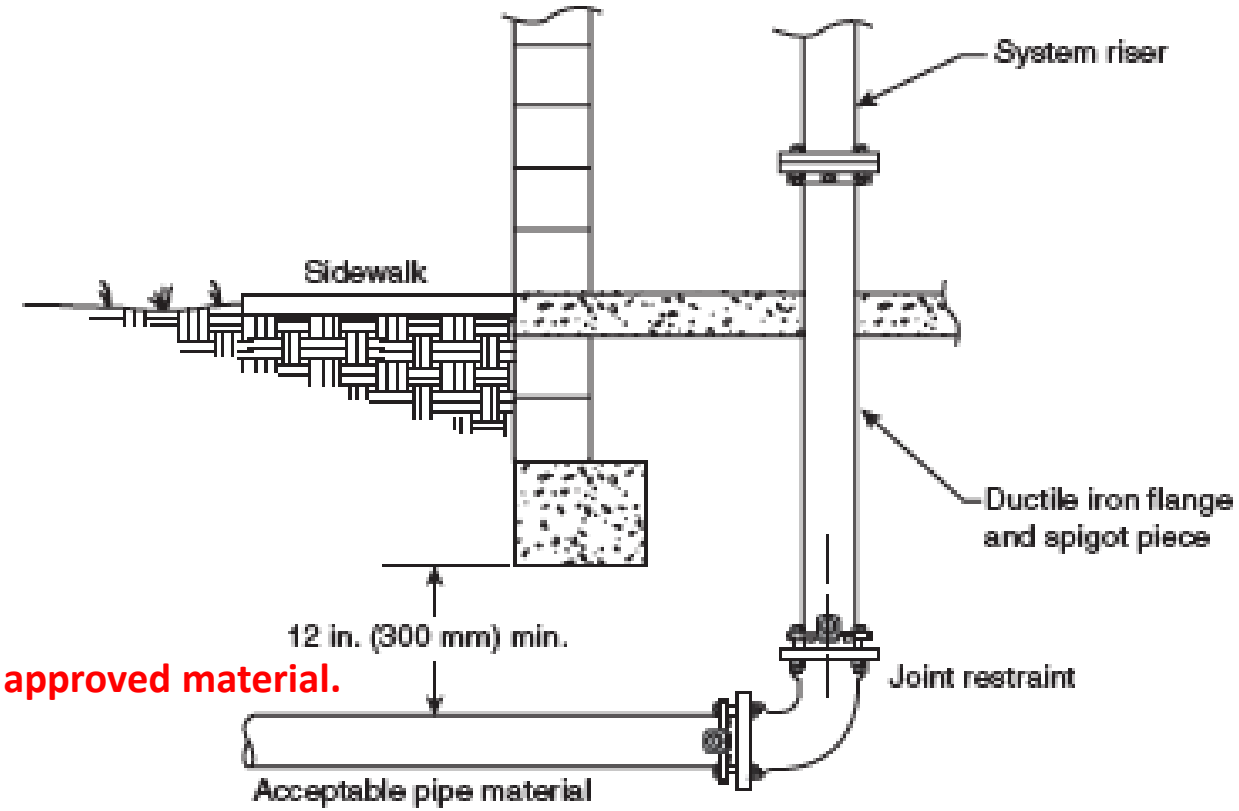
Private Service Mains under the buildings

Cl.8.4.3.1-Private fire service mains supplying fire protection systems within the building shall be permitted to extend no more than 10 ft (3.0 m), as measured from the outside of the building, under the building to the riser location.



Private Service Mains under the buildings

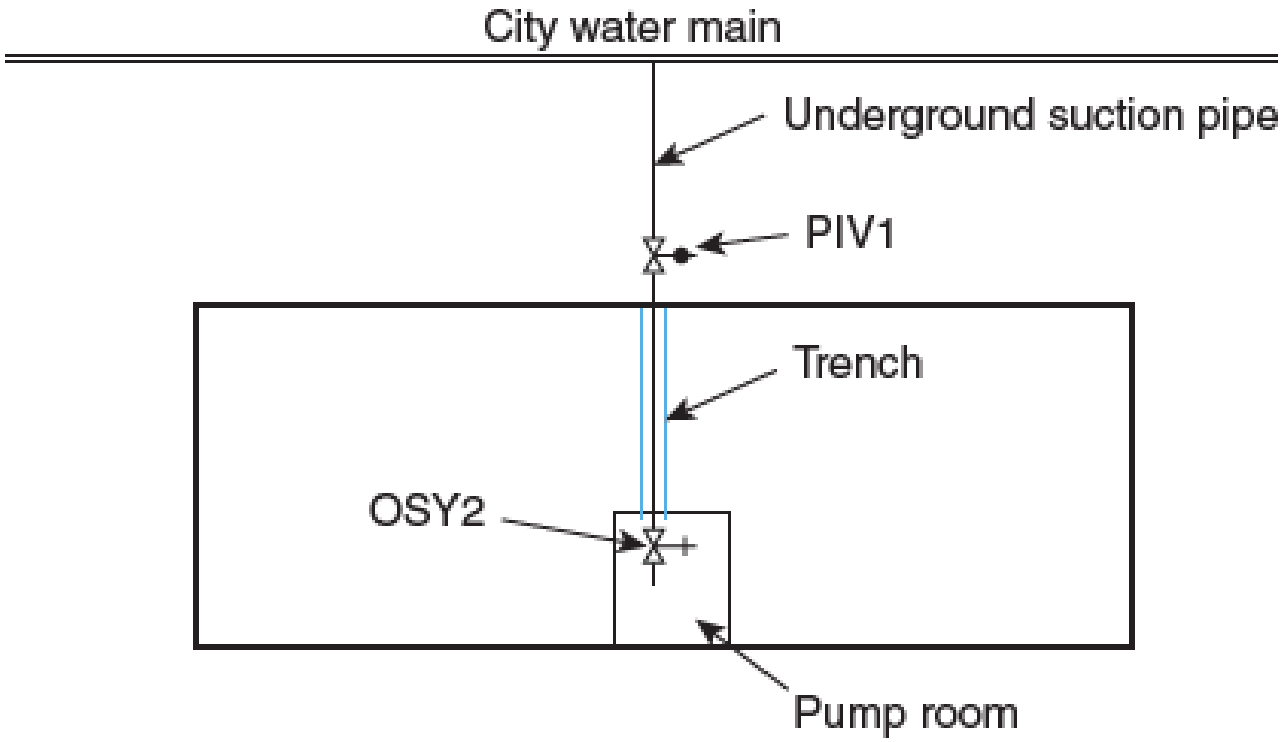
Cl. 8.4.3.1.2- Piping shall be installed a minimum of 12 in. (300 mm) below the bottom of building foundations or footers.



Requirement shall not apply when the piping is sleeved with an approved material.

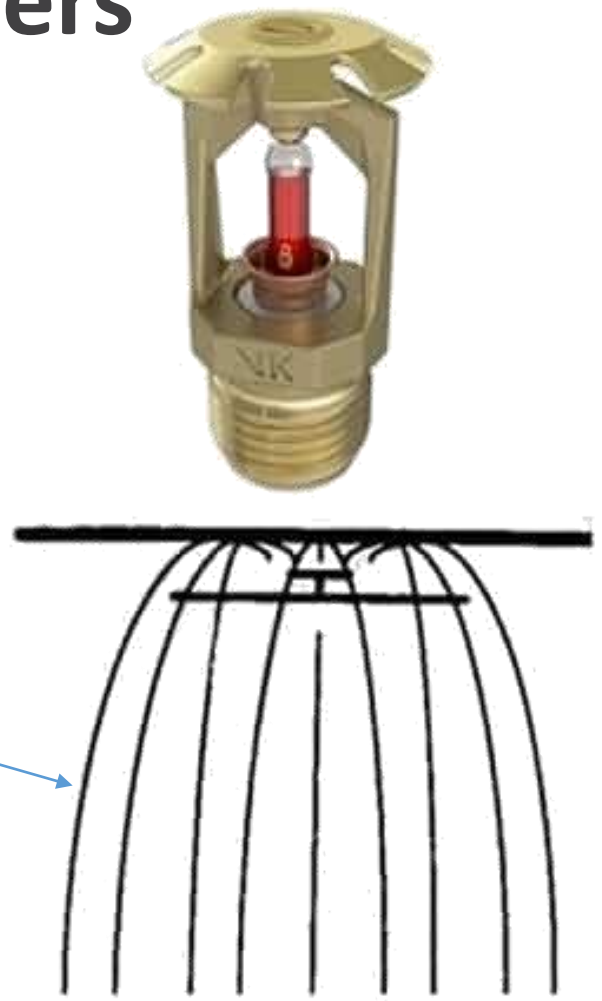
Private Service Mains under the buildings

Cl. 8.4.3.2- Private fire service mains shall not be permitted to extend more than 10 ft (3 m) under the building except as allowed in 8.4.3.2.1.

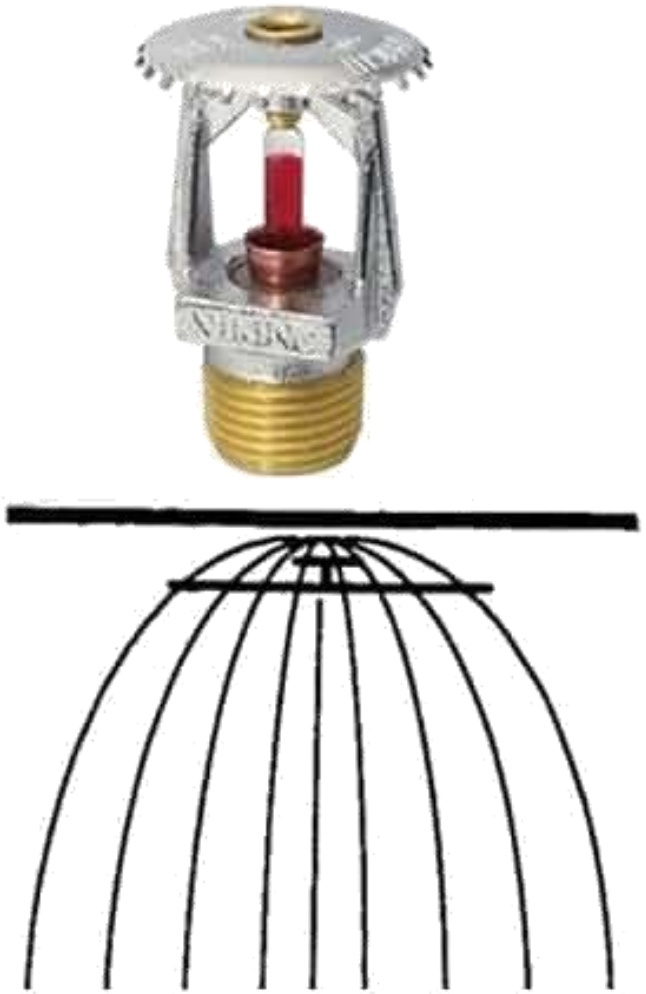


The Difference Between Standard Response and Quick Response Sprinklers

Until 1953, fire sprinklers had what we now call "conventional" or "old-style" deflectors, which would throw between 40 and 60% of their discharged water initially upwards rather than downwards.



Upright old-style sprinkler and spray pattern



Upright spray sprinkler and spray pattern

The Difference Between Standard Response and Quick Response Sprinklers

NFPA 13 defines “fast-response” and “standard-response” sprinklers based on these RTI values (**3.3.205.4**):

- **Fast response** sprinklers have RTIs of **50 or less**.
- **Standard response** sprinklers have RTIs of **80 or less.**

Standard vs QR vs Residential

Standard-Response
Pendent VK1021

Quick-Response
Pendent VK3021

Residential (Fast-Response)
Pendent VK468

What is the Hydraulic Advantage of QR Spr.

Because QR sprinklers open faster and thus may control fires sooner, **NFPA 13 encourages designers to use them** instead of standard response sprinklers in certain conditions. Specifically, designers can employ QR sprinklers where (**19.3.3.2.3.1**):

- The occupancy is light or ordinary hazard (the only time QR is allowed)
- The sprinkler system is wet-pipe
- The ceiling is no more than 20 feet high
- There are no unprotected ceiling pockets covering more than 32 $ft.^2$
- There are no unprotected areas above cloud ceilings

What is the Hydraulic Advantage of QR Spr.

Without Quick-Response	With Quick Response
Design density: 0.15 gpm/ft.2	Design Density: 0.15 gpm/ft2
Design area: 1500 ft.2	Design area: 900 ft.2
Required flow in design area: 225 gpm	Required flow in design area: 135 gpm

Pipe and Fittings

Not all pipe or tubing that meets these standards is *also* listed for fire sprinkler service. Pipes that are "listed" have been rigorously tested and found to meet the safety standards of a third-party certification agency. Metal pipes are listed to UL 852 and thermoplastic pipes are listed to UL 1821.

****If listed materials differ from Table 7.3.1.1, NFPA 13 permits their use as long as installers adhere to any limitations in the listing.

Table 7.3.1.1 Pipe or Tube Materials and Dimensions

Materials and Dimensions	Standard
Ferrous Piping (Welded and Seamless)	
Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use	ASTM A795/A795M
Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless	ASTM A53/A53M
Welded and Seamless Wrought Steel Pipe	ASME B36.10M
Standard Specification for Electric-Resistance-Welded Steel Pipe	ASTM A135/A135M
Copper Tube (Drawn, Seamless)	
Standard Specification for Seamless Copper Tube	ASTM B75/B75M
Standard Specification for Seamless Copper Water Tube	ASTM B88
Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube	ASTM B251
Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube	ASTM B813
Specification for Filler Metals for Brazing and Braze Welding	AWS A5.8M/A5.8
Standard Specification for Solder Metal, Section 1: Solder Alloys Containing Less Than 0.2% Lead and Having Solidus Temperatures Greater than 400°F	ASTM B32
Alloy Materials	ASTM B446
CPVC	
Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)	ASTM F442/F442M
Brass Pipe	
Standard Specification for Seamless Red Brass Pipe, Standard Sizes	ASTM B43
Stainless Steel	
Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes	ASTM A312/A312M

Table 7.4.1 Fittings Materials and Dimensions

Materials and Dimensions	Standard
Cast Iron	
Gray Iron Threaded Fittings, Classes 125 and 250	ASME B16.4
Gray Iron Pipe Flanges and Flanged Fittings, Classes 25, 125, and 250	ASME B16.1
Malleable Iron	
Malleable Iron Threaded Fittings, Classes 150 and 300	ASME B16.3
Steel	
Factory-Made WroughtButtwelding Fittings	ASME B16.9
Buttwelding Ends	ASME B16.25
Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service	ASTM A234/A234M
Pipe Flanges and Flanged Fittings, NPS ½ through NPS 24 Metric/Inch Standard	ASME B16.5
Forged Fittings, Socket-Welding and Threaded	ASME B16.11
Copper	
Wrought Copper and Copper Alloy Solder Joint Pressure Fittings	ASME B16.22
Cast Copper Alloy Solder Joint Pressure Fittings	ASME B16.18
CPVC	
Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80	ASTM F437
Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40	ASTM F438
Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80	ASTM F439
Bronze Fittings	
Cast Copper Alloy Threaded Fittings, Classes 125 and 250	ASME B16.15
Stainless Steel	

Pipe and Fittings

The pipe schedule or type indicates the thickness of the pipe wall

Summation of Variables Affecting Fire Sprinkler Pipe Selection				
	Pipe or Tube Type			
Property	Steel Sch. 40	Typical lightwall steel	Copper Type M	CPVC SDR 13.5
color	black	silver	copper	bright orange
weight of the DN25 (1 in.) size (kg/m)	2.5	1.8	0.7	0.4
melting point (MP) or heat distortion temperature (HDT)	(MP) 1427-1538°C (2600-2800°F)	(MP) 1427-1538°C (2600-2800°F)	(MP) 1082°C (1980°F)	(HDT) 103°C (217°F)
damage susceptibility	low	low	low	high with UV exposure and impacts
corrosion susceptibility design C factor	high/ 120	high/ 120	moderate/ 150	low/ 150
occupancy classification NFPA standards	not limited	not limited	not limited	NFPA 13 light hazard, 13D, 13R, concealed and restricted exposure NFPA 90A
maximum ambient temperature	not limited	not limited	not limited	66°C (150°F)
flexibility/hanger spacing for the DN25 (1 in.) size (m)	not flexible/ 3.7	not flexible/ 3.7	slightly flexible/ 2.4	flexible/ 1.8
expansion concerns/solutions	negligible	negligible	negligible	yes/offsets direction changes, loops
fitting type	threaded grooved flanged plain-type	threaded grooved flanged plain-type	soldering brazing grooved	primer/solvent cement
compatible antifreeze	not limited*	not limited*	not limited*	glycerine*

*NFPA recommends that only antifreeze solutions of glycerine or propylene glycol be used when the sprinkler system is conn

Gauges

- Pressure gauges are a small but important component of the fire sprinkler system. Some systems only have water gauges, but others also have air gauges. Gauges help fire fighters, sprinkler system contractors, and building maintenance workers to determine the available water or air pressure at the gauge location.
- In addition, a gauge can help to determine whether there is a problem with the system if the gauge reading is outside the normal or expected pressure readings.
- Water gauges are typically installed on the supply and system sides of the various fire sprinkler system valves and fire pumps, at the tops of standpipes, at the main drain, at each floor level when feeding a sprinkler system from a standpipe, and on each side of pressure-regulating devices. Air gauges are installed on the system side of certain fire sprinkler valves, on system air sources, on air supply lines, and on quick-opening devices.
- Gauges should not be subject to freezing temperatures, should have a shut-off valve, and should be capable of draining.

Valves

- All automatic fire sprinkler system control valves must be indicating-type valves so that a person can look at the valve and determine if the valve is open, partially open, or shut. In addition, these valves require identification with a permanent metal or rigid plastic weatherproof sign, which must identify the area of the building served by that valve (National Fire Protection Association 2019, *NFPA 13,* Section 16.9.12.1).
- All indicating valves must be able to handle 175 psi or carry an appropriate rating for an anticipated pressure above 175 psi. Fully open indicating valves shall not close in less than 5 seconds when operated at maximum possible speed (National Fire Protection Association 2019, *NFPA 13,* Section 7.6.1). Indicating valves in fire sprinkler systems are usually 2 in. or larger and include the outside screw and yoke (OS&Y) valve, butterfly indicator valve, wall post indicator valve (WPIV), and post indicator valve (PIV)

Spacing & Location – Ceiling Construction Type

Obstructed : Panel construction and other construction where beams, trusses, or other members impede heat flow or water distribution in a manner that materially affects the ability of sprinklers to control or suppress a fire.

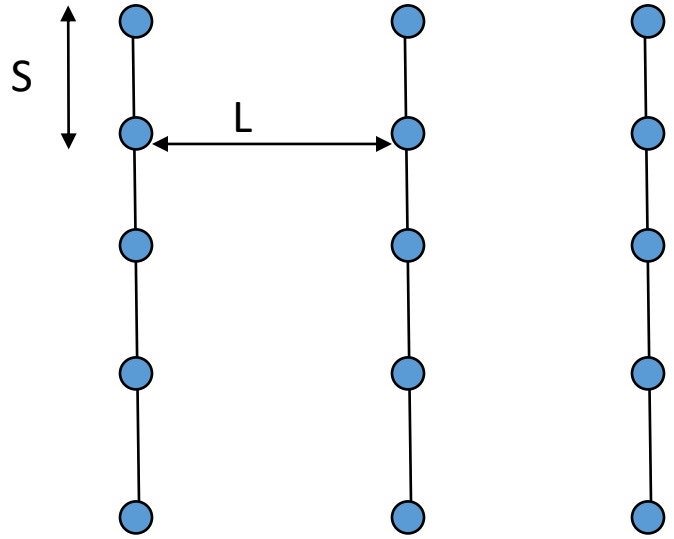
Spacing & Location – Ceiling Construction Type

Unobstructed :

1. Construction where beams, trusses, or other members do not impede heat flow or water distribution in a manner that materially affects the ability of sprinklers to control or suppress a fire.
2. Horizontal structural members are not solid and openings are at least 70% of the cross section area and the depth of the member does not exceed the least dimension of the opening.
3. All construction where the spacing of structural members exceeds 7.5 ft on center.

8.5: Position,Location,Spacing & use of Sprinklers

Determination of Protection area of Coverage



Along branch lines

Choose larger of

- Distance between sprinklers
- Twice distance to wall or obstruction

– This dimension is “S”

Between branch lines

- Distance between branch lines
- Twice distance to wall or obstruction

– This dimension is “L”

8.5: Position,Location,Spacing & use of Sprinklers

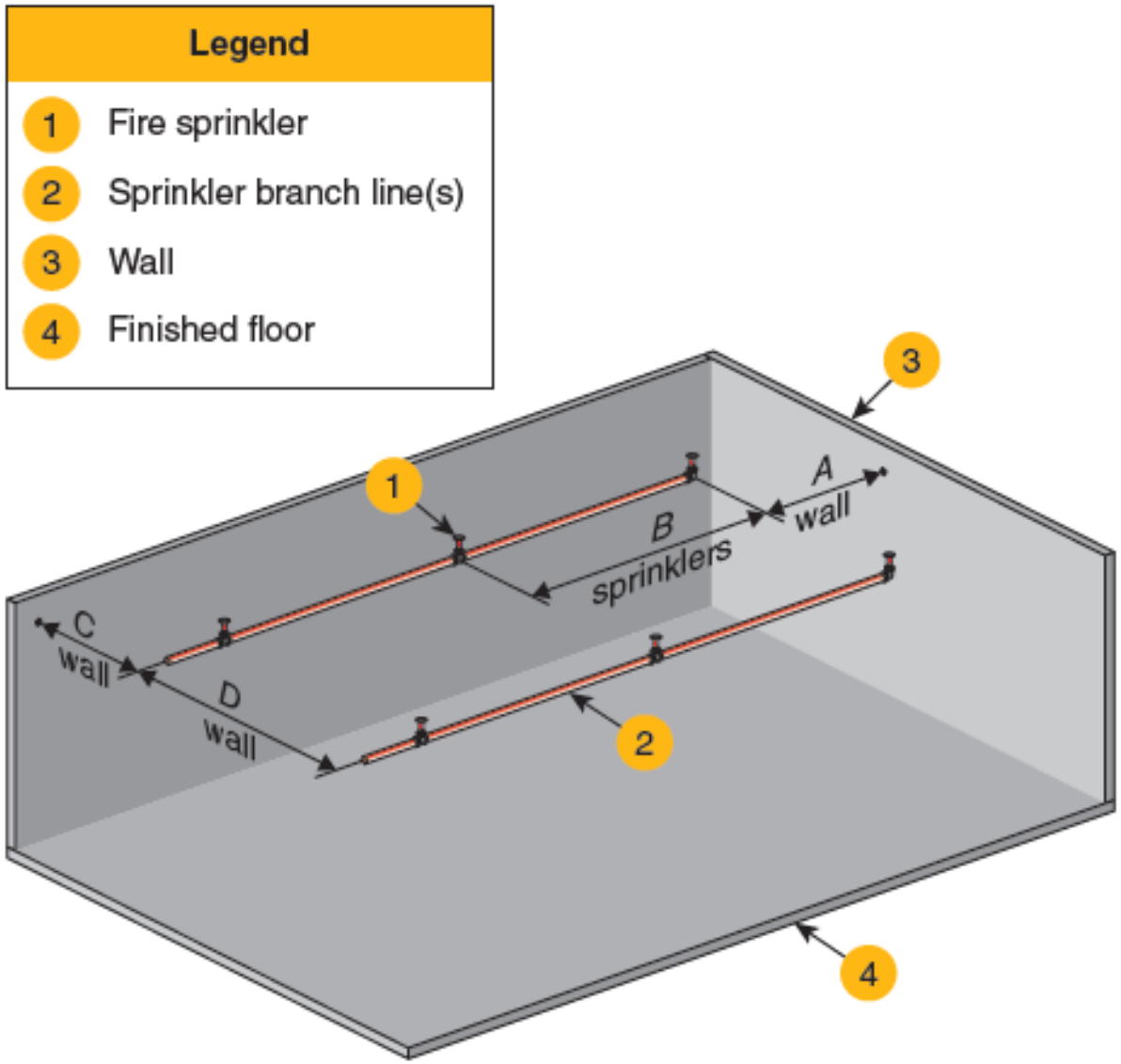
Determination of Protection area of Coverage

Area of Coverage = S x L

Where ; S = Distance along the branch line

L = Distance between the branch line

The maximum area of coverage of any sprinkler shall not exceed 400 ft_2 (36 m_2).



 # 8.5.2.1.1 (1)

If 2A > B then 2A = S

If B > 2A then B = S

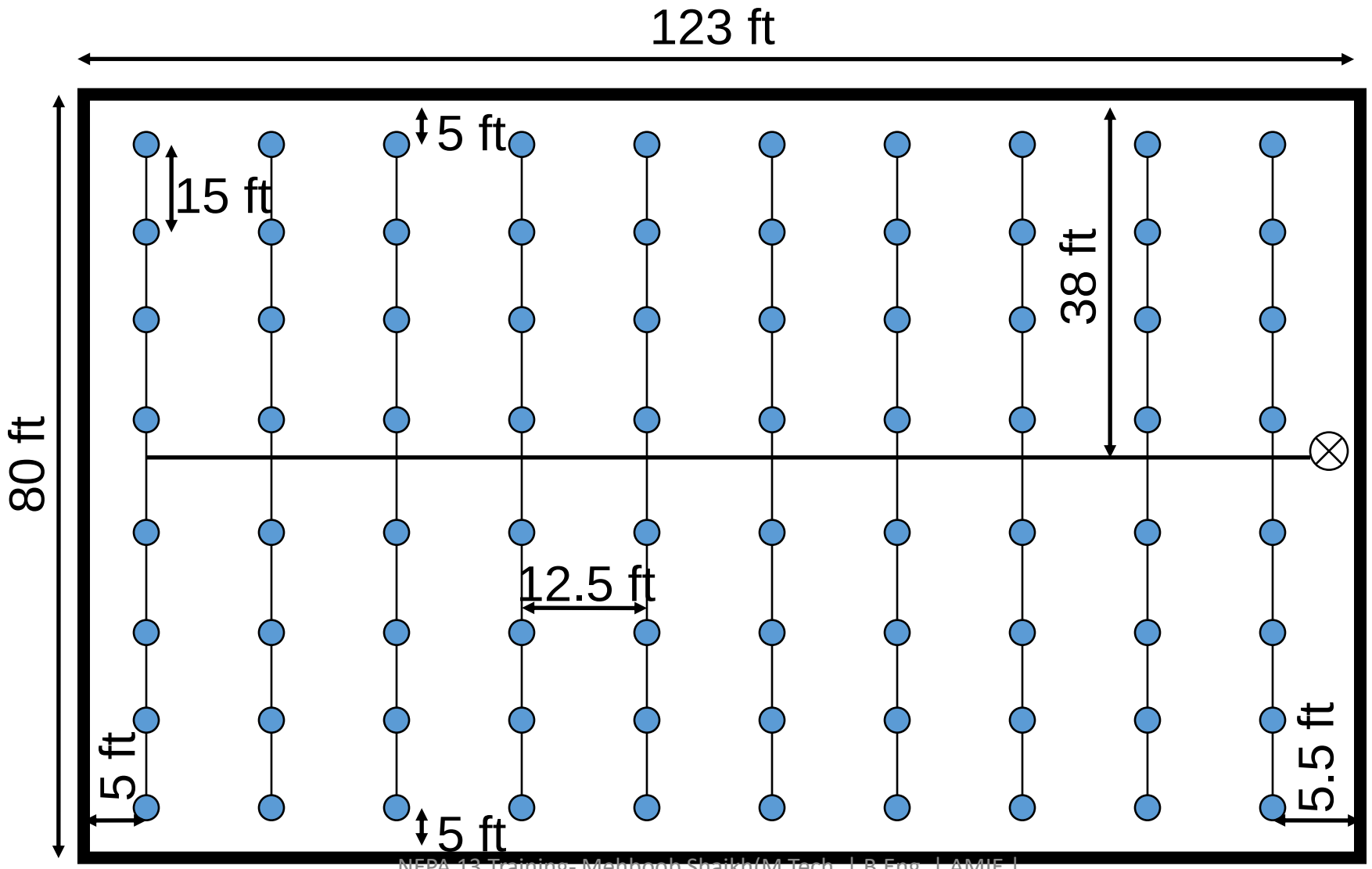
 # 8.5.2.1.1 (2)

If 2C > D then 2C = L

If D > 2C then D = L

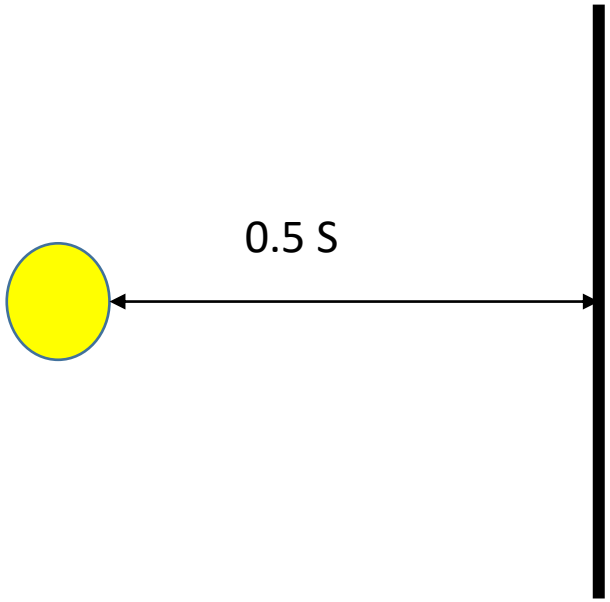
Example: Plan View

Determine area of Coverage for sprinklers



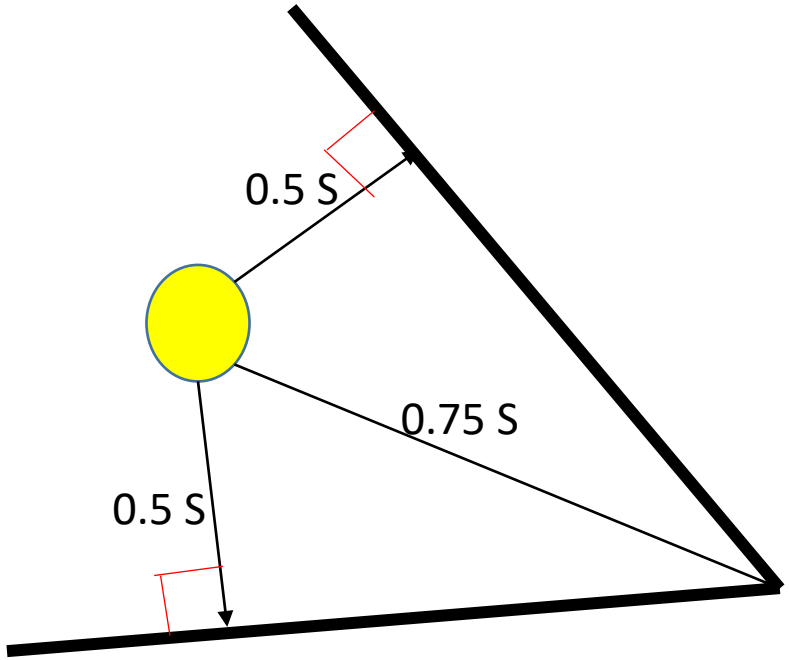
Measuring distance from wall

- Cl. 8.5.3.3.2 - Measure perpendicular distance between sprinkler and wall. This is the dimension that is not allowed to exceed ½ the allowable distance between sprinklers



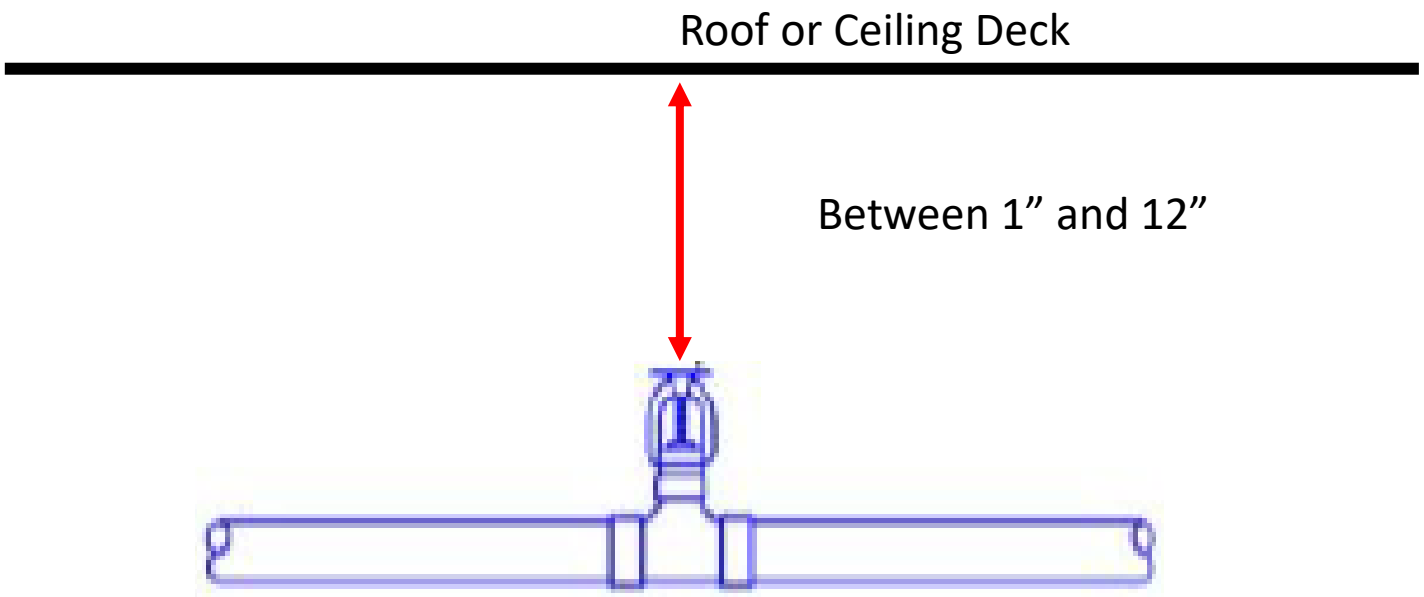
Measuring distance from wall

- Cl. 8.6.3.2.3 – for angled or irregular shaped walls sprinkler to corner must not exceed 0.75 allowable distance between sprinklers



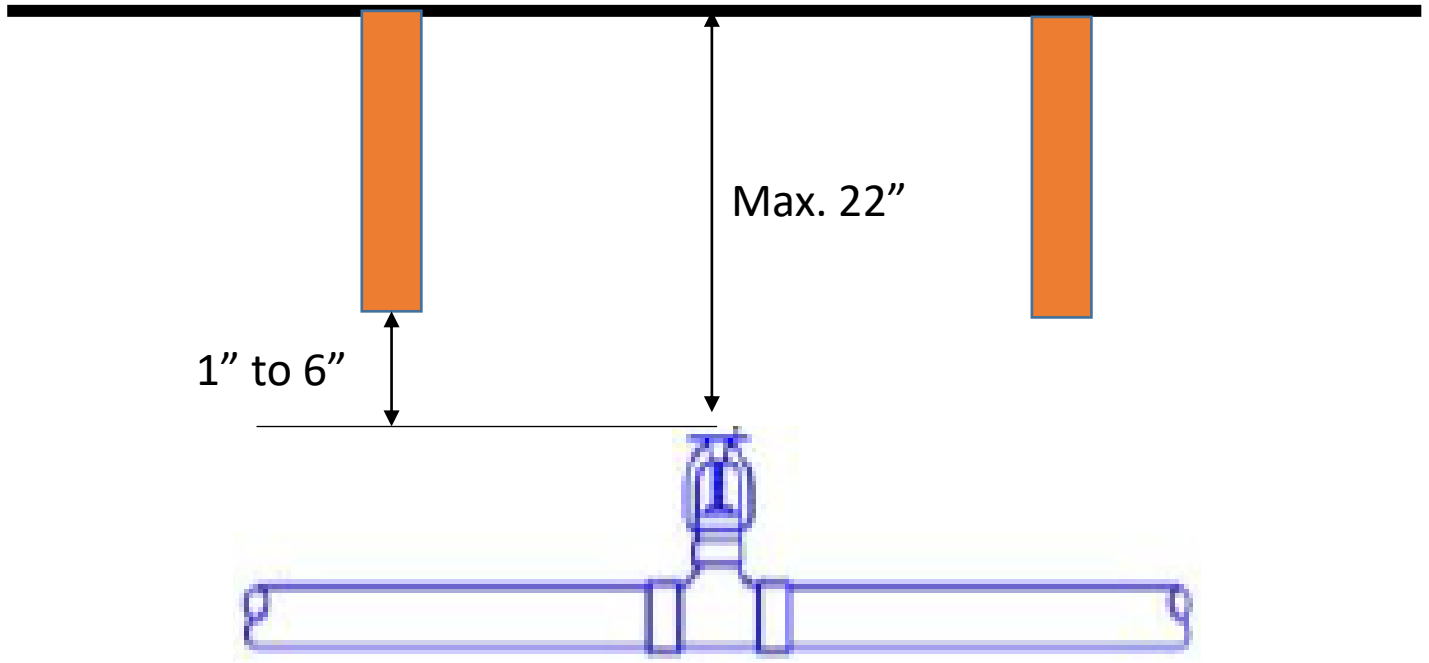
8.6.4- Deflector Positions

- Distance below Ceiling
- Unobstructed Construction



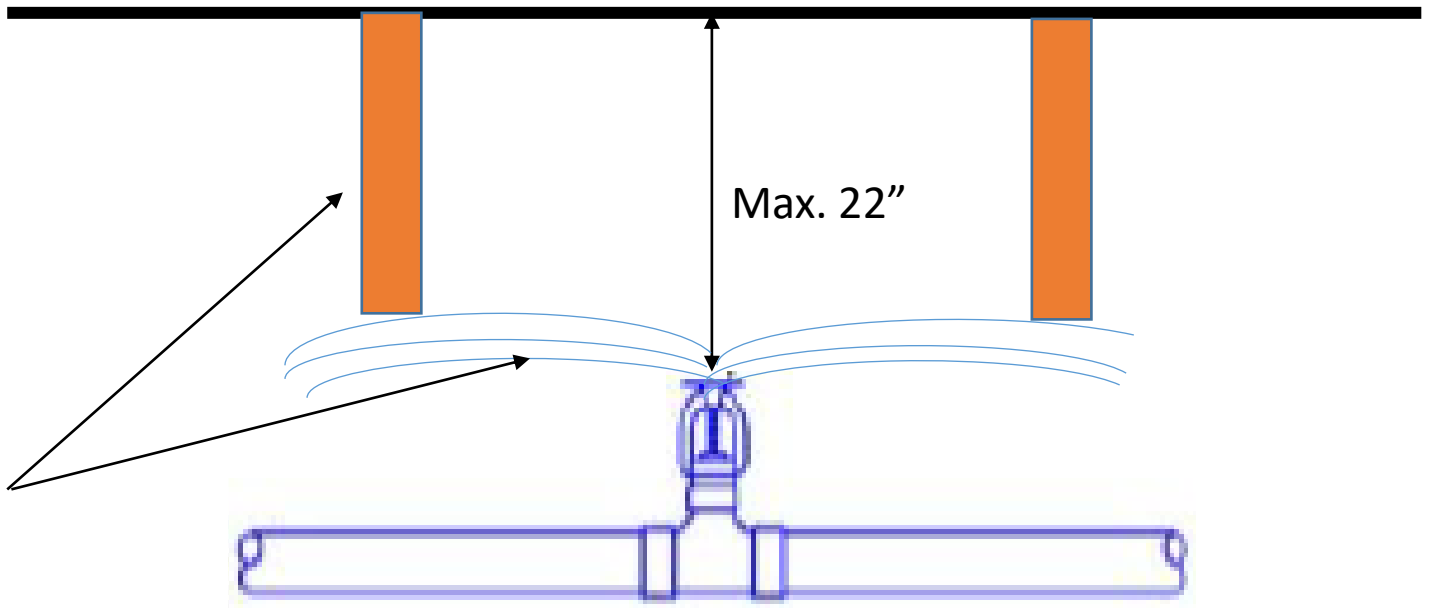
8.6.4- Deflector Positions

- Distance below Ceiling
- obstructed Construction- 8.6.4.1.2 (1)



8.6.4- Deflector Positions

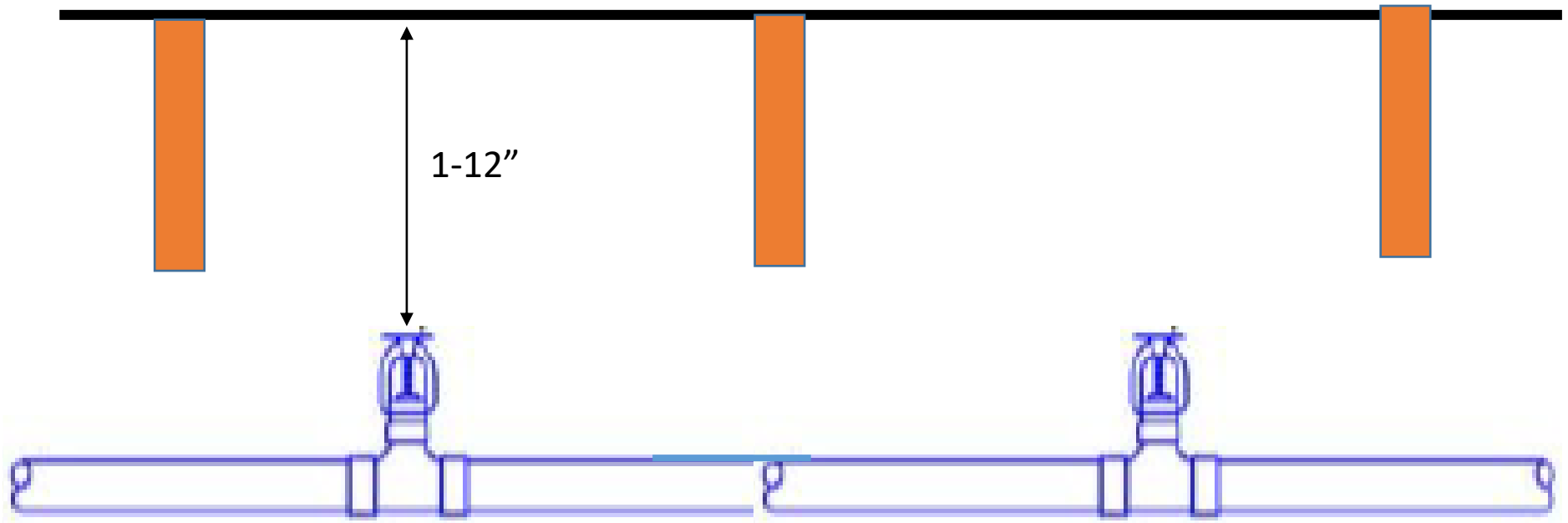
- Distance below Ceiling
- obstructed Construction- 8.6.4.1.2 (2) – Beam Rule



Make sure spray clears structural member.

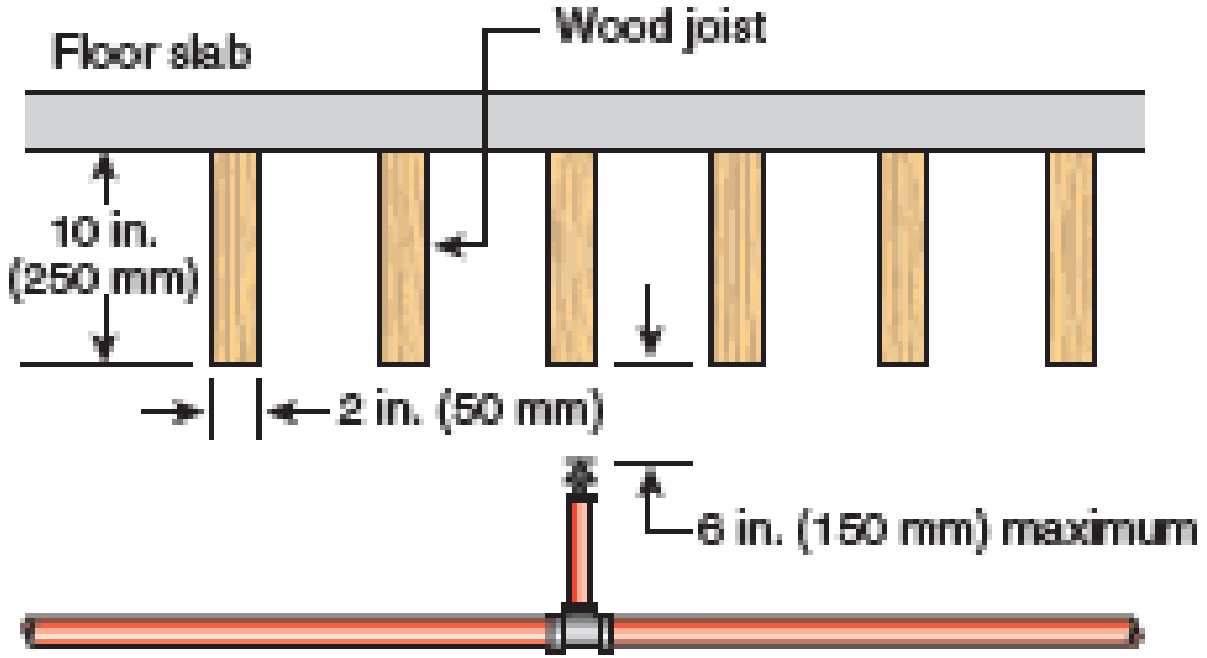
8.6.4- Deflector Positions

- Distance below Ceiling
- obstructed Construction- 8.6.4.1.2 (3)



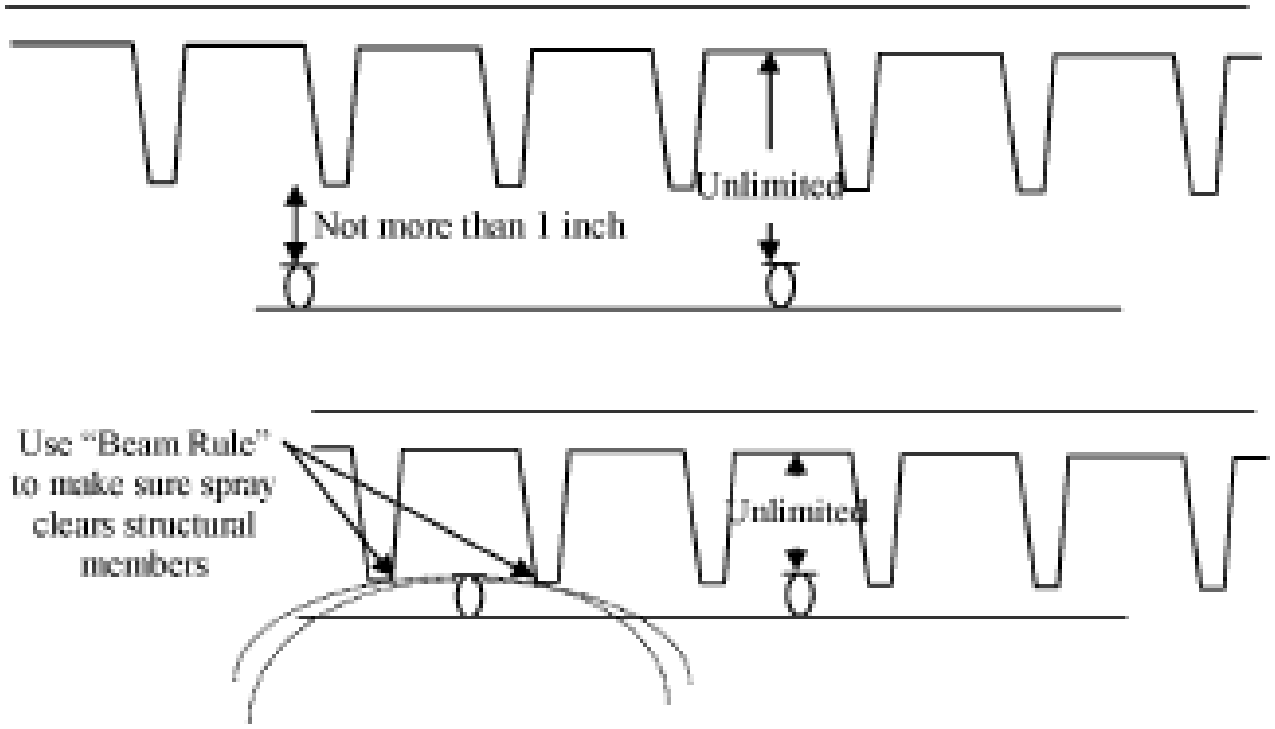
8.6.4- Deflector Positions

- Distance below Ceiling
- obstructed Construction- 8.6.4.1.2 (4)

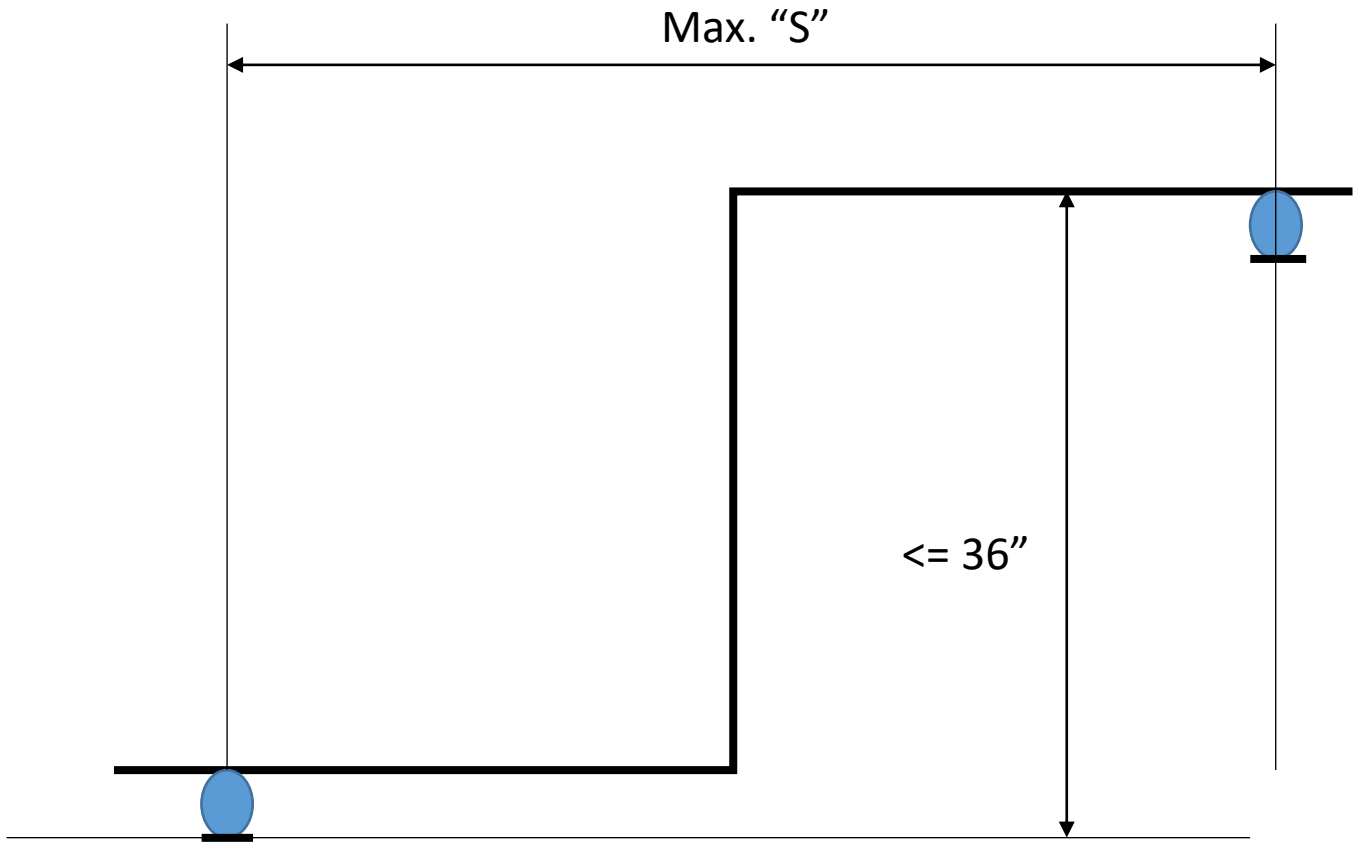


8.6.4- Deflector Positions

- Distance below Ceiling
- obstructed Construction- 8.6.4.1.2 (5)

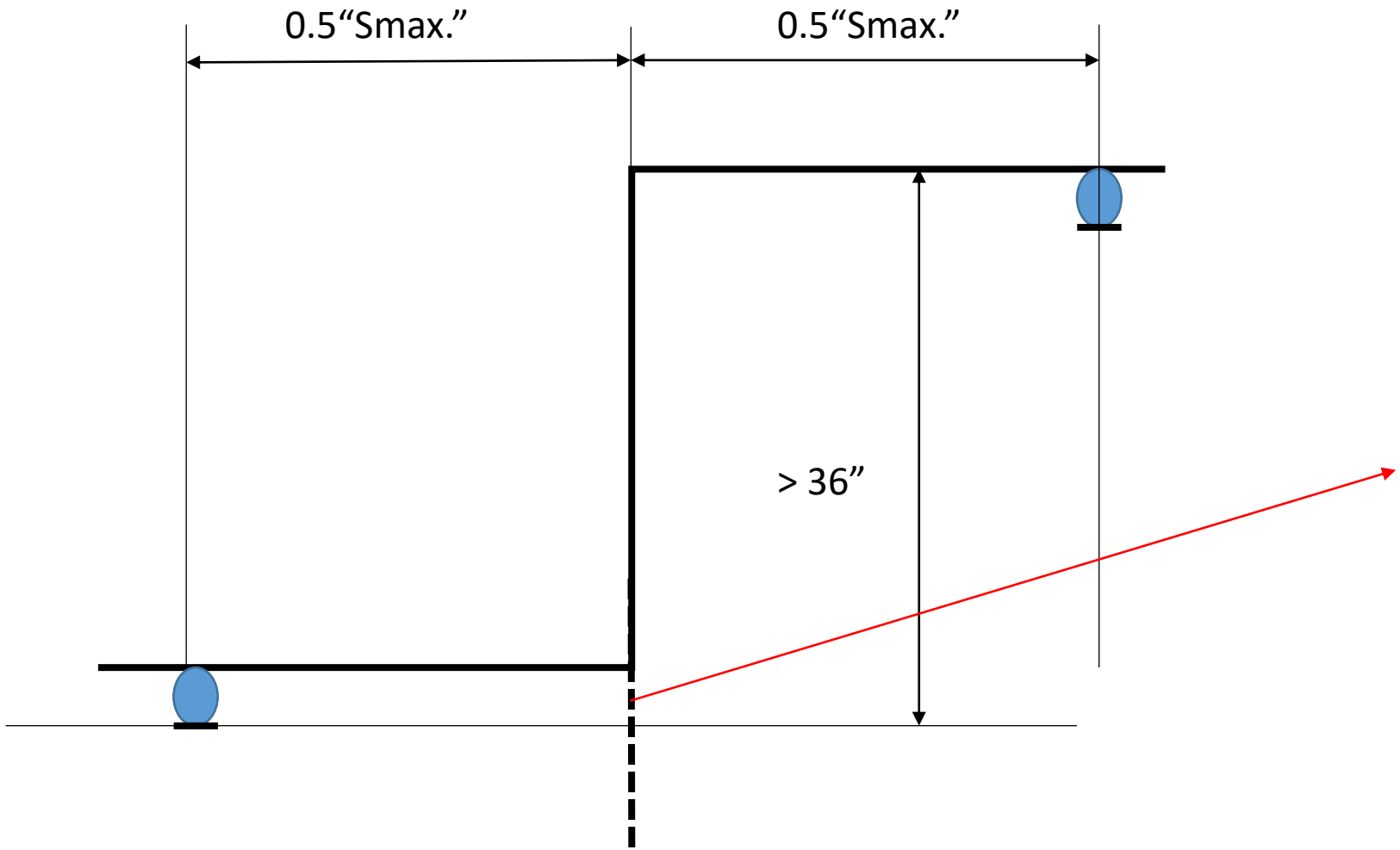


Non Uniform Ceiling



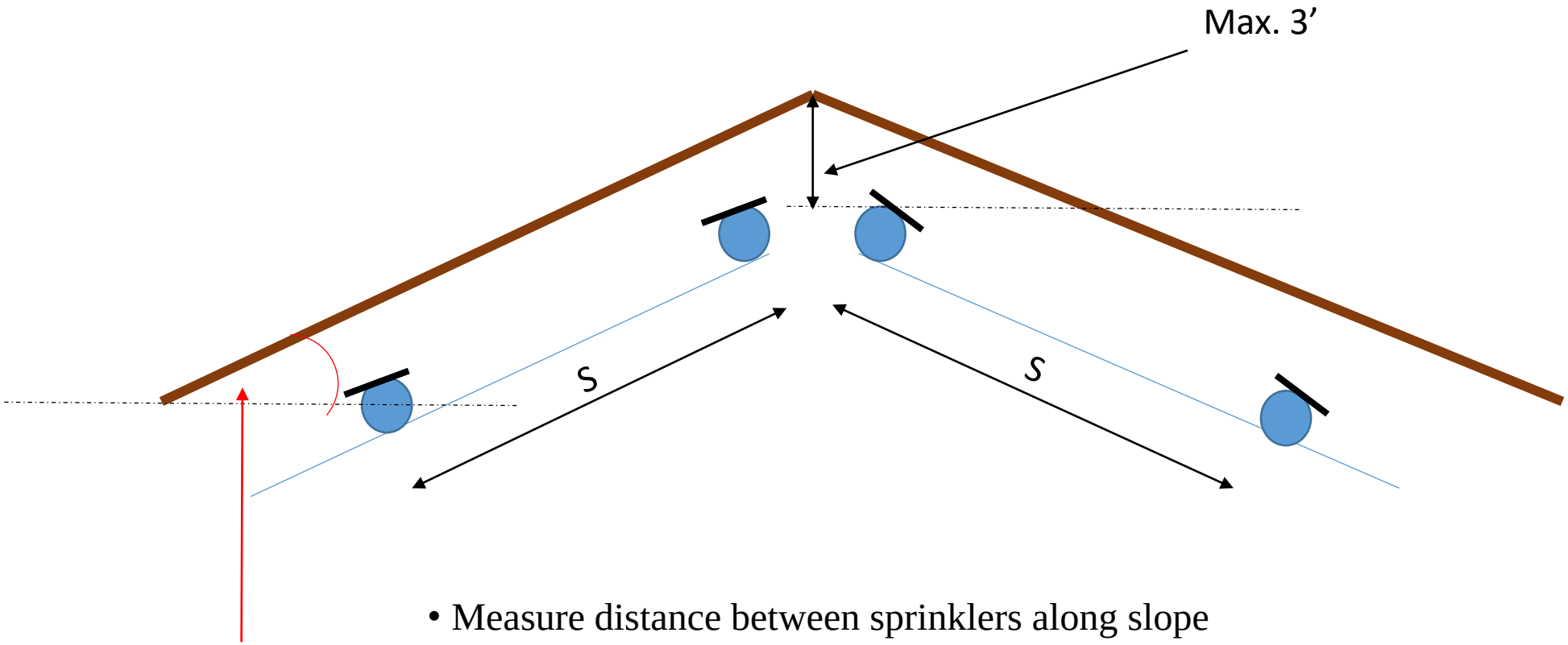
Sprinkler @ upper elevation must meet obstruction rules if protecting spaces under lower ceiling.

Non Uniform Ceiling



Treat as wall for the purpose of sprinkler spacing.

Sloped Ceiling



- Measure distance between sprinklers along slope
- Highest sprinkler 3 ft maximum from peak

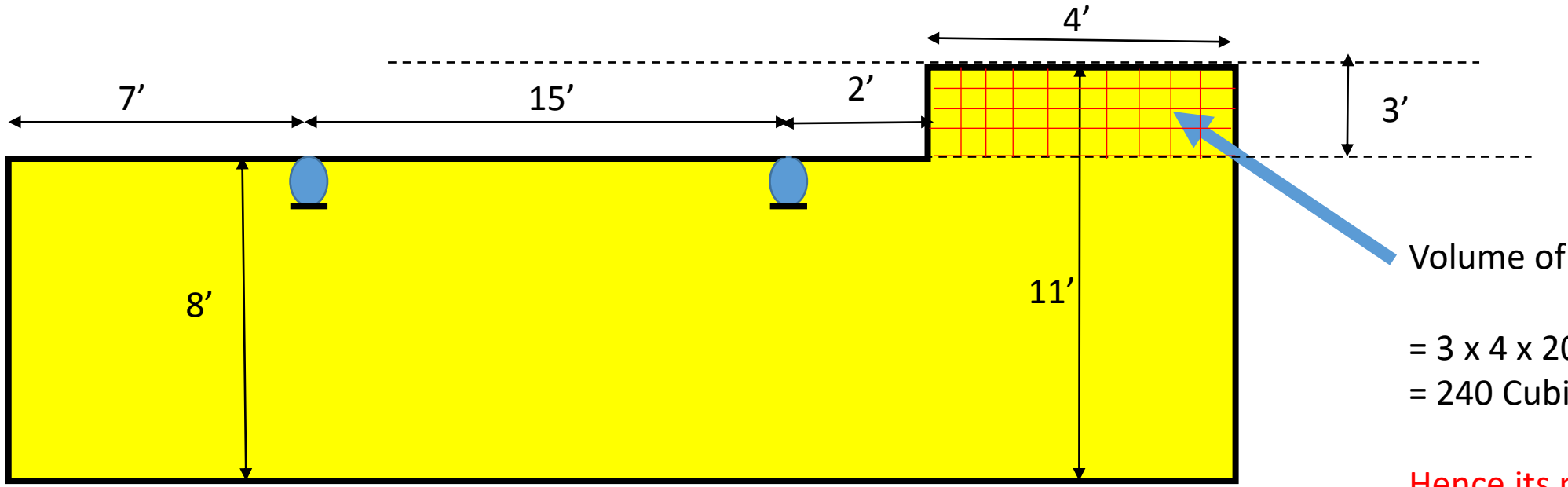
8.6.7- Ceiling Pockets

Sprinklers can only be omitted from ceiling pockets when the following are met

- Volume does not exceed 1000 ft3
- Depth of the pocket does not exceed 36 in
- Floor space under the pocket is covered by sprinklers at the lower ceiling elevation
- Total size of all unprotected pockets within 10ft of each other does not exceed 1000 cubic feet
- Construction is noncombustible or limited combustible finish
- Quick response sprinklers are used throughout the compartment

8.6.7- Ceiling Pockets

Are sprinklers required in the upper ceiling area if the occupancy is light hazard and the sprinklers are on 15 x 15 spacing? Assume room is 20 ft wide in the dimension not shown.



Volume of this Pocket

= 3 x 4 x 20
= 240 Cubic Ft. < 1000 Cubic ft.

Hence its not required

Obstruction Rules

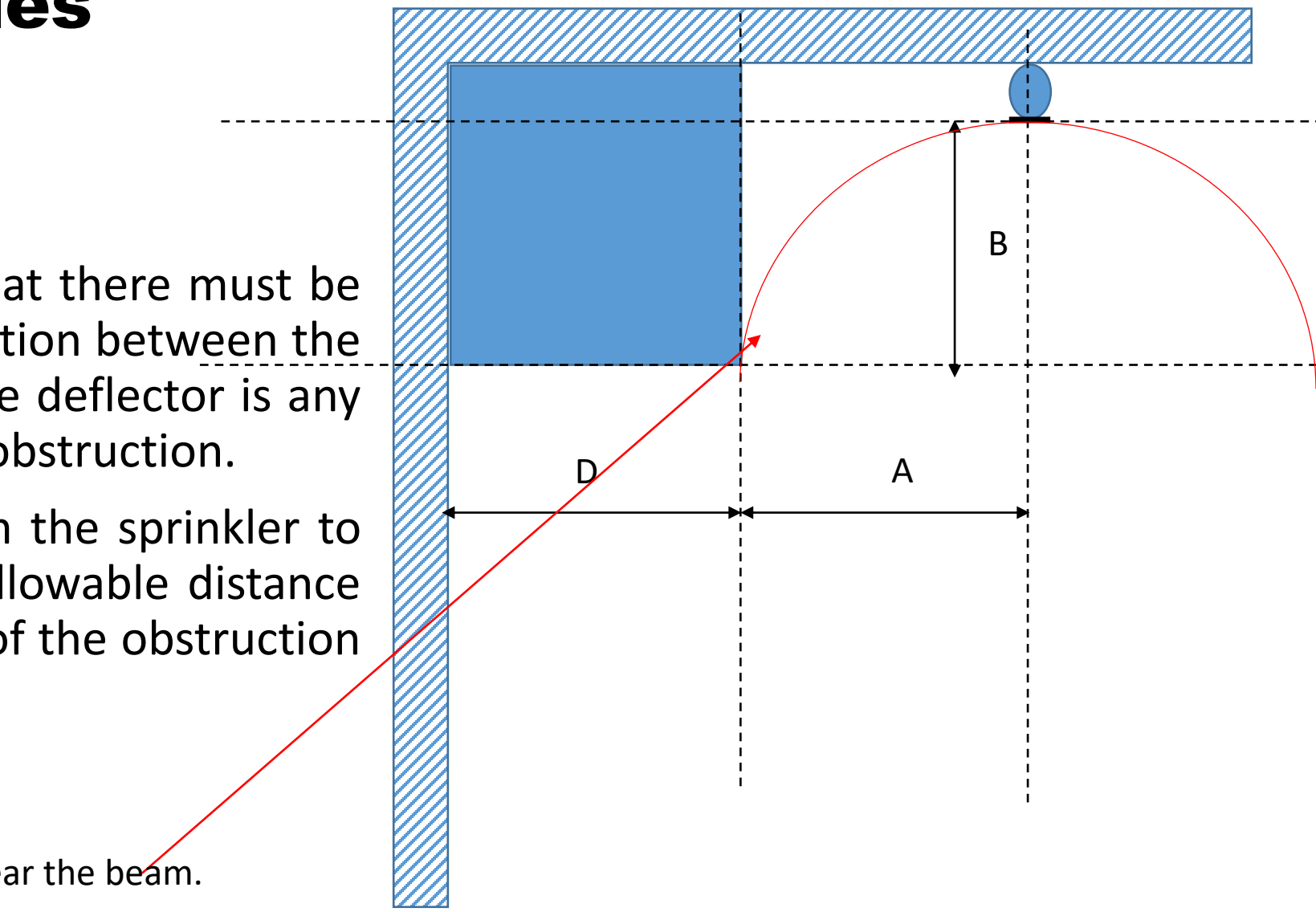
1. The Beam Rule
2. The Three Time Rule
3. The Four foot & wide obstruction Rule

Obstruction Rules

The Beam Rule :

In short the “beam rule” states that there must be at least 1 foot (0.3048 m)of separation between the sprinkler and the obstruction if the deflector is any distance above the bottom of the obstruction.

As the distance (A) increases from the sprinkler to the obstruction the greater the Allowable distance from the deflector to the bottom of the obstruction (B)



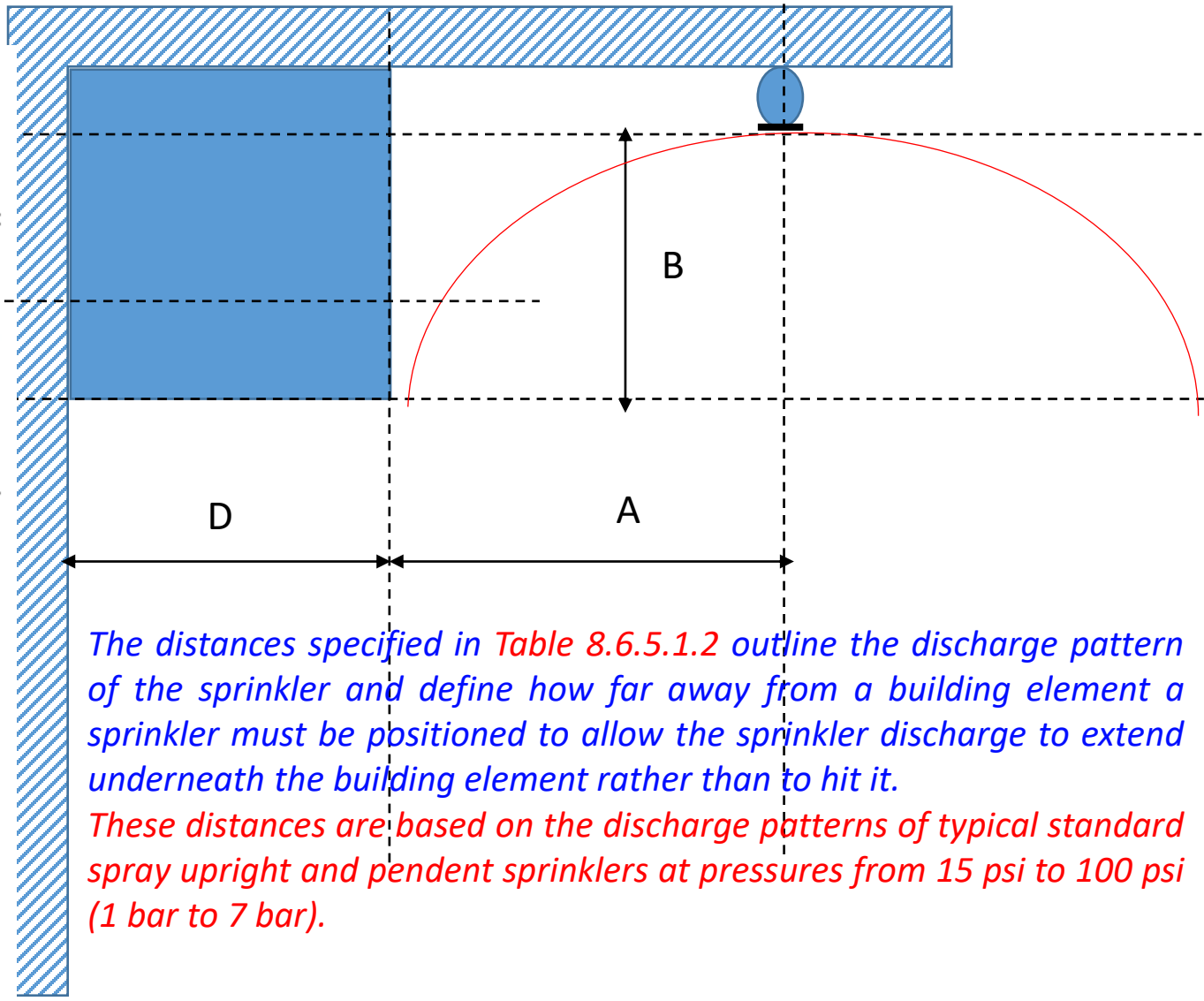
Spray Umbrella should clear the beam.

Obstruction Rules

The Beam Rule :

Table 8.6.5.1.2 Positioning of Sprinklers to Avoid Obstructions to Discharge [Standard Spray Upright/Standard Spray Pendent (SSU/SSP)]

Distance from Sprinklers to Side of Obstruction *(A)*	Maximum Allowable Distance of Deflector Above Bottom of Obstruction *(B)* (in.)
Less than 1 ft	0
1 ft to less than 1 ft 6 in.	2½
1 ft 6 in. to less than 2 ft	3½
2 ft to less than 2 ft 6 in.	5½
2 ft 6 in. to less than 3 ft	7½
3 ft to less than 3 ft 6 in.	9½
3 ft 6 in. to less than 4 ft	12
4 ft to less than 4 ft 6 in.	14
4 ft 6 in. to less than 5 ft	16½
5 ft to less than 5 ft 6 in.	18
5 ft 6 in. to less than 6 ft	20
6 ft to less than 6 ft 6 in.	24
6 ft 6 in. to less than 7 ft	30
7 ft to less than 7 ft 6 in.	35



The distances specified in Table 8.6.5.1.2 outline the discharge pattern of the sprinkler and define how far away from a building element a sprinkler must be positioned to allow the sprinkler discharge to extend underneath the building element rather than to hit it.

These distances are based on the discharge patterns of typical standard spray upright and pendent sprinklers at pressures from 15 psi to 100 psi (1 bar to 7 bar).

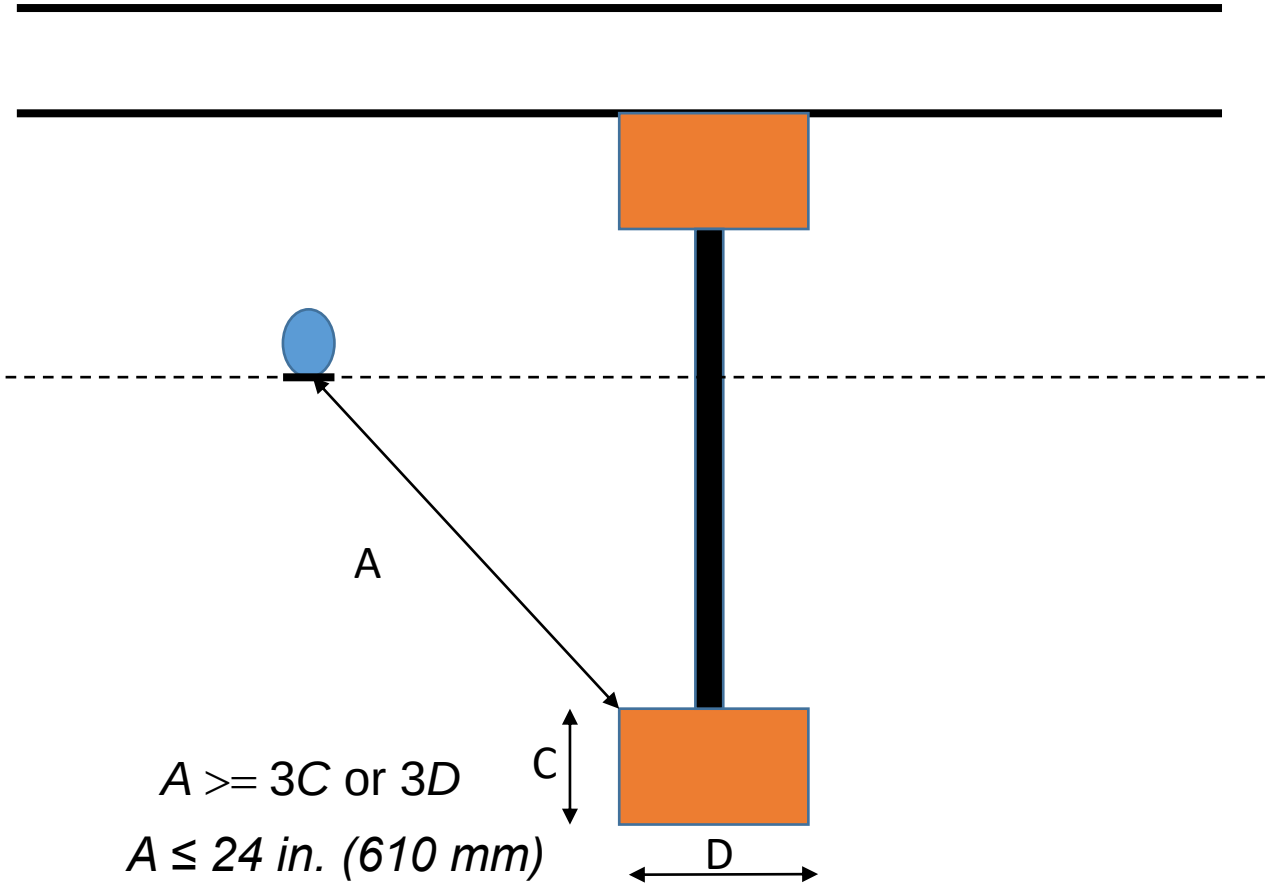
Obstruction Rules

The Three Time Rule :

It states that unless specific requirements are met *"sprinklers shall be positioned away from obstructions a minimum distance of three times the maximum dimensions of the obstruction"*, up to a maximum of 24 inches (0.6096 m) though the *"maximum clear distance does not apply to obstructions in the vertical orientation*

This rule have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant dry shadow on the other side of the obstruction

This works for small non-continuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Three Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction



(Use dimension C or D, whichever is greater)

Obstruction Rules

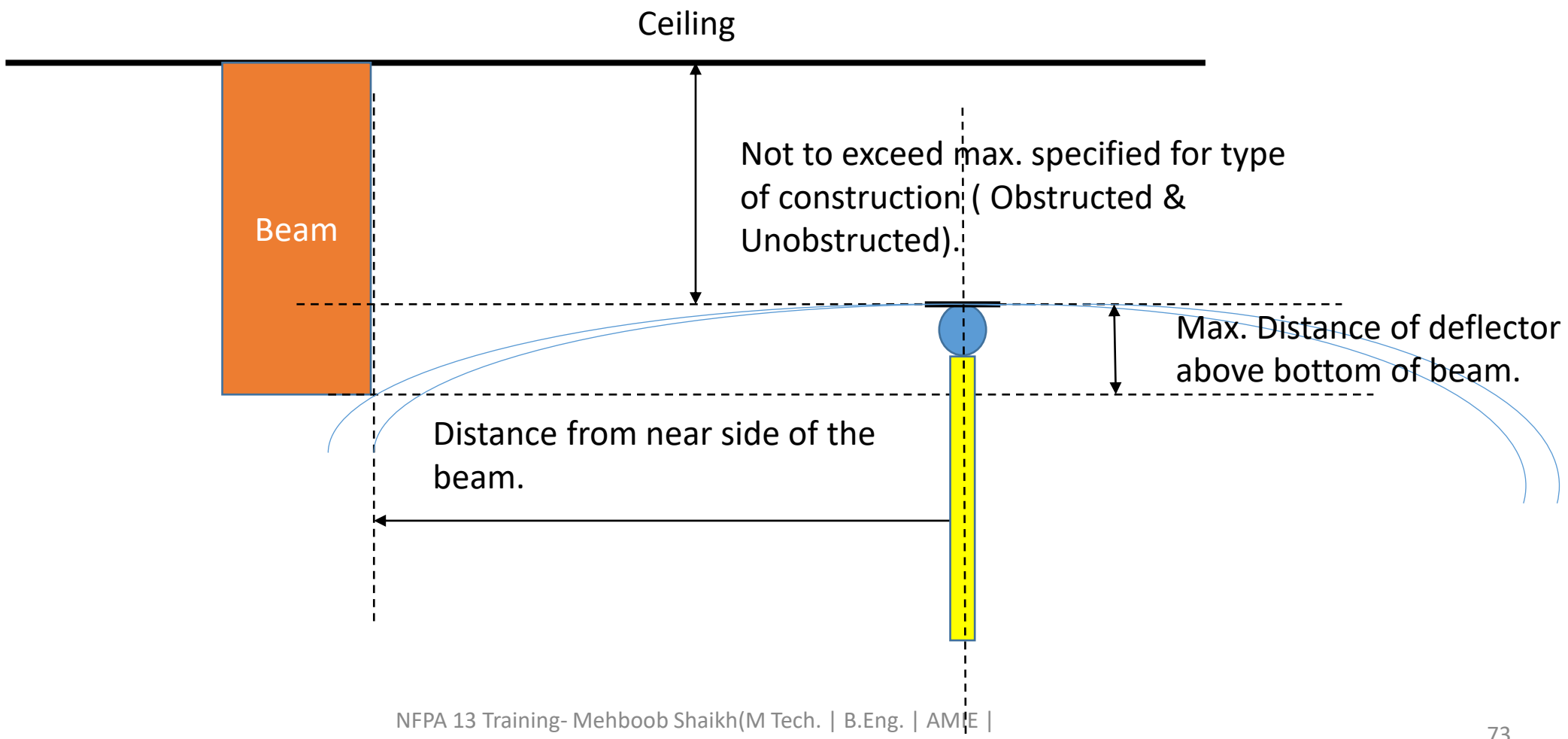
The Four-Foot and Wide Obstruction Rule

The *"Four Times Rule"* is really just an extension of the *"three times rule"* however it covers extended coverage sprinklers and the maximum clearance is 36 inches (0.9144 m).

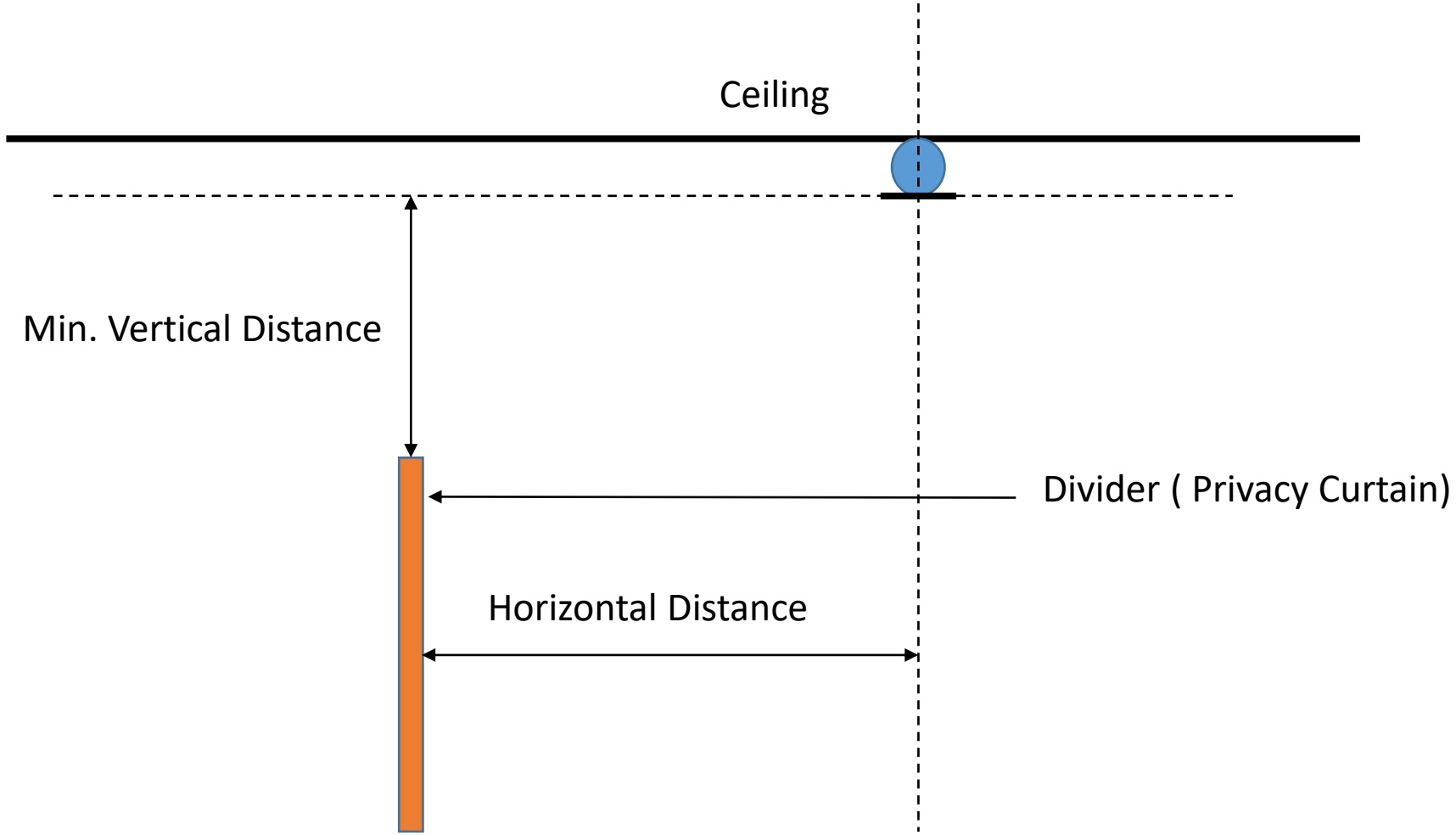
For obstructions wider than 4 feet (1.2192 m), sprinkler protection is required below the obstruction with deflectors to be located less than 12 inches (0.3048 m) from the bottom of the obstruction.

For obstructions less than 4 feet (1.2192 m) in width sprinklers may not be required underneath the obstruction

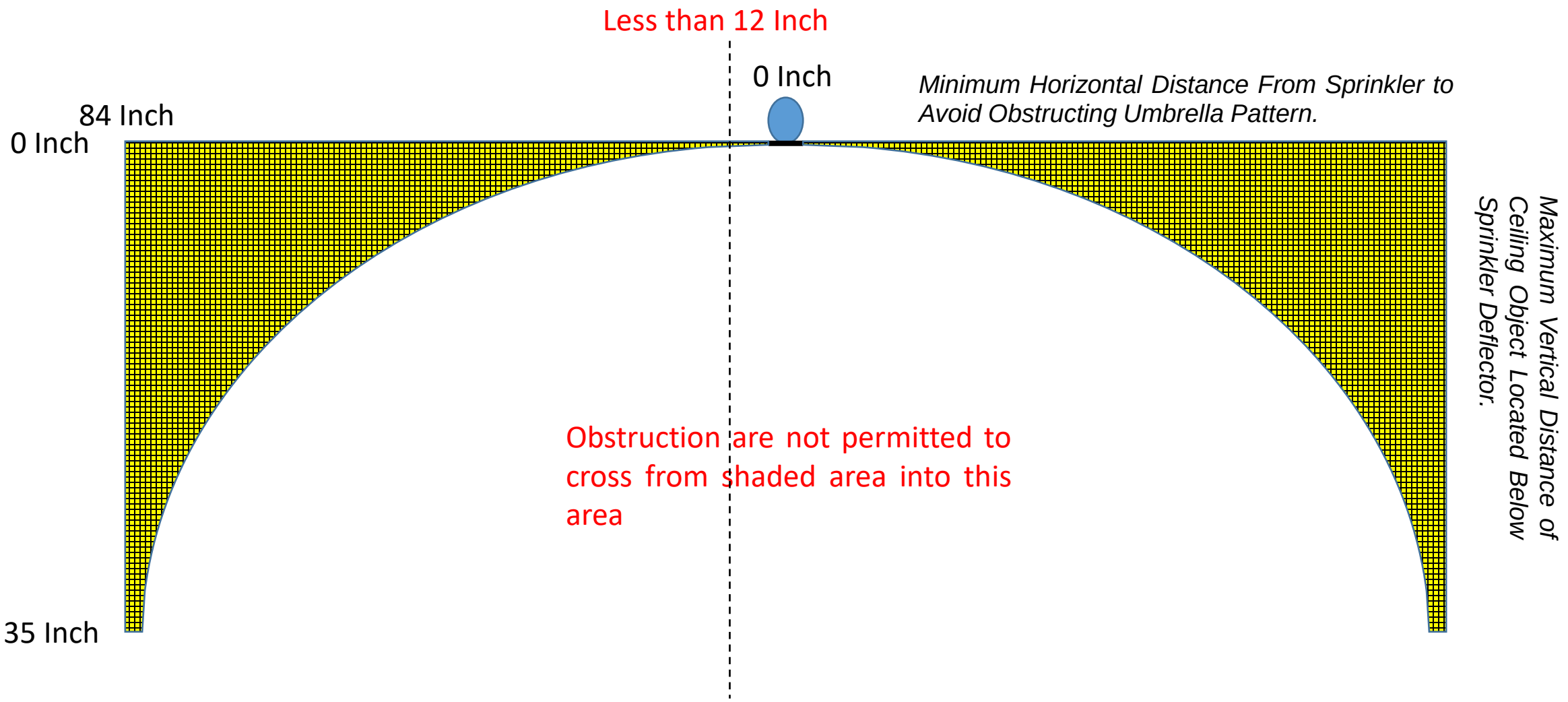
8.6.5 – Obstruction to Sprinkler Discharge



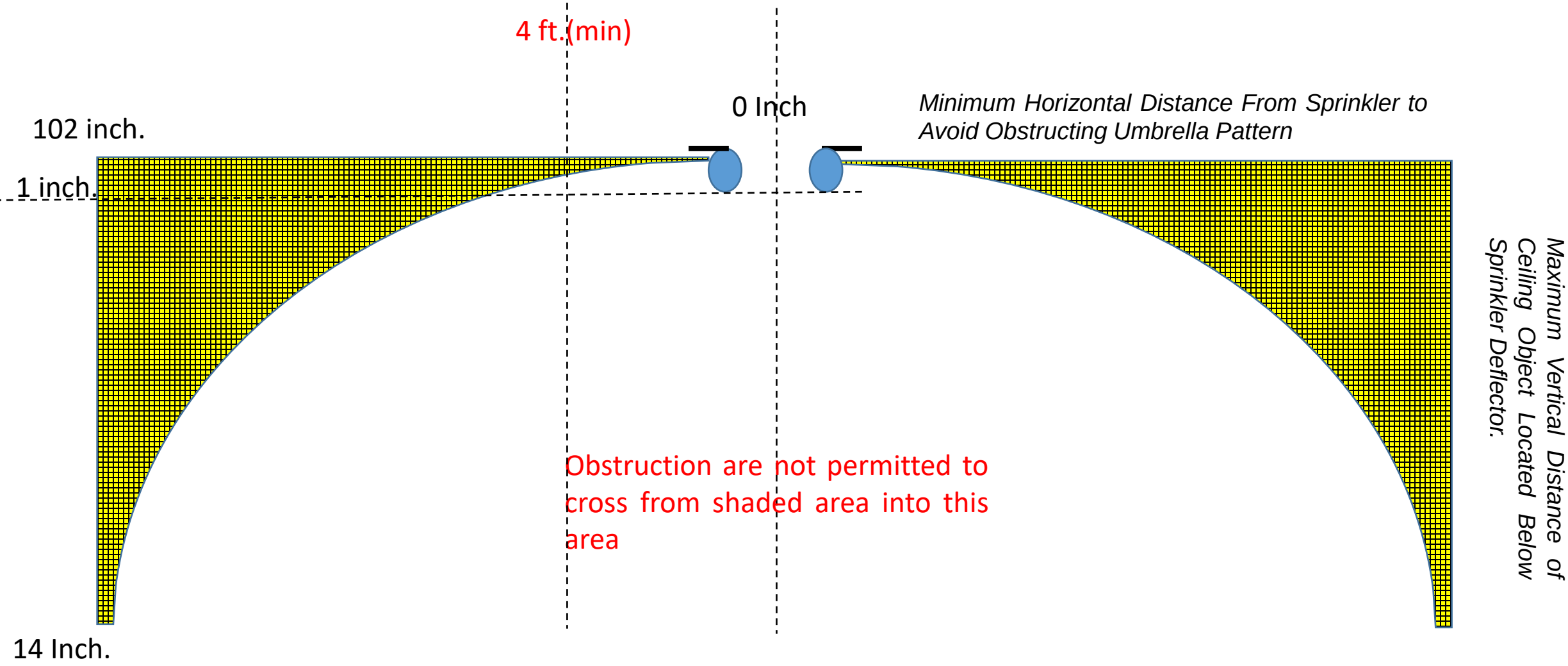
8.6.5 – Obstruction to Sprinkler Discharge



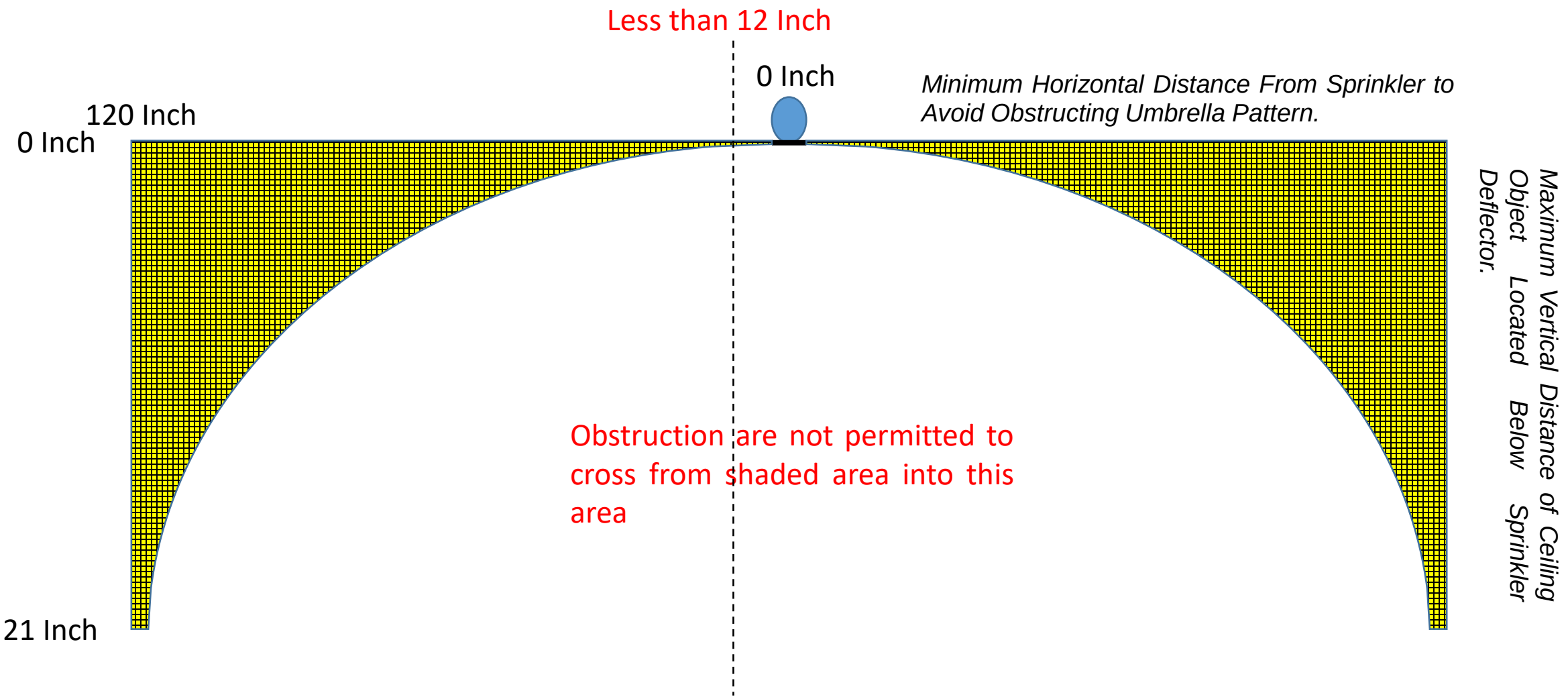
8.6.5- SSP and SSU – Non Storage



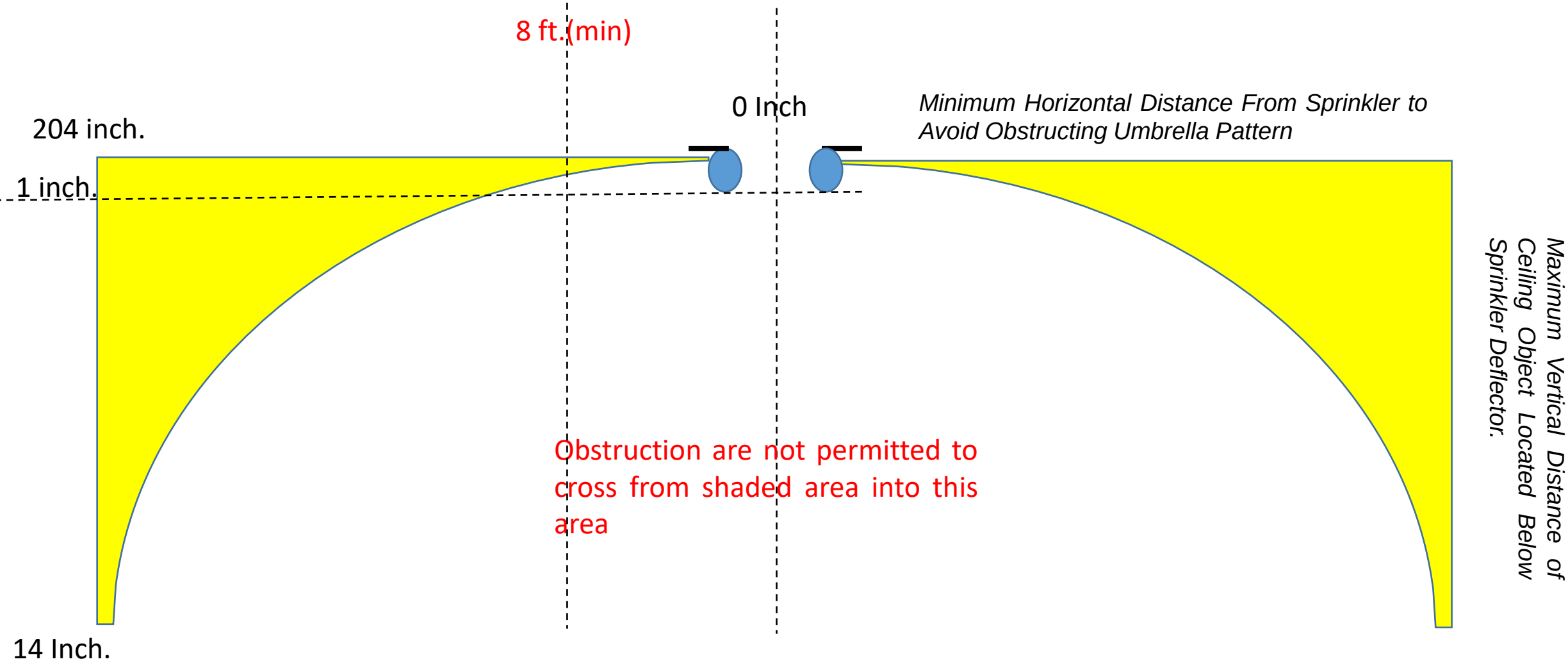
8.7.5 - Standard Coverage Sidewall – Non Storage



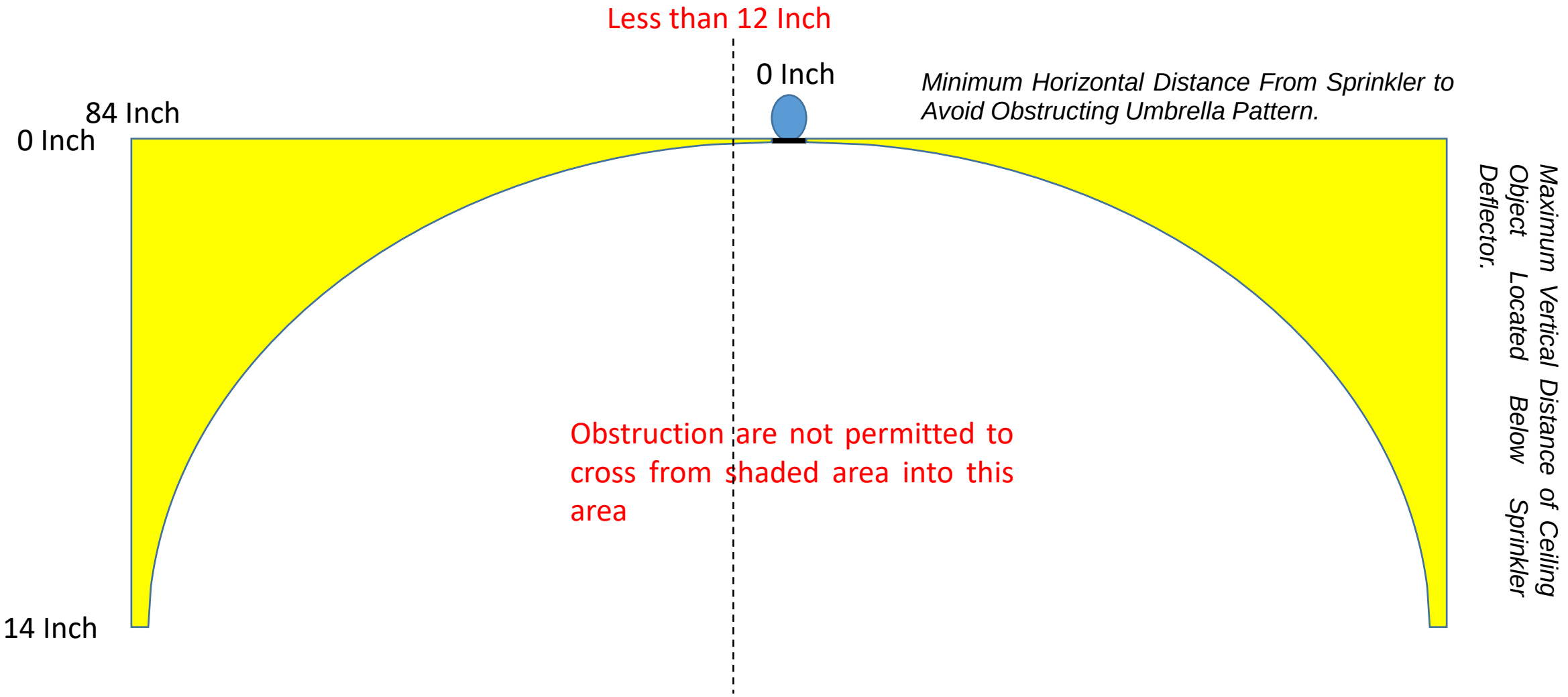
8.8.5- SSP and SSU EC – Non Storage



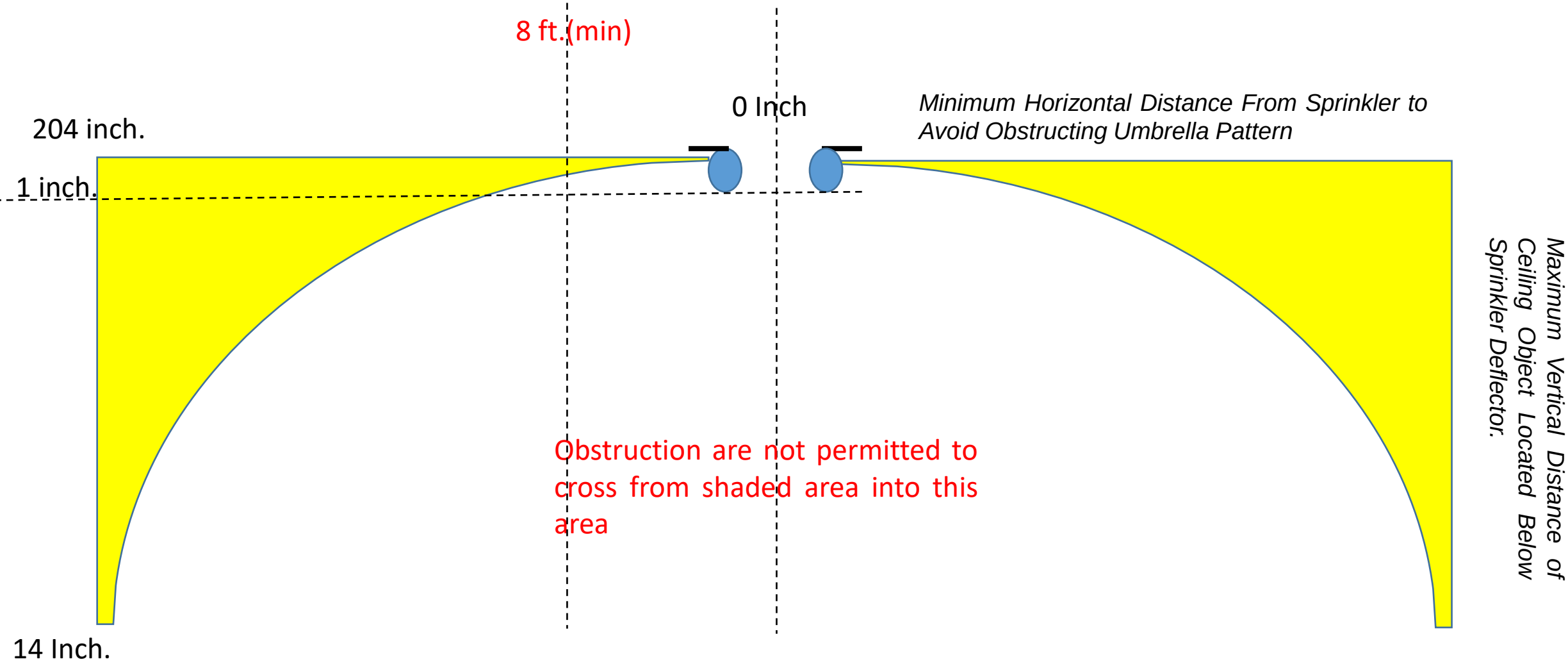
8.9.5 - Extended Coverage Sidewall – Non Storage



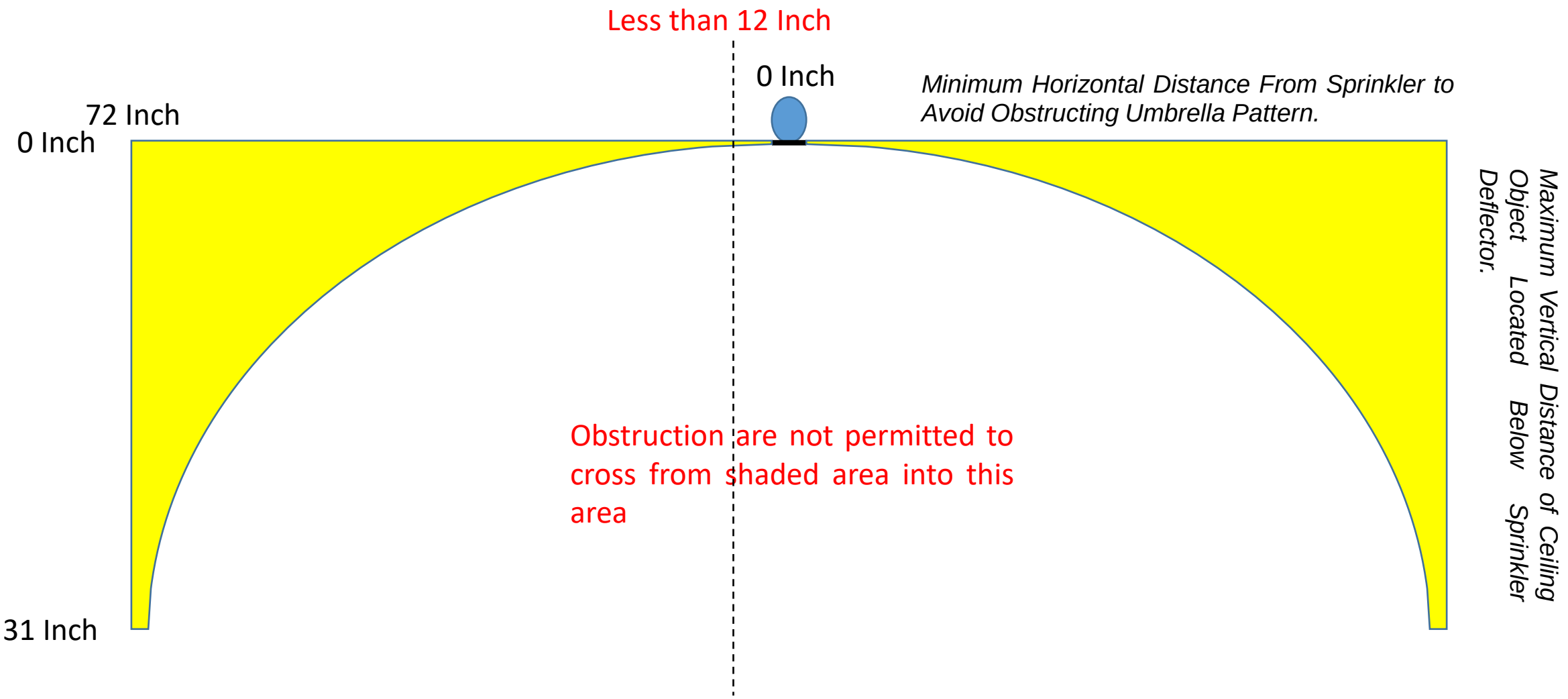
8.10.6- Residential Pendant and upright– Non Storage



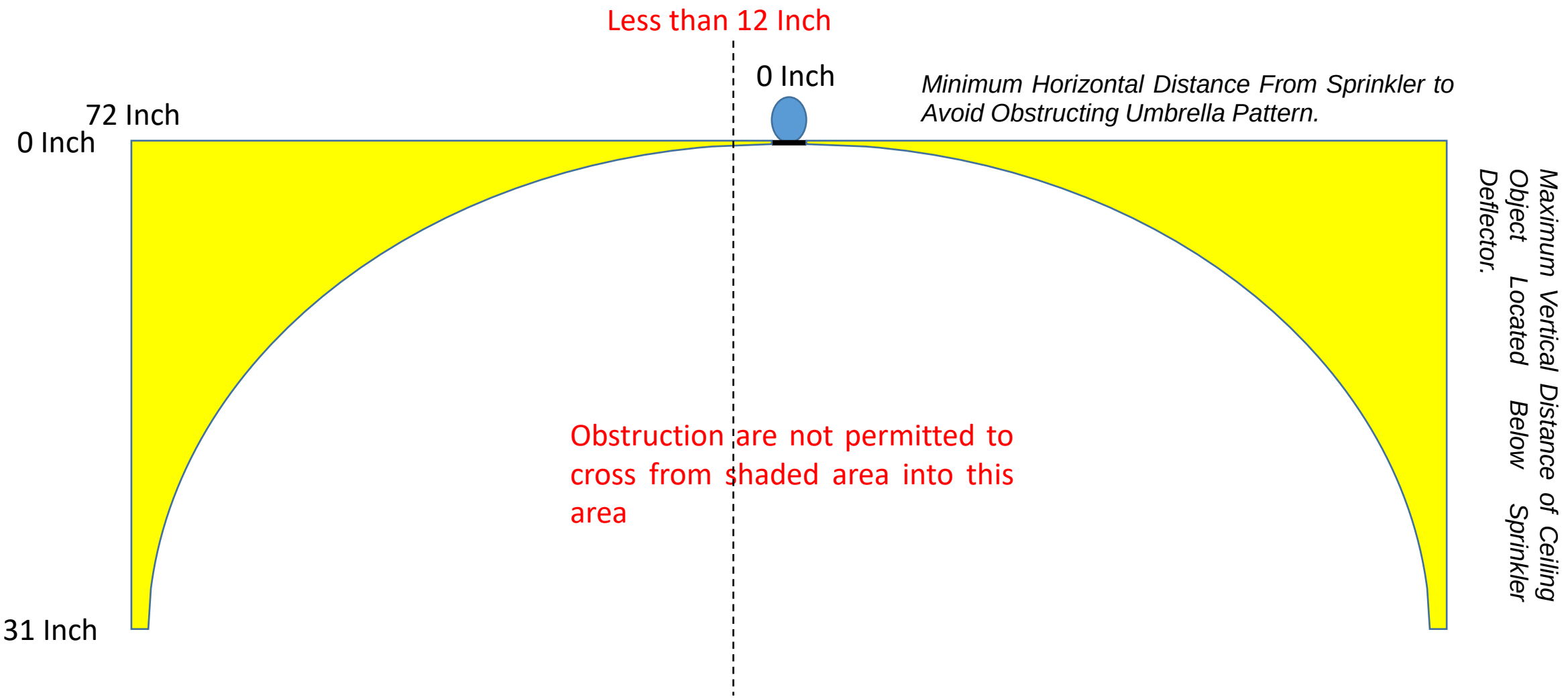
8.10.7 – Residential Sidewall – Non Storage



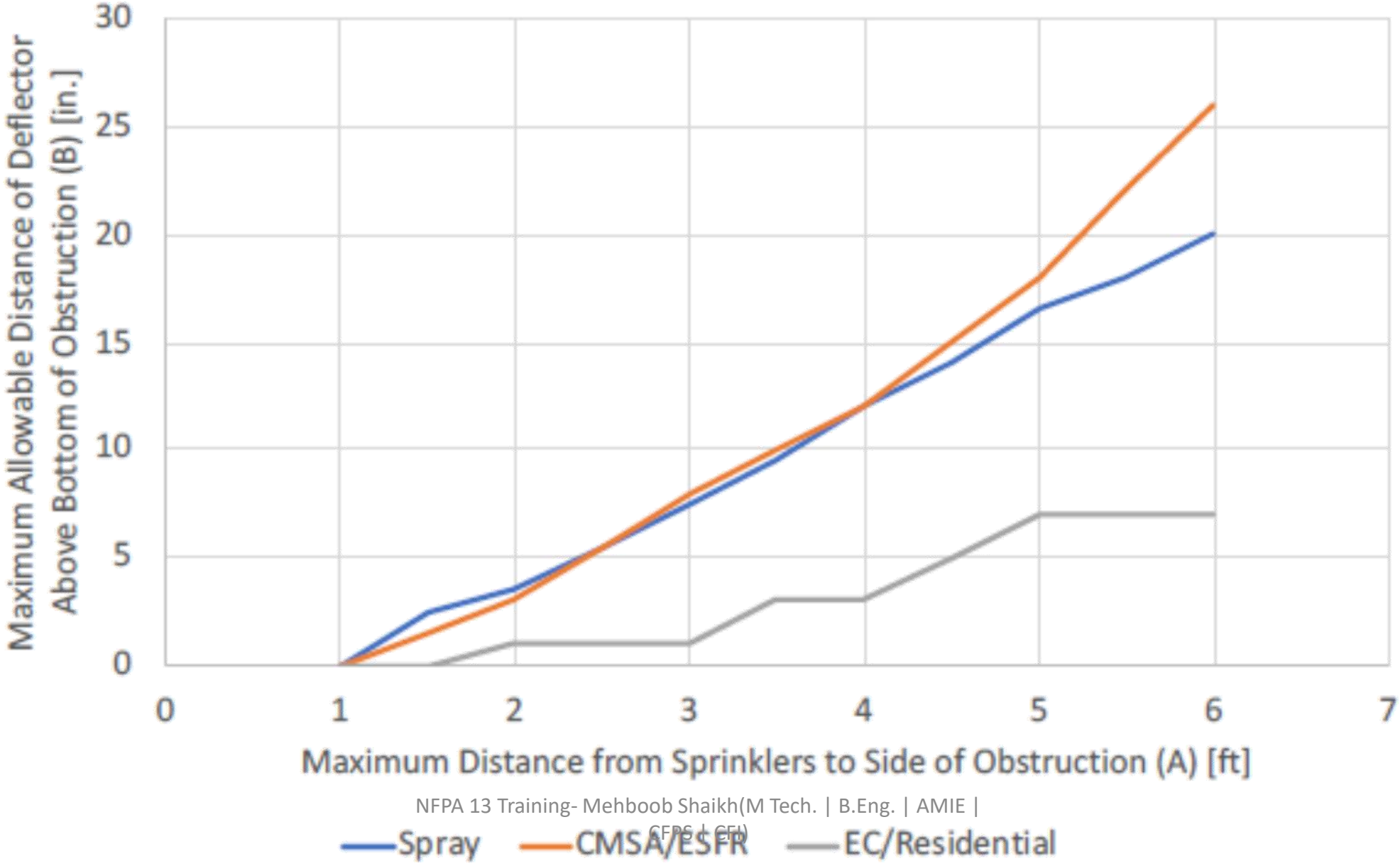
8.11.5- CMSA Sprinklers



8.12.5- ESFR Sprinklers



COMPARISON


Maximum Allowable Distance of Deflector Above Bottom of Obstruction (B) [in.]
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
Maximum Distance from Sprinklers to Side of Obstruction (A) [ft]
Spray
CMSA/ESFR
EC/Residential

Available Height for Storage

Max. Height at which commodities can be stored above the floor and still maintain necessary clearance from structural members and the required clearance below sprinklers

Encapsulation

A method of packaging that either consists of a plastic sheet completely enclosing the sides and top of a pallet load containing a combustible commodity, a combustible package, or a group of combustible commodities or combustible packages, or consists of combustible commodities individually wrapped in plastic sheeting and stored exposed in a pallet load.

The term *encapsulated* does not apply to plastic-enclosed products or packages inside a large, neoplastic, enclosed container.

Where there are holes or voids in the plastic on the top of the carton that exceed more than half of the area of the cover, the term *encapsulated* does not apply

Expanded Plastics (Foamed or Cellular)

Those plastics, the density of which is reduced by the presence of numerous small cavities (cells), interconnecting or dispersed throughout their mass.

Unexpanded Plastics

Unexpanded plastics are higher density materials that may be formed into different shapes such as drums, containers, toys etc.

Free-Flowing Plastic Materials

Those plastics that fall out of their containers during a fire, fill flue spaces, and create a smothering effect on the fire.

High-Piled Storage

Solid-piled, palletized, rack storage, bin box, and shelf storage in excess of 12 ft. (3.7 m) in height.

Reinforced plastic pallet(RPP)

A plastic pallet incorporating a secondary reinforcing material (such as steel or fiberglass) within the pallet.

Hold their structure and integrity longer allowing air gaps to remain longer within the pallet, which fuels the flames and creates a more intense fire

Types of Storage Arrangements

Bin Box Storage :

Storage in five-sided wood, metal, or cardboard boxes with open face on the aisles in which boxes are self-supporting or supported by a structure so designed that little or no horizontal or vertical space exists around boxes.

Should be made up of
Wood, metal or Cardboard

Types of Storage Arrangements

Palletized Storage :

Storage of commodities on pallets or other storage aids that form horizontal spaces between tiers of storage.

Types of Storage Arrangements

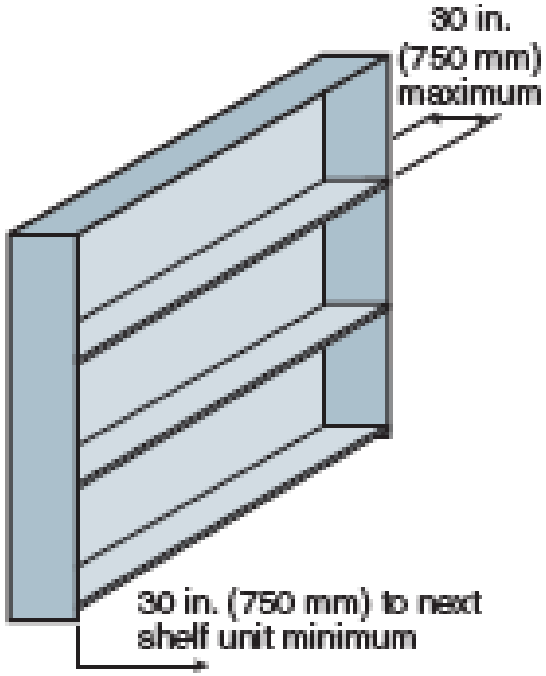
Solid Pile Storage :

Storage of commodities stacked on each other.

Types of Storage Arrangements

Shelf Storage :

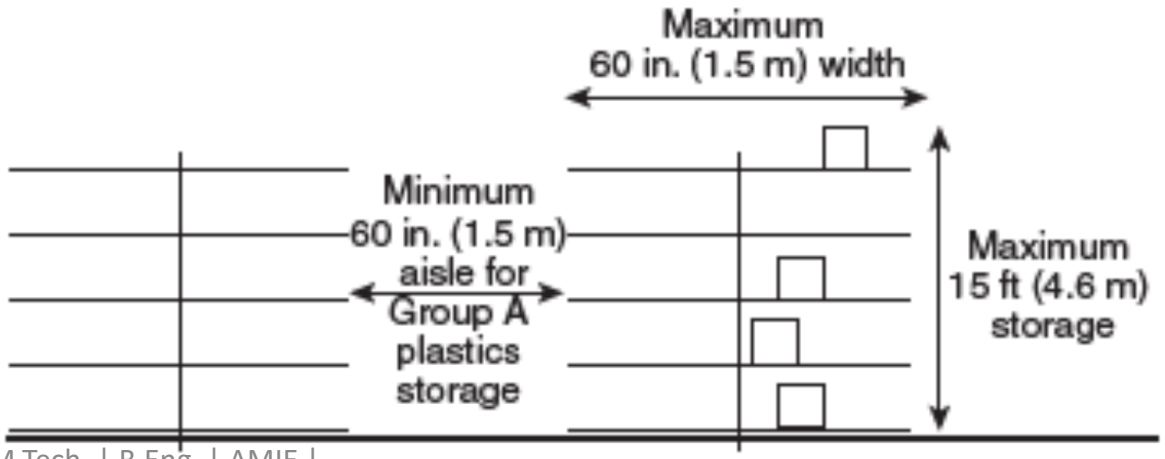
Storage on structures up to and including 30 in. (0.76 m) deep and separated by aisles at least 30 in. (0.76 m) wide.



Types of Storage Arrangements

Back to Back Shelf Storage :

Two solid or perforated shelves up to 30 in. (0.76 m) in depth each, not exceeding a total depth of 60 in. (1.52 m), separated by a longitudinal vertical barrier such as plywood, particleboard, sheet metal, or equivalent, with a maximum 0.25 in. (6.4 mm) diameter penetrations and no longitudinal flue space and a maximum storage height of 15 ft (4.57 m).

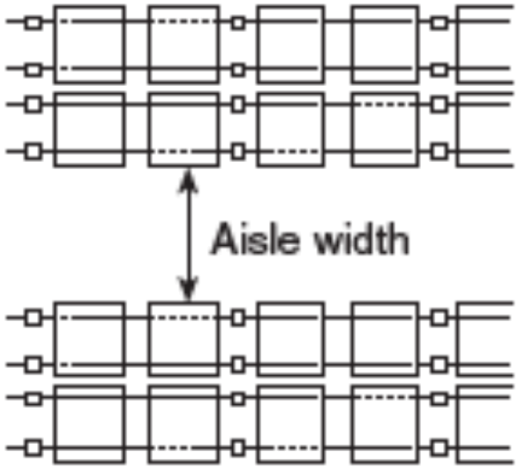


Types of Storage Arrangements

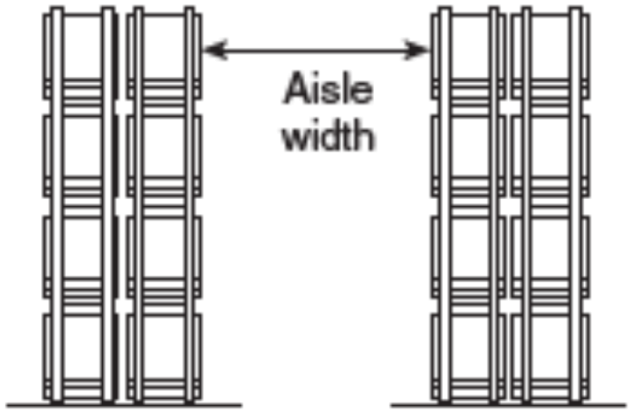
Rack Storage *(Can be fixed, single row, double row, multiple row)*

What is an Aisle…?

The horizontal dimension between the face of the loads in racks under consideration.



Plan View

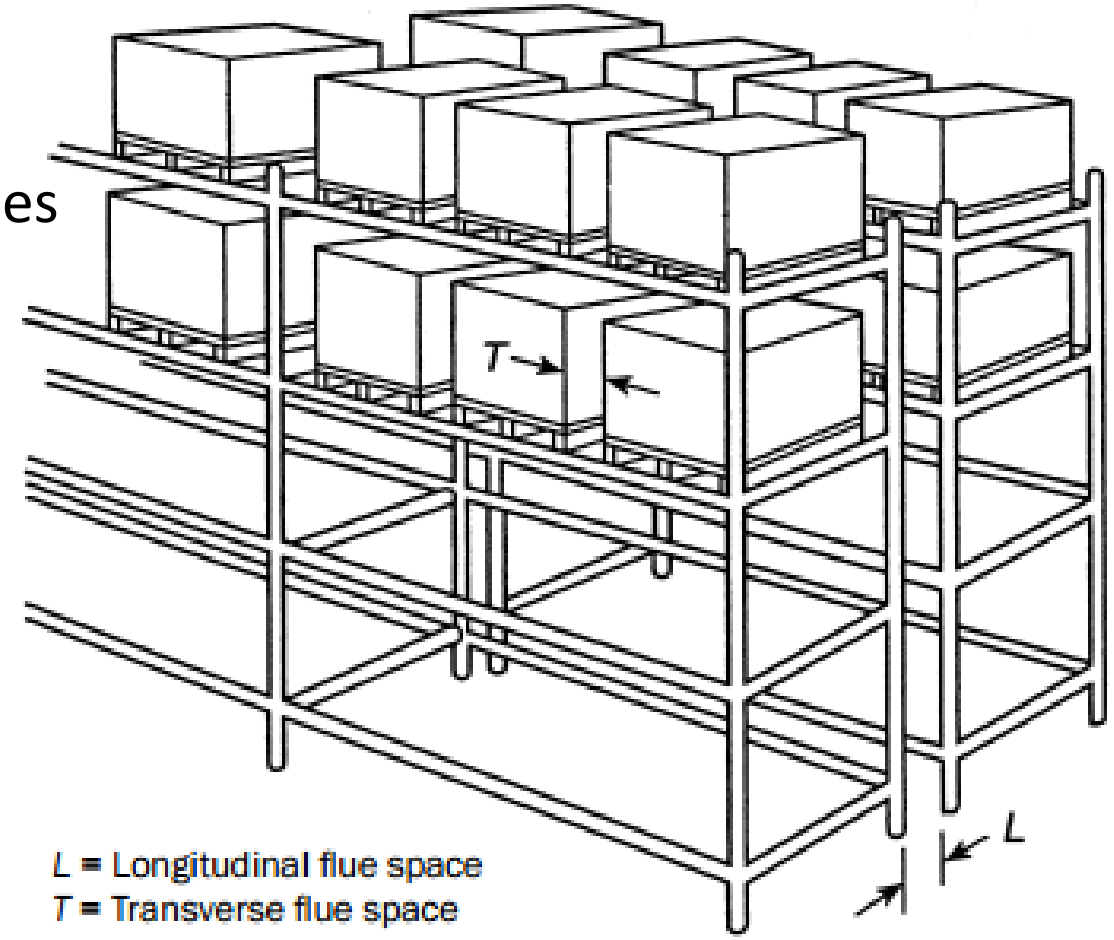


End View

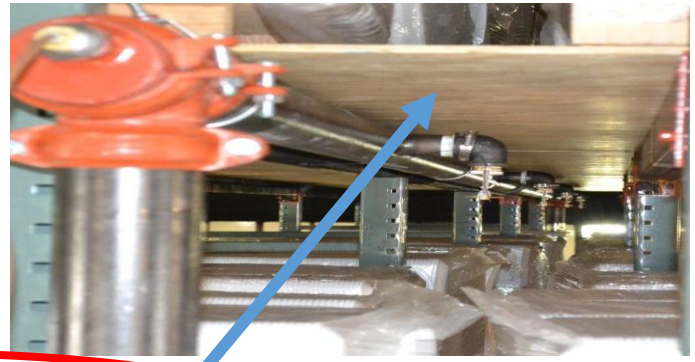
Types of Storage Arrangements

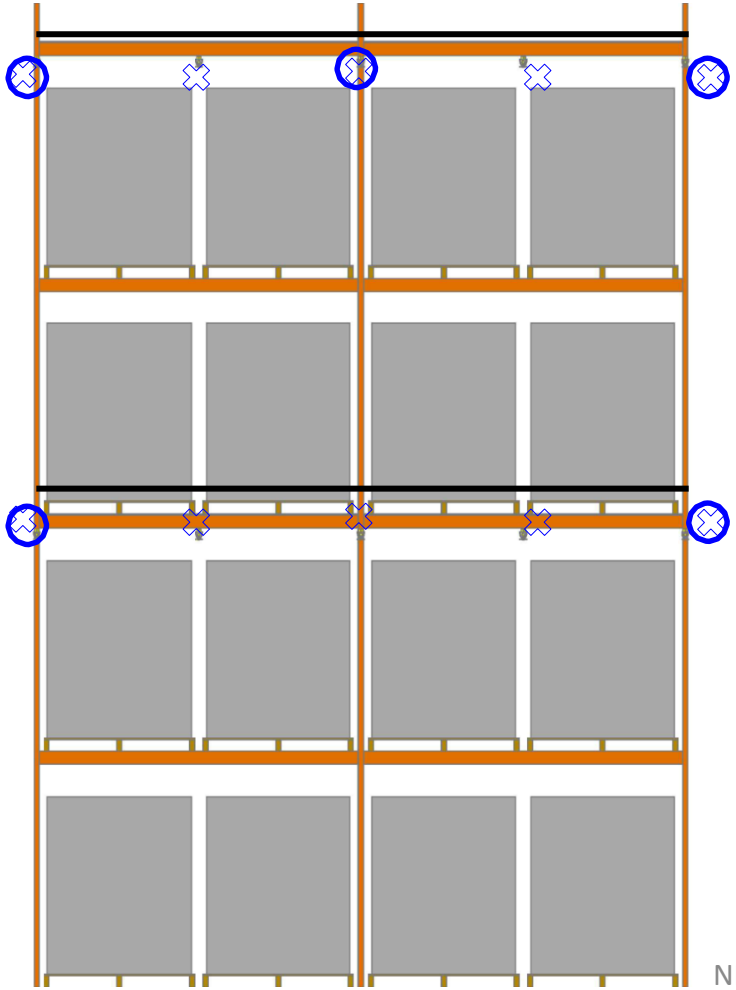
Rack Storage :

What is an Longitudinal & Transverse Flue Spaces



Use of Sprinkler in Racks





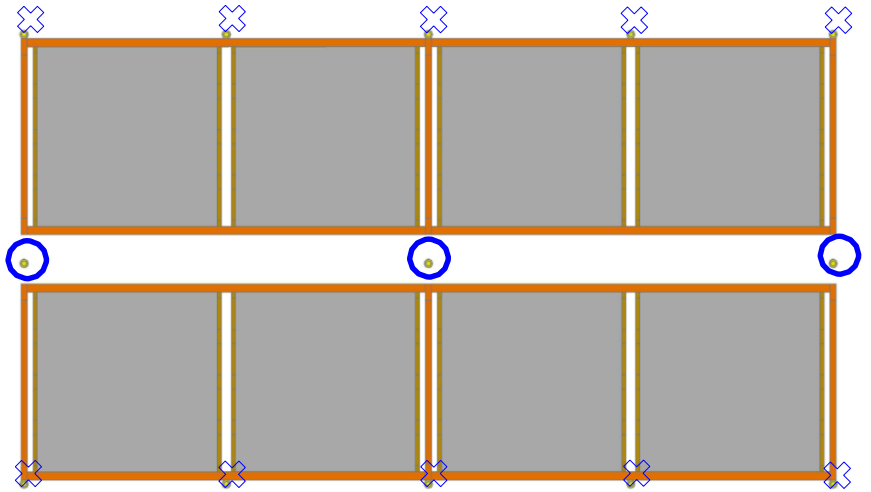
Elevation View

Prevents vertical spread of fire.

= Horizontal Barrier

= Longitudinal Flue Space Sprinklers

= Face Sprinklers



Plan View

Pile Stability

- Stable :Those arrays where collapse, spillage of content, or leaning of stacks across flue spaces is not likely to occur soon after initial fire development.
- Unstable : Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces occurs soon after initial fire development

Let’s Understand the Core Concept !!!

According to survey

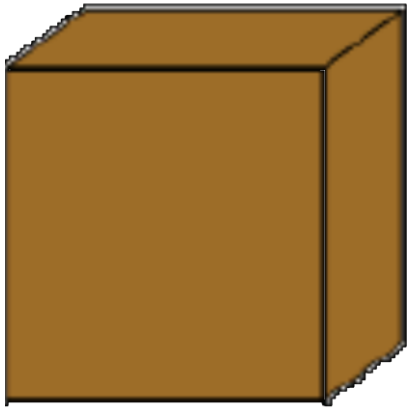
Fires in storage properties, . . . account for

I. 15.5 percent of nonresidential structure fires,
II. 19.5 percent of associated property damage,
III. 11.4 percent of associated civilian deaths, and
IV. 9.2 percent of associated civilian injuries.
V. In storage properties, the leading occupancies in which these fires occur are agriculture products storage facilities (38%), unclassified storage facilities (23%), and general-item storage facilities (14%)

Design Checklist for Sprinkler System

- Commodity Class
- Type of Pallet
- Storage Arrangement
- Ceiling height, Storage Height, Ceiling Clerance
- If the Storage is miscellaneous ?
- Other Consideration

Commodity Classification



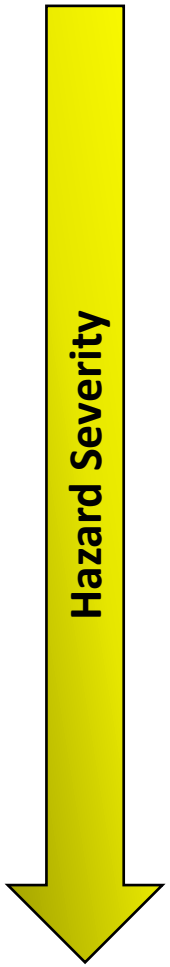
Warehouse commodity (Carton, packaging, plastic)

Plastic Group A-C

Class I -IV

Classify grouped commodity into one of seven hazard groups (Based on HRR)

Commodity Classification



Class Or Group	Class or Group Materials
Class 1	Essentially non-combustible products in corrugated cartons on combustible pallets
Class 2	Class I products in slatted wooden crates, solid wooden boxes or multiple thickness paperboard cartons with or without pallets
Class 3	Wood, paper, natural fiber cloth or 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 4	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
Plastics	Cartoned Unexpanded Group A Plastic
	Exposed Unexpanded Group A Plastic
	Cartoned Expanded Group A Plastic
	Exposed Expanded Group A Plastic

Commodity Classification -

Standardized Test Commodities

Class II

Cartoned Unexpanded Group A Plastic

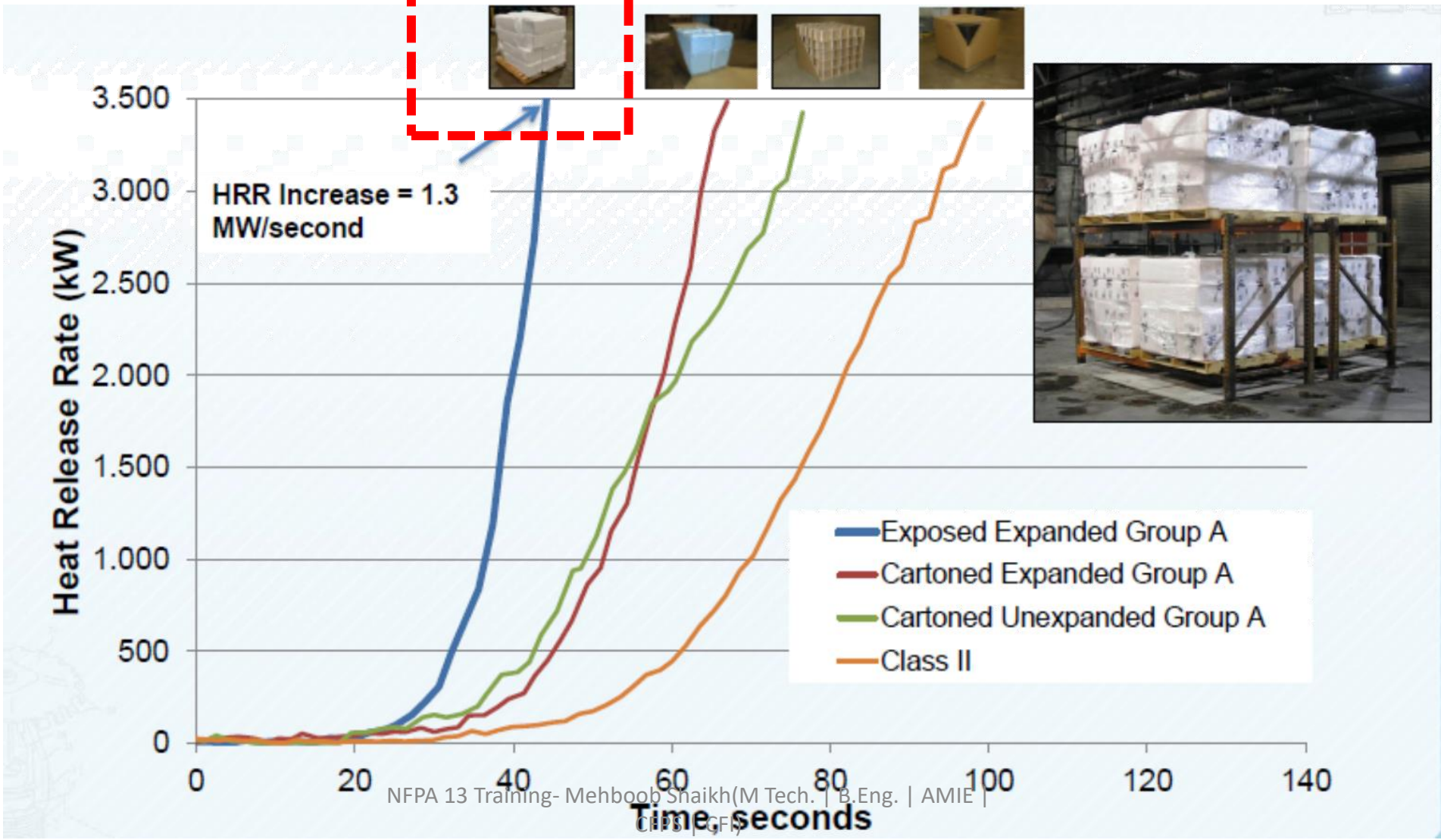
Class III

Cartoned, Expanded Group A Plastic

Class IV

Exposed, Expanded Group A Plastic

HRR Growth Curve of Standard Test Commodities



Type of Pallet

- Wood
- URPP – one Class Modification

One class upgrade for un-reinforced plastic pallets

Class II → Class III

Class IV → Group A Plastics

- RPP – Two Class Modification

Two class upgrade for reinforced plastic pallets

Class II → Class IV

Class IV → Group A Plastics

Storage Arrangement

- **Rack**
- Single row
- Double row
- Multiple row
- **Shelf**
- Open rack
- Solid shelving
- Slatted shelf
- Solid Shelf
- **Back to Back Shelf**
- **Solid pile**
- **Pelletized**
- **Bin box**

Storage Arrangements

- Bulk Storage
- Solid Pile Storage
- Palletized Pile Storage
- Rack Storage

NFPA #13 defines high-piled storage as any rack, palletized, or solid-pile storage in excess of 12’ in height.

Storage Height and Clearance

“Fire severity is a function of height. The taller the burning materials, the more rapidly the flames will accelerate”

“Materials stored twice as high will burn much more than twice as fast.”

Design Height can be determined by

(1) What the warehouse manager *says* the storage height will be limited to

(2) The elevation of the bottom of the lowest *beam* or structural roof member of the building. This is also refer to by those in the commercial real estate business as the building's "clear height"

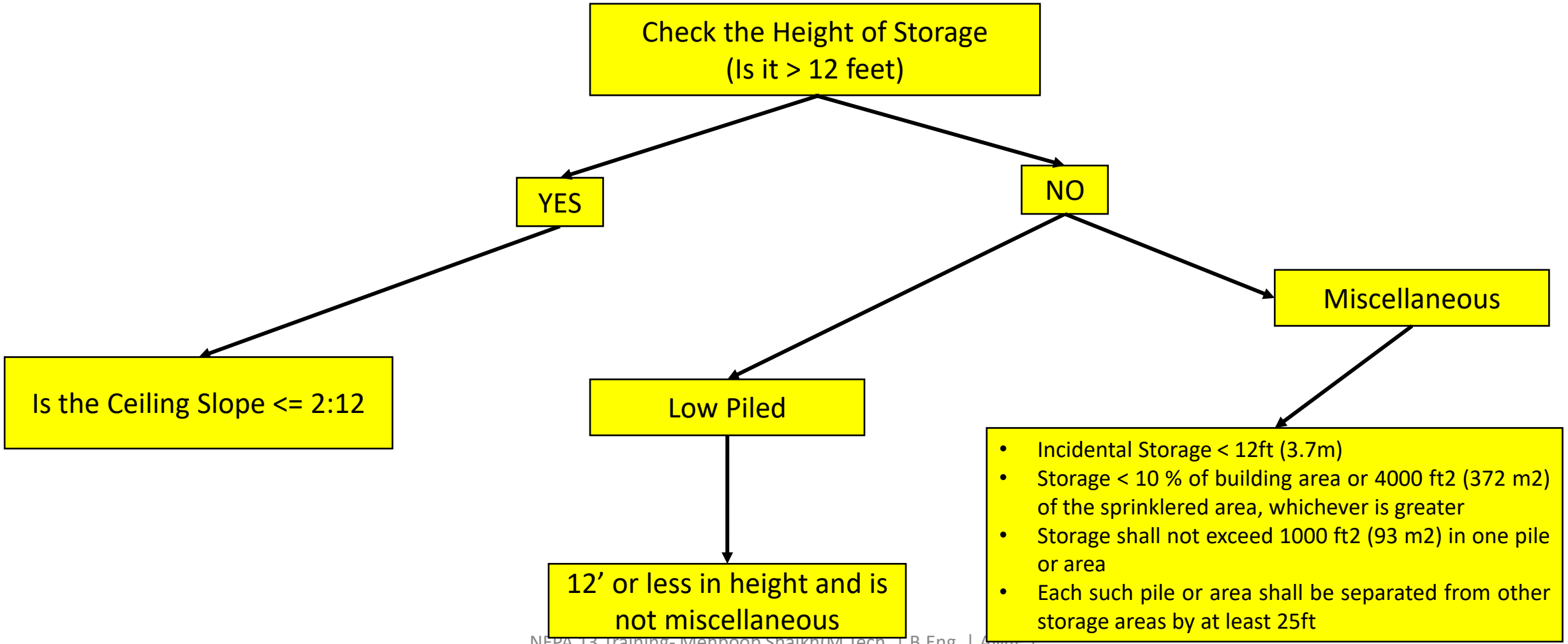
(3) The elevation of the bottom of the lowest steel *bar-joist* web inside the building

(4) 18" below the deflector of the sprinkler-heads

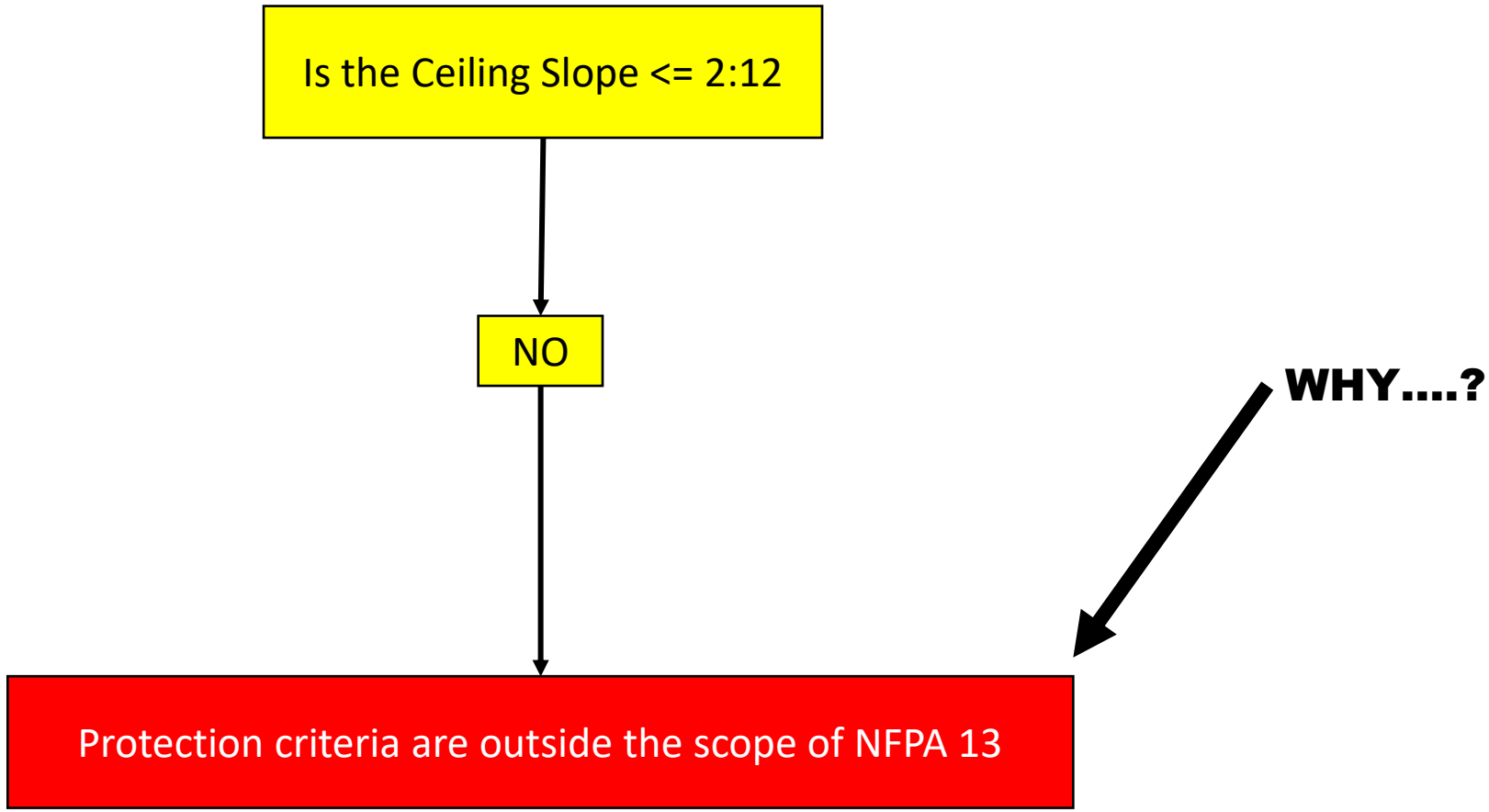
How to Navigate through NFPA 13 for Storage Requirements ?

FOR CLASS 1 TO 4 & GROUP B & C PLASTICS

How to Navigate through NFPA 13 for Storage Requirements ?



How to Navigate through NFPA 13 for Storage Requirements ?



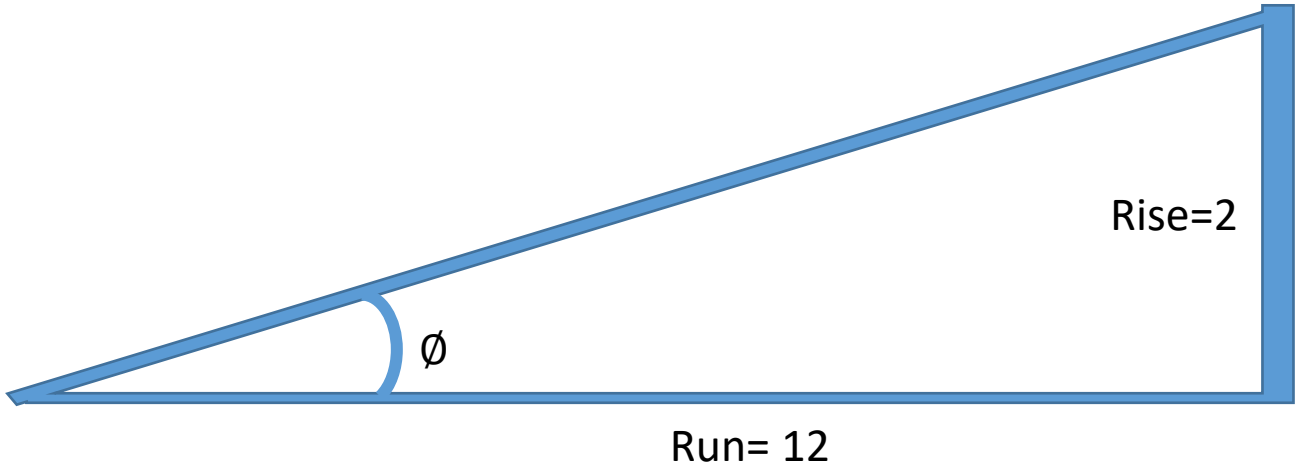
Why Protection criteria for slope ceiling more than 2:12 are outside the scope of NFPA 13 ?

Firstly lets Understand the Slope of 2:12

$$\tan \emptyset = \frac{Opp\ side}{Adj\ Side}$$

$$\tan \emptyset = \frac{2}{12}$$

$$\emptyset = 9.42$$



Allowable Angle of inclination shall not be more than 9.42 degrees

Why Protection criteria for slope ceiling more than 2:12 are outside the scope of NFPA 13 ?

According to a joint study Conducted by FM Global & FPRF on a numerical fire model called " FireFOAM" following conclusionS were made on the effect of Ceiling slope on sprinkler activations and spray Transport.

Objectives of this study :

1. Evaluate sprinkler activation times and patterns from ceiling jet simulations
2. Evaluate effect of ceiling inclination on water mass flux distributions over a rack-storage commodity.
3. Understand the effect of sprinkler orientation

- two sprinkler orientations: deflector parallel-to-ceiling or parallel-to-floor

Why Protection criteria for slope ceiling more than 2:12 are outside the scope of NFPA 13 ?

Spray Result :

- For <=18.4 degrees (deflector parallel-to-ceiling)
- Water from the sprinklers on the lower side is projected towards the fire region.

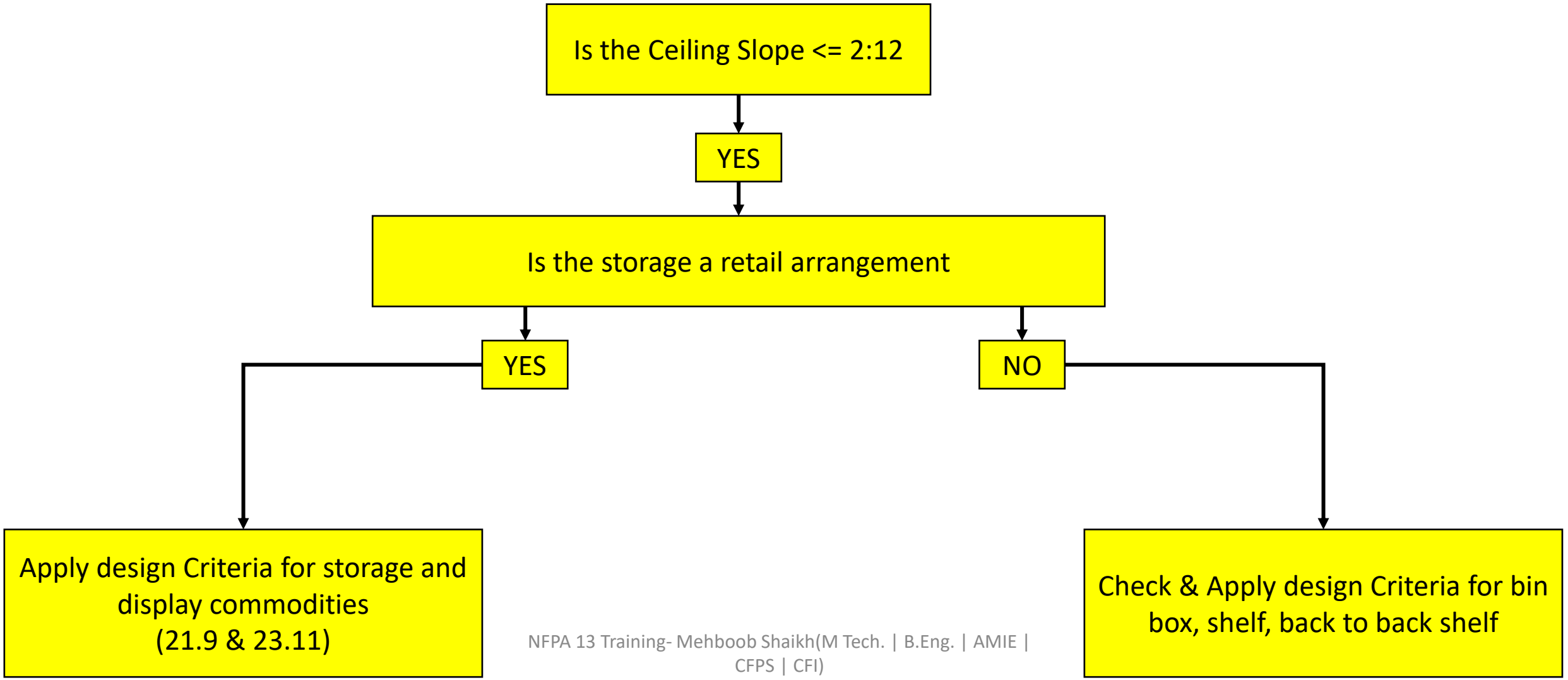
Why Protection criteria for slope ceiling more than 2:12 are outside the scope of NFPA 13 ?

Spray Result :

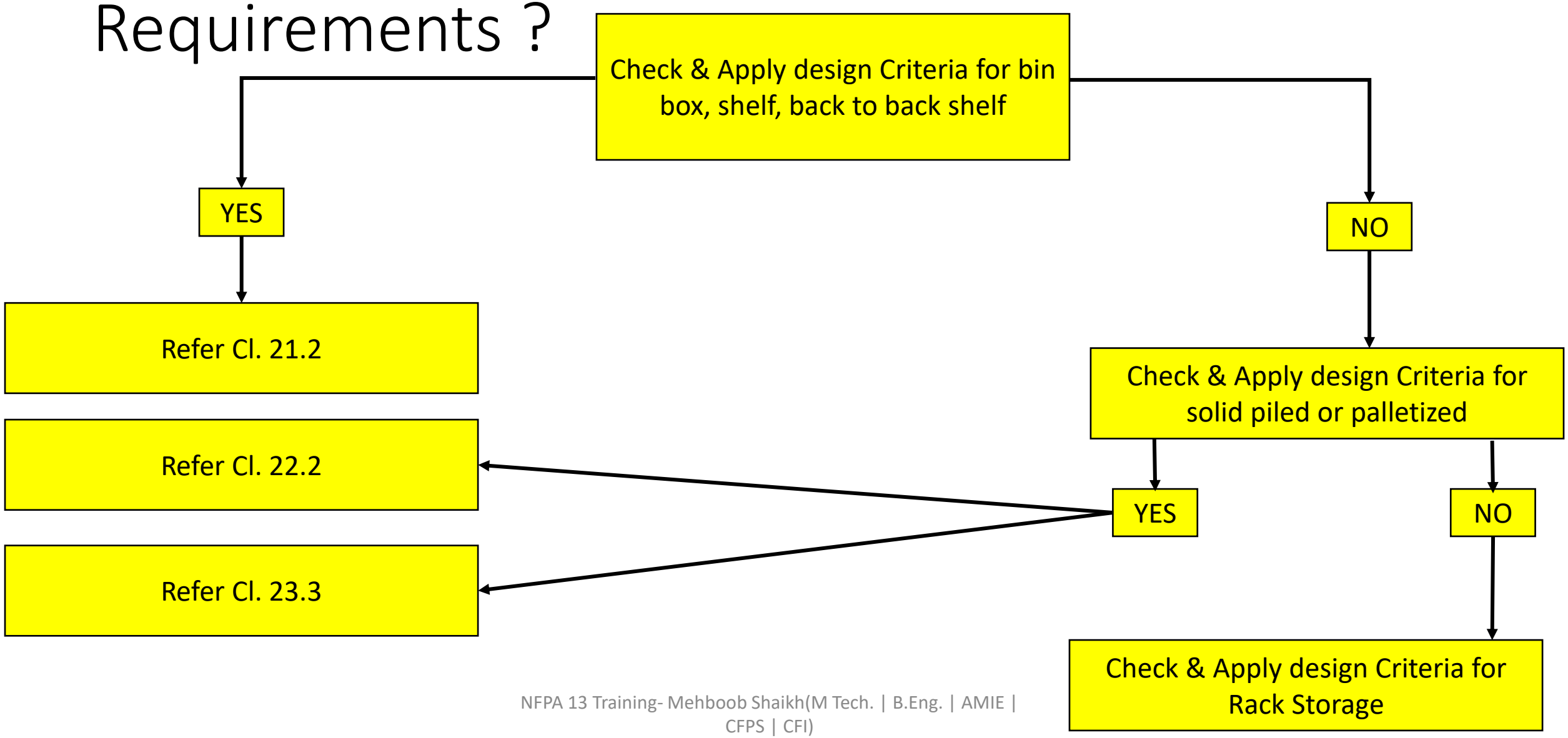
For 33.7 inclination

- low spray density on the fire region due to highly skewed activation pattern
- *water flux to fire region reduced by 54-76% as compared to horizontal ceiling*

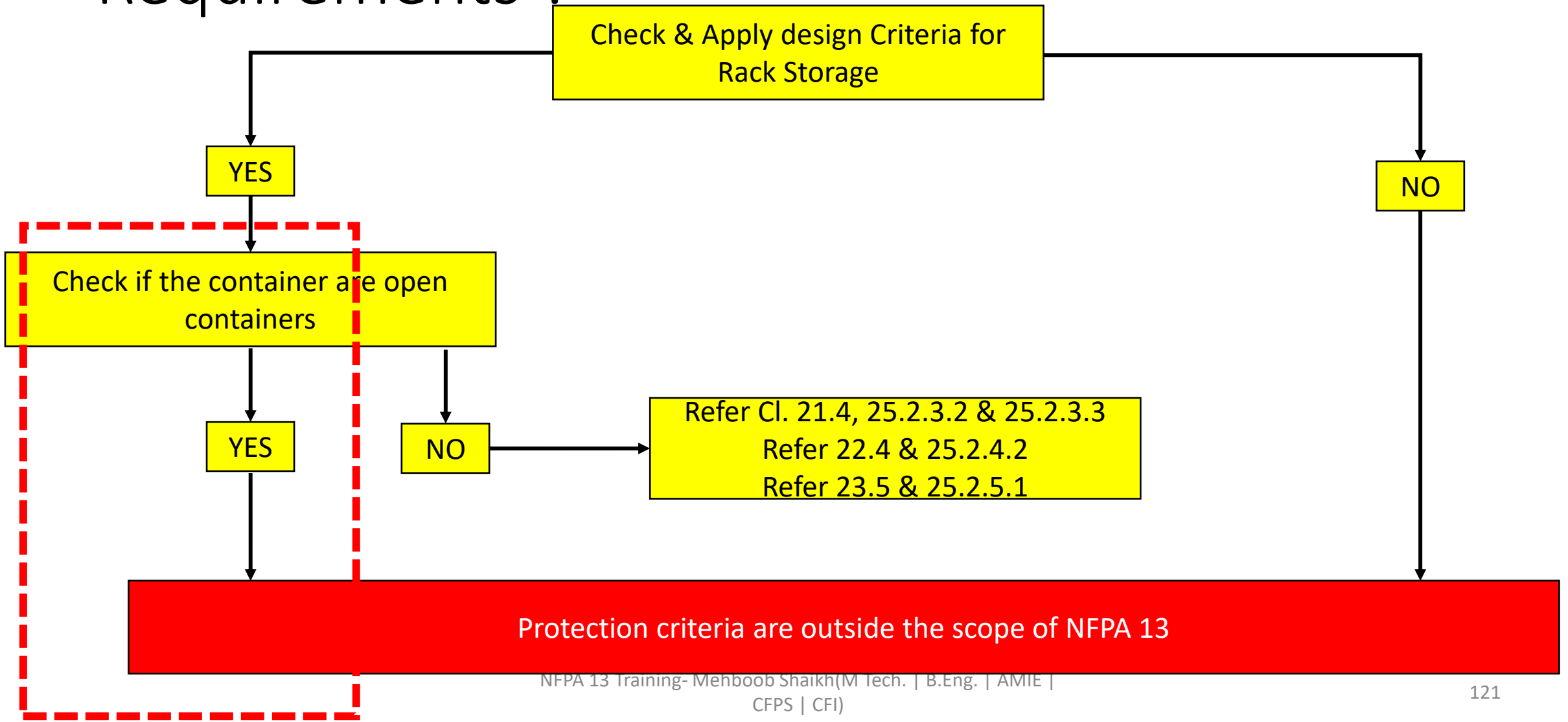
How to Navigate through NFPA 13 for Storage Requirements ?



How to Navigate through NFPA 13 for Storage Requirements ?



How to Navigate through NFPA 13 for Storage Requirements ?



Why NFPA 13 Does Not Permit Open-Top Containers ?

Loss experience and large-scale fire tests indicate a greater hazard with open-top combustible (paper, cardboard, or wood) containers. *The major factor appears to be the capture and retention of ceiling sprinkler discharge within the open-top container* and less water flow down the flue and aisle faces. This does not apply to open-top containers with mesh sides.

Tank Sizing

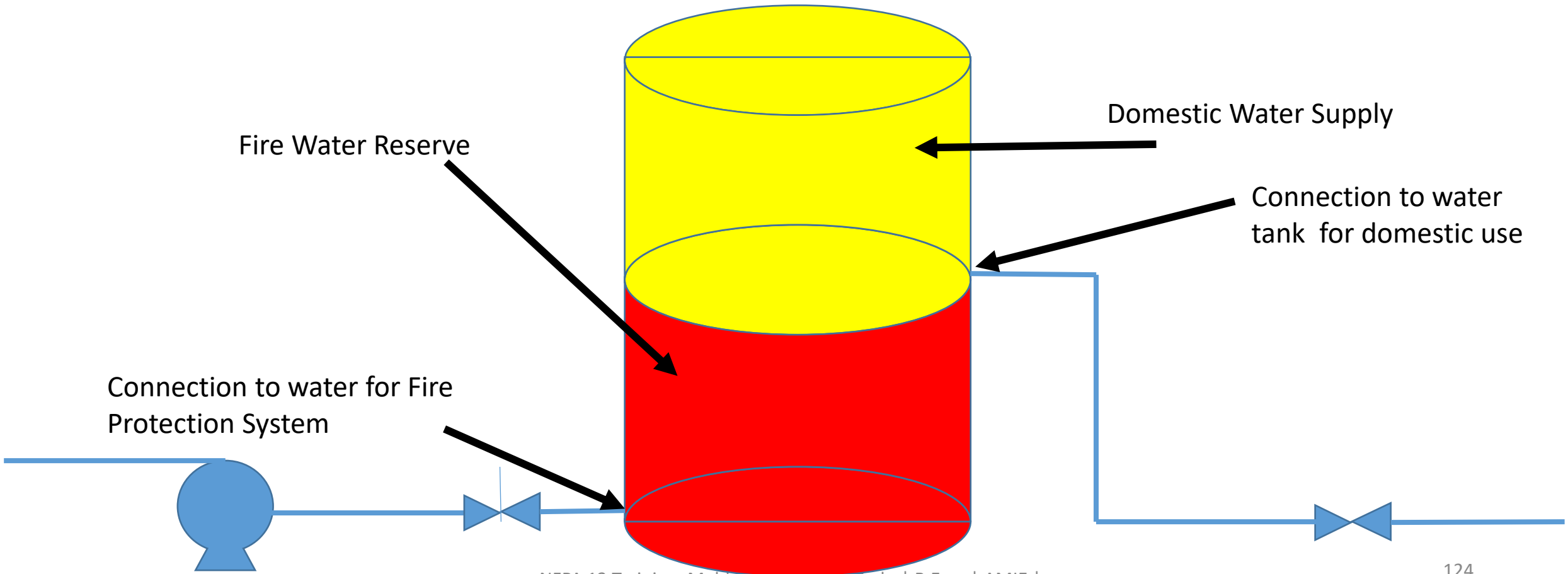
Cl. 20.12.2.1 - Tanks shall be sized to supply the equipment that they serve.

Tank Size = Sprinkler Demand + (Internal + External Hose) Demand

Its not same as that of Standpipe System, this is only for manual fire fighting by the fire fighters along with sprinkler operation

Check if its required at site else as per local AHJ

Tank Sizing - Serve both domestic and fire protection uses



Q1 : Can ESFR systems protect all types of rack storage?

No.

- There is no one ESFR system available to protect all types of rack storage, rather there are several types of ESFR sprinkler heads and required water pressures, with each one of them to be applied in specific storage scenarios. It should also be noted that ESFR systems cannot be applied to open top containers. However, since the concern with open top containers relates to these containers retaining the water (like a reservoir) and not allowing the water to flow down to the lowest levels of a rack, there is no harm if open top containers are used in the lowest level of the rack (at or near the floor)

Q2 : Once an ESFR system is installed, can any business move in and store however they want?

No.

- Each type of ESFR sprinkler head can protect a different set of commodities. For example, based on the NFPA 13 standard, K-25 ESFR cannot protect cartoned expanded plastics, such as products that have >25% by volume of foam packaging in a cardboard box (FM Global Loss Prevention Data Sheet DS 8-9 does offer K-25 ESFR options for protecting cartoned expanded plastics.
- These FM protection schemes, however, need to be applied as alternative means of protection criteria to NFPA 13). For building owners or in warehouses, where the types of storage fluctuates, the best return for your ESFR dollar is the K-17 ESFR head, which protects a large variety of products, but still requires comparatively low water pressures.

Q3 : Are there instances where in-rack sprinklers are required, even when the building is equipped with an ESFR system?

Yes.

- There are several instances where in-rack sprinklers are required with an ESFR system. For example, in cases where solid shelves are proposed in the racks, in-racks sprinklers will be required. Additionally, close attention must be paid to the ESFR tables in NFPA 13, especially Tables 16.2.3.1, 16.3.3.1, 17.2.3.1, and 17.3.3.1 for ceiling heights greater than 40 feet. Many of the ESFR options in these tables require in-rack sprinklers.

Q4 : Can I store products which are not protected by the ceiling level ESFR?

Yes

There may be circumstances that an existing ceiling level ESFR sprinkler system cannot protect some of the products stored in a warehouse. This is often the case if the ESFR system was specified for Class I-IV commodities, but some of the products stored in the racks are of higher hazard, e.g. rack storage of exposed Group A plastics. In these cases, new protection schemes prescribed in the 2016 edition of NFPA 13 allow the existing ceiling level protection to remain unchanged while protecting the racks with the higher hazard commodities with an ‘alternative protection’ scheme, see Sections 16.1.2.4 (Class I-IV) and 17.1.2.9 (Plastics and Rubber) for more detail. These Alternative Protection schemes applied to only a few racks (with the higher hazard) can be very cost effective in these situations. These schemes can also be used in combination with solid shelves on these ‘alternatively protected’ racks, but in these cases will require in-rack sprinklers at every level.

Q5: Can ESFR sprinkler systems be used with solid shelving?

Yes

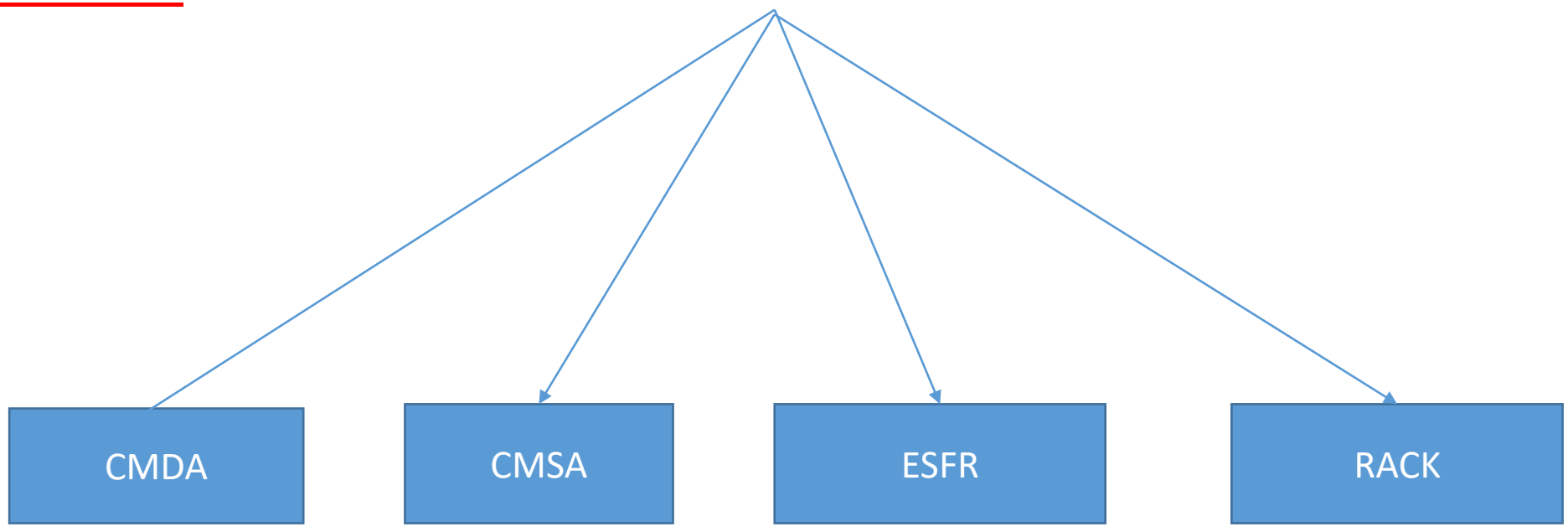
one of the biggest changes since the release of NFPA 13 2013 Edition and the protection of commodities on racks with ESFR is the allowance for ESFR sprinklers in combination with solid shelving! ESFR sprinkler are now allowed to protect racks with solid shelving if in-rack sprinkler protection is installed

Why NFPA 13 Does Not Permit Open-Top Containers ?

Loss experience and large-scale fire tests indicate a greater hazard with open-top combustible (paper, cardboard, or wood) containers. *The major factor appears to be the capture and retention of ceiling sprinkler discharge within the open-top container* and less water flow down the flue and aisle faces. This does not apply to open-top containers with mesh sides.

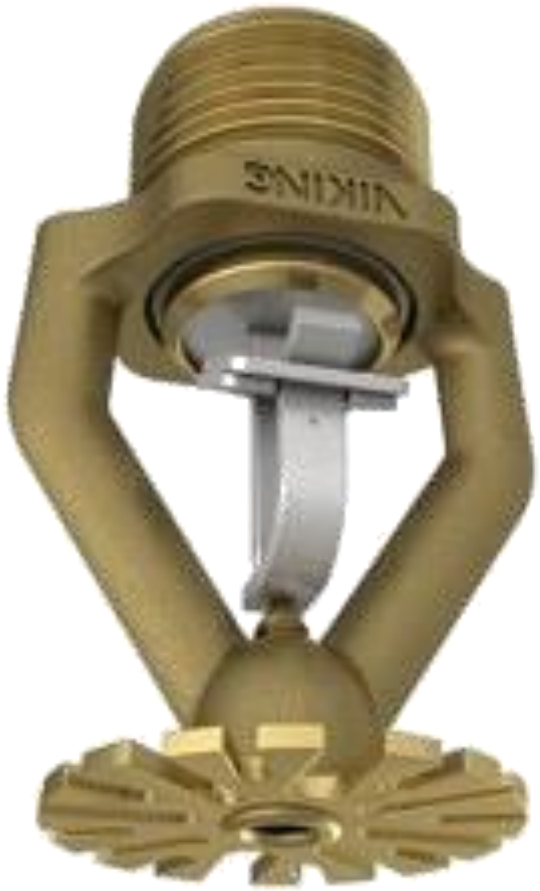
Sprinkler Selection

- A precise design approach is necessary to meet the challenges of these occupancies, an effort that includes using **storage fire sprinklers.**



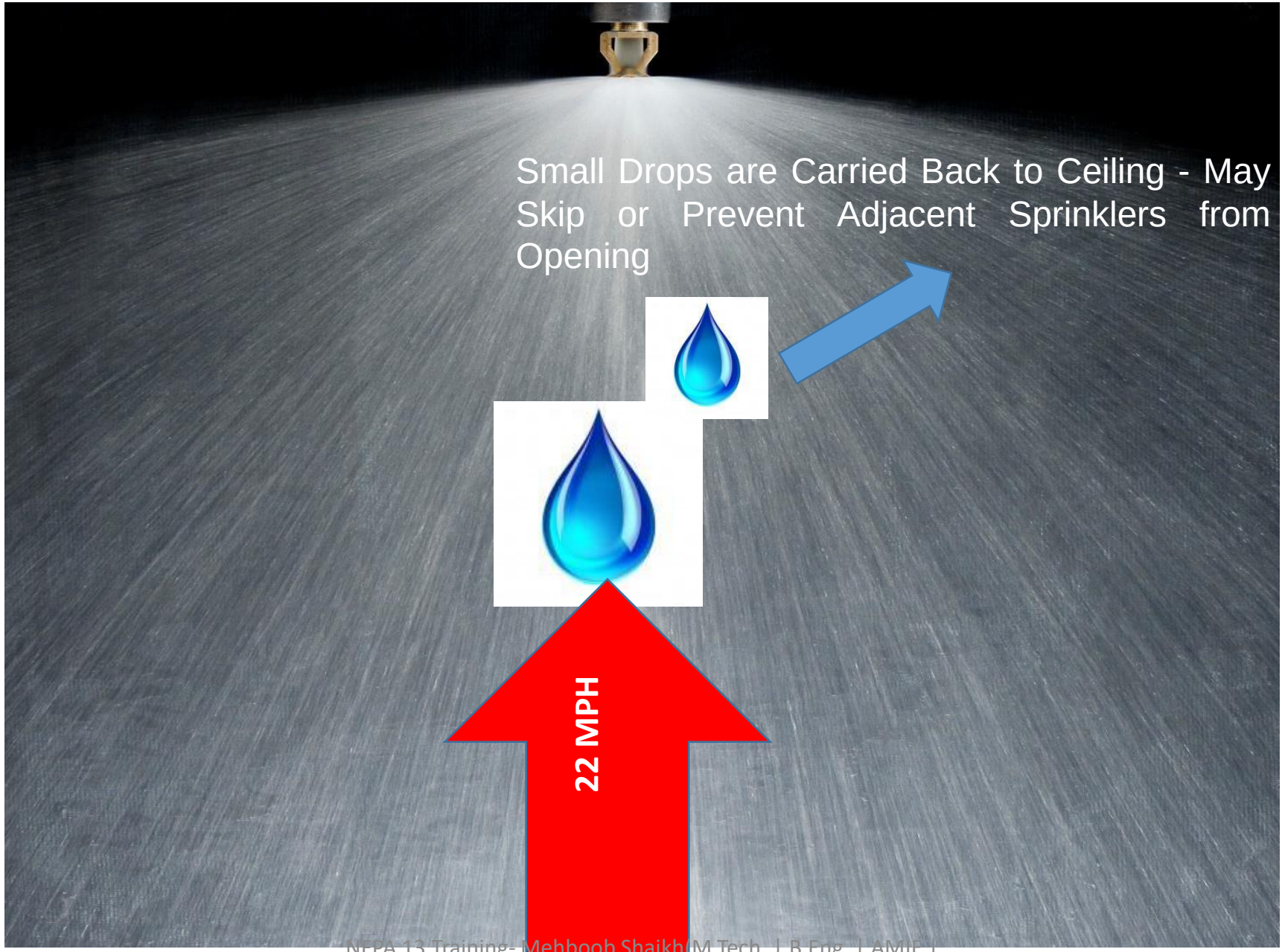
Standard Commercial
VK3521
K=8

CMDA
VK377
K=11.2



CMSA
VK592
K=19.6

ESFR
VK500
K=14


Small Drops are Carried Back to Ceiling - May Skip or Prevent Adjacent Sprinklers from Opening
22 MPH

CMDA: control-mode density area sprinklers

- The “control-mode” in a control mode density area (CMDA) sprinkler refers to the fact that these heads provide wetting and cooling to control a fire until first responders can arrive. “Density-area” refers to how CMDA systems are designed.
- A set of density-area curves specifies the amount of water flow required for a given area. The system and its water source are engineered based on them to provide the necessary flow and pressure.

CMDA: control-mode density area sprinklers

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- A set of density-area curves specifies the amount of water flow required for a given area. The system and its water source are engineered based on them to provide the necessary flow and pressure.

CMDA: control-mode density area sprinklers

- Does that mean **CMDA sprinklers are almost identical to average fire sprinklers** ?
- Yes in Both Shape and Functions
- The two things separating a CMDA sprinkler from a regular sprinkler are **larger K-factors** and **higher temperature ratings**.

CMSA: Control-mode special application sprinklers

- Like CMDA sprinklers, control-mode special application (CMSA) sprinklers are designed for “control” functions: wetting and cooling to prevent fire spread. And like most storage sprinklers, CMSA sprinklers usually have large K-factors. However, they differ from CMDA sprinklers in two ways.

CMSA: Control-mode special application sprinklers

1. CMSA sprinklers have unique sprinkler deflectors that produce different water droplet sizes and spray patterns. This makes CMSA sprinklers suited to “special applications;” in other words, high-challenge storage occupancies. The unique deflector also requires the sprinklers to carry a different listing.
2. CMSA sprinklers don’t use the design concepts employed by CMDA sprinklers. No density/area curves are involved. Instead, different variables are analyzed to calculate the necessary flow and pressure for a given system

ESFR: Early-suppression fast response sprinklers

- Unique among fire sprinklers, early-suppression fast-response (ESFR) sprinklers provide **fire suppression** instead of **fire control**. The goal of ESFR sprinklers isn't preventing fire spread until firefighters can fully extinguish it. Rather, they are meant to **activate quickly** and **attack a fire directly.** The idea is that early fire suppression requires less total water, allows less fire spread, and ultimately makes sprinkler systems less expensive

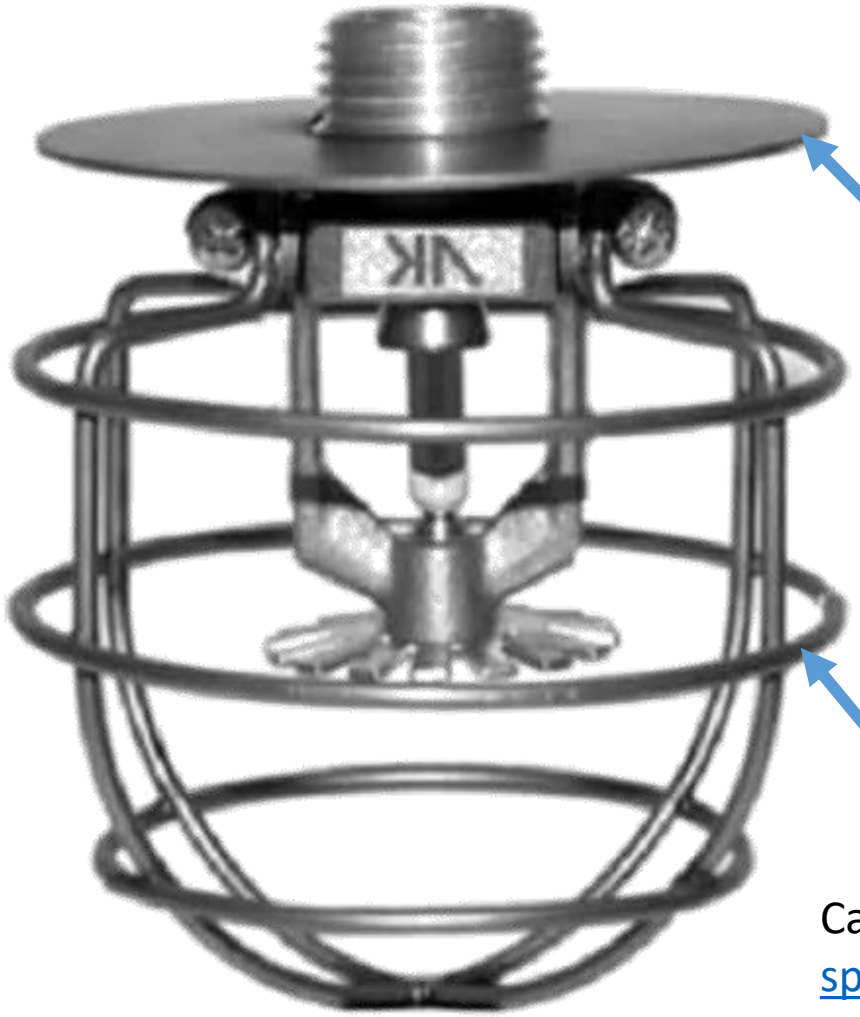
ESFR: Early-suppression fast response sprinklers

- ESFR sprinklers have large K-factors and feature uniquely designed deflectors meant to produce large, high-momentum droplets that won't evaporate before penetrating a fire plume. Another major distinguishing characteristic of ESFR sprinklers is fast-response elements designed to operate sooner than standard sprinkler elements.

In-rack fire sprinklers

- In-rack sprinklers work just like their name suggests: sprinkler risers and branch pipes are installed with storage racks to put sprinklers **as close to potential fires as possible**. Of course, doing so creates unique infrastructure challenges for warehouses—storage racks become more permanent when plumbing is involved. But it solves the issues posed by height and obstruction.
- Various ESFR and Control Mode ceiling level sprinklers introduced since 1980 have led to ceiling-only protection dominating the storage sprinkler market. But as storage buildings have evolved, the limitations of ceiling-only sprinkler protection have become apparent

In-rack fire sprinklers



Water Shield - Protect in-rack sprinklers from the spray of other sprinklers.

Water from a ceiling-level sprinkler head (or another in-rack head) could cool the heat-sensitive element of sprinklers near it, preventing them from operating as designed.

Cage Guard - Protect sprinklers from heavy loads and machinery moving around them

Why In Rack Sprinklers ?

There are situations where tests have determined that ceiling sprinklers—no matter how large the K-factor or water pressure—can't provide adequate control or suppression. Extremely flammable commodities, high ceilings, high-piled storage, and obstructions to water are common culprits. In these cases, **in-rack fire sprinklers** are necessary.

Why In Rack Sprinklers ?

- Location matters. Being located closer to a rack storage fire gives in-rack sprinklers an advantage over ceiling sprinklers in terms of both activation and delivering water to the burning commodity. Thus, in-rack sprinklers have the potential to activate when a fire is smaller and requires less water to control.
- A key feature of in-rack sprinklers is that they do not depend on the configuration of the building enclosure. The tallest current listing for an ESFR sprinkler without in-rack sprinklers is 48 ft. There are typically no limits on building height with in-rack sprinklers

Why In Rack Sprinklers ?

Two of the biggest challenges with ESFR sprinklers which do not affect in-rack sprinklers:

(1) Sloped ceilings and

(2) Complicated ESFR obstruction rules.

Limits of Ceiling Only Sprinkler

1. Height :

The original ESFR sprinkler had a Nominal K-factor of 14.0 gpm/psi1/2 and was designed with a discharge pressure of 50 psi to protect Cartoned Unexpanded Group A plastics stored up to 25 ft. high under ceilings up to 30 ft. in height

Limits of Ceiling Only Sprinkler

What Does NFPA 13 say ?

- NFPA 13 limits K14.0 ESFR sprinklers to ceiling heights of 35 ft. when protecting rack storage, unless in-rack sprinklers are provided.

- Ceiling-only design criteria to protect rack storage under ceilings up to 45 ft. tall are available with larger orifice K22.4 and K25.2 ESFR sprinklers. Specific application criteria are also available for certain ESFR sprinklers under ceiling heights up to 48 ft.

Limits of Ceiling Only Sprinkler

Limitations of ESFR as a Ceiling Only Sprinkler

- To be effective, an ESFR sprinkler must operate early in the development of a storage fire. Even with a very sensitive operating element, ceiling-only ESFR sprinklers are challenged to activate prior to a fire spreading across an aisle as ceiling heights increase beyond 45 ft. The design criteria available for ESFR sprinklers under a 48 ft. ceiling require minimum 6 ft. or 8 ft. aisles. For storage buildings taller than 48 ft., in-rack sprinklers are likely to be required.

- Modern distribution facilities using either multi-level work platforms (pick modules) or automated storage and retrieval systems often gain efficiency by increasing the building height beyond the limits of ceiling-only sprinkler systems.

Limits of Ceiling Only Sprinkler

2. Water Demand :

Even if not required by height, the efficiency of ceiling sprinklers decreases with height. As ceiling heights increase, the water demand required for ceiling-only sprinkler systems also increases

Limits of Ceiling Only Sprinkler

Water Demand :

Ceiling Height (ft)	Sprinkler	Basic Sprinkler Water Demand (gpm)
30	K25.2 EC	828
35	K25.2 EC	1275
40	K16.8 ESFR	1454
45	K22.4 ESFR	1700
48	K28.0 ESFR Specific Application	1987

Limits of Ceiling Only Sprinkler

2. Water Demand :

Previous Table illustrates how the efficiency of ceiling-only sprinkler protection decreases with ceiling height above 30 ft. Increasing the ceiling height by just 5 ft., 17%, from 30 ft. to 35 ft. increases the basic sprinkler water demand by more than 50%. Increasing the ceiling height by 60%, from 30 ft. to 48 ft., increases the basic sprinkler water demand by 140%. Thus, even in buildings that could be protected with ceiling sprinklers, ceiling-only sprinkler protection may not be the most efficient use of water.

Limits of Ceiling Only Sprinkler

3. More Hazardous Commodity:

- The discussion so far has referenced protection criteria for Cartoned Unexpanded Group A plastics. More hazardous commodities such as tires, Exposed Group A plastics, and aerosols present an increased challenge to a sprinkler system.

- These commodities typically require in-rack sprinklers to be provided at lower storage heights than would be required for a Cartoned Unexpanded Group A plastic commodity.

Limits of Ceiling Only Sprinkler

3. More Hazardous Commodity:

- For example, NFPA 13 limits storage of rubber tires on racks to 35 ft. of storage under a 40 ft. ceiling with ESFR sprinkler protection at the ceiling. The criterion requires more than 2,600 gpm of basic sprinkler water demand from K25.2 ESFR sprinklers.
- Thus, while ceiling-only criteria are available for storage of Cartoned Unexpanded Group A plastics under ceilings up to 48 ft. tall, other commodities have lower ceiling height limits for ceiling-only protection. Even when ceiling-only protection options are available, the water demand or other required features may make the installation of in-rack sprinklers preferable.

Overview of FM Data Sheet 8-9

2.3 Protection

2.3.1 General

2.3.1.1 When determining the fire protection options for a storage facility, consider all the protection options the water supply can support. This approach will help maximize operational flexibility when considering potential future commodity changes and/or storage arrangements.

Recommended Ceiling only Sprinklers

2.3.3.2 K-Factors, Nominal Temperature Rating, RTI Rating, and the Orientation of Ceiling-Level Storage Sprinklers

2.3.3.2.1 Use only FM Approved sprinklers listed in the *Approval Guide* under the heading of Storage Sprinklers (Ceiling-Level) for any ceiling-level sprinkler options in this data sheet.

Currently, FM Approved ceiling-level Storage sprinklers have K-factor values ranging from 11.2 (160) to 33.6 (480). See Appendix A for a definition of K-factor as well as the units used for its indicated value.

Note that the following sprinklers are not FM Approved as ceiling-level Storage sprinklers:

- K8.0 (K115) and smaller
- On-Off type sprinklers
- ECLH type sprinklers
- ECOH type sprinklers

Ceiling-Level Sprinkler System Design Criteria

- Table 7: Ceiling-Level Protection Guidelines for Class 1, 2 and 3 Commodities in Open-Frame Rack Storage Arrangements
- Table 8: Ceiling-Level Protection Guidelines for Class 4 and Cartoned Unexpanded Plastic Commodities in Open-Frame Rack Storage Arrangements
- Table 9: Ceiling-Level Protection Guidelines for Cartoned Expanded Plastic Commodities in Open-Frame Rack Storage Arrangements
- Table 10: Ceiling-Level Protection Guidelines for Uncartoned Unexpanded Plastic Commodities in Open-Frame Rack Storage Arrangements
- Table 11: Ceiling-Level Protection Guidelines for Uncartoned Expanded Plastic Commodities in Open-Frame Rack Storage Arrangements

Ceiling-Level Sprinkler System Design Criteria

Table 7. Ceiling-Level Protection Guidelines for Class 1, 2 and 3 Commodities in Open-Frame Rack Storage Arrangements

Protection of Class 1, 2 and 3 Commodities in Open-Frame Storage Racks; No. of AS @ psi (bar)																				
Max. Ceiling Height, ft (m)	Wet System, 160°F (70°C) Nominally Rated, Pendent Sprinklers										Wet System, 160°F (70°C) Nominally Rated, Upright Sprinklers							Dry System, 280°F (140°C) Nominally Rated, Upright Sprinklers		
	Quick Response						Standard Response				Quick Response				Standard 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)	K11.2 (K160)	K14.0 (K200)	K16.8 (K240)	K25.2EC (K360EC)	K11.2 (K160)	K16.8 (K240)	K25.2 (K360)	K11.2 (K160)	K16.8 (K240)	K25.2 (K360)
10 (3.0)	12 @ 7 (0.5)	9 @ 7 (0.5)	9 @ 7 (0.5)	9 @ 20 (1.4)	9 @ 20 (1.4)	6 @ 20 (1.4)	12 @ 7 (0.5)	9 @ 7 (0.5)	9 @ 16 (1.1)	9 @ 7 (0.5)	12 @ 7 (0.5)	9 @ 7 (0.5)	9 @ 7 (0.5)	6 @ 20 (1.4)	12 @ 7 (0.5)	9 @ 7 (0.5)	9 @ 7 (0.5)	16 @ 7 (0.5)	16 @ 7 (0.5)	16 @ 7 (0.5)
20 (6.0)	12 @ 10 (0.7)	12 @ 7 (0.5)	12 @ 7 (0.5)	9 @ 20 (1.4)	9 @ 20 (1.4)	6 @ 20 (1.4)	12 @ 10 (0.7)	12 @ 7 (0.5)	9 @ 16 (1.1)	9 @ 10 (0.7)	12 @ 10 (0.7)	12 @ 7 (0.5)	12 @ 7 (0.5)	6 @ 20 (1.4)	12 @ 10 (0.7)	12 @ 7 (0.5)	12 @ 7 (0.5)	16 @ 10 (0.7)	16 @ 7 (0.5)	16 @ 7 (0.5)
25 (7.5)	15 @ 16 (1.1)	12 @ 16 (1.1)	12 @ 11 (0.8)	9 @ 20 (1.4)	9 @ 20 (1.4)	6 @ 22 (1.5)	15 @ 16 (1.1)	15 @ 10 (0.7)	9 @ 16 (1.1)	9 @ 10 (0.7)	15 @ 16 (1.1)	12 @ 16 (1.1)	12 @ 11 (0.8)	6 @ 22 (1.5)	15 @ 16 (1.1)	15 @ 7 (0.5)	10 @ 20 (1.4)	20 @ 16 (1.1)	20 @ 7 (0.5)	20 @ 7 (0.5)
30 (9.0)	18 @ 50 (3.5)	12 @ 50 (3.5)	12 @ 35 (2.4)	9 @ 20 (1.4)	9 @ 20 (1.4)	6 @ 30 (2.1)	18 @ 50 (3.5)	18 @ 32 (2.2)	9 @ 16 (1.1)	9 @ 10 (0.7)	18 @ 50 (3.5)	12 @ 50 (3.5)	12 @ 35 (2.4)	6 @ 30 (2.1)	18 @ 50 (3.5)	18 @ 22 (1.5)	12 @ 20 (1.4)	25 @ 50 (3.5)	25 @ 22 (1.5)	25 @ 10 (0.7)
35 (10.5)		12 @ 75 (5.2)	12 @ 52 (3.6)	12 @ 29 (2.0)	12 @ 23 (1.6)	6 @ 60 (4.1)[a]			15 @ 25 (1.7)	9 @ 30 (2.1)				8 @ 40 (2.8)				See Section 2.3.6.1		
40 (12.0)		12 @ 75 (5.2)	12 @ 52 (3.6)	9 @ 50 (3.5)	@ 40 (2.8)					9 @ 30 (2.1)										

[a] An acceptable alternative design is 8 @ 40 (2) when a 12 ft (3.6 m) maximum linear spacing is used

The ceiling-level protection options highlighted in green represent those for which the hose stream demand is 250 gpm (950 L/min) and the duration is 1 hour. These highlighted options have the potential result in less fire, smoke, and water damage than other acceptable options and thus may, from a sustainability standpoint, be preferable

Ceiling-Level Sprinkler System Design Criteria

The design guidelines for ceiling-level Storage sprinklers are based on five main attributes assigned to a sprinkler. They are:

1) K-Factor (orifice size)
2) Orientation (pendent or upright)
3) Response time index rating (quick-response or standard-response)
4) Nominal temperature rating
5) Sprinkler spacing (standard or extended-coverage)

Once the commodity hazard, storage arrangement, and peak ceiling height for the protected area is known, the protection design options for the sprinkler system can be determined using the appropriate protection table in combination with the five sprinkler attributes

In-Rack Sprinklers (IRAS)

2.3.4 In-Rack Sprinklers (IRAS)

2.3.4.1 General

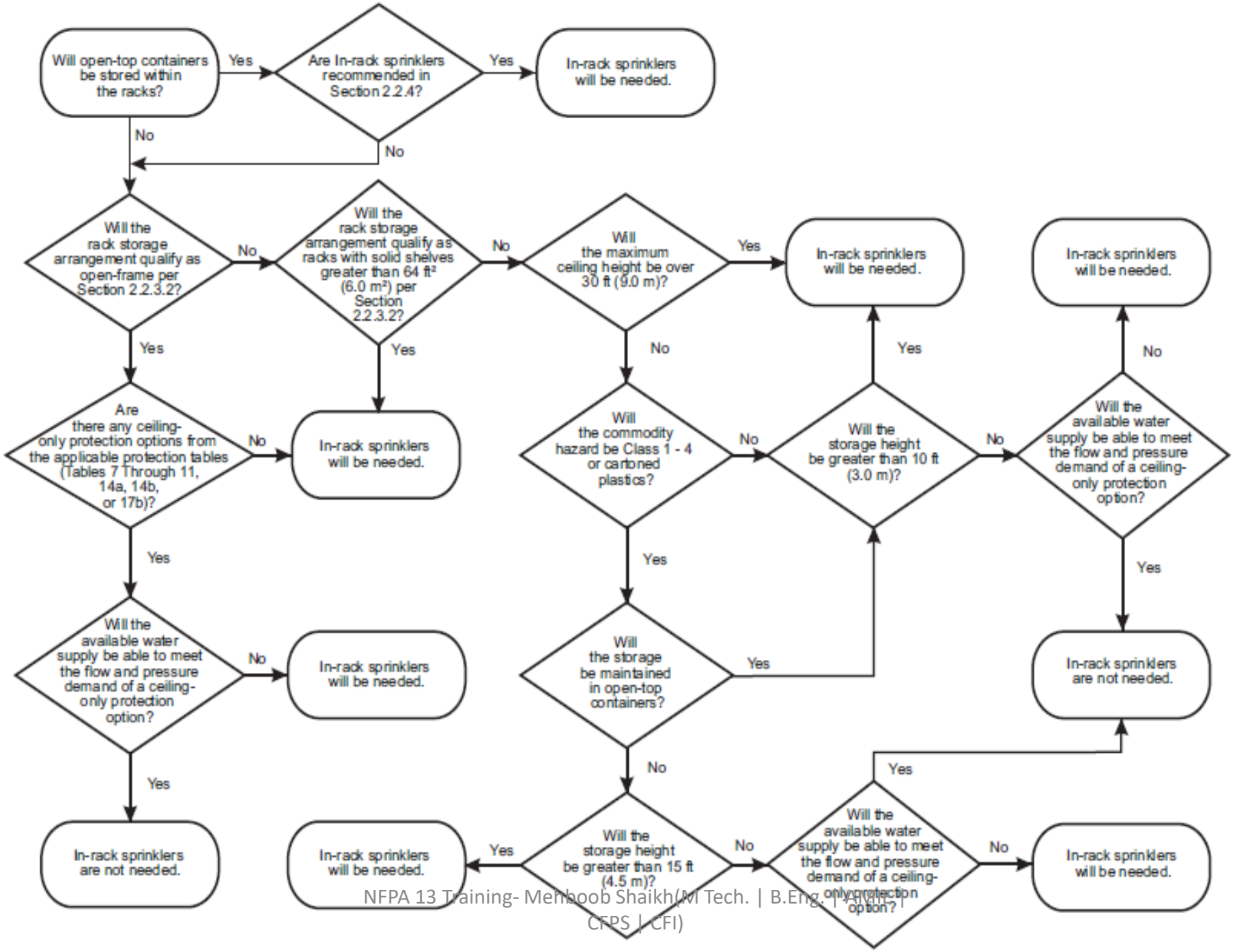
Protection options for rack storage arrangements are based on ceiling-only sprinkler systems, or a combination of ceiling-level and in-rack sprinkler systems. When in-rack sprinklers are needed, they can be used in combination with any of the ceiling sprinklers listed in the protection tables indicated for rack storage.

In-Rack Sprinklers (IRAS)

2.3.4.2 When In-Rack Sprinklers are Needed

The need for in-rack sprinklers is dependent on several parameters, including commodity hazard, ceiling height, available water supply, the presence of solid shelves or open-top containers, and the width and location of flue spaces. See Section 2.2.3.2 to determine if the storage racks meet the guidelines to be treated as open-frame racking. Use Figure 3 to determine when in-rack sprinklers are recommended.

FM Global Data Sheet 8-9
(Flowchart for evaluating the need for in-rack sprinklers)


Will open-top containers be stored within the racks?
Yes
Are In-rack sprinklers recommended in Section 2.2.4?
Yes
In-rack sprinklers will be needed.
No
No
Will the rack storage arrangement qualify as open-frame per Section 2.2.3.2?
No
Will the rack storage arrangement qualify as racks with solid shelves greater than 64 ft² (6.0 m²) per Section 2.2.3.2?
No
Will the maximum ceiling height be over 30 ft (9.0 m)?
Yes
In-rack sprinklers will be needed.
In-rack sprinklers will be needed.
Yes
Yes
No
No
Are there any ceiling-only protection options from the applicable protection tables (Tables 7 Through 11, 14a, 14b, or 17b)?
No
In-rack sprinklers will be needed.
Will the commodity hazard be Class 1 - 4 or cartoned plastics?
No
Will the storage height be greater than 10 ft (3.0 m)?
No
Will the available water supply be able to meet the flow and pressure demand of a ceiling-only protection option?
Yes
Yes
Yes
Yes
Will the available water supply be able to meet the flow and pressure demand of a ceiling-only protection option?
No
In-rack sprinklers will be needed.
Will the storage be maintained in open-top containers?
Yes
In-rack sprinklers are not needed.
Yes
No
Yes
In-rack sprinklers are not needed.
In-rack sprinklers will be needed.
Will the storage height be greater than 15 ft (4.5 m)?
Yes
No
Will the available water supply be able to meet the flow and pressure demand of a ceiling-only protection option?
No
In-rack sprinklers will be needed.

Where In-Racks Become Mandatory Based on Ceiling Height – FM 8-9		
Chapter	Commodity	Building Height
Tables 7 - 11	Class I – IV and Cartoned Unexpanded Plastic	>45 ft (13.7 m)
	Cartoned and Uncartoned Expanded Plastic	>40 ft (12.1 m)

FM Global vs NFPA

- FM has eliminated all names of storage sprinklers such as ESFR, CMSA and CMDA, NFPA still uses the names to differentiate the rules
- FM has banned K5.6 (K80) and K8.0 (K115) from ceiling protection of storage, NFPA restricts the use but not a ban
- FM has banned 286 degree (high temperature) sprinklers from wet systems
- FM has eliminated density and area from design considerations, NFPA still highly dependent on density curves
- FM has eliminated storage height from design consideration of ceiling only protection, storage height and clearance a significant design consideration in NFPA
- FM and NFPA now recognize ceiling only designs with as few as 6 sprinklers in the hydraulic demand

Selecting FM Standards

- 1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.
- 1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.
- 1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

When NFPA is the referenced code by law, Section 1.5 is used to submit a FM design.

NFPA 13 and FM 8-9 Starting Points

• NFPA 13

// Commodity Class
- Building Height
- Storage
  - Arrangement - Palletized or Rack
  - Height
    - From floor
    - Clearance to Ceiling
- Sprinkler System
  - Wet
    - ESFR
    - CMSA
    - CMDA
    - Special
  - Dry
    - CMSA
    - CMDA
    - Special

• FM 8-9

// Commodity Class
- Building Height
- Storage
  - Arrangement - Palletized or Rack
- Sprinkler System
  - Wet
    - Pendent QR or SR
    - Upright QR or SR
  - Dry
    - Upright 280^{0}F (140C)

45 ft (13,7 m) Ceiling Recommendation Rack Storage With No In-Rack Sprinklers

- Model ESFR-25
  - K-Factor 25.2 (360)
- NFPA/FM Global Exceptions
  - No Solid Shelves
  - Open-top containers
  - Uncartoned Unexpanded Plastic
  - Cartoned or Uncartoned Expanded Plastic

40 ft (12,2 m) Ceiling Recommendation Rack Storage With No In-Rack Sprinklers

- Model ESFR-25
  - K-Factor 25.2 (360)
- NFPA/FM Global Exceptions
  - No Solid Shelves
  - Open Top containers
- NFPA Exceptions
  - Cartoned or Uncartoned Expanded Plastic
- Other available options include Model ESFR-17 Pendent and Model ESFR-1

35 ft (10,5 m) Ceiling Recommendation Rack Storage With No In-Rack Sprinklers

- Model EC-25
  - K-Factor 25.2 (360)
- NFPA Exceptions
  - No Solid Shelves
  - No Open Top containers
  - Cartoned or Uncartoned Expanded Plastic
- FM Global Exceptions
  - No Solid Shelves
  - Open Top containers
  - Uncartoned Unexpanded Plastic
  - Cartoned or Uncartoned Expanded Plastic
- Other available options include Model ESFR-25, Model ESFR-17 Pendent, Model ESFR-17 Upright and Model ESFR-1

Specific Application Listing Tyco Model ESFR-25

- Provide ceiling-only protection up to a
  - **48 ft (14.6 m) Ceiling**
  - **43 ft (13.1 m) Storage**
- Eliminates need for in-rack sprinklers NFPA 13
- Lower pressure provides flexibility wh compared to other listed sprinklers
- 10-Year Limited Warranty

tyco

Worldwide Contacts | www.tyco-fire.com

Model ESFR-25
Early Suppression, Fast Response Pendent Sprinklers
25.2 K-factor

General Description

The TYCO Model ESFR-25 Pendent Sprinklers are Early Suppression, Fast Response Sprinklers* having a nominal K-factor of 25.2. (Refer to Figure 1.) They are suppression-mode sprinklers that are especially advantageous as a means of eliminating the use of in-rack sprinklers when protecting high-piled storage.

The Model ESFR-25 Sprinklers are primarily used for ceiling-only sprinkler protection of (but not limited to) the following storage applications:

- Most encapsulated or non-encapsulated common materials including cartoned, unexpanded plastics.
- Uncartoned (exposed) expanded plastics in accordance with NFPA 13 and FM Global standards.
- Some storage arrangements of rubber tires, roll paper, flammable liquids, aerosols, and automotive components.

For more specific criteria, refer to Table 1 as well as the applicable design standard.

The Model ESFR-25 Pendent Sprinklers provide the system designer with hydraulic and sprinkler placement options not presently available to the traditional ESFR sprinklers having nominal K-factors of 14.0 and 16.8. In particular, the Model ESFR-25 Sprinkler has been designed to operate at substantially lower end head pressure, as compared to ESFR Sprinklers having nominal K-factors of 14.0 and 16.8. This feature offers flexibility when sizing system piping, as well as possibly reducing or eliminating the need for a system fire pump.

Also, Model ESFR-25 Sprinklers permit use of a maximum deflector-to-ceiling distance of 18 inches (450 mm) versus 14 inches (356 mm). Additionally, a storage arrangement of 40 ft. (12.2 m) with a ceiling height of 45 ft. (13.7 m) does not require in-rack sprinklers as do other ESFR Sprinklers having nominal K-factors of 14.0 and 16.8.

The Model ESFR-25 Sprinklers are listed by Underwriters Laboratories (UL) for specific applications with a maximum storage height of 43 ft. (13.1 m) with a maximum ceiling height of 48 ft. (14.6 m) without the requirement for in-rack sprinklers. Refer to the Specific Application Listing (UL) for the design criteria.

Applications for the TYCO ESFR Sprinklers are expanding beyond currently recognized installation standards. For information on research fire tests (e.g., with flammable liquids and aerosols) that may be acceptable to an authority having jurisdiction, contact the Technical Services department.

IMPORTANT

Always refer to Technical Data Sheet TFP700 for the "INSTALLER WARNING" that provides cautions with respect to handling and installation of sprinkler systems and components. Improper handling and installation can permanently damage a sprinkler system or its components and cause the sprinkler to fail to operate in a fire situation or cause it to operate prematurely.

NOTICE

The Model ESFR-25 Sprinklers described herein must be installed and maintained in compliance with this document, as well as with the applicable standards of the National Fire Protection Association, in addition to the standards of any authority having jurisdiction (e.g., FM Global). Failure to do so may impair the performance of these devices.

The owner is responsible for maintaining their fire protection system and devices in proper operating condition. The installing contractor or sprinkler manufacturer should be contacted with any questions.

In all cases, the appropriate NFPA or FM installation standard, or other applicable standard, must be referenced to ensure applicability and to obtain complete installation guidelines. The general guidelines in this data sheet are not intended to provide complete installation criteria.

Sprinkler Identification Number (SIN)

TY9226

TY9226 is a re-designation for C9226, G8441, and S8010.

Technical Data

Approvals
UL and C-UL Listed
FM and VdS Approved
LPCB Approved (094b/01 and 07/01)
NYC under MEA 358-01-E
CE Certified (DoP 11.03/05

Maximum Working Pressure
175 psi (12.1 bar)

Pipe Thread Connections
1 inch NPT
ISO 7-R1

Discharge Coefficient
K = 25.2 GPM/psi$^{1/2}$
(362.9 LPM/bar$^{1/2}$)

Temperature Ratings
165°F (74°C)
214°F (101°C)

Page 1 of 4 OCTOBER 2012 TFP312

Specific Application Listing Tyco Model ESFR-25 – Key Design Criteria

- Temperature rating: 212˚ F (100˚ C)
- Deflector to top of storage: ≥ 36 in (914 mm)
- Deflector to ceiling distance 6 – 14 in (152 – 356 mm)
- Sprinkler system design: NFPA 13 for ESFR Sprinkler based on 45 PSI (3.1 bar)
- Minimum aisle width: 8 ft (2,4 m)

Chapter- 21
Protection of High Piled Storage Using Control Mode Density Area (CMDA) Sprinklers

Content

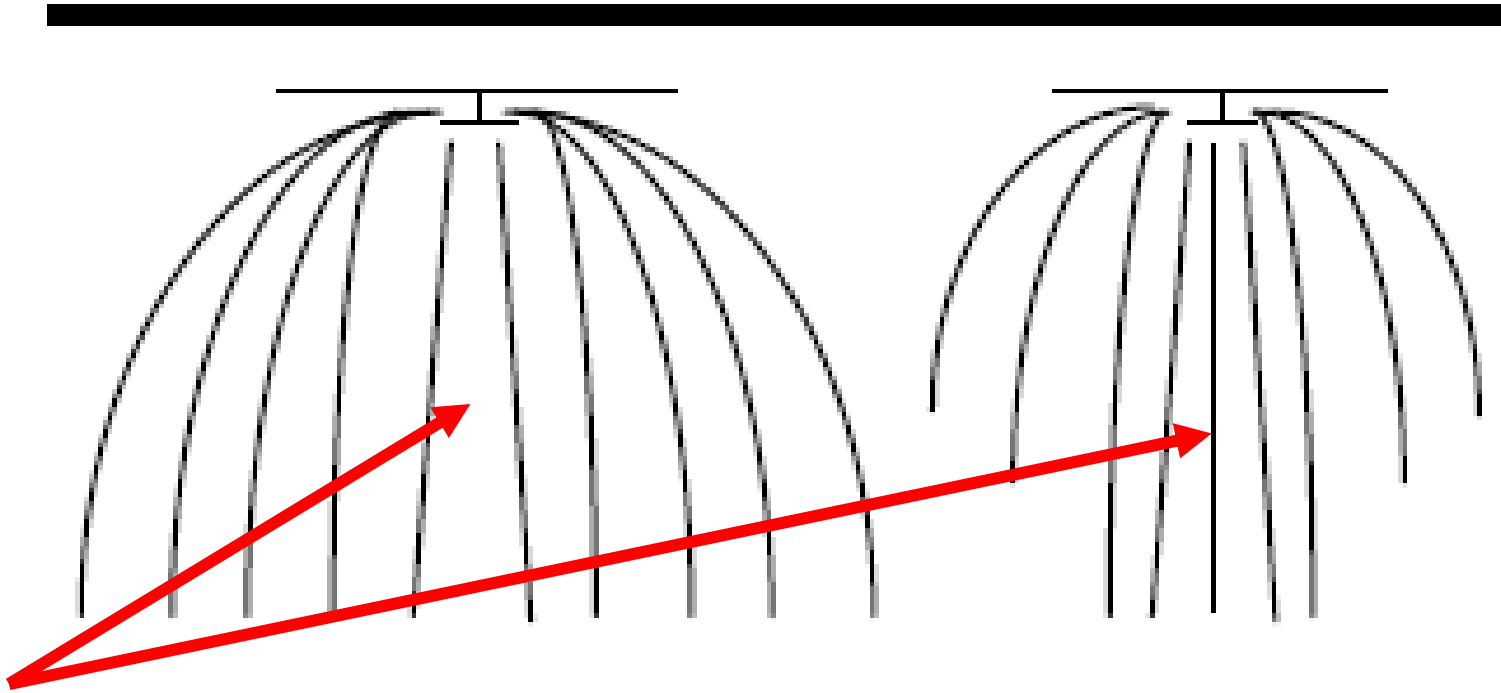
- General
- Criteria for Palletized, Solid-Piled, Bin Box, Shelf, or Back-to-Back Shelf Storage of Class I Through Class IV Commodities.
- Criteria for Palletized, Solid-Piled, Bin Box, Shelf, or Back-to-Back Shelf Storage of Plastic and Rubber Commodities.
- Criteria for Rack Storage of Class I Through Class IV Commodities.
- Criteria for Single-, Double-, and Multiple-Row Racks for Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height.
- Criteria for Rack Storage Rubber Tires.
- Criteria for Roll Paper Storage.
- Special Design for Rack Storage of Class I Through Class IV Commodities and Group A Plastics Stored Up to and Including 25 ft (7.6 m) in Height.
- Sprinkler Design Criteria for Storage and Display of Class I Through Class IV Commodities, Cartoned Nonexpanded Group A Plastics and Nonexpanded Exposed Group A Plastics in Retail Stores.

Content

- Criteria for Baled Cotton Storage.
- Criteria for Carton Records Storage with Catwalk Access.
- Criteria for Compact Storage of Commodities Consisting of Paper Files, Magazines, Books, and Similar Documents in Folders and Miscellaneous Supplies with No More Than 5 Percent Plastics Up to 8 ft (2.4 m) High.

Use of standard- response sprinklers with a K-factor of K-5.6

Storage situations that need a density of only 0.2 gpm per ft2 (8.2 mm/min) or less are less demanding than most storage occupancies and are valid for K-5.6 orifice size sprinklers.



It has been recognized that water droplet momentum is critical to achieving fire control or suppression.

Use of Ordinary- and intermediate-temperature sprinklers using density of high-temperature sprinklers

- The original fire tests that were conducted to determine the discharge criteria for solid-piled, palletized, and rack storage were conducted with K-5.6 (80) and K-8.0 (115) sprinklers.
- *During those tests, it was noticed that the use of high-temperature sprinklers could significantly reduce the number of sprinklers that opened during a fire, which has the effect of conserving the water supply.*
- *Density/area criteria were developed for high-temperature sprinklers with K-5.6 (80) or K-8.0 (115) to take advantage of this conservation by either allowing a reduction in sprinkler densities for the same design area or reducing the design area for the same discharge densities*

Criteria for Palletized, Solid-Piled, Bin Box, Shelf, or Back-to-Back Shelf Storage of Class I Through Class IV Commodities

21.2 - Protection limits for CMDA Sprinklers

(1) Nonencapsulated commodities that are solid-piled, palletized, or bin box storage up to 30 ft (9.1 m) in height

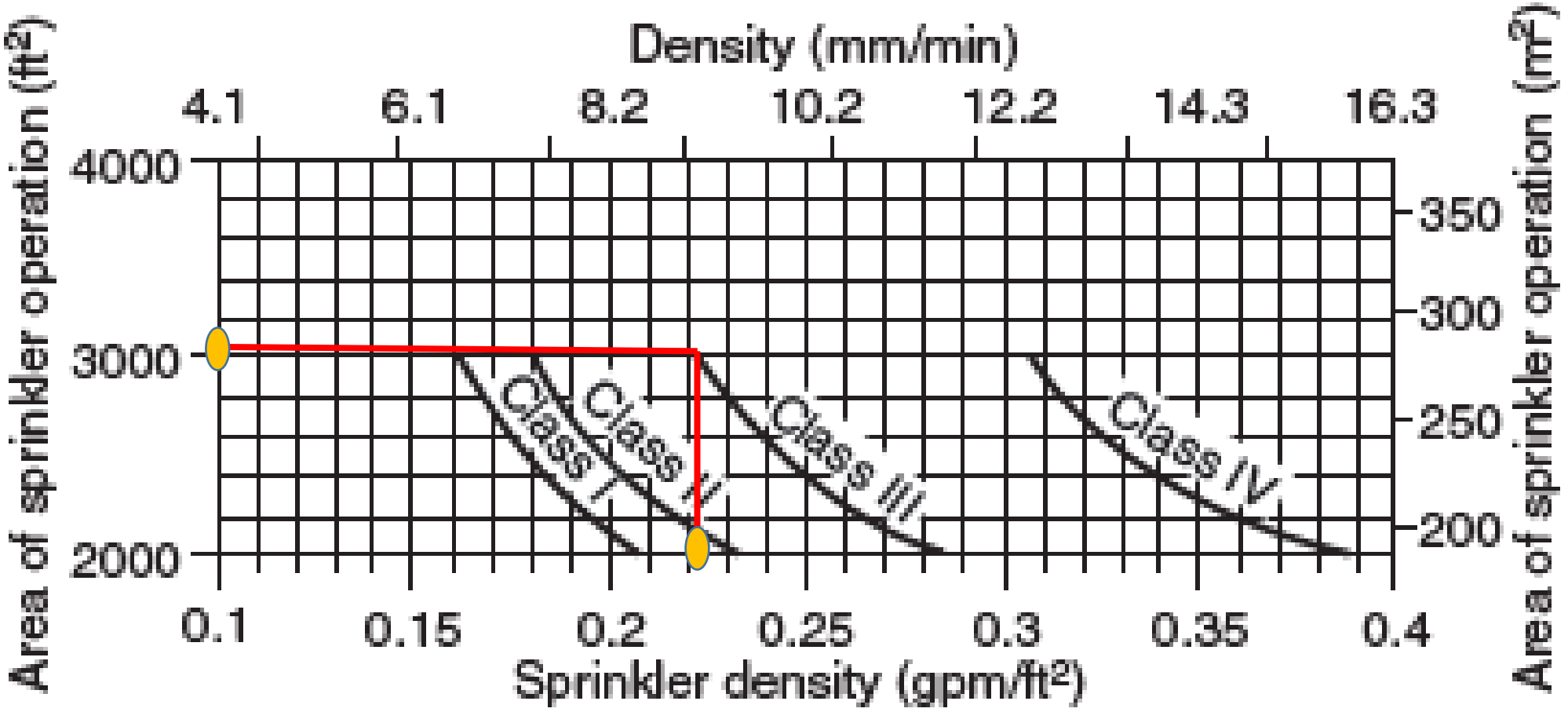
(2) Nonencapsulated commodities on shelf storage up to 15 ft (4.6 m) in height

(3)Encapsulated commodities that are solid-piled, palletized, bin box, or shelf storage up to 15 ft (4.6 m) in height

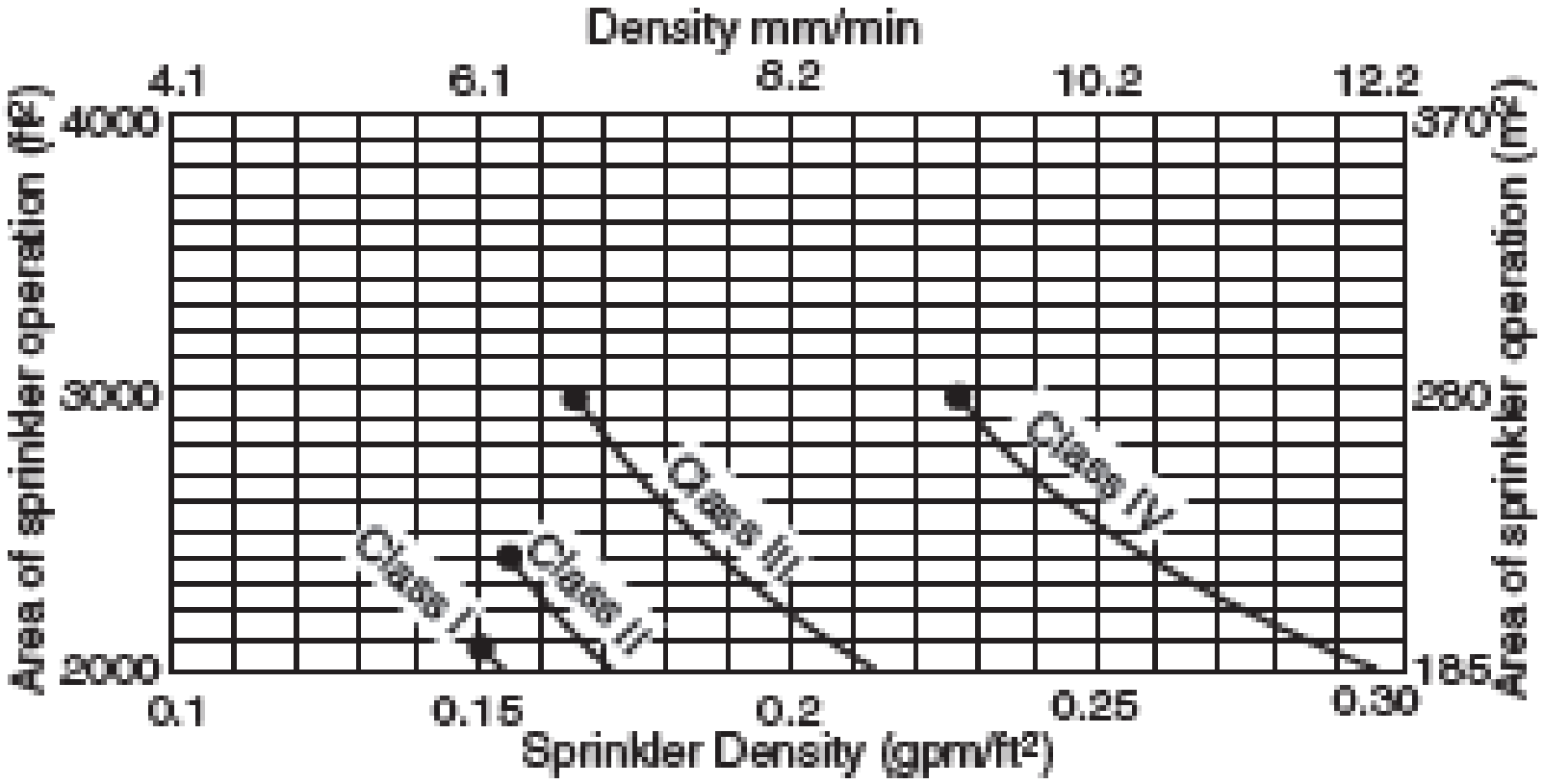
(4) Back-to-back shelf storage up to 15 ft (4.6 m) in height

(5) Encapsulated storage of solid-piled and palletized Class I through IV commodities permitted in accordance with 21.2.3 for storage heights over 15 ft (4.6 m) up to and including 20 ft (6.1 m)

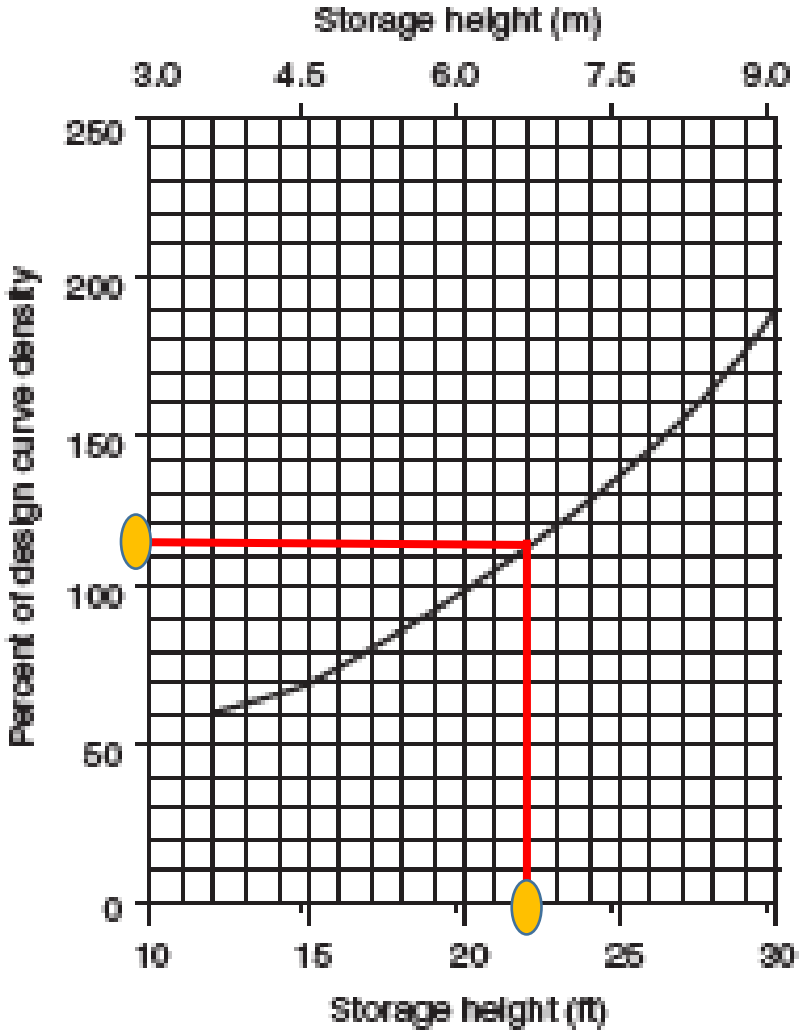
Sprinkler System Design Curves for 20 ft (6.1 m) High Storage — Ordinary Temperature–Rated Sprinklers



Sprinkler System Design Curves for 20 ft (6.1 m) High Storage — High Temperature–Rated Sprinklers



Ceiling Sprinkler Density vs. Storage Height



Example

- Storage- greeting cards in boxes in cartons on pallets Height — 22 ft. (6.7 m)
- Clearance to ceiling — 6 ft (1.8 m)
- Sprinklers — ordinary temperature
- System type — dry

Determine the density and area of operation.

Solution

Classification of Stored Commodity : Class 3

Selection of Density area : 0.225 gpm/sf @ area of 3000 SF

Adjustment for height of storage = 1.15 x 0.225 = 0.26 GPM/SF

Adjustment for Dry Pipe System = 1.3 x 3000 = 3900 SF

Confirmation of Min. Densities and area have been achieved

The minimum design density for a dry sprinkler system is 0.15 gpm/ft2 over 2600 ft2

Solution

The minimum design density for a dry sprinkler system is 0.15 gpm/ft2 over 2600 ft2

Corresponding density at 3000 SF will be 0.17 GPM/SF (Satisfied)

Therefore,

The design density and area of application equals 0.26 gpm/ft2 over 3900 ft2 (10.6 mm/min over 360 m2).

21.3 - Protection limits for CMDA Sprinklers

(1) Commodities that are stored palletized, solid piled, or in bin boxes up to 25 ft (7.6 m) in height.

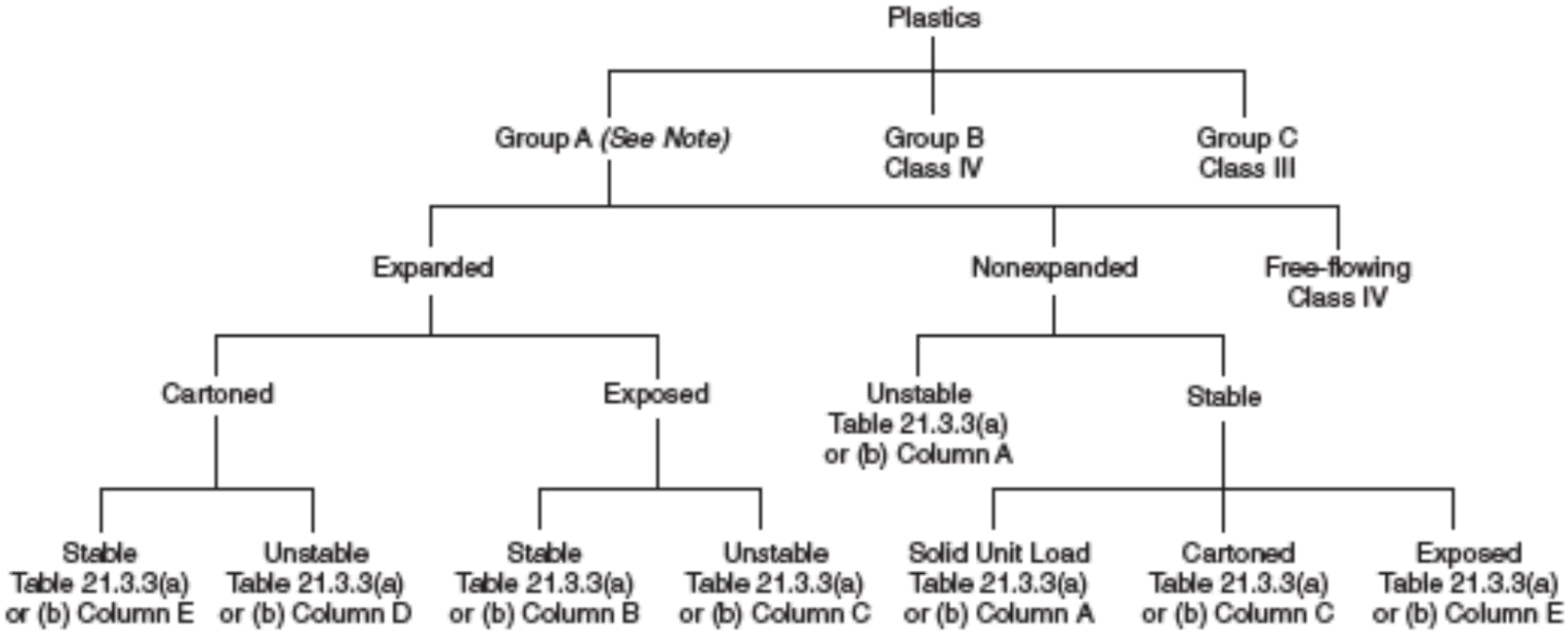
(2) Commodities that are stored in shelf storage up to 15 ft (4.6 m) in height.

(3) Commodities that are stored using back-to-back shelf storage up to 15 ft (4.6 m) in height. The minimum aisle width shall be 5 ft (1.5 m).

Back-to-Back Shelf Storage of Cartoned Nonexpanded Group A Plastics

Storage Height		*Ceiling Height*		
ft	*m*	*ft*	*m*	*Protection*
Over 5 up to 8	1.5/2.4	Up to 14	4.3	Ordinary Hazard Group 2
Up to 12	3.7	Up to 15	4.6	0.45 gpm/ft^2 over 2500 ft^2 18.3 mm/min/230 m^2
Up to 12	3.7	Up to 30	9.1	0.6 gpm/ft^2 over 2500 ft^2 24.5 mm/min/230 m^2
Up to 15	4.6	Up to 30	9.1	0.7 gpm/ft^2 over 2500 ft^2 28.5 mm/min/230 m^2

Decision Tree for plastic Commodities



Note: Cartons that contain Group A plastic material are permitted to be treated as Class IV commodities under either of the following conditions:

(1) There are multiple layers of corrugation or equivalent outer material that would significantly delay fire involvement of the Group A plastic.

(2) The amount and arrangement of Group A plastic material within a carton with a single layer of corrugation would not be expected to significantly increase the fire hazard.

Design Densities for Palletized, Solid-Piled, Bin Box, or Shelf Storage of Group A Plastic Commodities (S.I. Units)

TABLE 21.3.3(a) & TABLE 21.3.3(b)

Criteria for Rack Storage of Class I Through Class IV Commodities Stored Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m) in Height

Refer ***TABLE 21.4.1.2 for density of*** *Single- or Double-Row Racks — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft*

Criteria for Multiple row racks

- Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m) with Aisles 8 ft (2.4 m) or Wider.
- Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles More Narrow Than 8 ft (2.4 m)

Refer ***TABLE 21.4.1.3.1 for density of*** *Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider and Storage Height Over 12 ft (3.7 m) Up to 25 ft (7.6 m)*

Refer ***TABLE 21.4.1.3.2 for density of*** *Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower Than 8 ft (2.4 m), Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)*

Criteria for Rack Storage of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height

Refer Chapter 25

Control Mode Density/Area Sprinkler Protection Criteria for Single-, Double-, and Multiple-Row Racks for Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

Refer Table 21.5.1.1 Control Mode Density/Area Sprinkler Protection Criteria for Single-, Double-, and Multiple-Row Racks for Group A Plastic Commodities in Cartons Stored Up to and Including 25 ft (7.6 m) in Height

Chapter- 22
CMSA Requirement for Storage Applications

Content

- General
- Palletized and Solid-Piled Storage of Class I Through Class IV Commodities. – **Table 22.2**
- Palletized and Solid-Piled Storage of Non-expanded and Expanded Group A Plastic Commodities -**Table 22.3**
- Single-, Double-, and Multiple-Row Rack Storage for Class I Through Class IV Commodities - **Table 22.4**
- Single-, Double-, and Multiple-Row Racks of Group A Plastic Commodities - **Table 22.5**
- Rubber Tires - **Table 22.6**
- Roll Paper Storage - **Table 22.7**

Chapter- 23
ESFR Requirement for Storage Applications

Content

- General
- ESFR Design Criteria.
- Early Suppression Fast-Response (ESFR) Sprinklers for Palletized or Solid-Piled Storage of Class I Through Class IV Commodities - Table 23.3.1.
- Early Suppression Fast-Response (ESFR) Sprinklers for Palletized or Solid-Piled Storage of Group A Plastic Commodities - Table 23.4.2
- Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Class I Through Class IV Commodities - Table 23.5.1
- Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Group A Plastic Commodities - Table 23.6.1
- Protection of Exposed Expanded Group A Plastics.
- ESFR Protection of Rack Storage of Rubber Tires - Table 23.8
- Early Suppression Fast-Response (ESFR) Sprinklers for Protection of Roll Paper Storage - Table 23.9
- Plastic Motor Vehicle Components - Table 23.10
- Sprinkler Design Criteria for Storage and Display of Class I Through Class IV Commodities, Cartoned Nonexpanded Group A Plastics and Nonexpanded Exposed Group A Plastics in Retail Stores.

Content

- Protection of High Bay Records Storage.
- Slatted Shelves.

Chapter- 24
Alternative Sprinkler System Design for Ch. 20 through 25

Intent of the Chapter

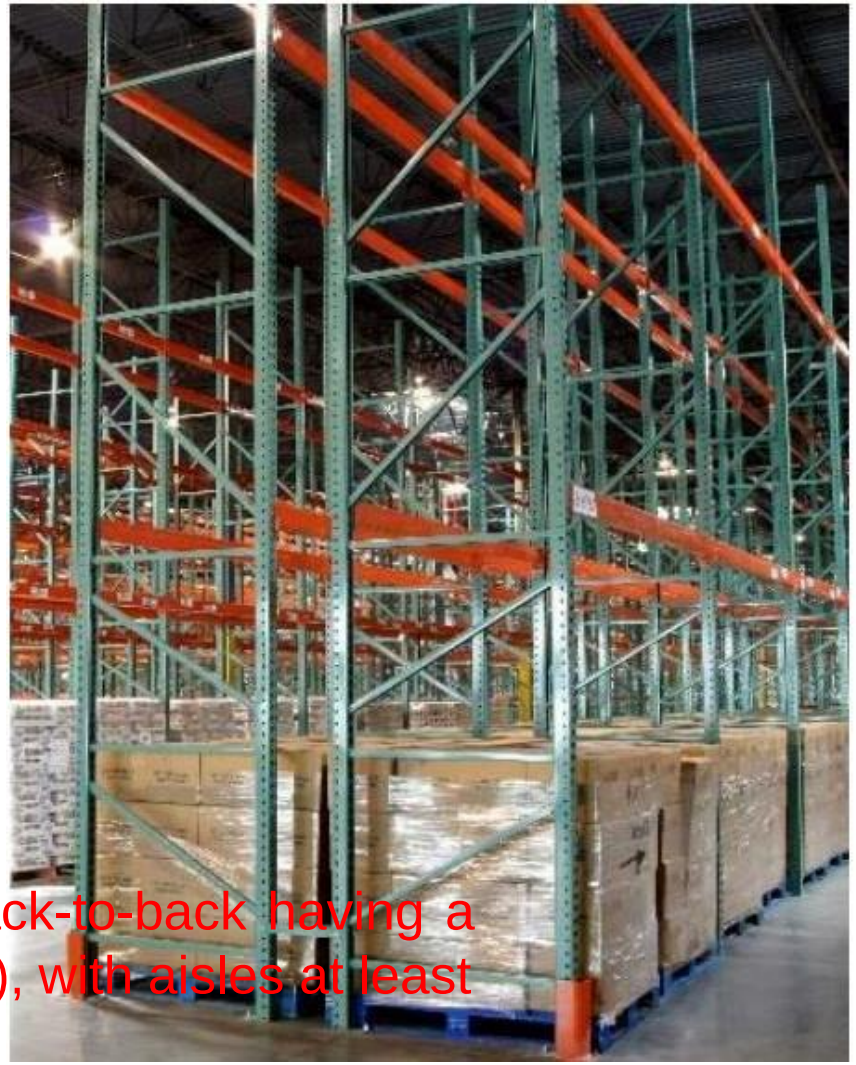
- The intent of this chapter is to set a basis to allow manufacturers to conduct full-scale fire tests and then submit the results of the tests to the NFPA 13 Technical Committee on Sprinkler System Discharge Criteria. If, upon review, the committee determines that the test results are successful and that the minimum criteria have been met, the sprinkler will be added to the tables in Chapter 24

Chapter- 25
Protection of Rack Storage using In rack Sprinklers

Single Row Rack

Racks that have no longitudinal flue space and that have a width up to 6ft (1.8m) with aisles at least 3.5ft (1.1m) from other storage.

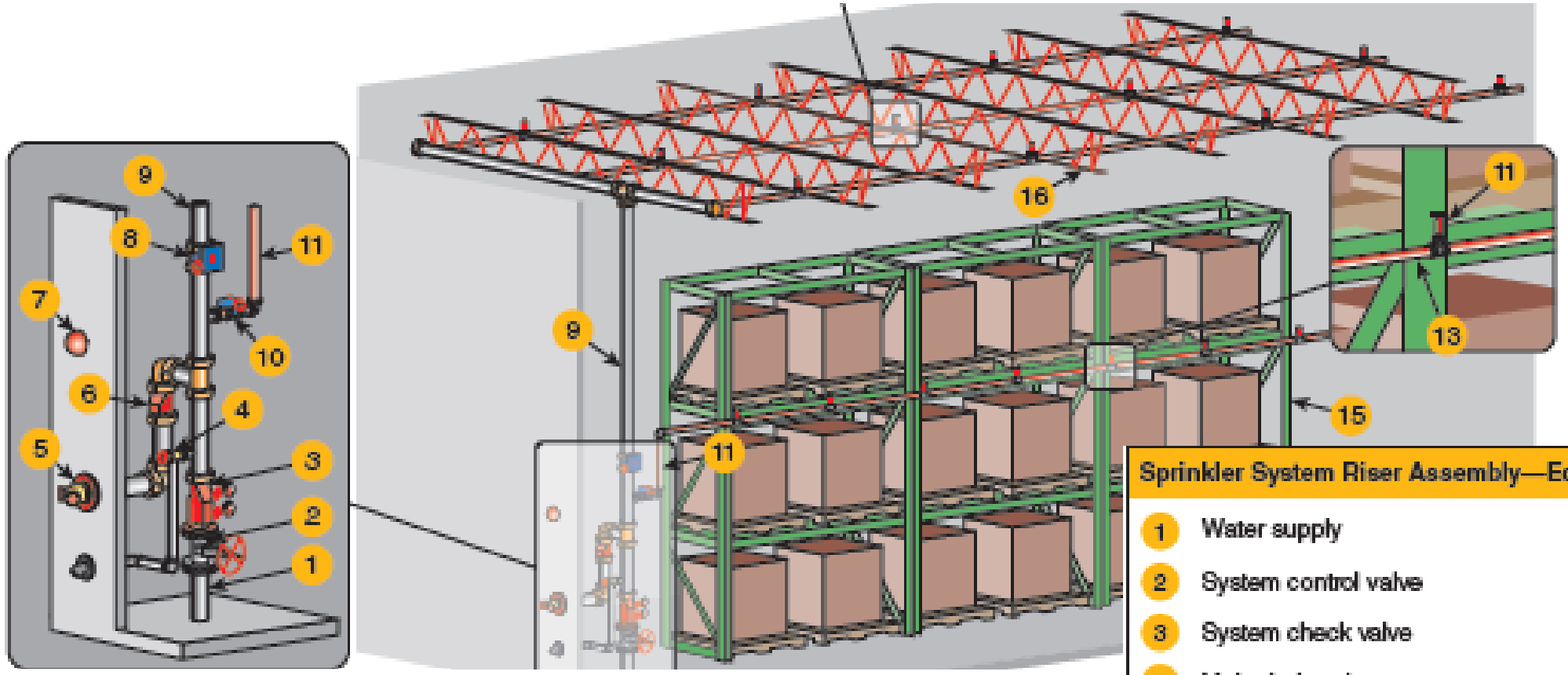
Double Row Rack



Two single-row racks placed back-to-back having a combined width up to 12ft (3.7m), with aisles at least 3.5ft (1.1m) on each side.

Multiple Row Rack

Racks greater than 12ft (3.7m) wide or single- or double-row racks separated by aisles less than 3.5ft (1.1m) wide having an overall width greater than 12ft (3.7m).



Sprinkler System & Building—Legend

12 Ceiling/overhead fire sprinklers

13 In-rack fire sprinkler(s)

14 Branch line(s)

15 Rack structure

16 Roof support structure

Sprinkler System Riser Assembly—Equipment Legend

1 Water supply

2 System control valve

3 System check valve

4 Main drain valve

5 Fire department connection

6 Check valve

7 Local waterflow alarm

8 Control valve for ceiling/overhead sprinklers

9 Feed main to ceiling/overhead sprinklers

10 Control valve for in-rack sprinklers

11 Feed main to in-rack sprinklers

3 Basic Questions:

- What is stored? (Classification of Commodities)
- How is it stored? (Storage Arrangements)
- How high is it stored?

✓< 12 feet

✓< = 25 feet

✓> 25 feet

Fire Control Vs Fire Suppression

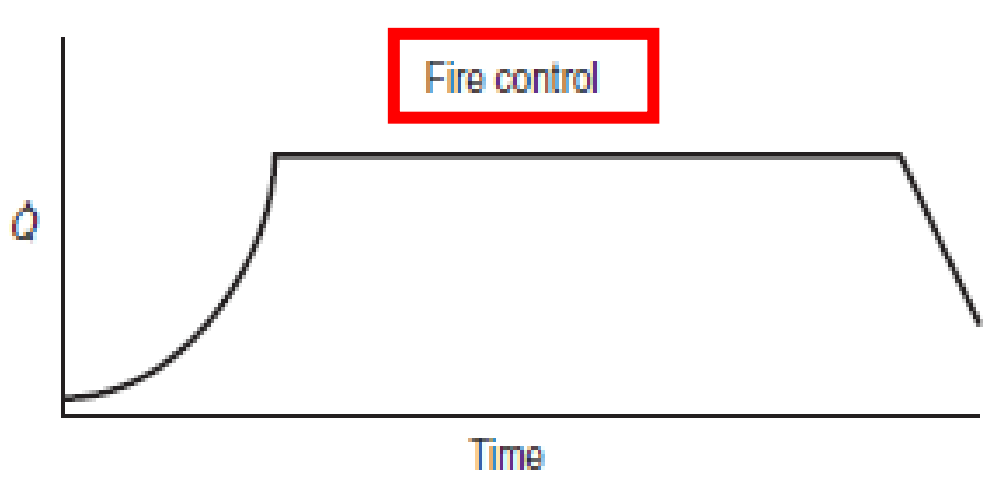


FIGURE 16.1.9 Representation of Fire Control by Sprinklers; Heat Release Rate ($\dot{Q}$) Versus Time

Vs

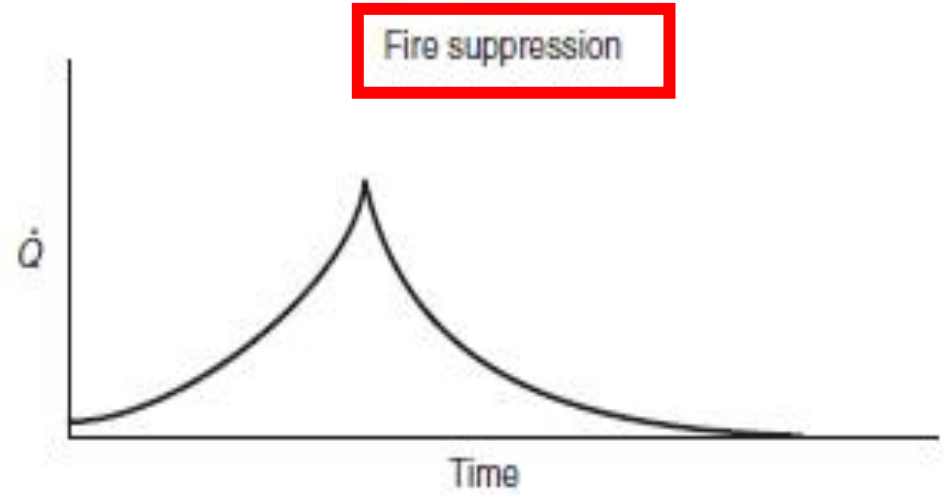
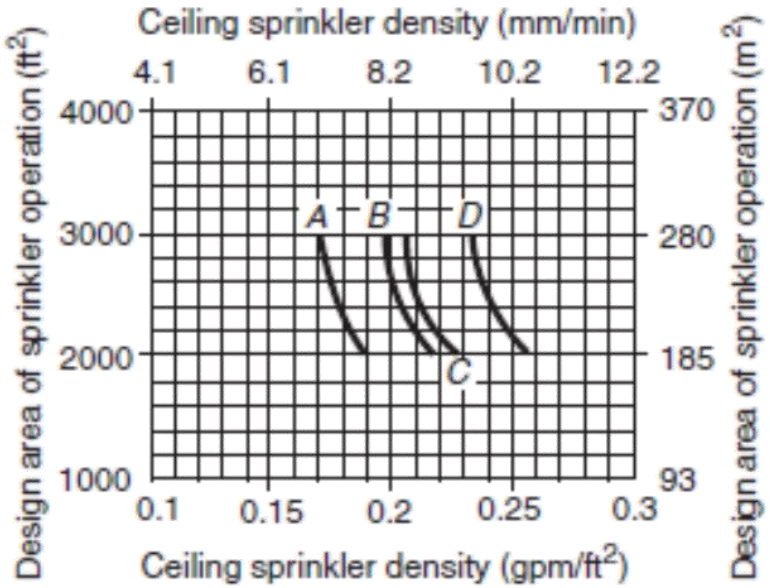


FIGURE 16.1.11 Representation of Fire Suppression by Sprinklers, Heat Release Rate ($\dot{Q}$) Versus Time

28 different density/area curves that apply to the rack storage of Class I through Class IV commodities stored on racks that are protected with in-rack sprinklers



Curve **Legend**

A — Single- or double-row racks with 8 ft (2.4 m) aisles with high-temperature ceiling sprinklers and ordinary-temperature in-rack sprinklers

B — Single- or double-row racks with 8 ft (2.4 m) aisles with ordinary-temperature ceiling sprinklers and ordinary-temperature in-rack sprinklers

C — Single- or double-row racks with 4 ft (1.2 m) aisles or multiple-row racks with high-temperature ceiling sprinklers and ordinary-temperature in-rack sprinklers

D — Single- or double-row racks with 4 ft (1.2 m) aisles or multiple-row racks with ordinary-temperature ceiling sprinklers and ordinary-temperature in-rack sprinklers

FIGURE 25.2.3.2.3.1(a) CMDA Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class I Nonencapsulated Commodities — Conventional Pallets.

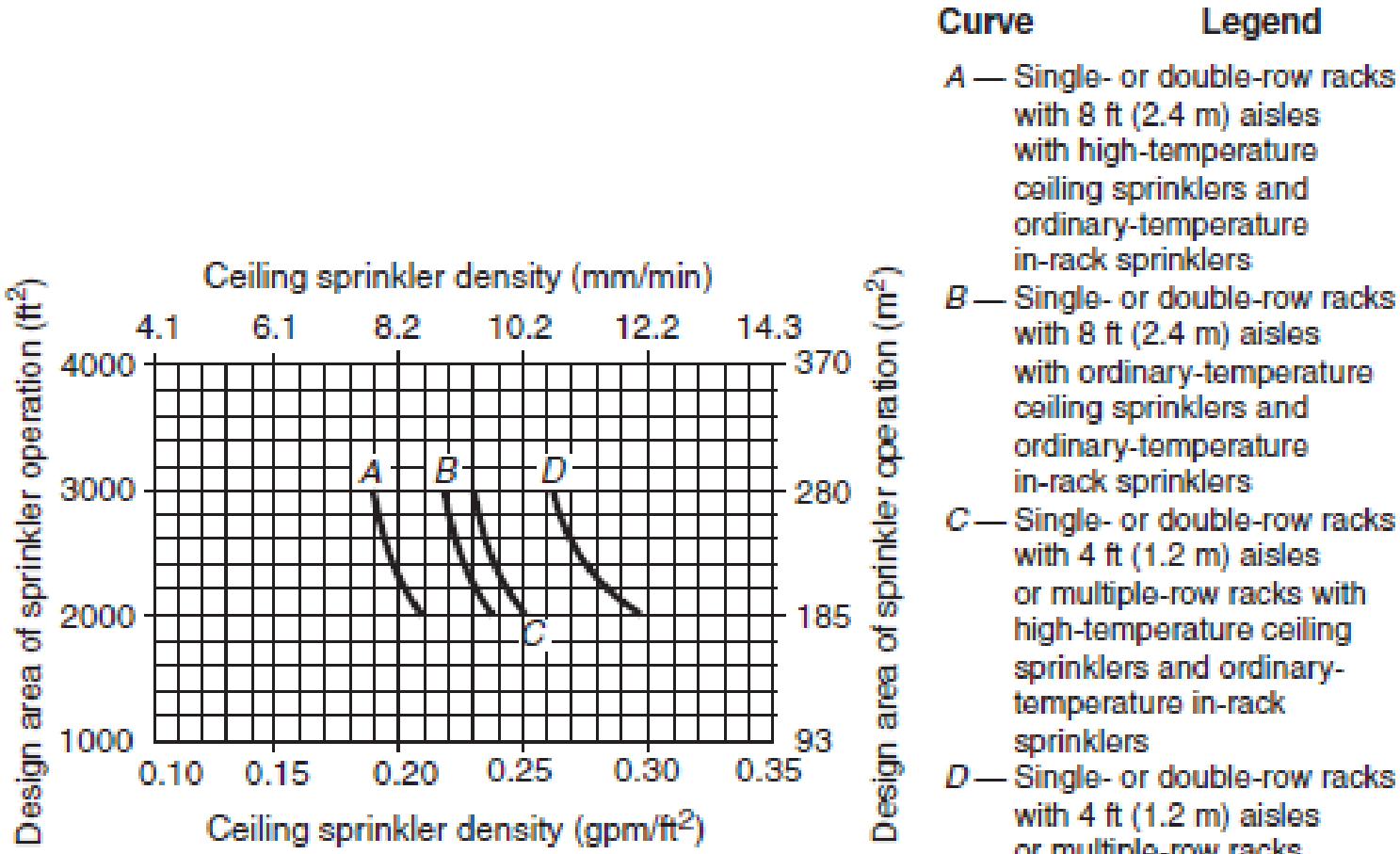


FIGURE 25.2.3.2.3.1(b) CMDA Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class II Nonencapsulated Commodities — Conventional Pallets.

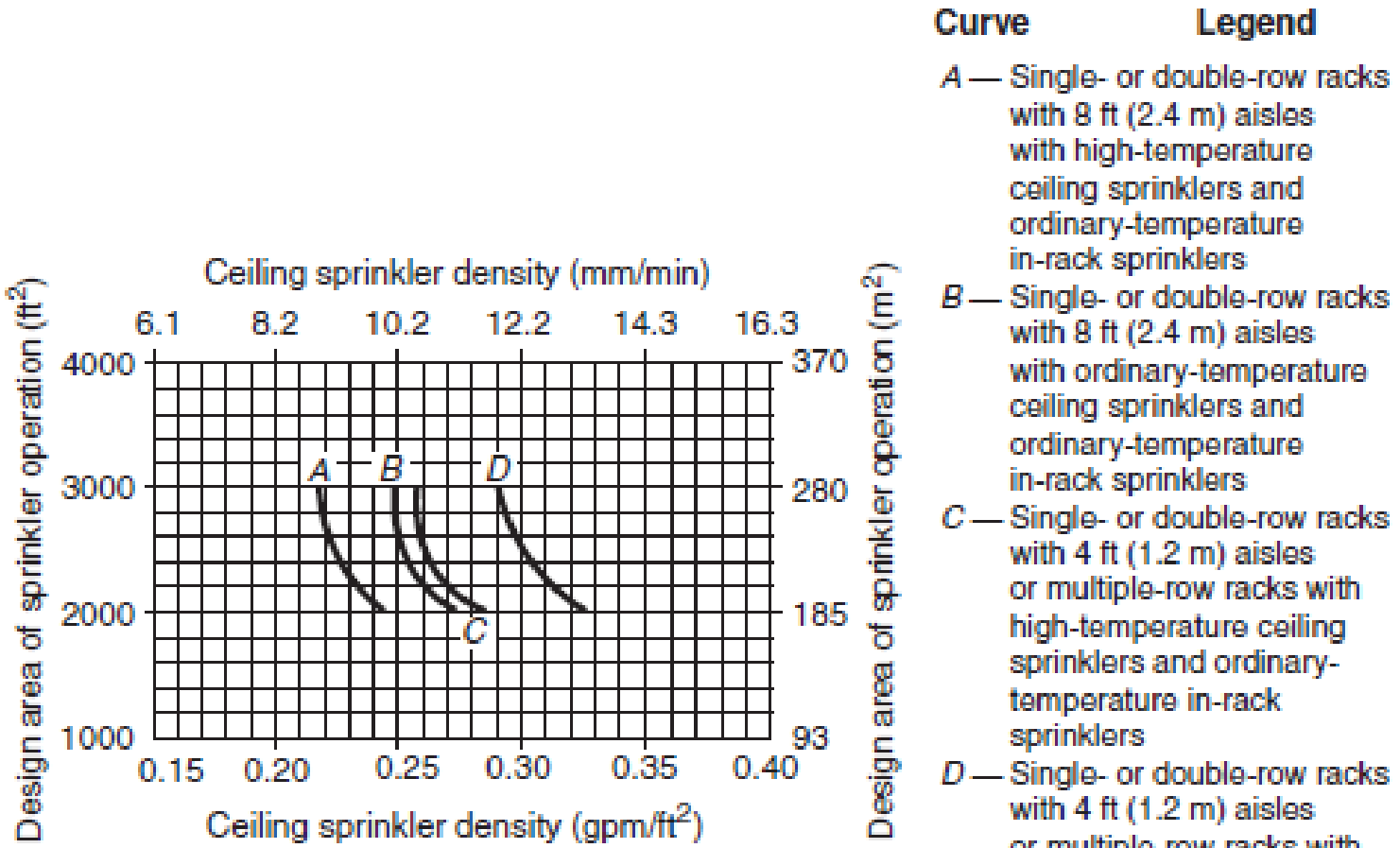


FIGURE 25.2.3.2.3.1(c) CMDA Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class III Nonencapsulated Commodities — Conventional Pallets.

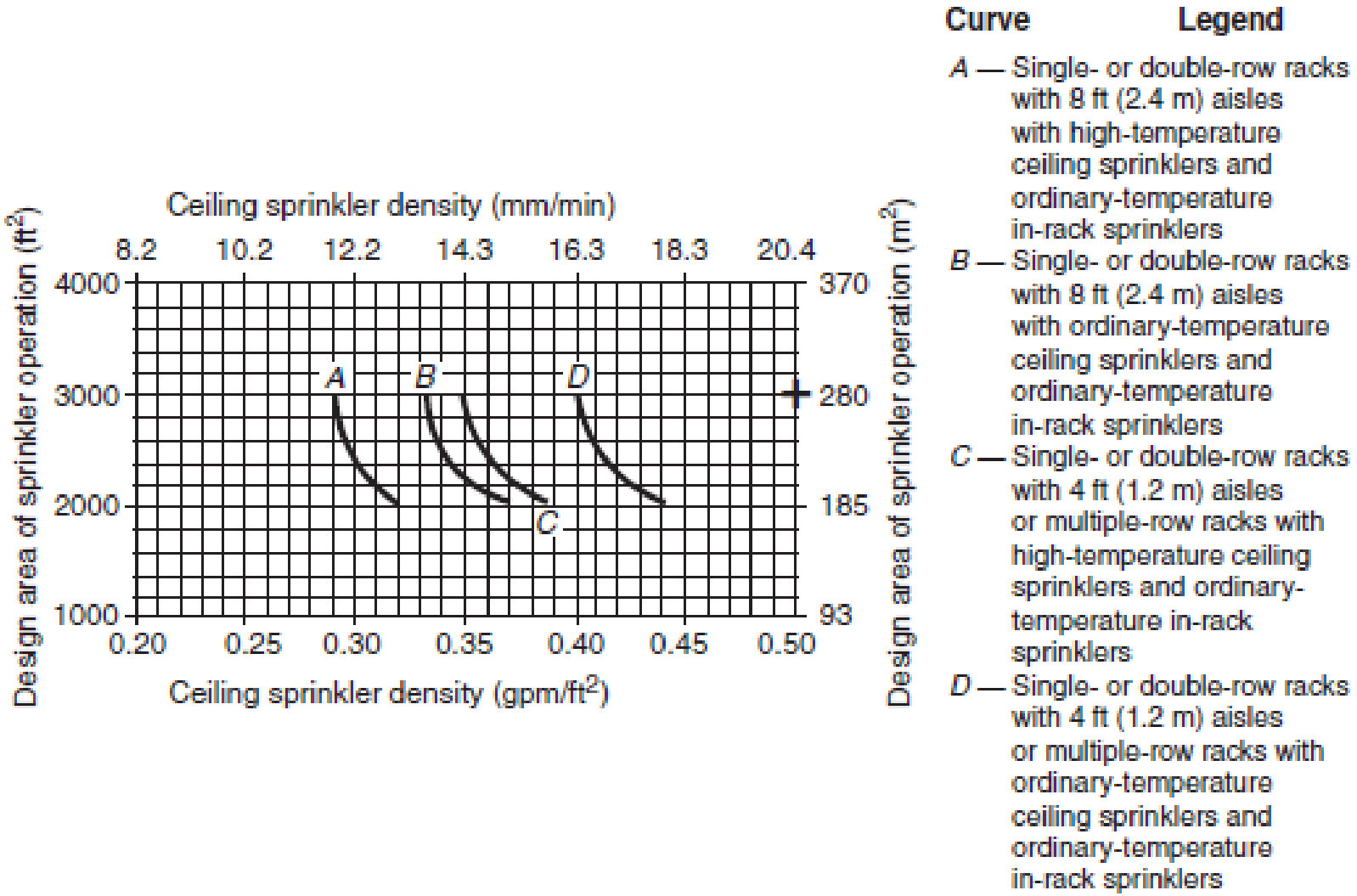


FIGURE 25.2.3.2.3.1(d) CMDA Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class IV Nonencapsulated Commodities — Conventional Pallets.

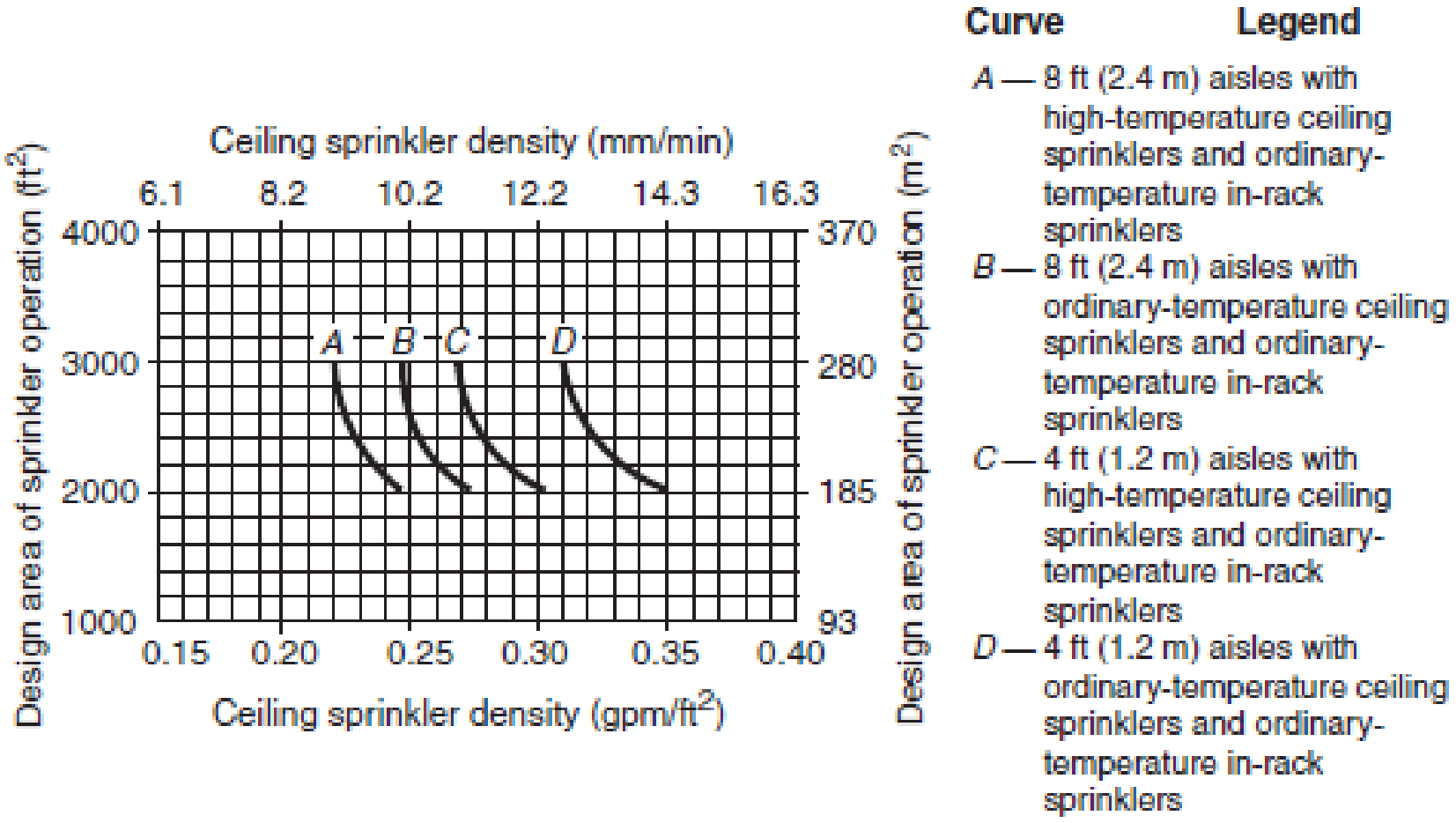


FIGURE 25.2.3.2.3.1(e) CMDA Sprinkler System Design Curves — Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Class I and Class II Encapsulated Commodities — Conventional Pallets.

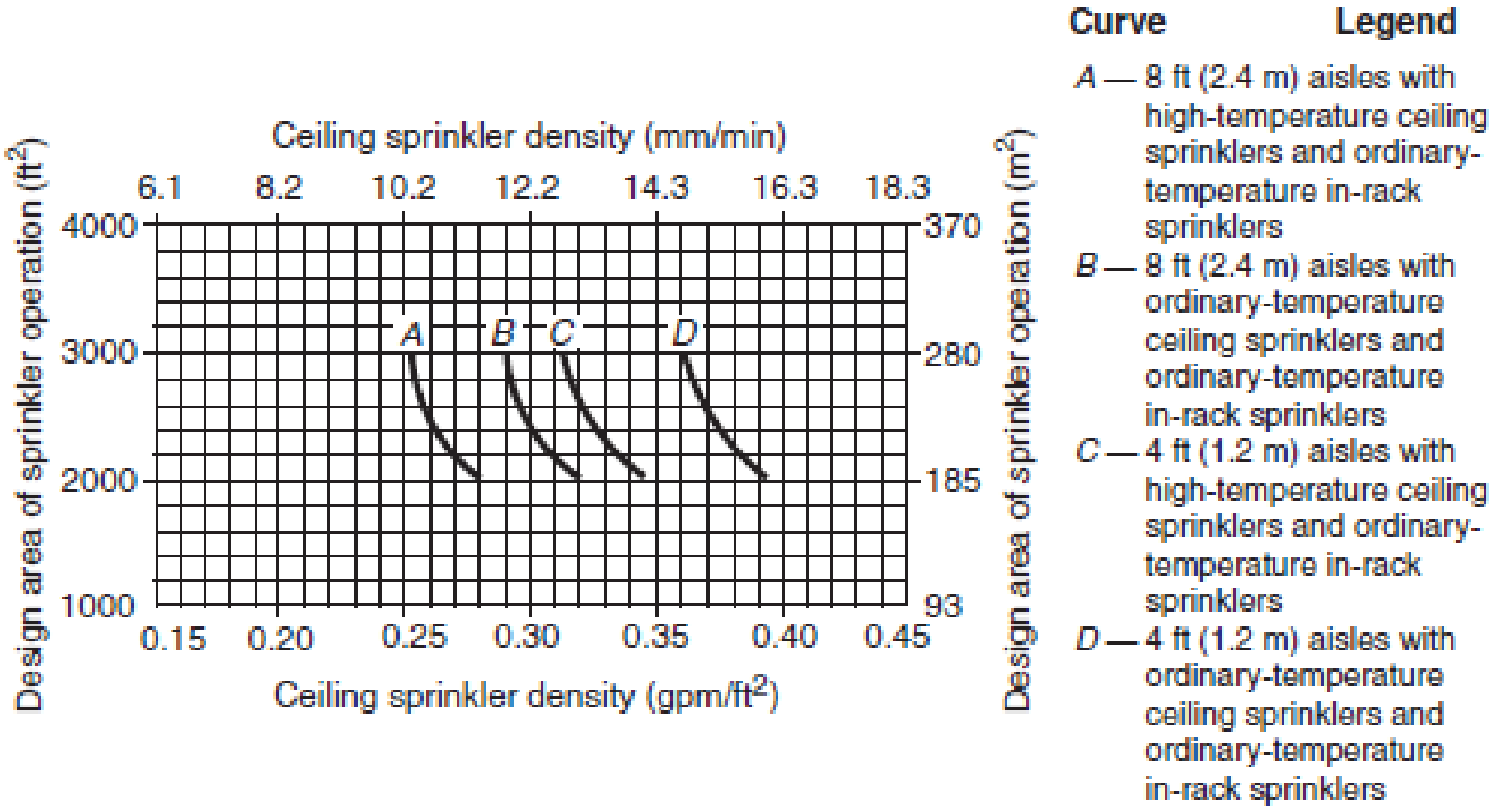
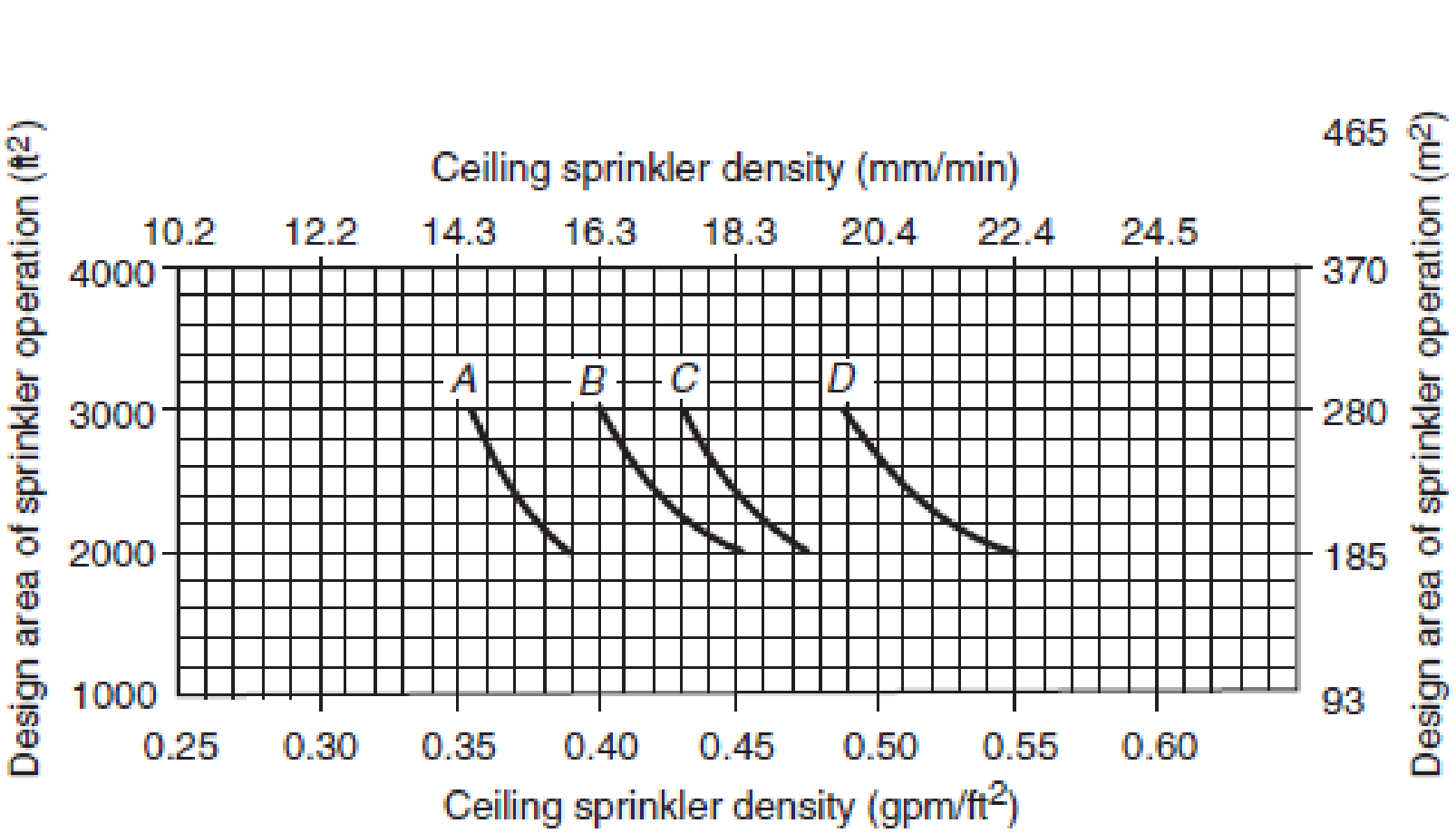


FIGURE 25.2.3.2.3.1(f) CMDA Sprinkler System Design Curves — Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Class III Encapsulated Commodities — Conventional Pallets.



Curve **Legend**

A — 8 ft (2.4 m) aisles with high-temperature ceiling sprinklers and ordinary-temperature in-rack sprinklers

B — 8 ft (2.4 m) aisles with ordinary-temperature ceiling sprinklers and ordinary-temperature in-rack sprinklers

C — 4 ft (1.2 m) aisles with high-temperature ceiling sprinklers and ordinary-temperature in-rack sprinklers

D — 4 ft (1.2 m) aisles with ordinary-temperature ceiling sprinklers and ordinary-temperature in-rack sprinklers

FIGURE 25.2.3.2.3.1(g) CMDA Sprinkler System Design Curves — Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Class IV Encapsulated Commodities — Conventional Pallets.

Requirement of In Rack Sprinklers

Depends upon

- Type of commodity (Type 1 to 4 and plastics)
- Height of the rack (Over 12’ & upto 25’ / Over 25’) with different aisle widths
- Arrangement of Rack (Single, Double & multiple rows)

Table 25.2.3.2.1 Determining Appropriate Ceiling-Level Protection Criteria Figure for Single- or Double-Row Racks of Class I Through Class IV Commodities — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Storage Height	Commodity Class	Encapsulated	Aisle Width*		No. of In-Rack Sprinkler Levels	Appropriate Figure and Curves		
			ft	m		Figure	Curves	Apply Figure 25.2.3.2.4.1
Over 12 ft (3.7 m) and up to and including 20 ft (6.1 m)	I	No	4	1.2	1 Level	25.2.3.2.3.1(a)	C and D	Yes
			8	2.4			A and B	
		Yes	4	1.2		25.2.3.2.3.1(c)	C and D	
			8	2.4			A and B	
	II	No	4	1.2		25.2.3.2.3.1(b)	C and D	
			8	2.4			A and B	
		Yes	4	1.2		25.2.3.2.3.1(e)	C and D	
			8	2.4			A and B	
	III	No	4	1.2		25.2.3.2.3.1(c)	C and D	
			8	2.4			A and B	
		Yes	4	1.2		25.2.3.2.3.1(f)	C and D	
			8	2.4			A and B	
	IV	No	4	1.2		25.2.3.2.3.1(d)	C and D	
			8	2.4			A and B	
		Yes	4	1.2		25.2.3.2.3.1(g)	C and D	

Example : 1

- Type of Commodity : Class 4, Encapsulated
- Storage Height : 21 feet
- Building Height : 30 feet
- Type of Rack Arrangement : Double row with Aisle width 4 foot
- Type of Sprinkler System : Wet Type

Determine Requirement of in rack sprinklers

Option-01

With CMDA Sprinklers

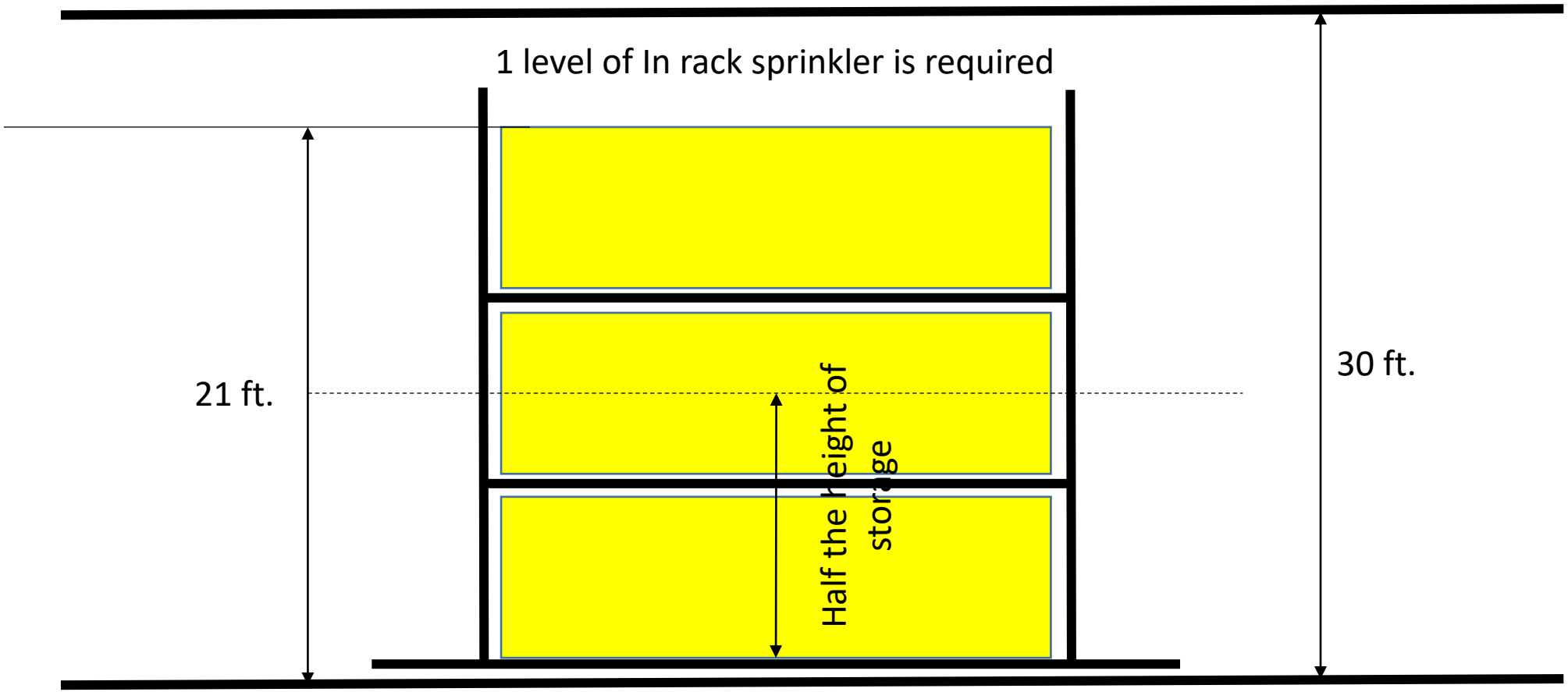
Table 25.2.3.2.1 Determining Appropriate Ceiling-Level Protection Criteria Figure for Single- or Double-Row Racks of Class I Through Class IV Commodities — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Storage Height	Commodity Class	Encapsulated	Aisle Width* ft	Aisle Width* m	No. of In-Rack Sprinkler Levels	Appropriate Figure and Curves: Figure	Curves	Apply Figure 25.2.3.2.4.1
Over 12 ft (3.7 m) and up to and including 20 ft (6.1 m)	I	No	4	1.2	1 Level	25.2.3.2.3.1(a)	C and D	Yes
			8	2.4			A and B	
		Yes	4	1.2		25.2.3.2.3.1(e)	C and D	
			8	2.4			A and B	
	II	No	4	1.2		25.2.3.2.3.1(b)	C and D	
			8	2.4			A and B	
		Yes	4	1.2		25.2.3.2.3.1(e)	C and D	
			8	2.4			A and B	
	III	No	4	1.2		25.2.3.2.3.1(c)	C and D	
			8	2.4			A and B	
		Yes	4	1.2		25.2.3.2.3.1(f)	C and D	
			8	2.4			A and B	
	IV	No	4	1.2		25.2.3.2.3.1(d)	C and D	
			8	2.4			A and B	
		Yes	4	1.2		25.2.3.2.3.1(g)	C and D	
			8	2.4			A and B	
Over 20 ft (6.1 m) and up to and including 22 ft (6.7 m)	I	No	4	1.2	1 Level	25.2.3.2.3.1(a)	C and D	No
			8	2.4			A and B	
		Yes	4	1.2		25.2.3.2.3.1(e)	C and D	
			8	[illegible]			A and B	
	II	No	4	1.2		25.2.3.2.3.1(b)	C and D	
			8	2.4			A and B	
		Yes	[illegible]	1.2		25.2.3.2.3.1(e)	C and D	
			8	2.4			A and B	
	III	No	4	1.2		25.2.3.2.3.1(c)	C and D	
			8	2.4			A and B	
		[illegible]	4	1.2		25.2.3.2.3.1(f)	C and D	
			8	2.4			A and B	
	IV	No	4	1.2		25.2.3.2.3.1(d)	C and D	
			8	2.4			A and B	
		Yes	4	1.2		25.2.3.2.3.1(g)	C and D	
			8	2.4			A and B	

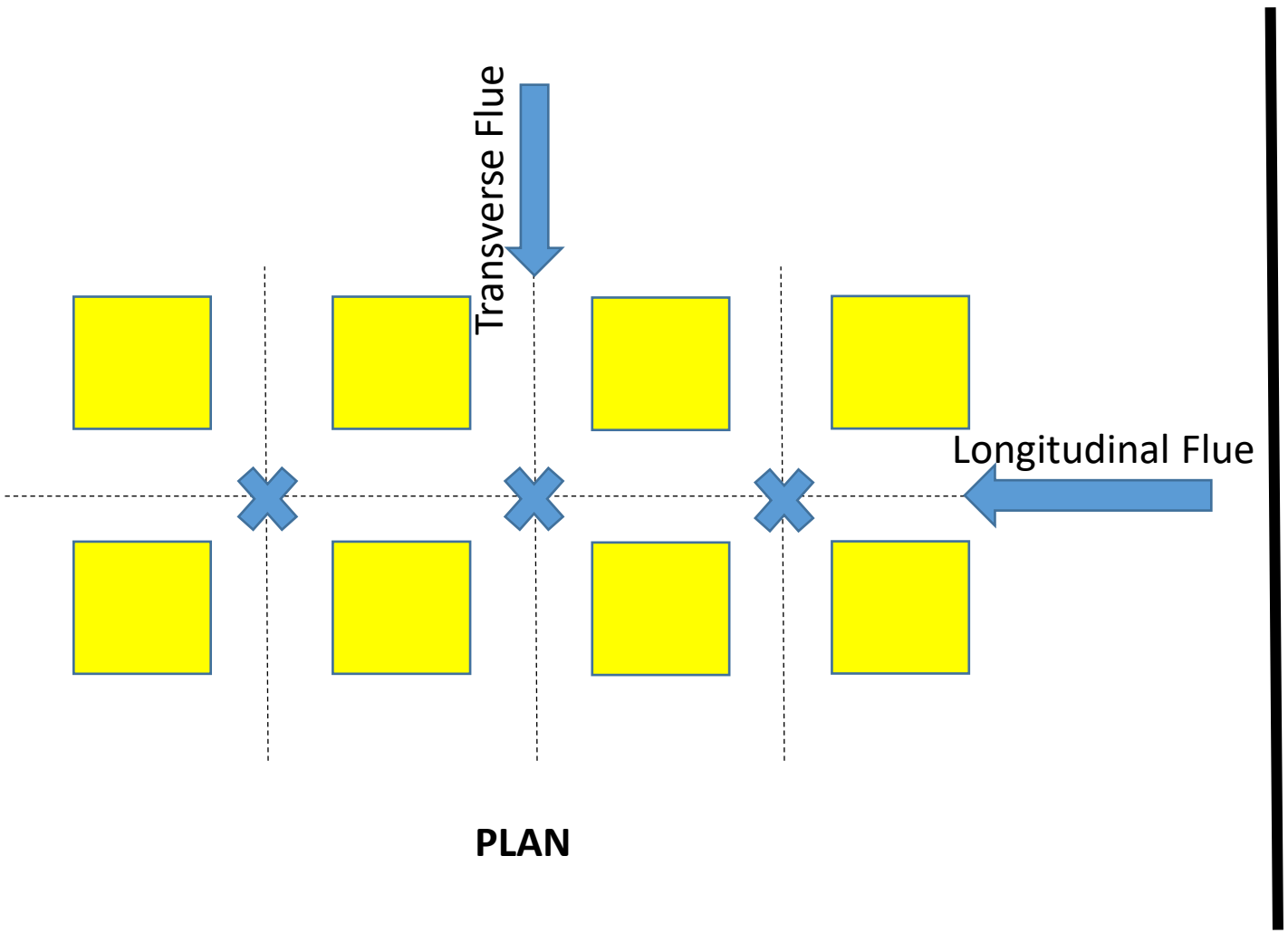
Table 25.2.4.2.1 CMSA Ceiling-Level Sprinkler Design Criteria for Rack Storage of Class I Through Class IV Commodities (Encapsulated and Nonencapsulated) Supplemented with In-Rack Sprinklers

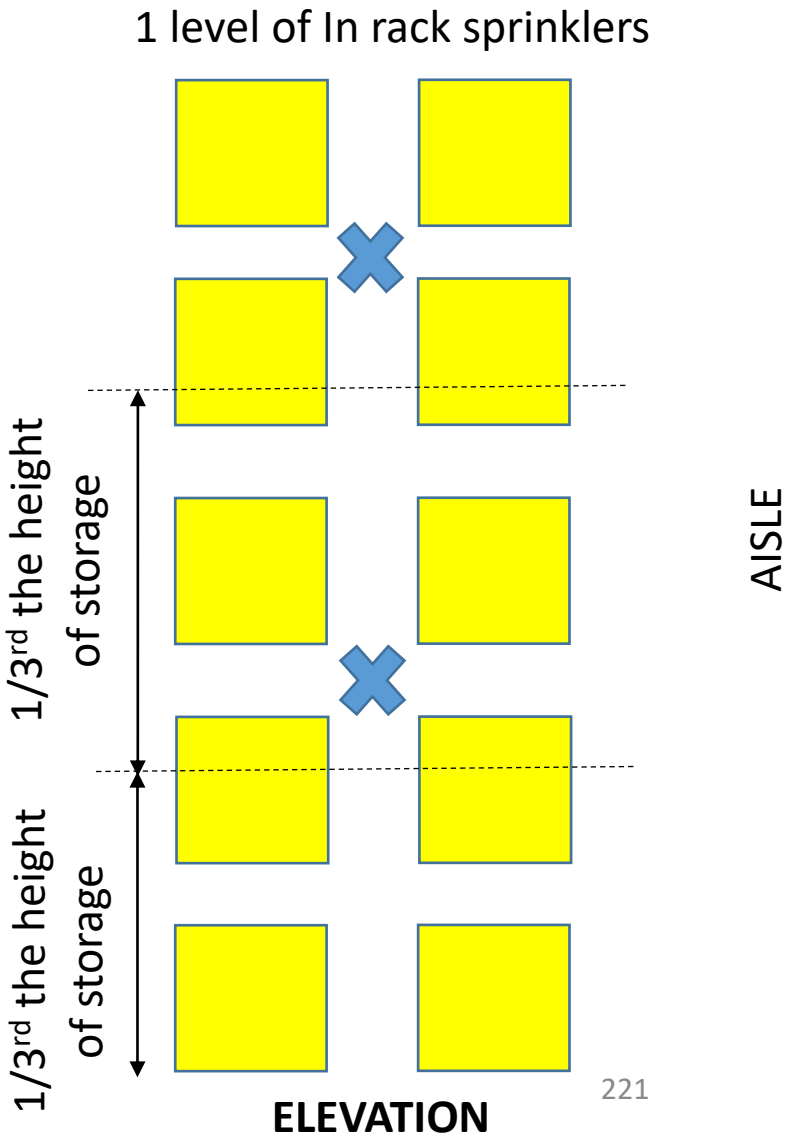
Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/ Roof Height		K-Factor/ Orientation	Type of System	No. of Ceiling Sprinklers in the Design	No. of Required Levels of In-Rack Sprinklers	Minimum Ceiling Sprinkler Operating Pressure	
		ft	m	ft	m					psi	bar
Single-, double-, and multiple-row racks (no open-top containers)	I or II	30	9.1	35	11	11.2 (160) Upright	Wet	20	One level	25	1.7
							Dry	30	One level	25	1.7
						16.8 (240) Upright	Wet	20	One level	15	1
							Dry	30	One level	15	1
	III	25	7.6	30	9.1	11.2 (160) Upright	Wet	15	One level	25	1.7
							Dry	25	One level	25	1.7
						16.8 (240) Upright	Dry	25	One level	15	1
				35	11	11.2 (160) Upright	Wet	15	One level	25	1.7
							Dry	25	One level	25	1.7
						16.8 (240) Upright	Wet	15	One level	15	1
							Dry	25	One level	15	1
	IV	25	7.6	30	9.1	11.2 (160) Upright	Wet	15	One level	50	3.4
				35	11	11.2 (160) Upright	Wet	[illegible]	One level	50	3.4
								15	One level	75	5.2
						16.8 (240) [illegible]	Wet	20	One level	22	1.5
								15	One level	35	2.4

Example-1


1 level of In rack sprinkler is required
21 ft.
30 ft.
Half the height of storage

Cl. 25.5.1.2- Horizontal Location of In-Rack Sprinklers





Spacing in Rack Sprinklers

***TABLE 25.5.2.2.1** In-Rack Sprinkler Horizontal Spacing for Class I, II, III, and IV Commodities Stored in Single- or Double-Row Racks Up to 25 ft (7.6 m) in Height Protected by CMDA Sprinklers at Ceiling Level*

Commodity Class	Aisle Width		Encapsulated	Maximum Allowable Linear Spacing	
	ft	m		ft	m
I, II	8	2.4	No	12	3.7
			Yes	8	2.4
	4	1.2	No	12	3.7
			Yes	8	2.4
III	8	2.4	No	12	3.7
			Yes	8	2.4
	4	1.2	No	10	3
			Yes	8	2.4
IV	8	2.4	No	10	3
			Yes	8	2.4
	4	1.2	No	10	3
			Yes	8	2.4

Example : 2

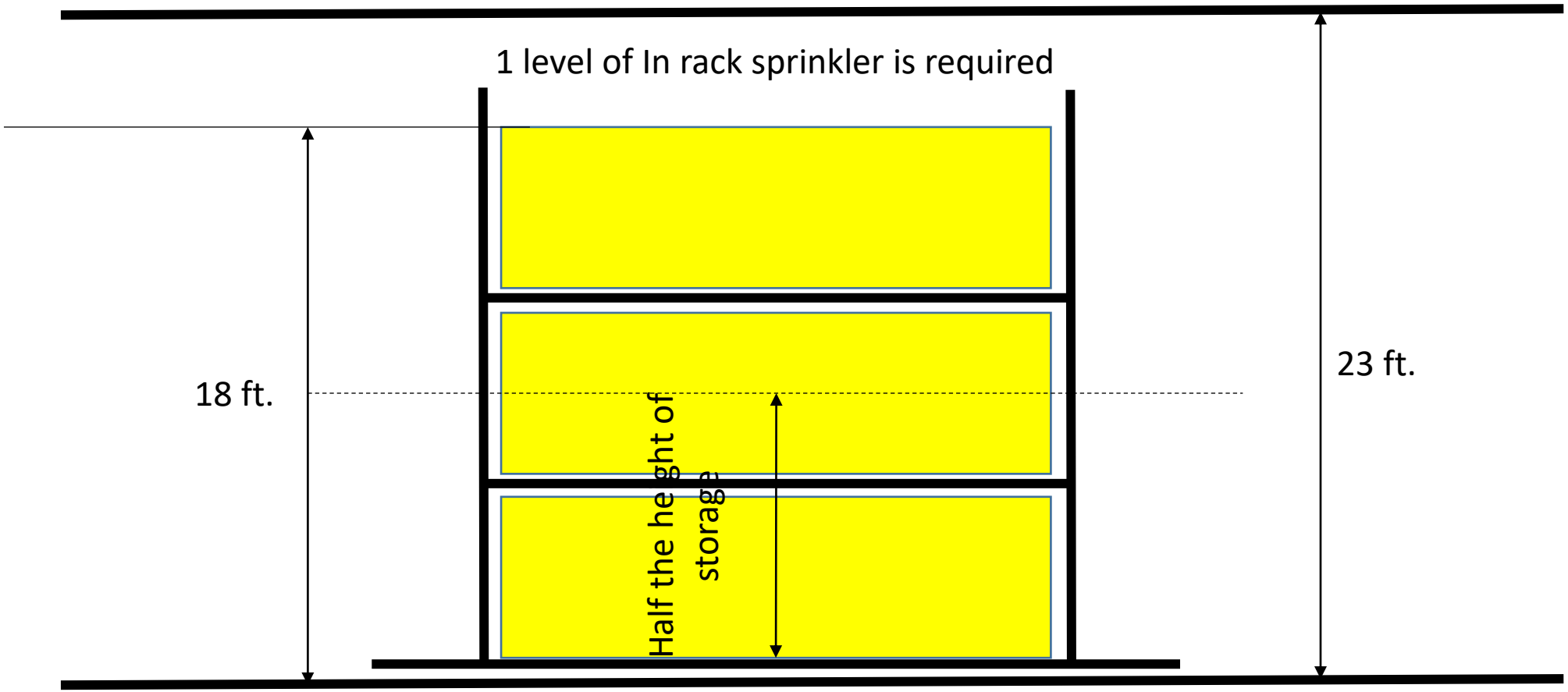
- Type of Commodity : Class 4, Encapsulated
- Storage Height : 18 feet
- Building Height : 23 feet
- Type of Rack Arrangement : Multiple row Rack with Aisle 15 feet deep
- Aisle Width : 6 feet
- Type of Sprinkler System : Wet Type

Determine Requirement of in rack sprinklers

Table 25.2.3.2.2.1 Determining Appropriate Ceiling-Level Protection Criteria Figure for Multiple-Row Racks of Class I Through Class IV Commodities — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider, and Storage Height Over 12 ft (3.7 m) Up to 25 ft (7.6 m)

Storage Height	Commodity Class	Encapsulated	No. of In-Rack Sprinkler Levels	Appropriate Figure and Curves		
				Figure	Apply Figure 25.2.3.2.4.1	Density Multiplier
Over 12 ft (3.7 m) and up to and including 15 ft (4.6 m)	I	No	1 Level	25.2.3.2.3.1(a)	Yes	1.0
		Yes				1.25
	II	No		25.2.3.2.3.1(b)		1.0
		Yes				1.25
	III	No		25.2.3.2.3.1(c)		1.0
		Yes				1.25
	IV	No		25.2.3.2.3.1(d)		1.0
		Yes				1.5
Over 15 ft (4.6 m) and up to and including 20 ft (6.1 m)	I	No	1 Level	25.2.3.2.3.1(a)	Yes	1.0
		Yes				1.25
	II	No		25.2.3.2.3.1(b)		1.0
		Yes				1.25
	III	No		25.2.3.2.3.1(c)		1.0
		Yes				1.25
	IV	No		25.2.3.2.3.1(d)		1.0
		Yes				1.5
Over 20 ft (6.1 m) and up to and including 25 ft (7.6 m)	I	No	1 Level	25.2.3.2.3.1(a)	No	1.0
		Yes				1.25
	II	No		25.2.3.2.3.1(b)		1.0
		Yes				1.25
	III	No		25.2.3.2.3.1(c)		1.0
		Yes				1.25
	IV	No	2 Levels	25.2.3.2.3.1(d)		1.0
		Yes	2 Levels			1.5

Example-2


1 level of In rack sprinkler is required
18 ft.
23 ft.
Half the height of storage

Spacing in Rack Sprinklers

***TABLE 25.5.2.2.2** In-Rack Sprinkler Horizontal Spacing for Class I, II, III, and IV Commodities Stored in Multiple-Row Racks Up to 25 ft (7.6 m) in Height Protected by Control Mode Density/Area Sprinklers at Ceiling Level*

Commodity Class	*Linear Spacing*		*Area Spacing*	
	ft	*m*	*ft²*	*m²*
I, II, III	12	3.7	100	9.3
IV	8	2.4	80	9

Example : 3

- Type of Commodity : Class 3, Encapsulated
- Storage Height : 35 feet
- Building Height : 40 feet
- Type of Rack Arrangement : Double row Rack
- Aisle Width : 4 feet
- Type of Sprinkler System : Wet Type

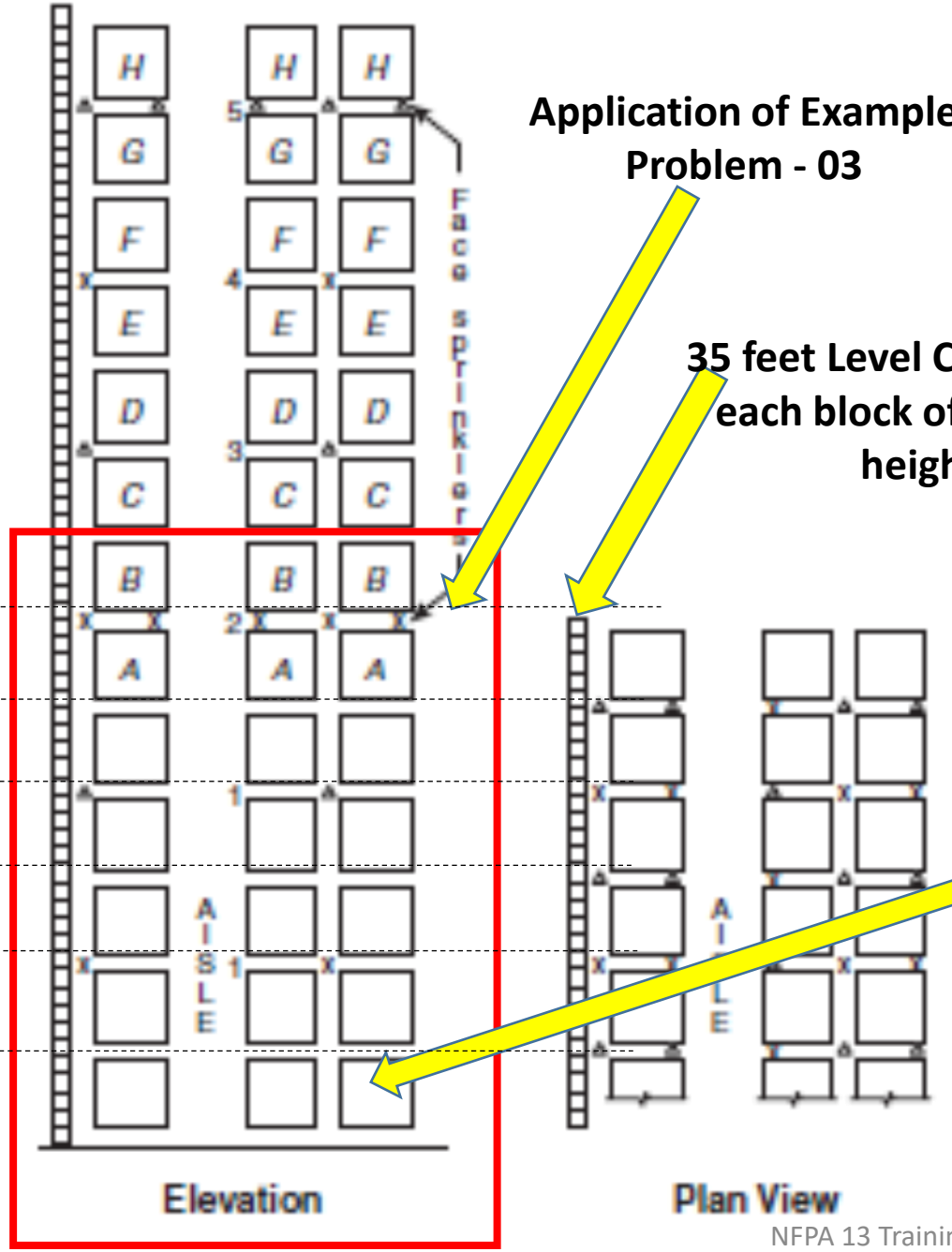
Determine Requirement of in rack sprinklers

Table 25.9.2.2.1 Double-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height with Aisles 4 ft (1.2 m) or More in Width Protected by CMDA Sprinklers at Ceiling Level

Commodity Class	In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing[a,b]		Figure	Maximum Storage Height	Stagger
	Longitudinal Flue[c]	Face[d,e]			
I	Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m) under horizontal barriers	None	25.9.2.2.1(a)	30 ft (9.1 m)	No
	Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m)	Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m)	25.9.2.2.1(b)	Higher than 25 ft (7.6 m)	Yes
I, II, III	Vertical at 10 ft (3.0 m) or at 15 ft (4.6 m) and at 25 ft (7.6 m)	None	25.9.2.2.1(c)	30 ft (9.1 m)	Yes
	Vertical 10 ft (3.0 m), Horizontal 10 ft (3.0 m)	Vertical 30 ft (9.1 m), Horizontal 10 ft (3.0 m)	25.9.2.2.1(d)	Higher than 25 ft (7.6 m)	Yes
	Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m)	Vertical 20 ft (6.1 m), Horizontal 5 ft (1.5 m)	25.9.2.2.1(e)		Yes
	Vertical 25 ft (7.6 m), Horizontal 5 ft (1.5 m)	Vertical 25 ft (7.6 m), Horizontal 5 ft (1.5 m)	25.9.2.2.1(f)		No
	Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m) under horizontal barriers with two lines of staggered in-rack sprinklers		25.9.2.2.1(g)		Yes

Application of Example Problem - 03

35 feet Level Considering each block of 5 feet in height

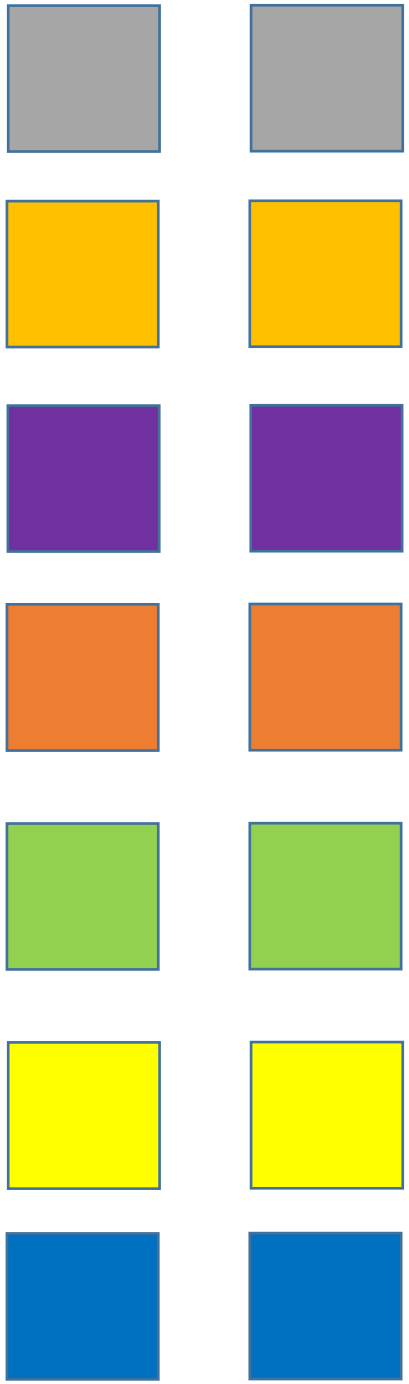


Notes:

1. Sprinklers labeled 1 shall be required where loads labeled *A* represent the top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *B* or *C* represent top of storage.
3. Sprinklers labeled 1, 2, and 3 shall be required where loads labeled *D* or *E* represent top of storage.
4. Sprinklers labeled 1, 2, 3, and 4 shall be required where loads labeled *F* or *G* represent top of storage.
5. Sprinklers labeled 1, 2, 3, 4, and 5 shall be required where loads labeled *H* represent top of storage.
6. For storage higher than represented by loads labeled *H*, the cycle defined by Notes 3, 4, and 5 is repeated with stagger as indicated.
7. The indicated face sprinklers shall be permitted to be omitted where commodity consists of unwrapped or unpackaged metal parts on wood pallets.
8. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
9. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

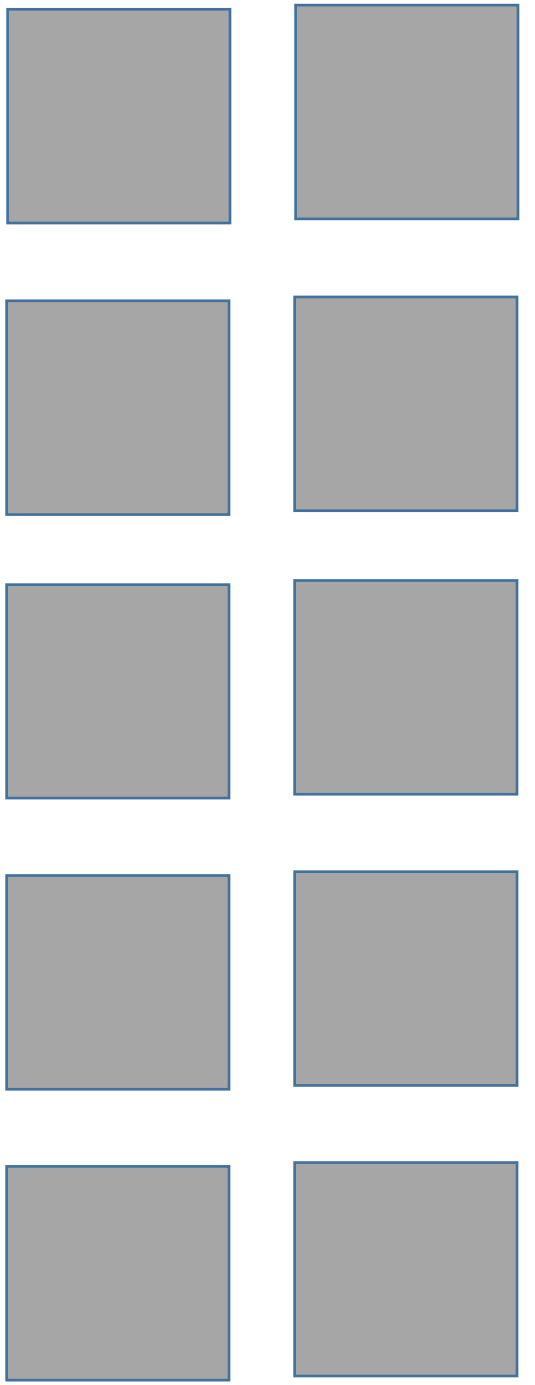
FIGURE 25.9.2.2.1(d) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 1.

Example : 3



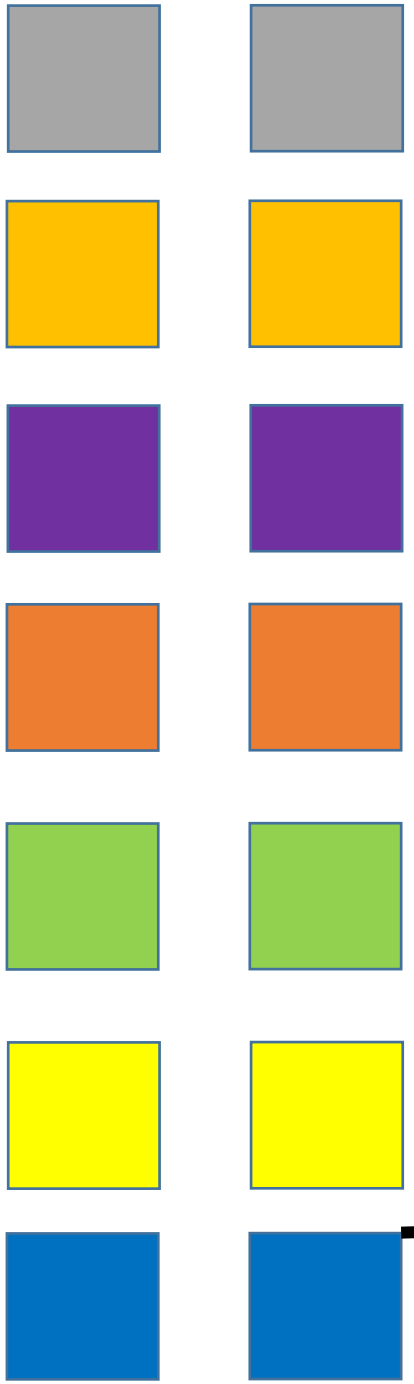
Elevation

Rack Continues

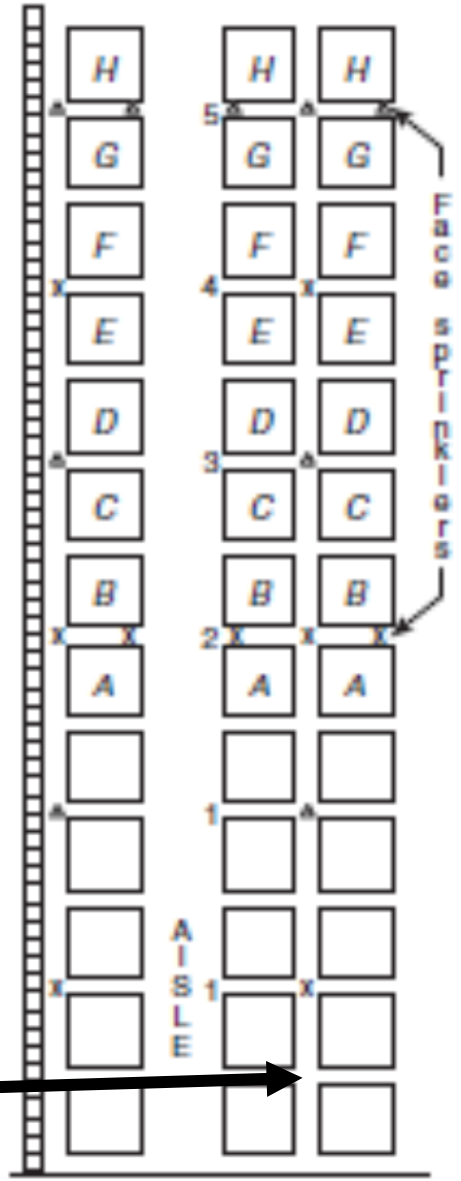


Plan

Example : 3



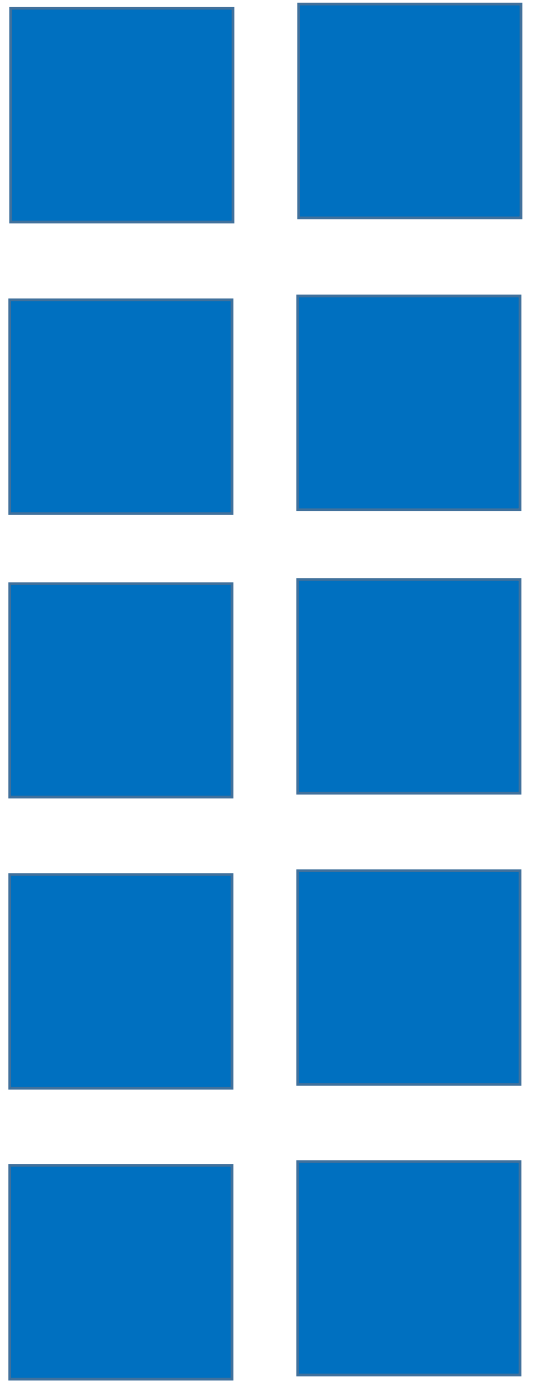
Elevation



Elevation

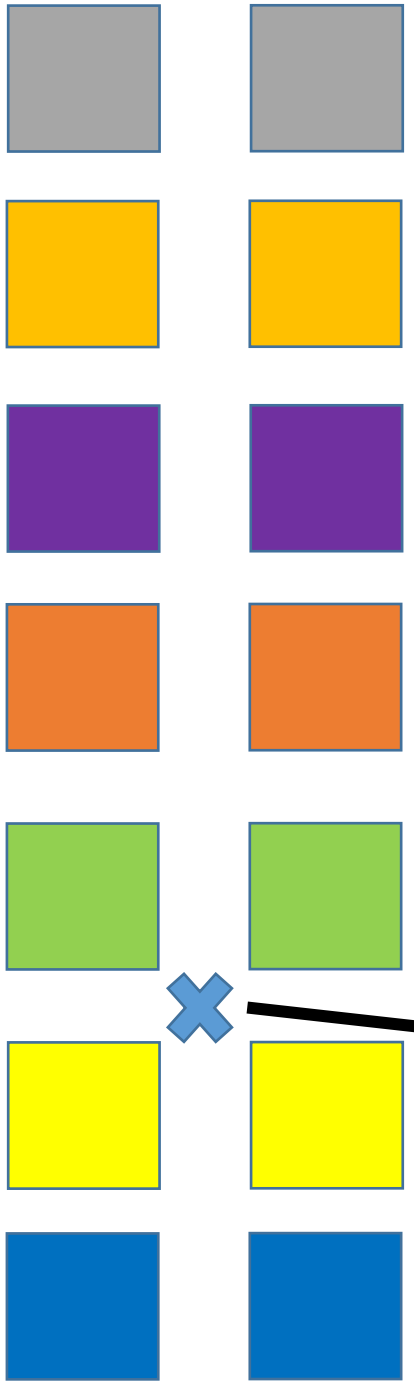
No Sprinkles Required at this level

Rack Continues

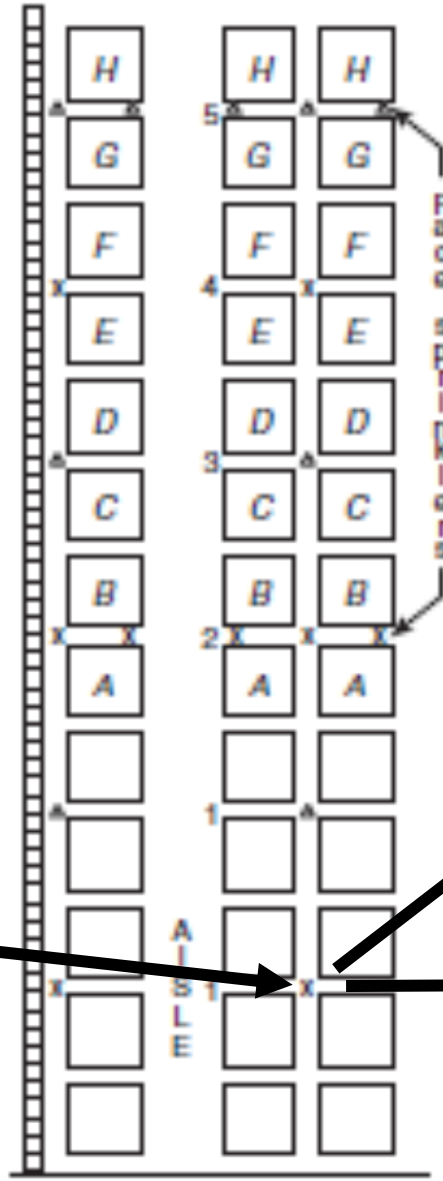


Plan 5 foot Level

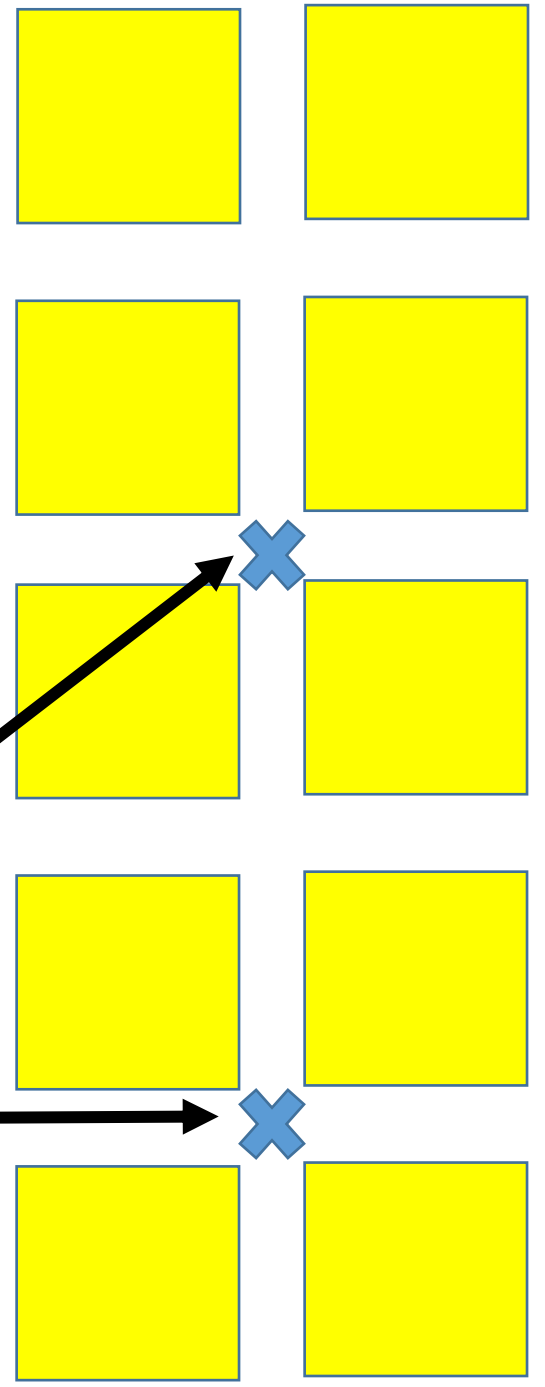
Example : 3



Elevation



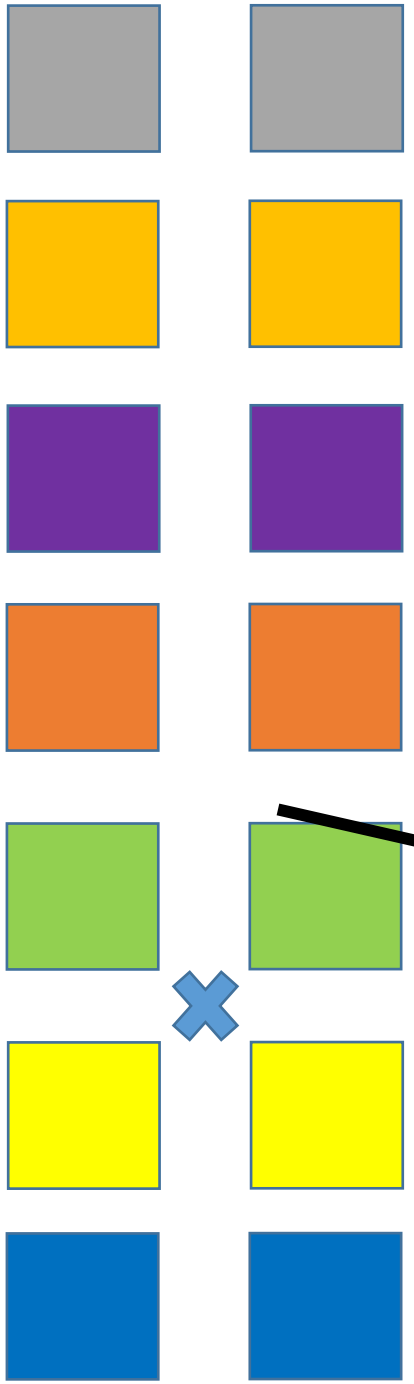
Elevation



Plan 10 feet Level

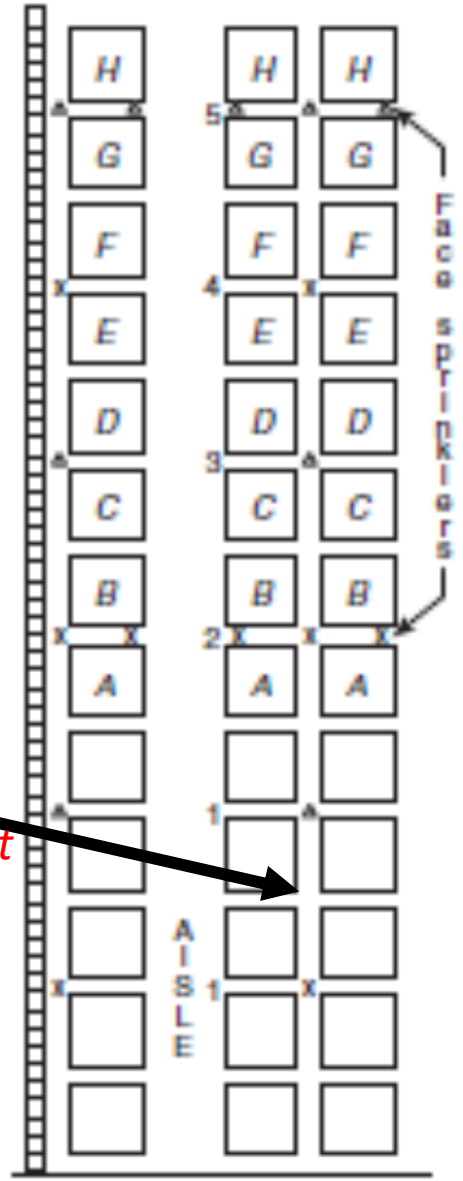
Rack Continues

Example : 3



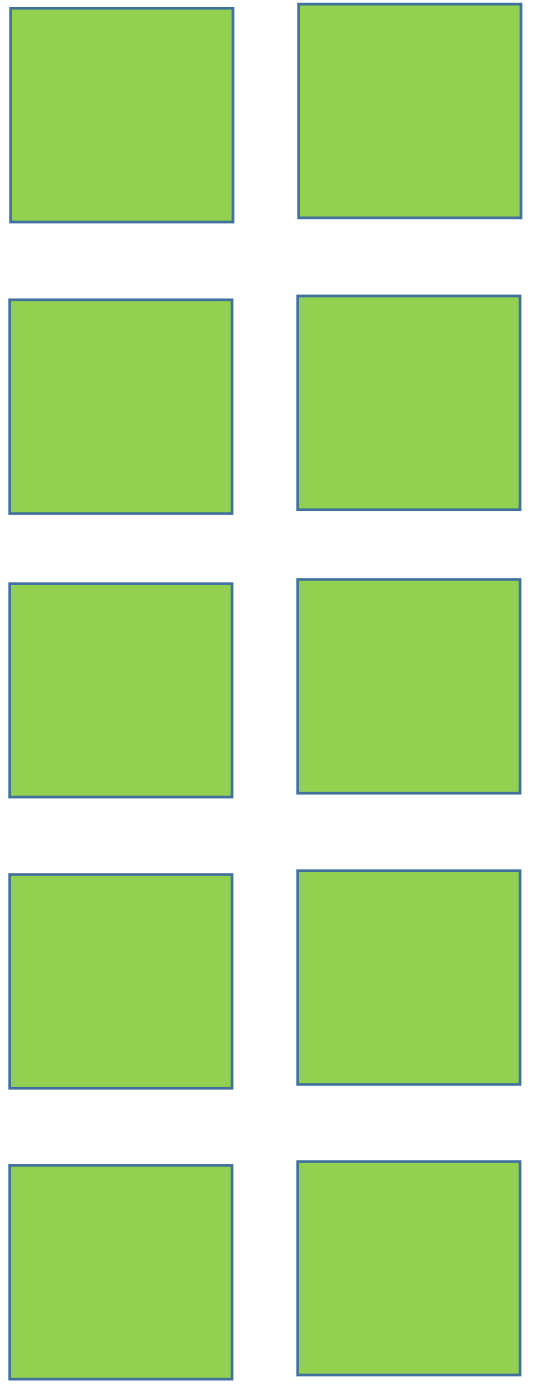
Elevation

No Sprinkles Required at this level



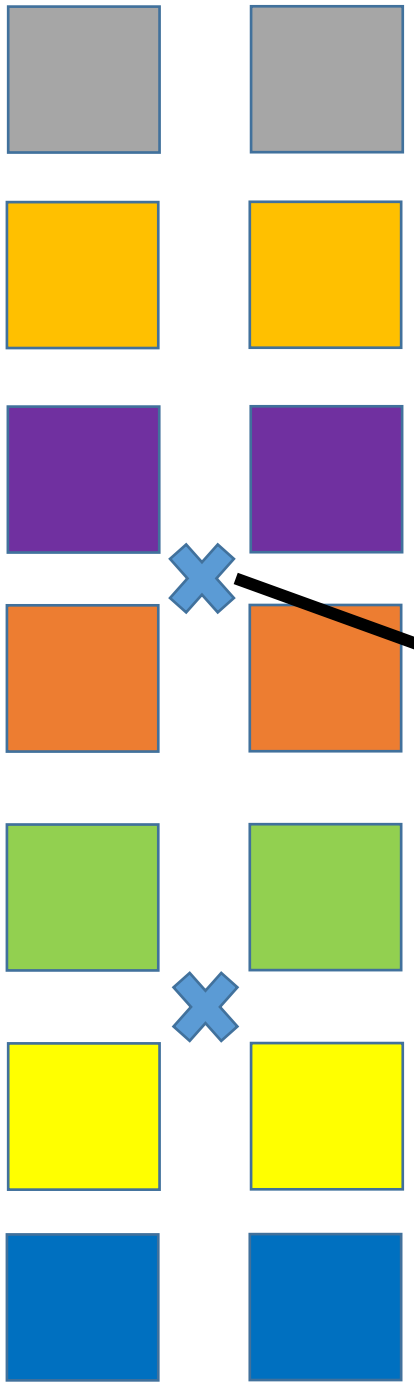
Elevation

Rack Continues

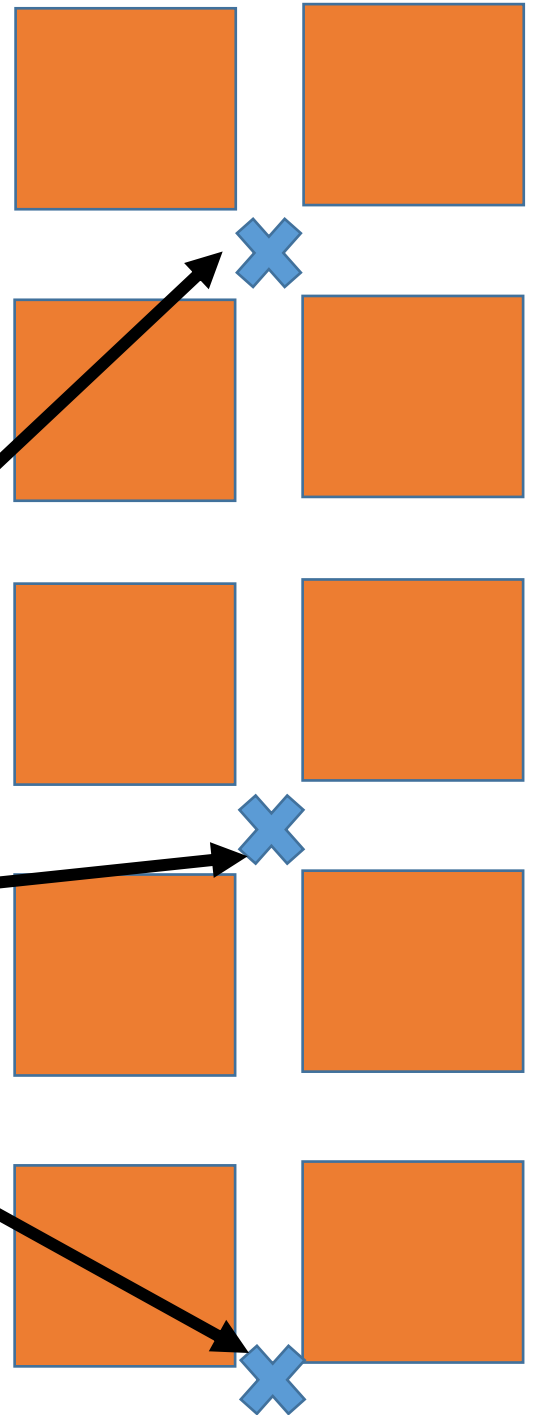


Plan 15 feet Level

Example : 3



Elevation

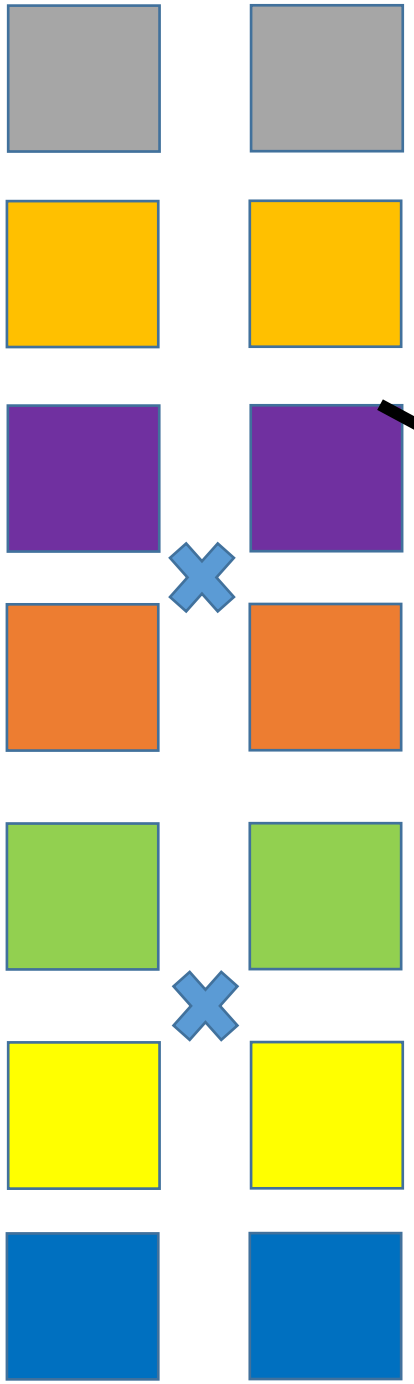


Plan 20 foot Level

Rack Continues

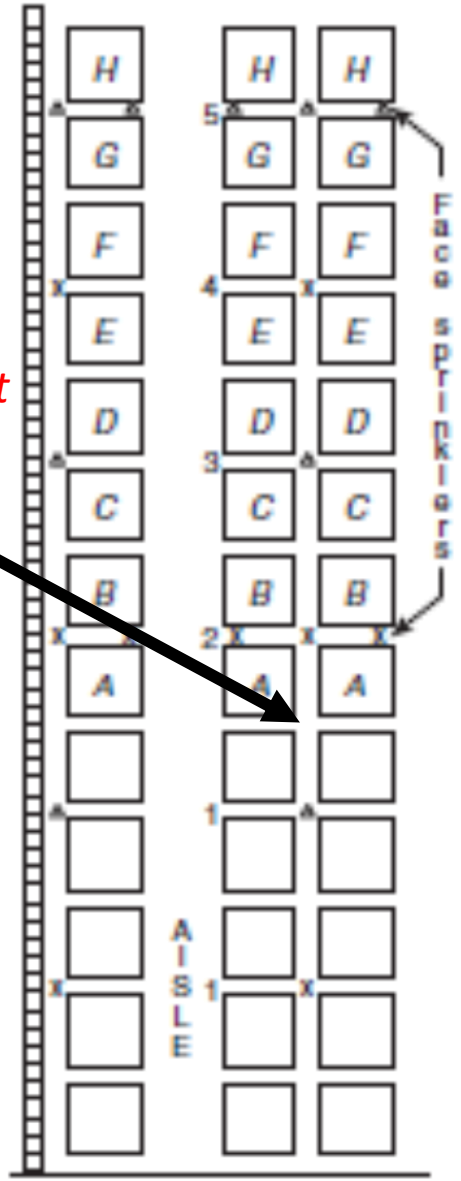
Elevation

Example : 3



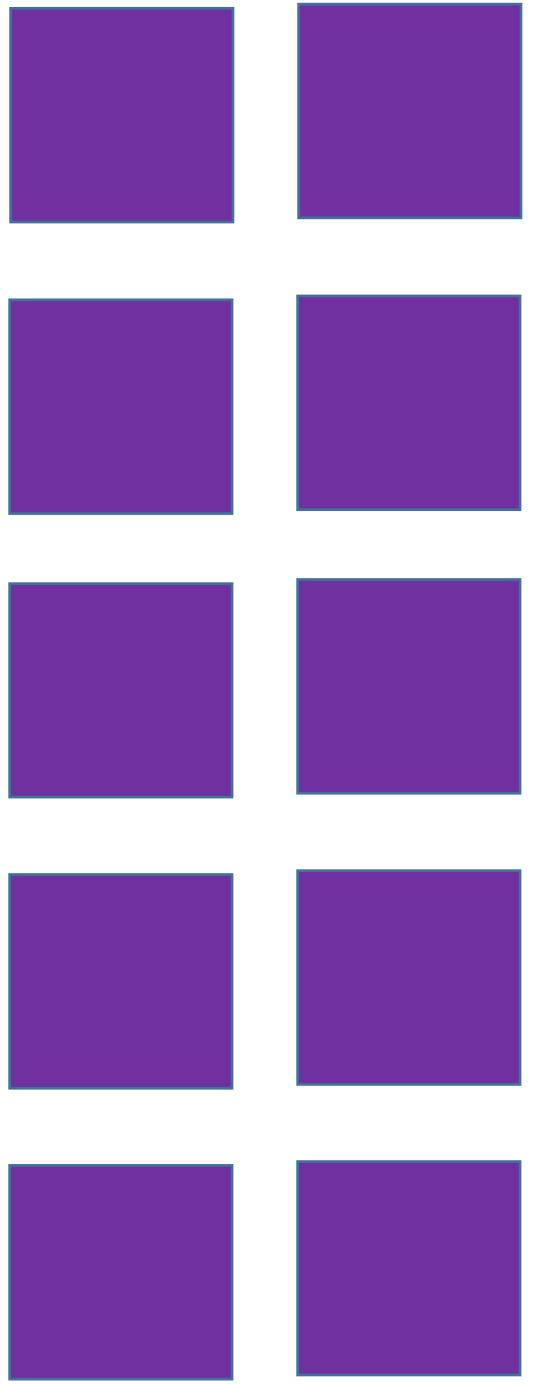
No Sprinkles Required at this level

Elevation



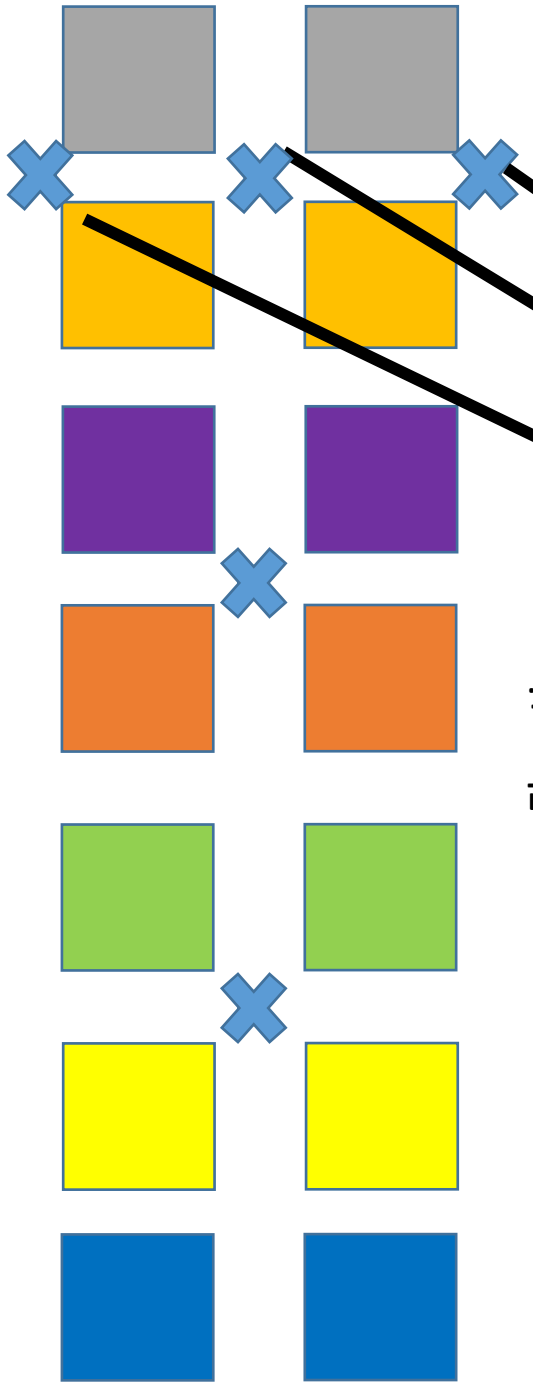
Elevation

Rack Continues



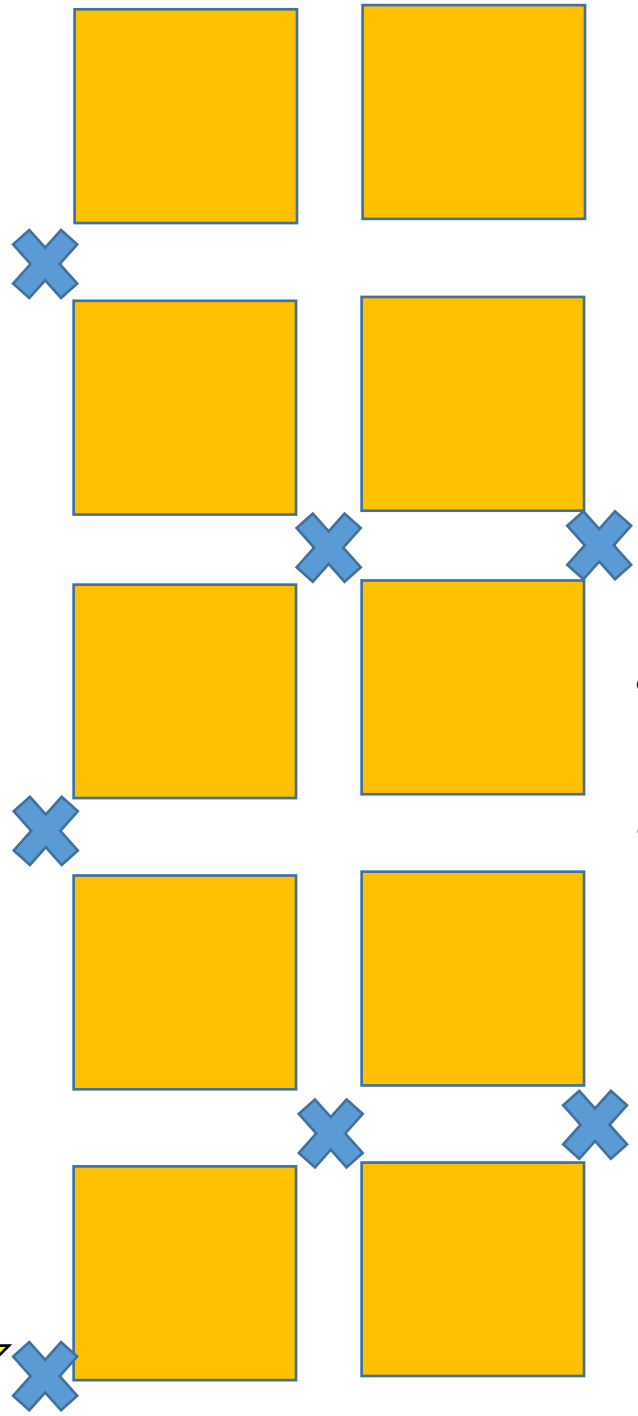
Plan 25 feet Level

Example : 3



Elevation

Rack Continues



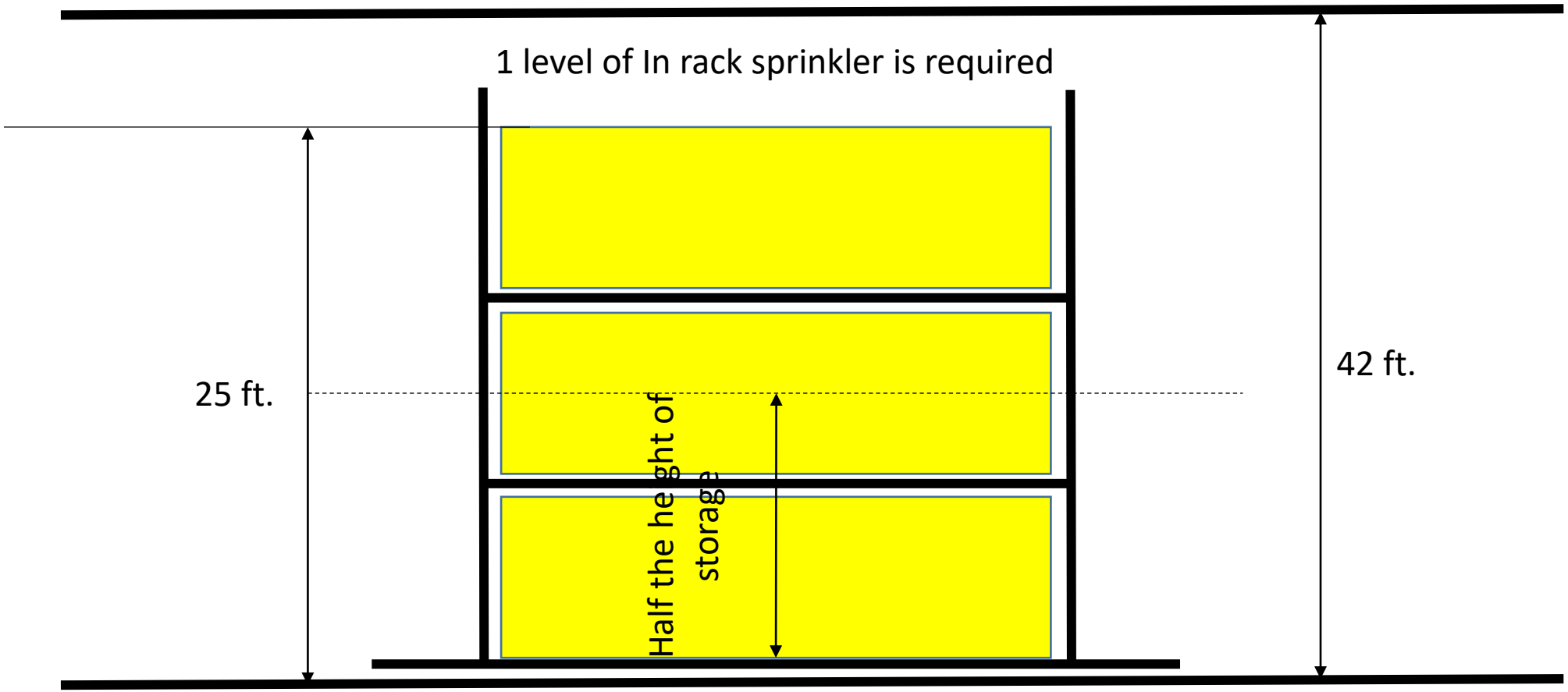
Plan 30 foot Level

Example : 4

- Type of Commodity : Class 4, Encapsulated
- Storage Height : 25 feet
- Building Height : 42 feet
- Type of Rack Arrangement : Double row Rack
- ESFR K = 16.8 pendant sprinkler at the ceiling.

Determine Requirement of in rack sprinklers

Example-4


1 level of In rack sprinkler is required
25 ft.
42 ft.
Half the height of storage

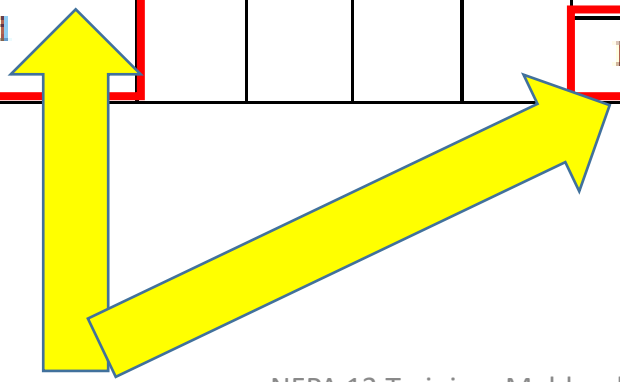
Example : 5

- Type of Commodity : Class 4, Encapsulated
- Storage Height : 25 feet
- Building Height : 42 feet
- Type of Rack Arrangement : Double row Rack
- ESFR K = 16.8 pendant sprinkler at the ceiling.

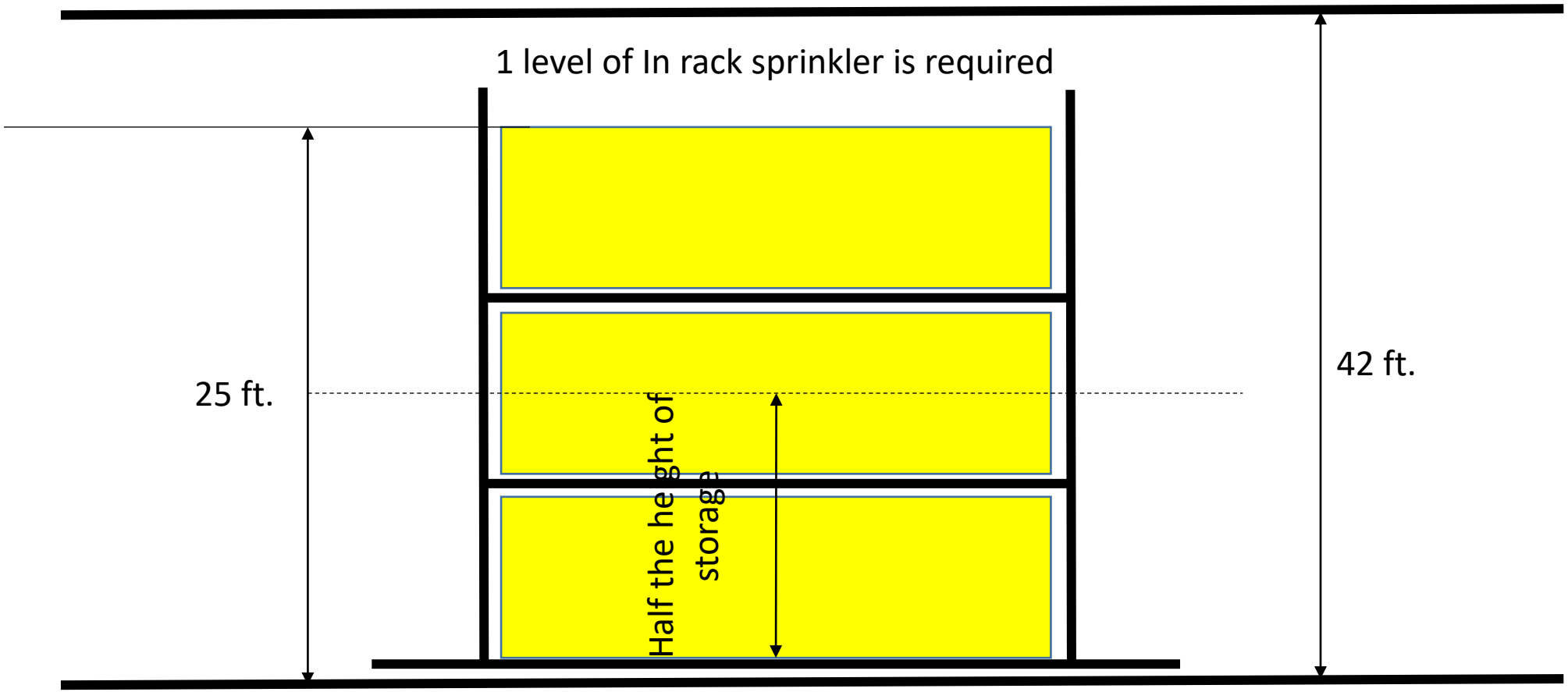
Determine Requirement of in rack sprinklers

Table 25.2.5.1.1 ESFR Ceiling-Level Sprinkler Design Criteria for Rack Storage of Class I Through Class IV and Group A Plastic Commodities (Encapsulated and Nonencapsulated) Supplemented with In-Rack Sprinklers

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/ Roof Height		K-Factor	Orientation	No. of Ceiling Sprinklers in the Design	No. of Required Levels of In-Rack Sprinklers	Minimum Ceiling Sprinkler Operating Pressure	
		ft	m	ft	m					psi	bar
Single-, double-, and multiple-row racks (no open-top containers)	Class I, II, III or IV, encapsulated or nonencapsulated, cartoned nonexpanded and exposed nonexpanded plastics	25	7.6	45	14	14.0 (200)	Pendent	12	One level	90	6.2
						16.8 (240)	Pendent	12	One level	63	4.3



Example-5


1 level of In rack sprinkler is required
25 ft.
42 ft.
Half the height of storage

Thank You