NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

SPRINKLER SELECTION FOR HIGH-PILED STORAGE

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PROGRAM DESCRIPTION

Explore the selection and application of automatic sprinklers for storage arrays where solid-pile, palletized, bin-box, shelf or rack storage commodity configurations exceed 12 feet. The course addresses the influence of various commodity and ceiling heights in sprinkler selection and system design. Learners should enter this program with the ability to apply NFPA 13 density/area design curves.

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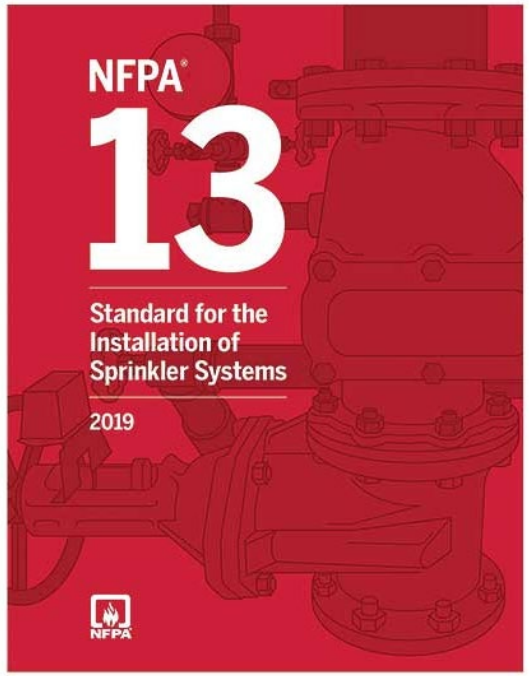
The Voice of the Fire Sprinkler Industry

Can anyone share an experience you've had involving high-piled storage and coordination of the International Fire Code with NFPA 13?

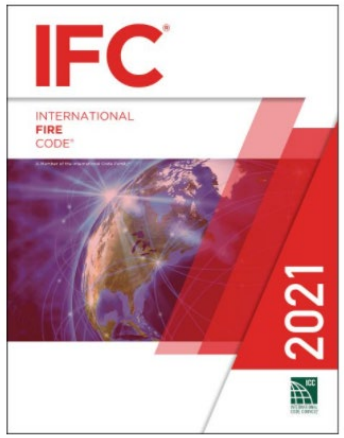
MODEL CODES

STANDARDS

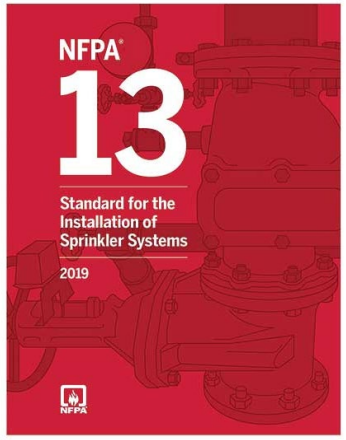


WHAT

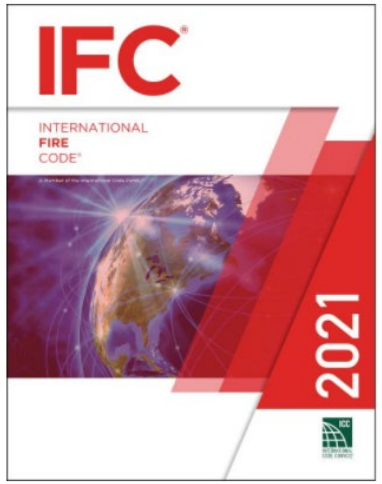
HOW

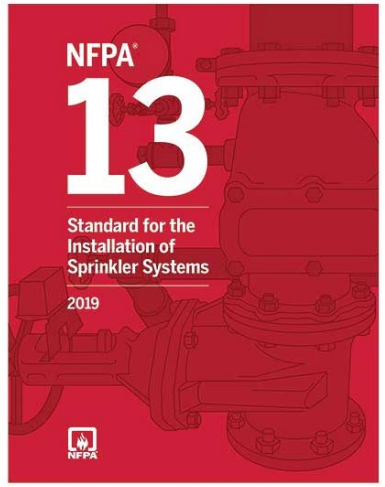


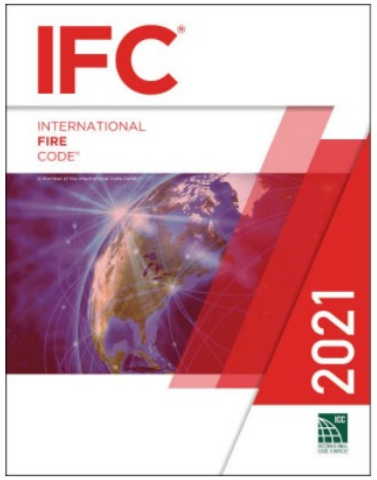
- ✓ Storage Layout Floor Plan
- ✓ General Fire Protection & Life Safety Requirements
- ✓ Fire Department Access roads
- ✓ Fire Department Access Doors

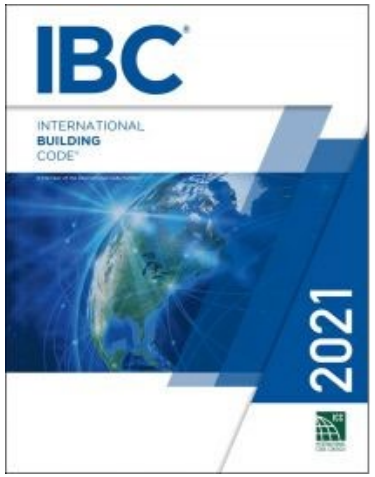


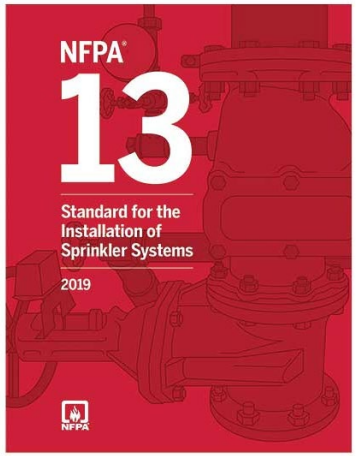
- ✓ What is the Commodity Classification?
- ✓ How is it stored?
- ✓ What is the height of the storage?
- ✓ Building height?
- ✓ What type of sprinkler is being used?
- ✓ Special Commodity?


IFC
INTERNATIONAL
FIRE
CODE
2021


NFPA
13
Standard for the
Installation of
Sprinkler Systems
2019
NFPA







STORAGE

- Group S-1 Examples (Moderate Hazard)
  - Combustible
    - Furniture
    - Lumber
    - Bulk Storage of Tires

- Group S-2 Examples (Low Hazard)
  - Non-combustible
    - Food Products
    - Metal Cabinets
    - Washers & Dryers

NON-STORAGE ("Occupancies")

- LH
- OH 1 & 2
- EH 1 & 2

STORAGE ("Commodities")

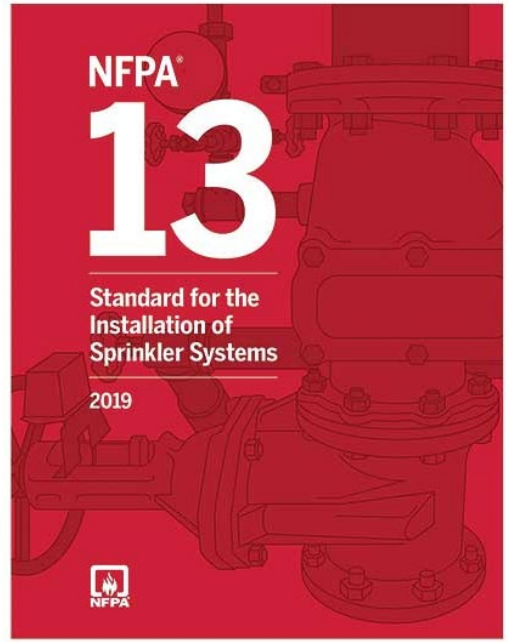
- Class I
- Class II
- Class III
- Class IV
- *Group C Plastics (Class III)*
- *Group B Plastics (Class IV)*
- Group A Plastics

CONFLICTS

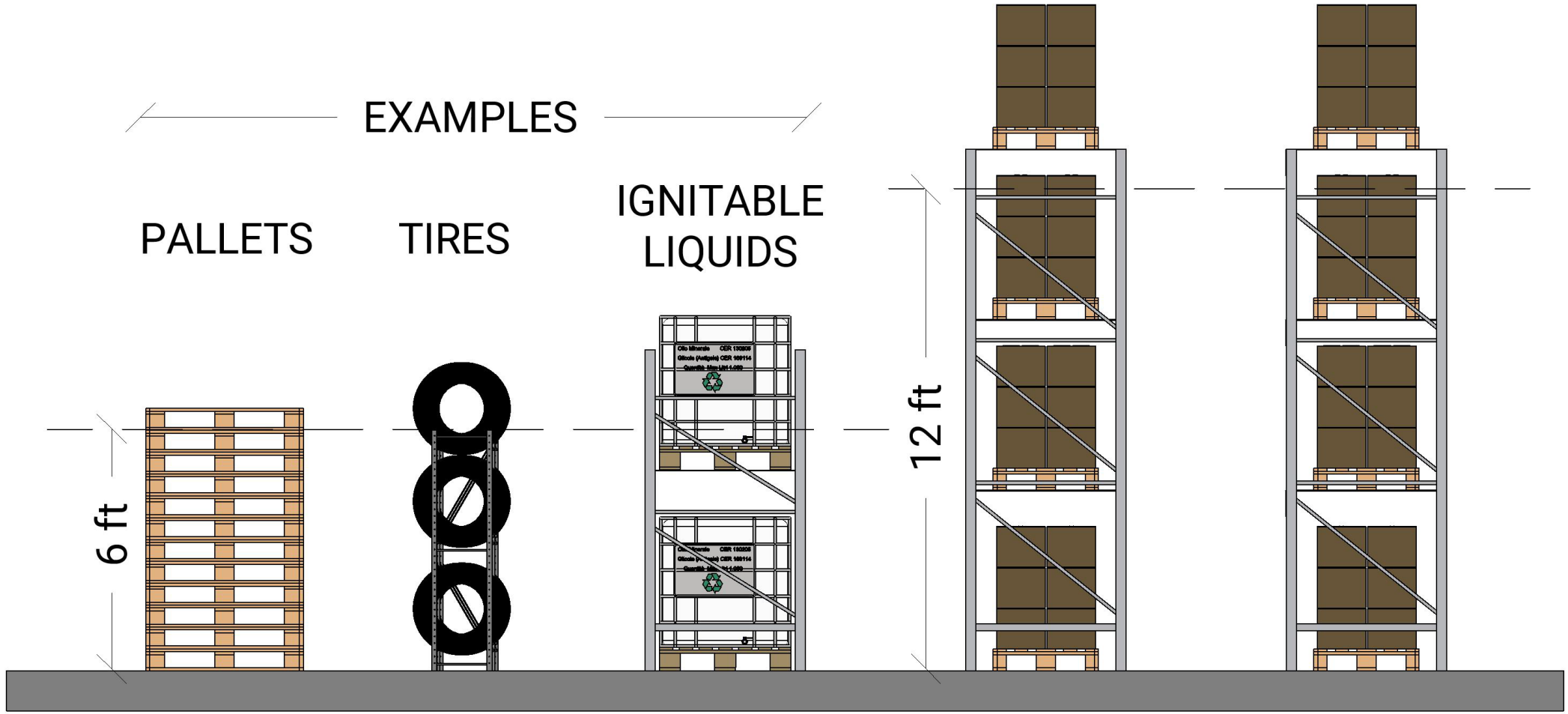
1

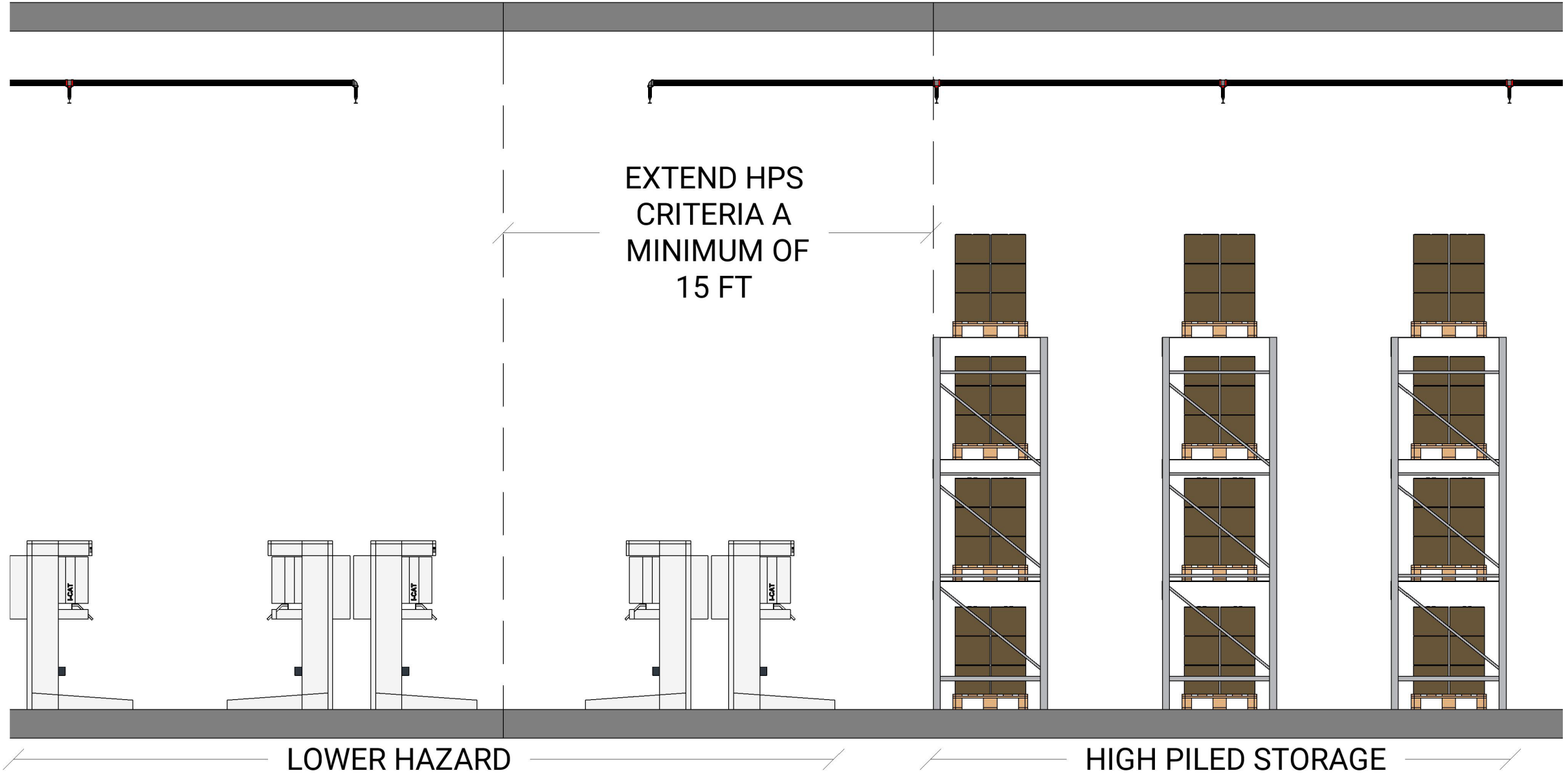
2

3



IFC CHAPTER 32



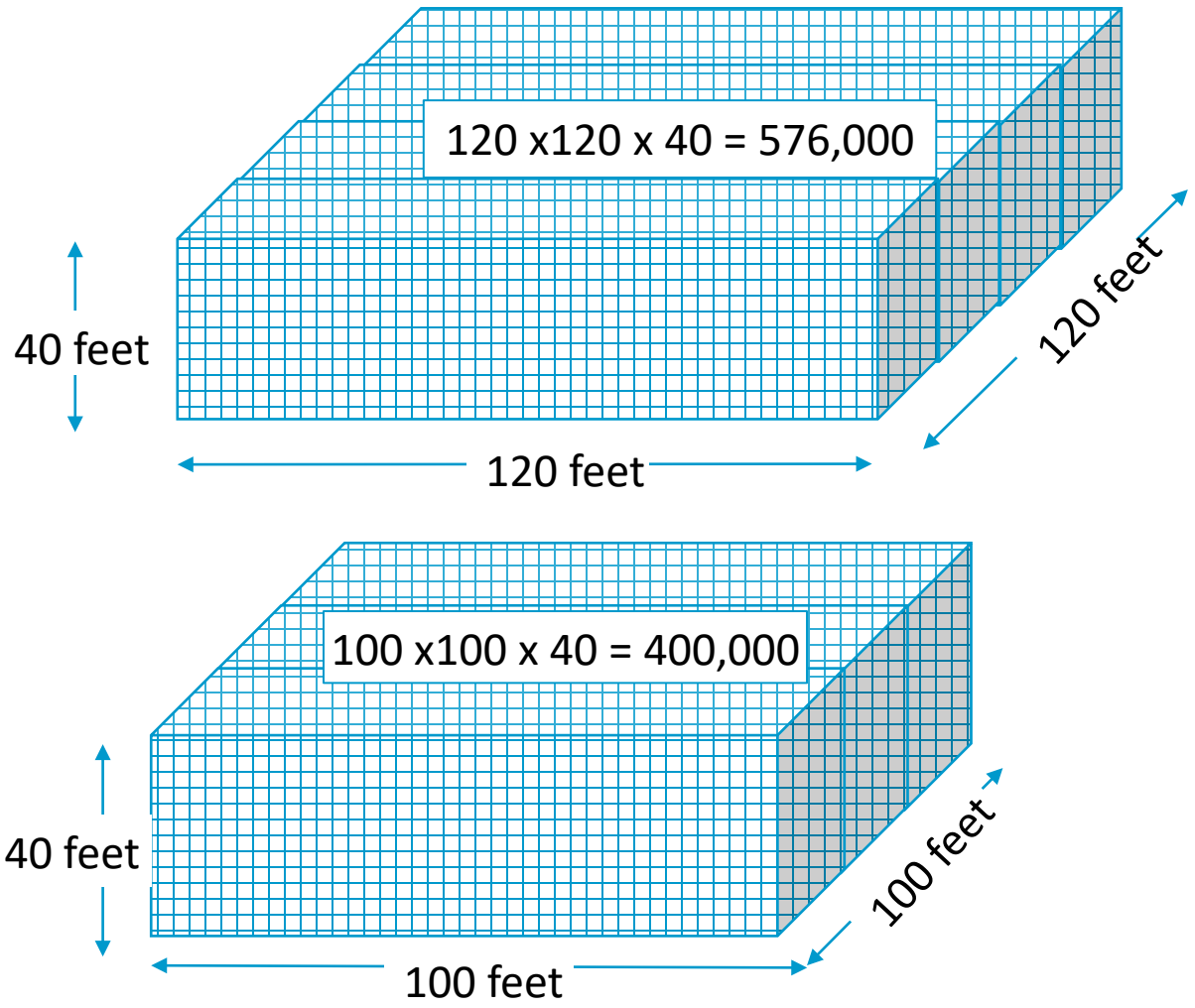

EXTEND HPS CRITERIA A MINIMUM OF 15 FT
LOWER HAZARD
HIGH PILED STORAGE

Courtesy Integra Code Consultants

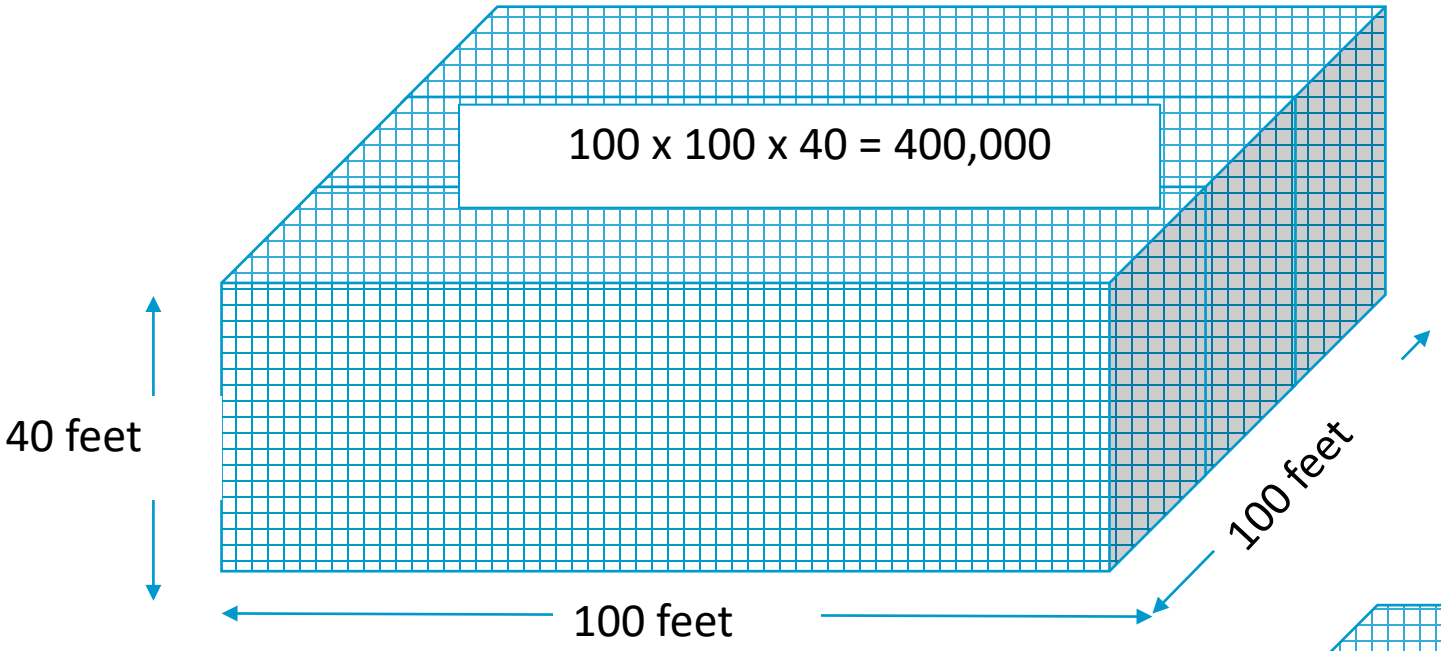
Commodity Class	Size of High Piled Storage Area (square feet)	All Storage Areas				Solid-Piled Storage, Shelf Storage and Palletized Storage		
		Automatic Fire Extinguishing System	Automatic Fire Detection System	Fire Dept Access Doors	Smoke and Heat Removal	Maximum Pile Dimension	Maximum Permissible Storage Height	Maximum Pile Volume
I – IV	0-500	NR	NR	NR	NR	NR	NR	NR
	501 – 2,500	NR	Yes	NR	NR	120	40	100,000
	2501 – 12,000 Open to the Public	Yes	NR	NR	NR	120	40	400,000
	2501 – 12,000 Not Open to the Public (Option 1)	Yes	NR	NR	NR	120	40	400,000
	2501 – 12,000 Not Open to the Public (Option 2)	NR	Yes	Yes	Yes	120	30	200,000
	12,000 – 20,000	Yes	NR	Yes	Yes	120	40	400,000
	20,001 – 500,000	Yes	NR	Yes	Yes	120	40	400,000
	> 500,000	Yes	NR	Yes	Yes	120	40	400,000

Commodity Class	Size of High Piled Storage Area (square feet)	All Storage Areas				Solid-Piled Storage, Shelf Storage and Palletized Storage		
		Automatic Fire Extinguishing System	Automatic Fire Detection System	Fire Dept Access Doors	Smoke and Heat Removal	Maximum Pile Dimension	Maximum Permissible Storage Height	Maximum Pile Volume
High-Hazard	0-500	NR	NR	NR	NR	60	NR	NR
	501 – 2,500 Open to the Public	Yes	NR	NR	NR	60	30	400,000
	501 – 2,500 Not Open to the Public (Option 1)	Yes	NR	NR	NR	60	30	400,000
	501 – 2,500 Not Open to the Public (Option 2)	NR	Yes	Yes	Yes	60	20	200,000
	2,501 – 300,000	Yes	NR	Yes	Yes	60	30	400,000
	300,001 – 500,000	Yes	NR	Yes	Yes	60	30	400,000

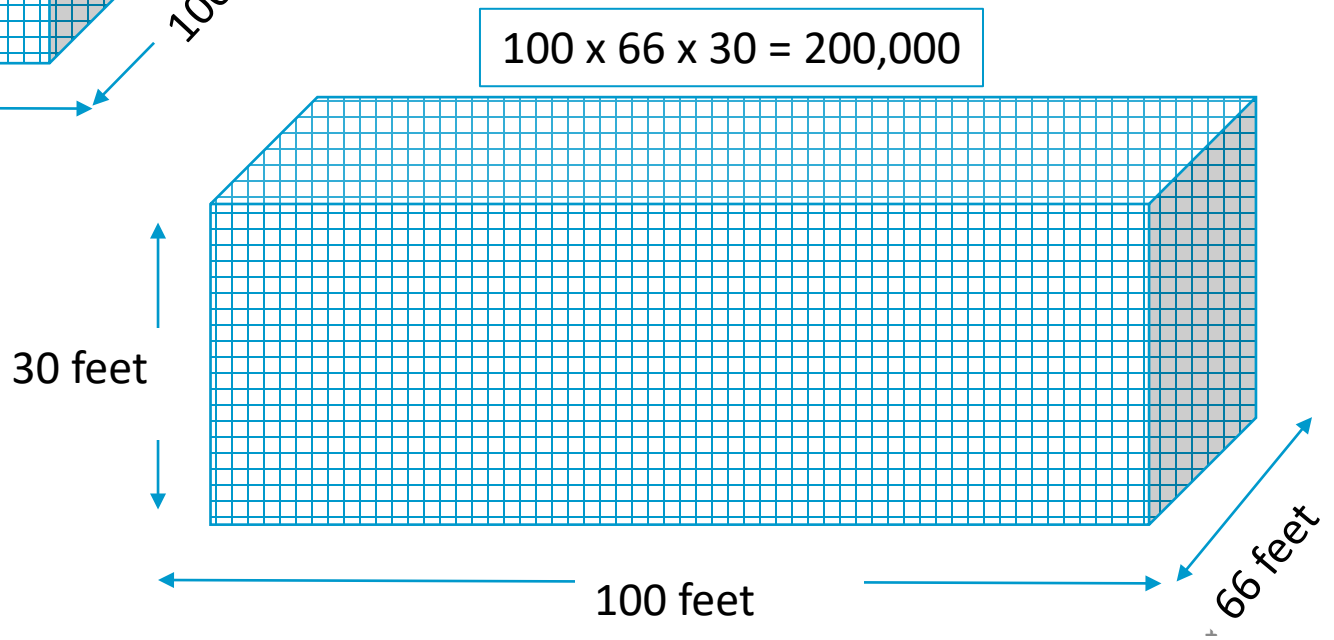
Solid-Piled Storage, Shelf Storage and Palletized Storage		
Maximum Pile Dimension	**Maximum Permissible Storage Height**	**Maximum Pile Volume**
120	40	400,000
120	40	400,000
120	30	200,000



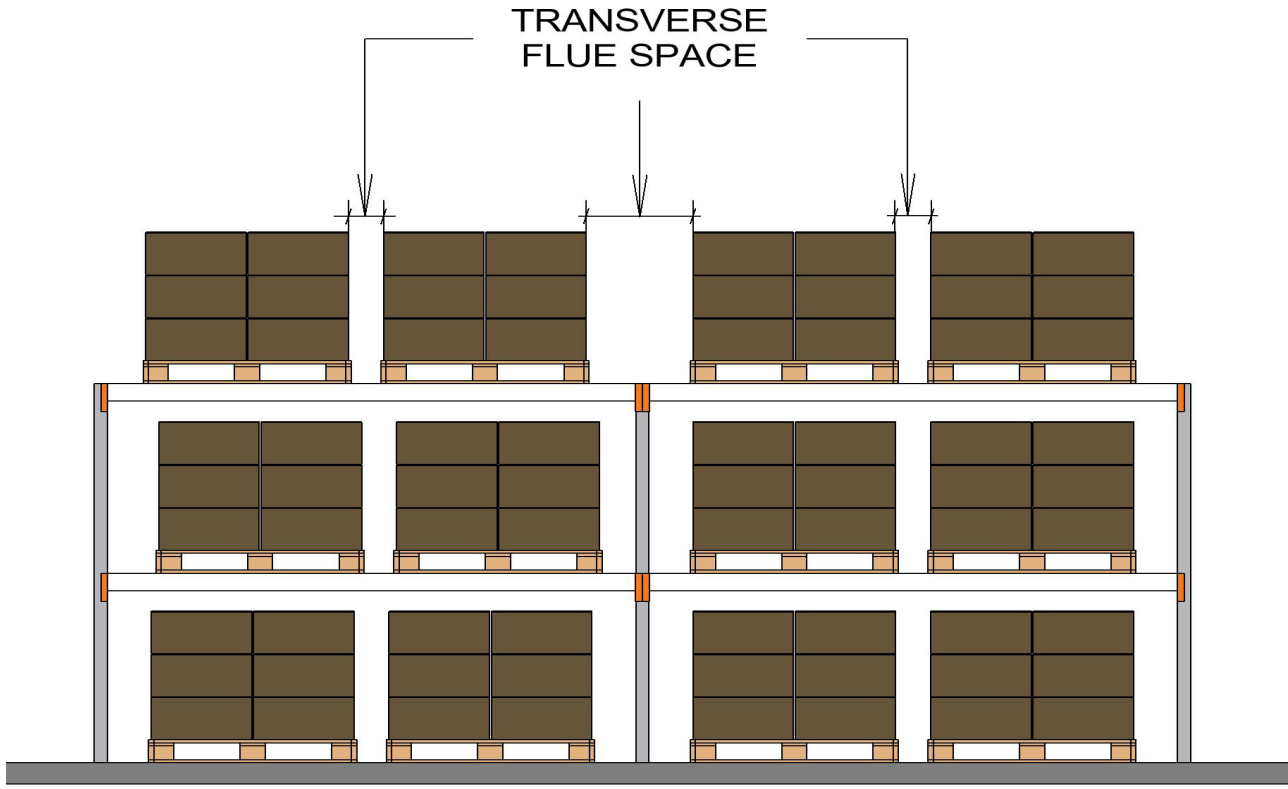
Option 1 – Sprinklered



Option 2- Not sprinklered

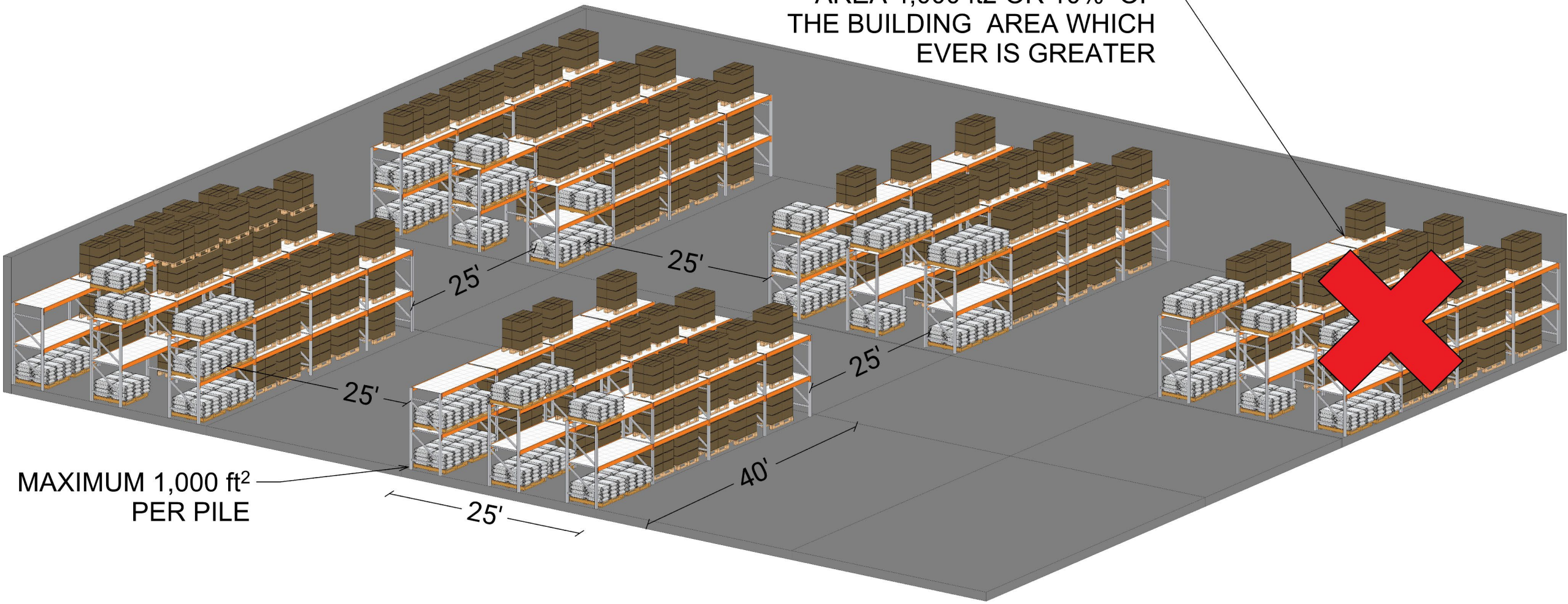


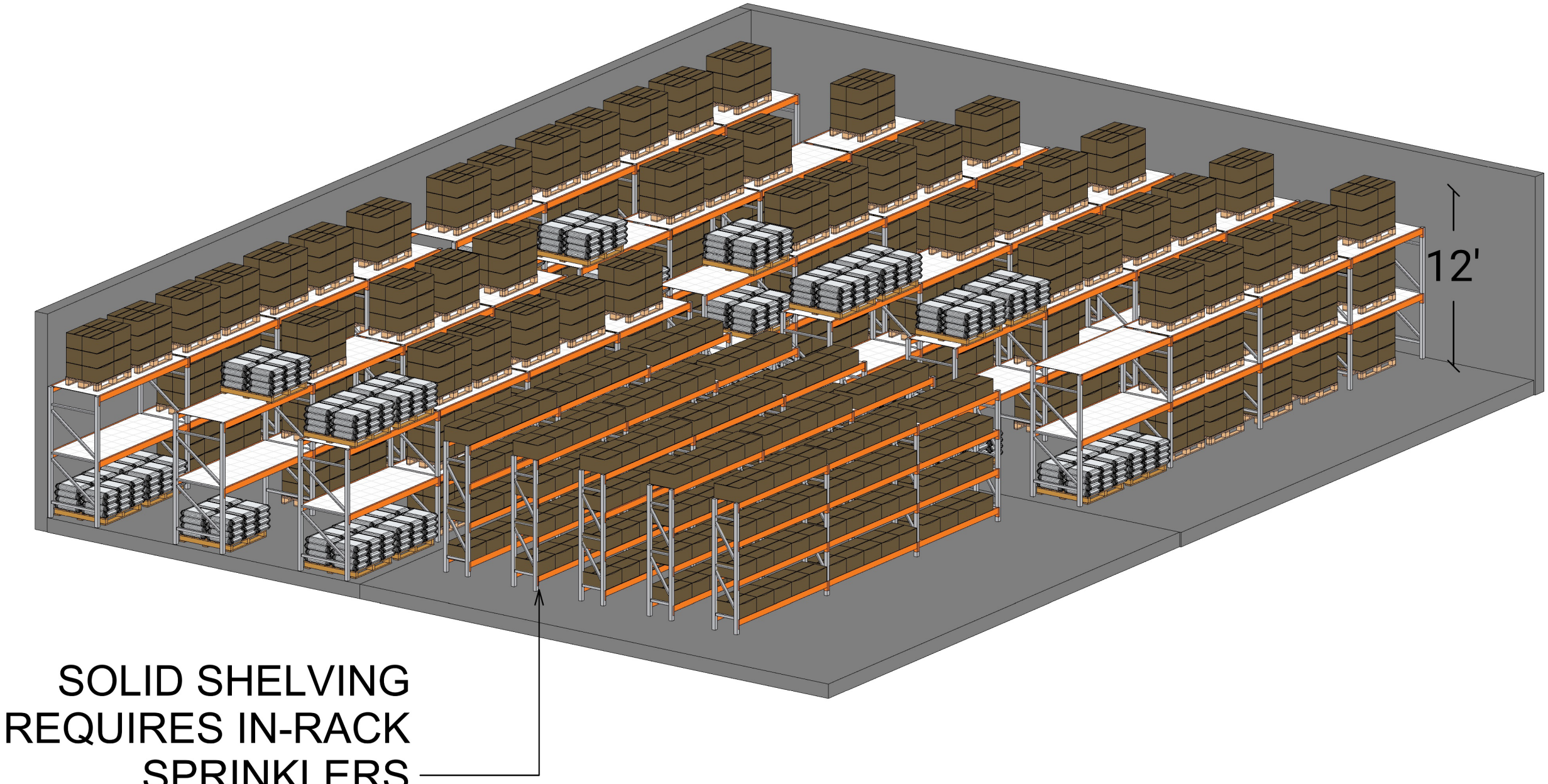
- Storage layout plan :
  - Location, dimensions, rack layout
  - Design storage height
  - Type(s) and location(s) of commodities
  - Commodity clearance requirements
  - Aisle dimensions
  - Location of FD access doors
  - Location of sprinkler control valves



Module Assessment

Conversation Quiz

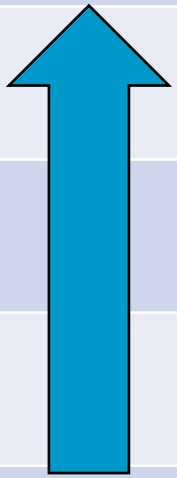

MAXIMUM TOTAL STORAGE AREA 4,000 ft2 OR 10% OF THE BUILDING AREA WHICH EVER IS GREATER
25'
25'
25'
25'
40'
25'
MAXIMUM 1,000 ft2 PER PILE

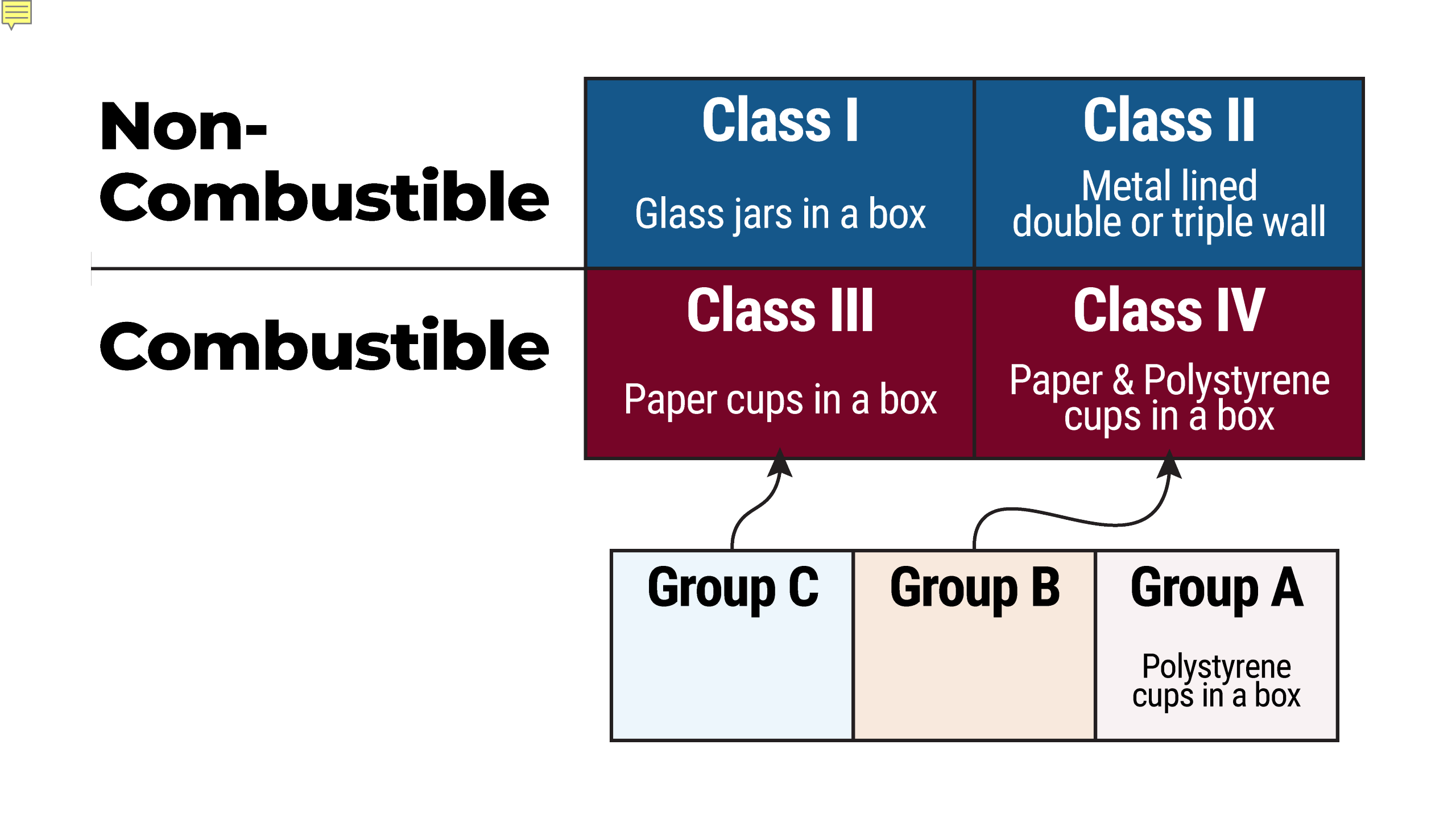

12'
SOLID SHELVING
REQUIRES IN-RACK
SPRINKLERS

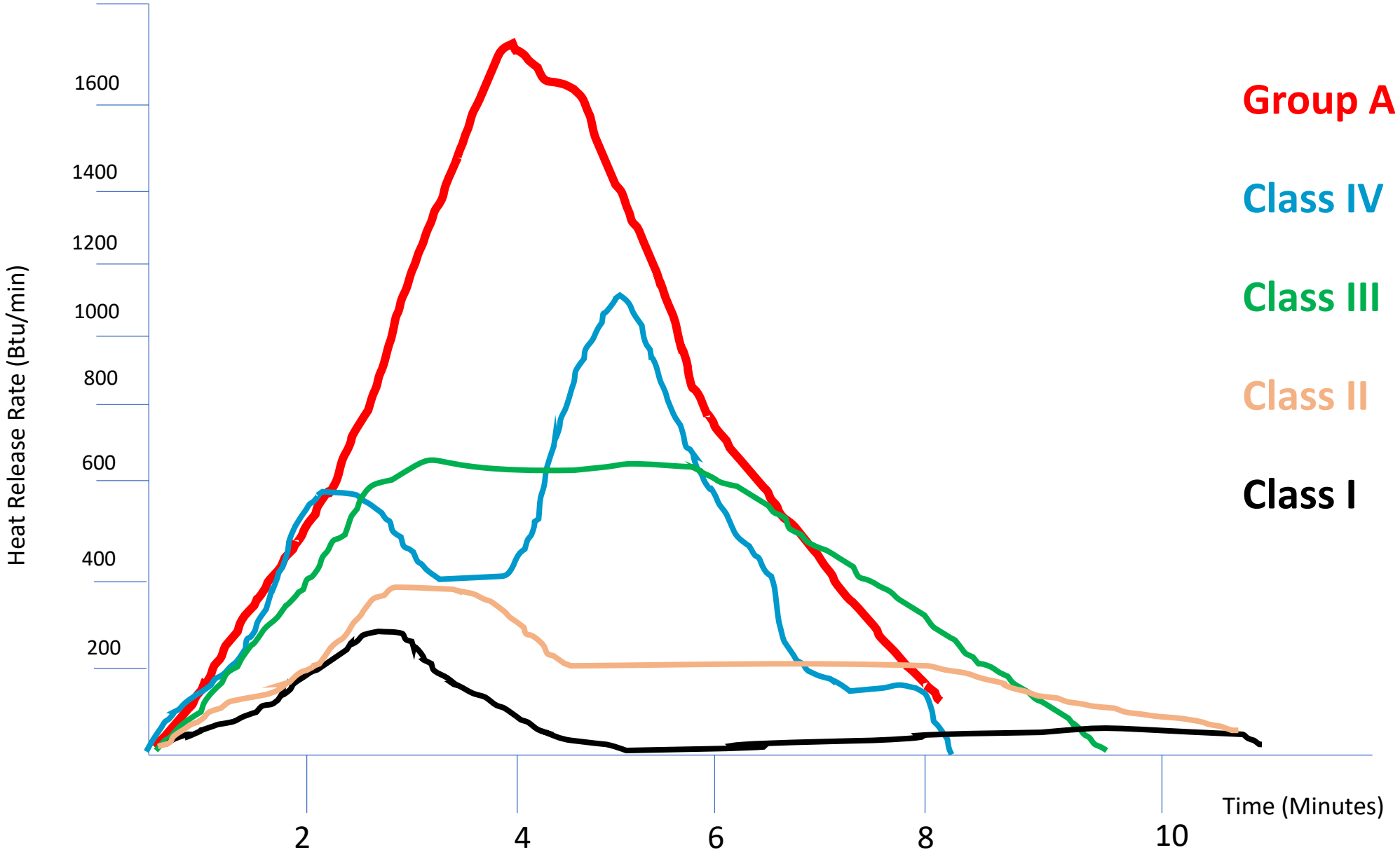
Module Assessment

Conversation Quiz

Commodity Class	Fire Hazard Ranking
Special or High-Hazards: Tires, Rolled paper, Group A plastics, Flammable/Combustible liquids, Aerosols	Highest Fire Hazard
Class IV Commodity	
Class III Commodity	
Class II Commodity	
Class I Commodity	Lowest Fire Hazard



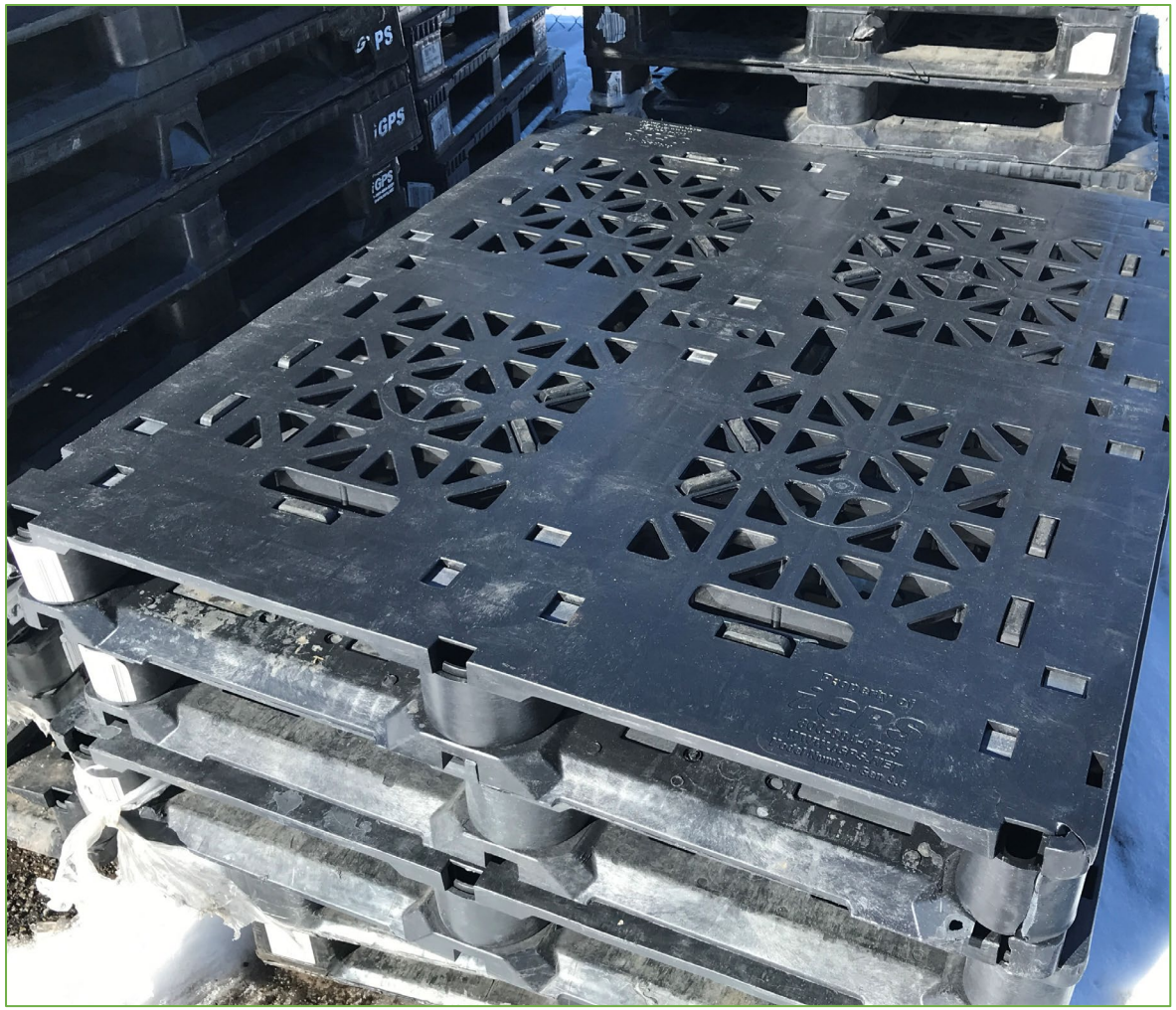

Non-Combustible
Combustible
Class I
Glass jars in a box
Class II
Metal lined double or triple wall
Class III
Paper cups in a box
Class IV
Paper & Polystyrene cups in a box
Group C
Group B
Group A
Polystyrene cups in a box


Heat Release Rate (Btu/min)
1600
1400
1200
1000
800
600
400
200
2
4
6
8
10
Time (Minutes)
Group A
Class IV
Class III
Class II
Class I

200
150
100
50
0
0
5
10
15
Time from Ignition (min)=-1.18
Normal Fabric Heat Release (kW)=0.2
Barrier Fabric Heat Release (kW)=-0.3

"A combination of *products*, primary *packaging*, and storage *pallet*."

Product: item being stored	Coffee mugs, engine blocks, plywood panels, wristwatches, toilet paper . . . .
Packing materials around the item	Cardboard boxes with dividers, steel containers, shrink wrap, boxes with foam "peanuts" . . . .
Containers: pallets, bins or storage method	Wood or plastic pallets, plastic, cardboard or paper bin boxes, crates, wooden spools . . .



Courtesy Integra Code Consultants

GREEN 12.5mm 1250x2000mm 15-07-21 05:04
GREEN 12.5mm 1250x2000mm 15-07-21 05:04
GREEN 12.5mm 1250x2000mm 15-07-21 05:05
GREEN 12.5mm 1250x2000mm 15-07-21 05:04
GREEN 12.5mm 1250x2000mm 15-07-21 05:04
GREEN 12.5mm 1250x2000mm 15-07-21 05:04
GREEN 12.5mm 1250x2000mm 15-07-21 05:04
GREEN 12.5mm 1250x2000mm 15-07-21 05:04
GREEN 12.5mm 1250x2000mm 15-07-21 05:03
GREEN 12.5mm 1250x2000mm 15-07-21 05:03
GREEN 12.5mm 1250x2000mm 19-07-21 01:52
GREEN 12.5mm 1250x2000mm 19-07-21 01:52
GREEN 12.5mm 1250x2000mm 19-07-21 01:52
GREEN 12.5mm 1250x2000mm 19-07-21 01:52
GREEN 12.5mm 1250x2000mm 19-07-21 01:50

VOLVO
LONG LIFE

Relative Fire Severity
Group A *Expanded* Plastic
Group A *Unexpanded*
Group A *Free Flowing*
Group B
Group C

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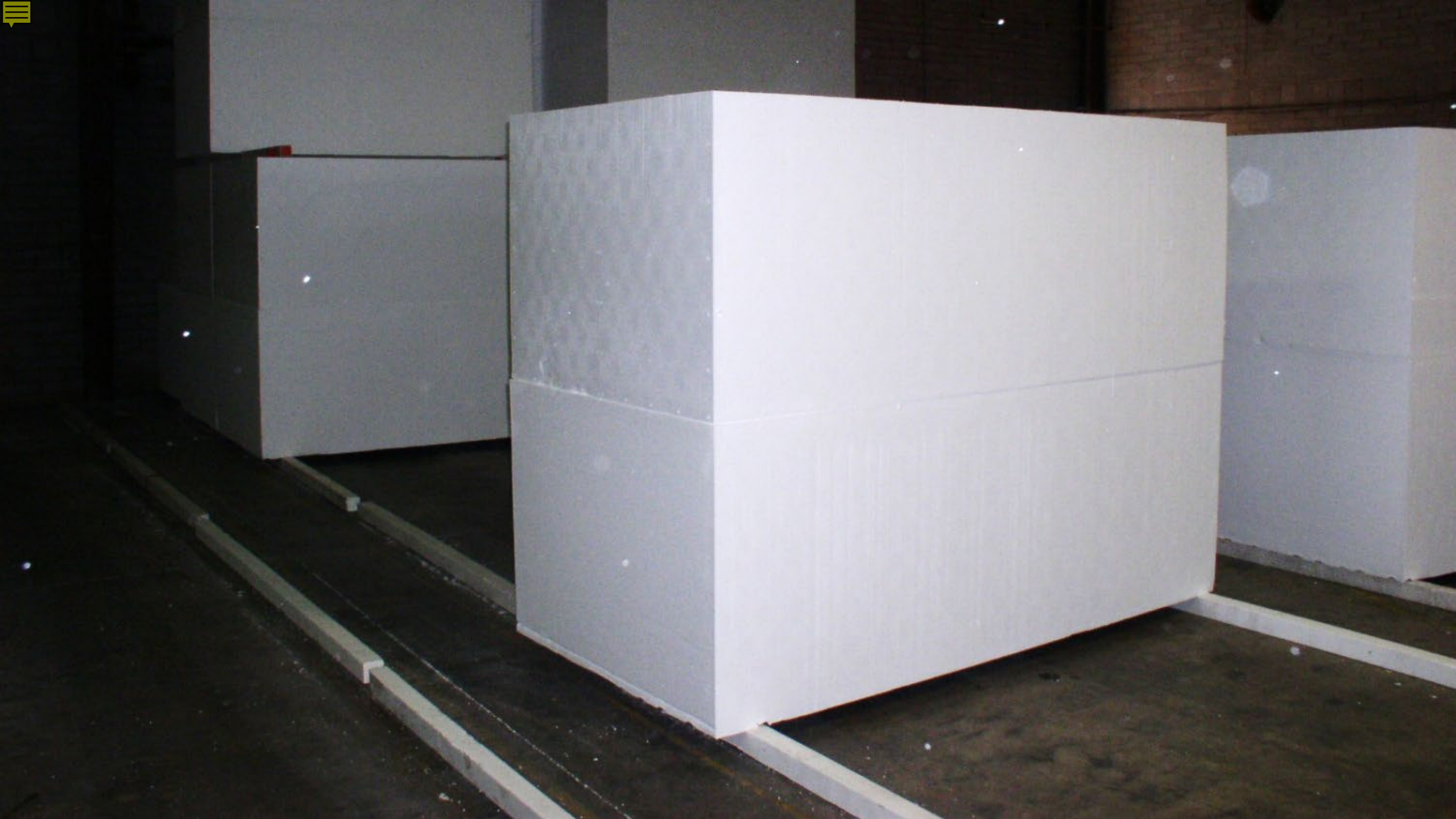
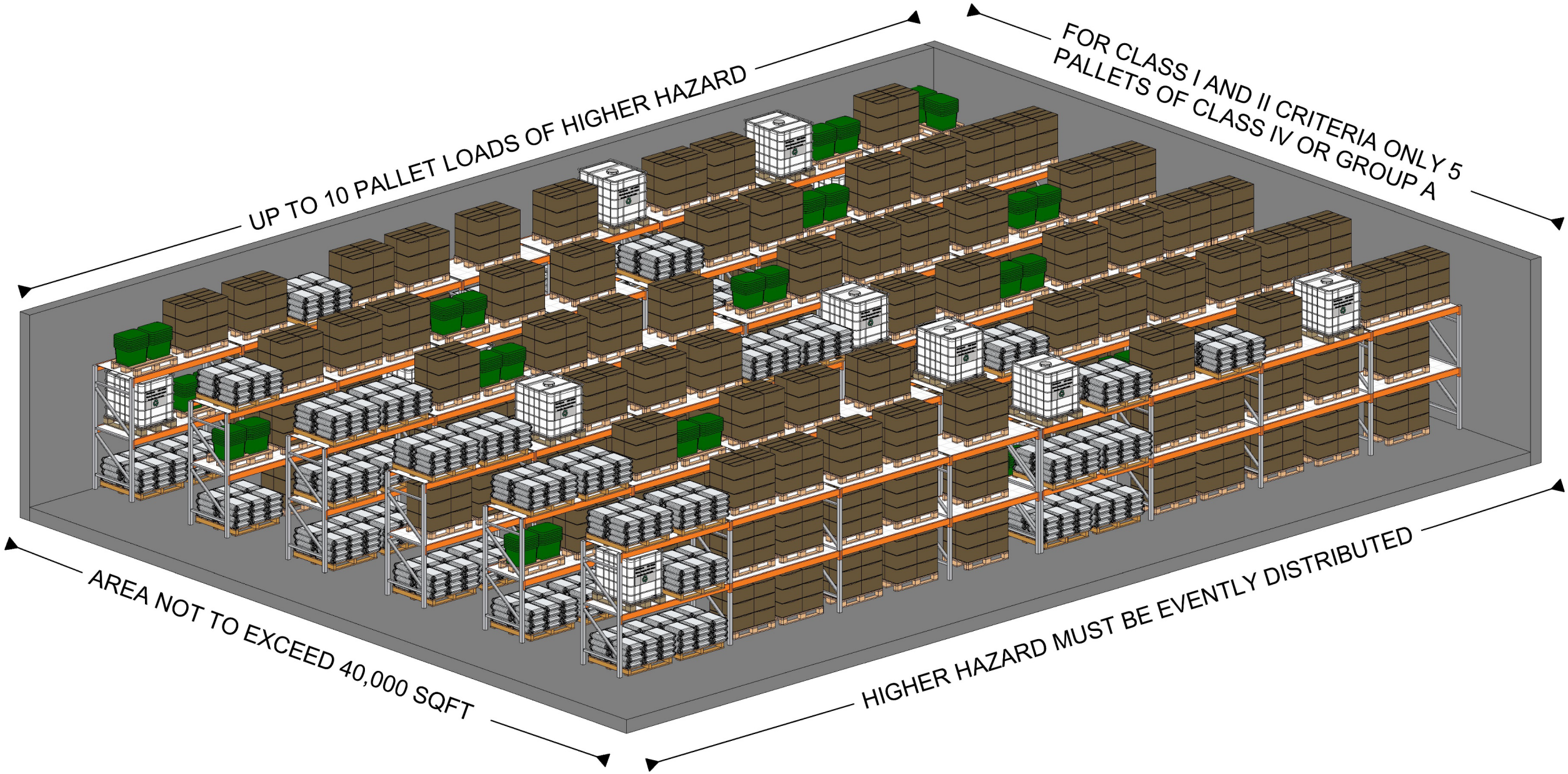
Higher heat of combustion/HRR

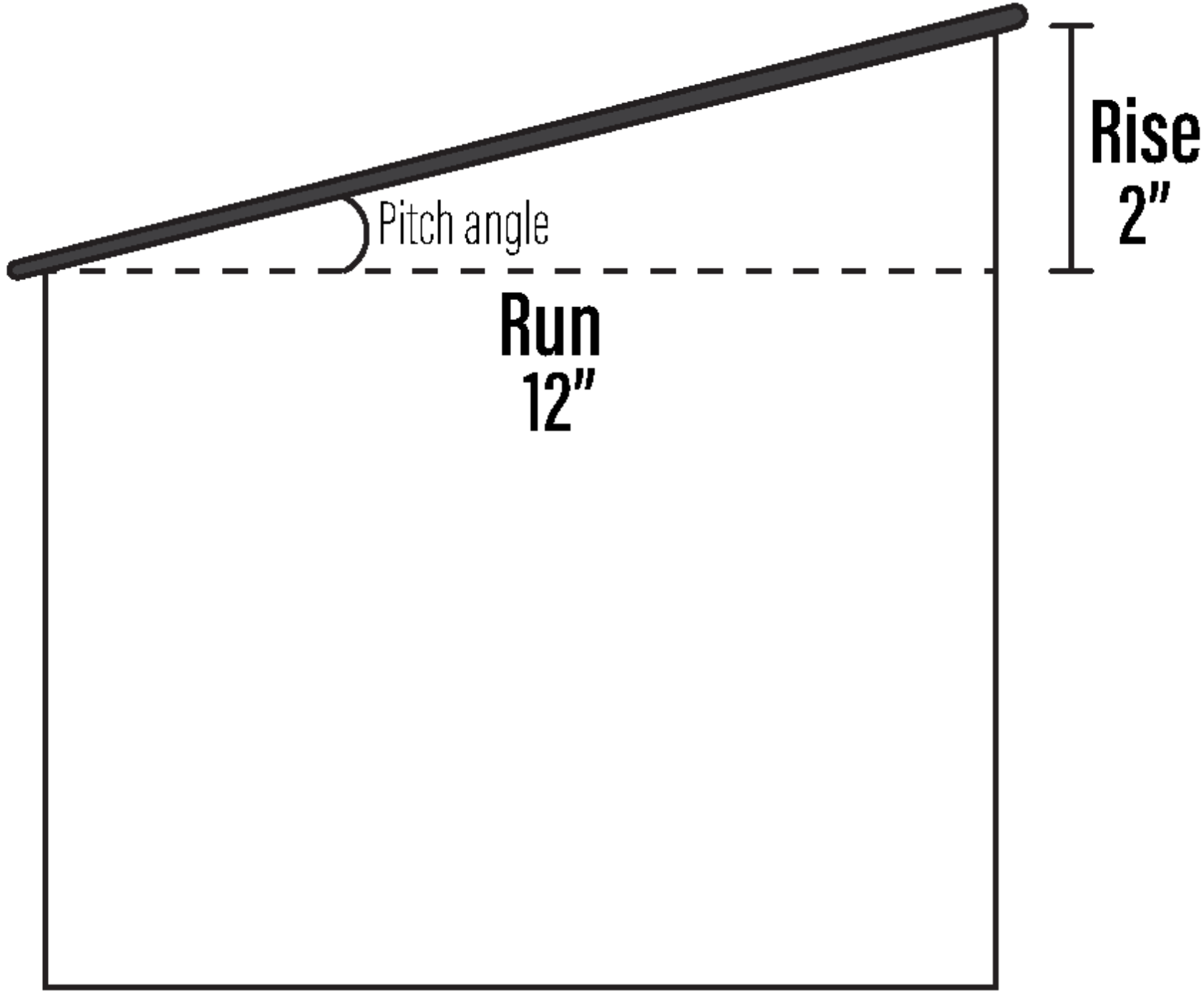


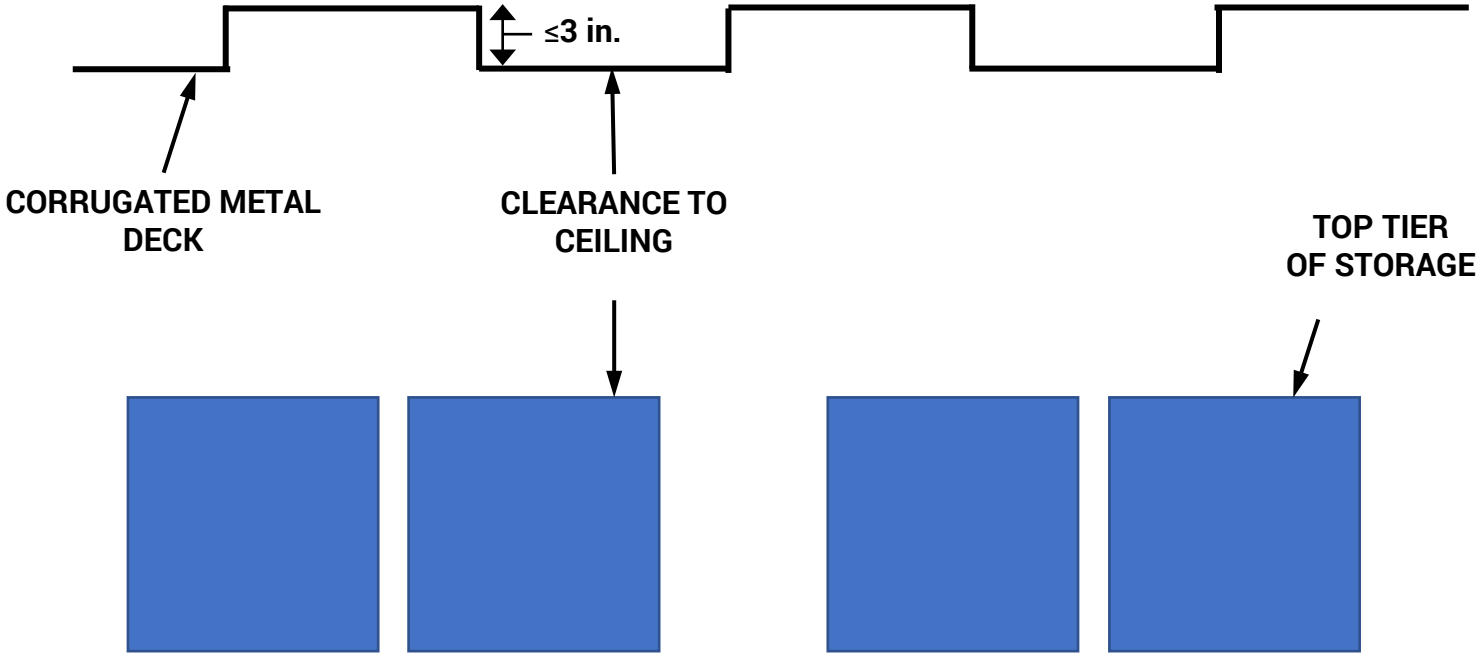
15-B-3
15-B-2


UP TO 10 PALLET LOADS OF HIGHER HAZARD
FOR CLASS I AND II CRITERIA ONLY 5 PALLETS OF CLASS IV OR GROUP A
AREA NOT TO EXCEED 40,000 SQFT
HIGHER HAZARD MUST BE EVENTLY DISTRIBUTED

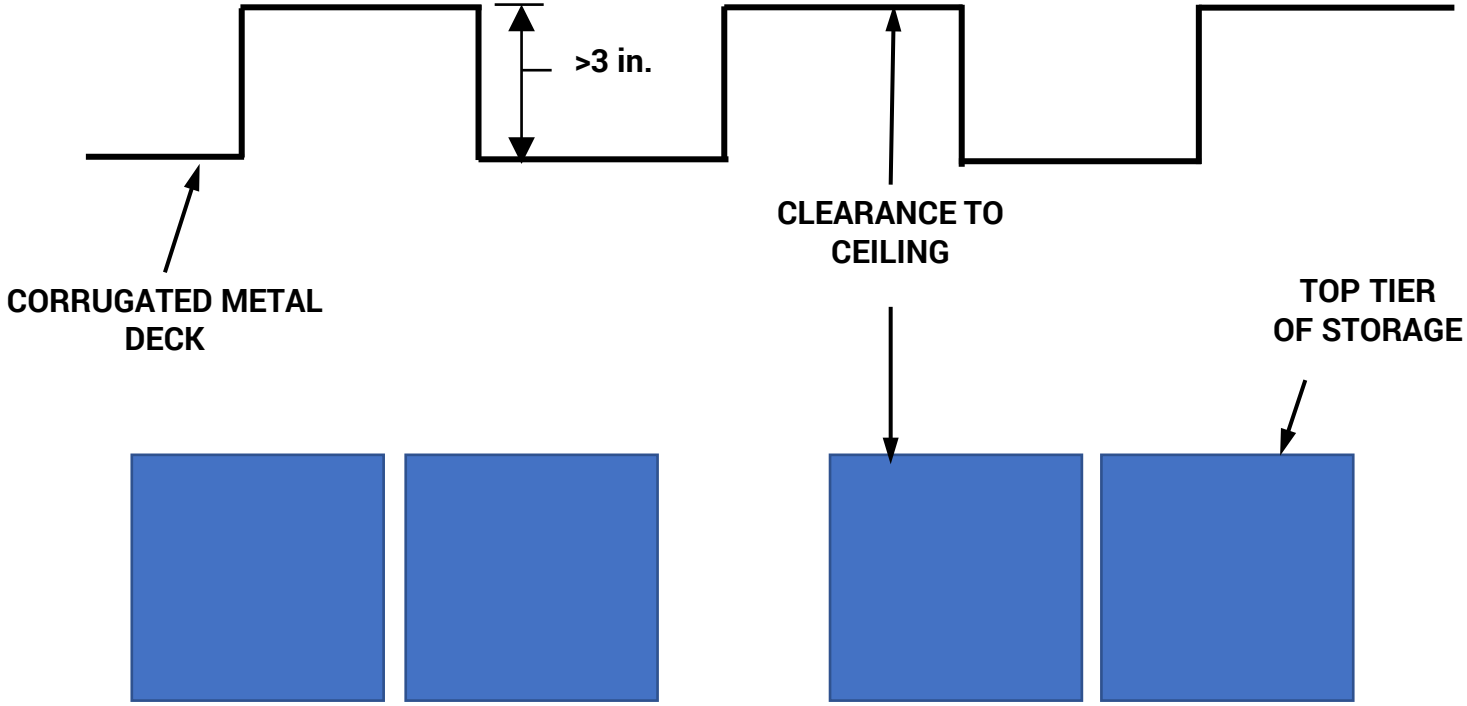
Module Assessment

Conversation Quiz

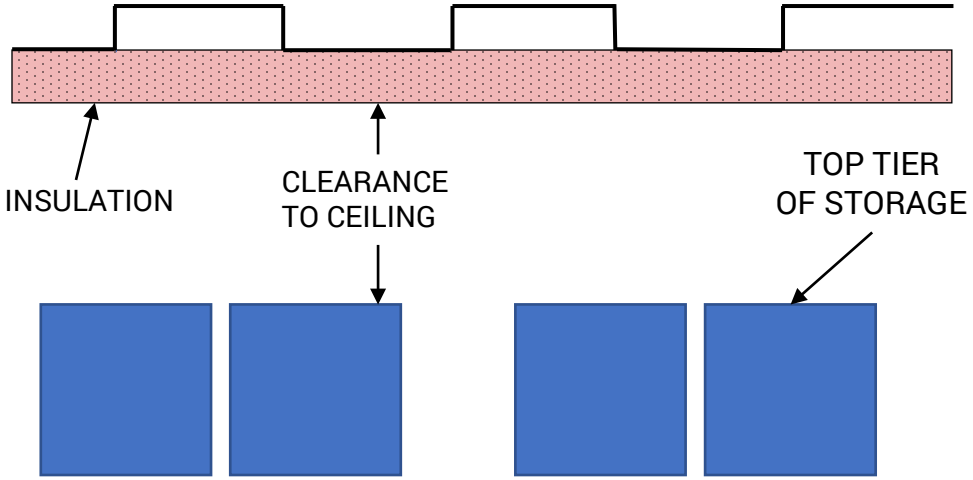

Rise
2"
Pitch angle
Run
12"



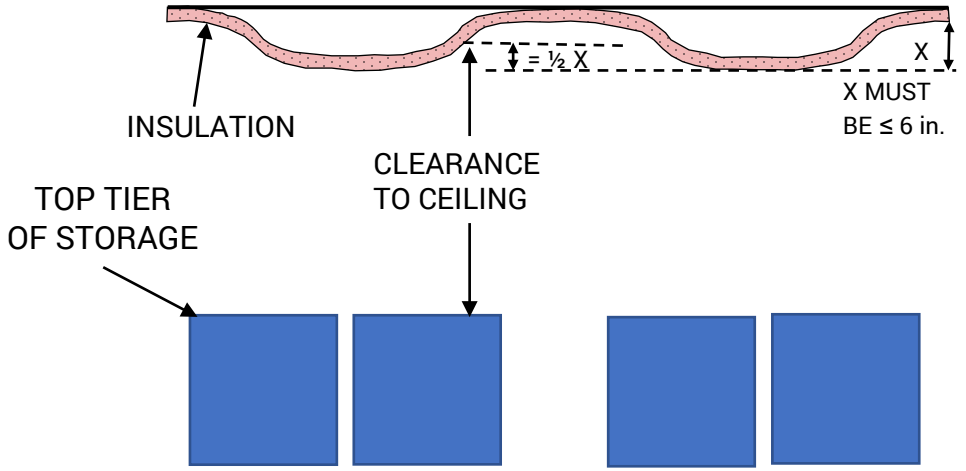
CORRUGATED DECK 3 INCHES OR LESS IN DEPTH



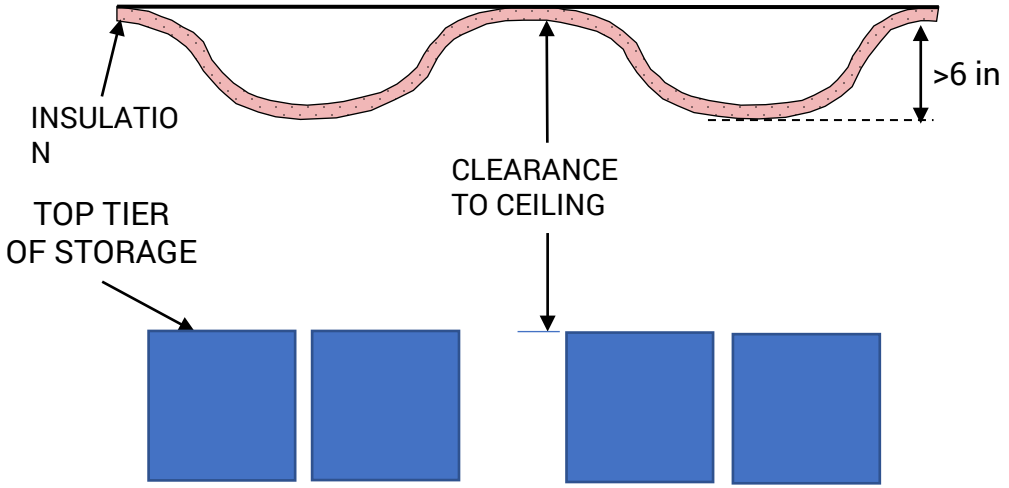
CORRUGATED DECK GREATHER THAN3 INCHES IN DEPTH



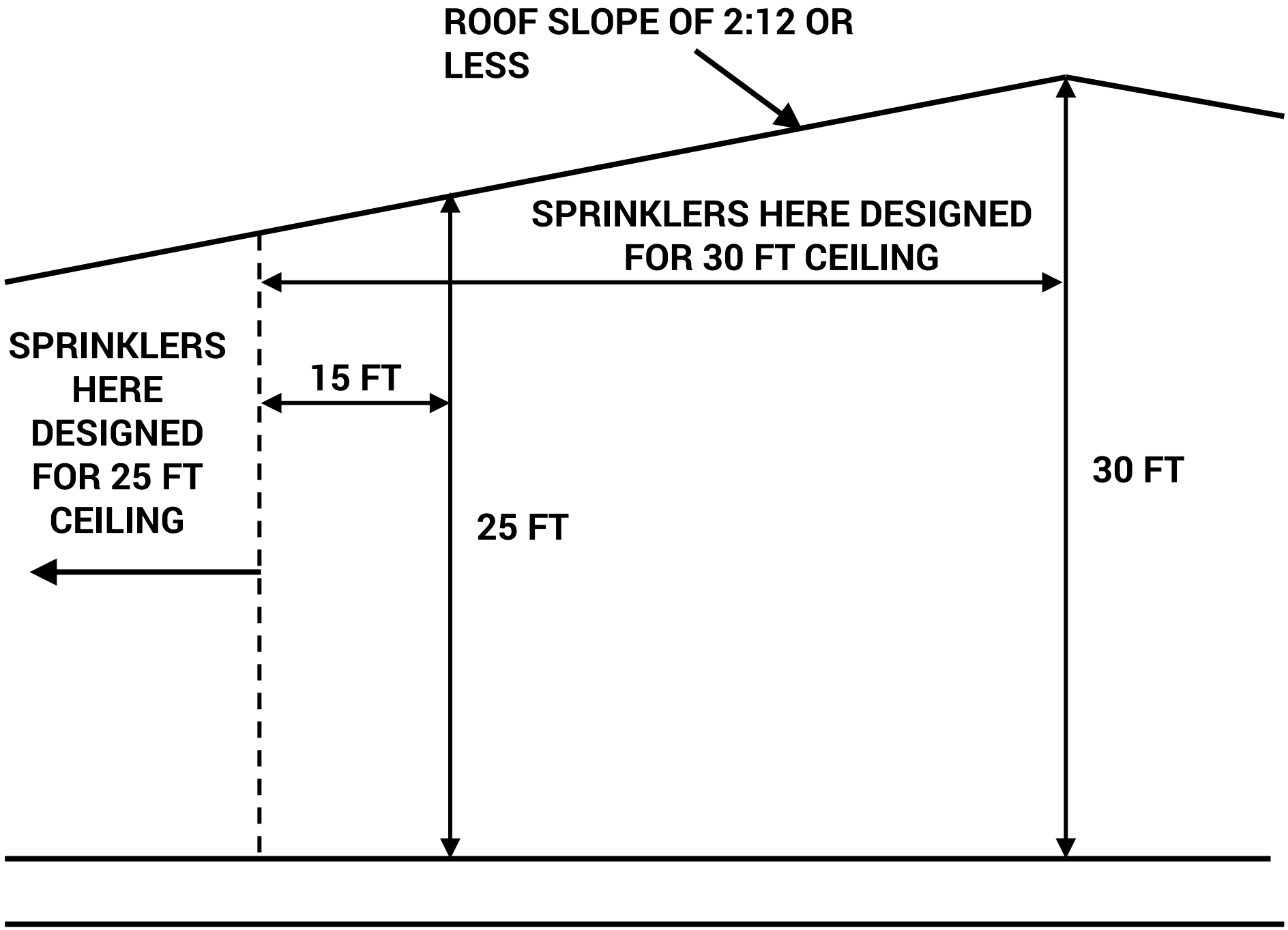
INSULATION TIGHT TO CEILING

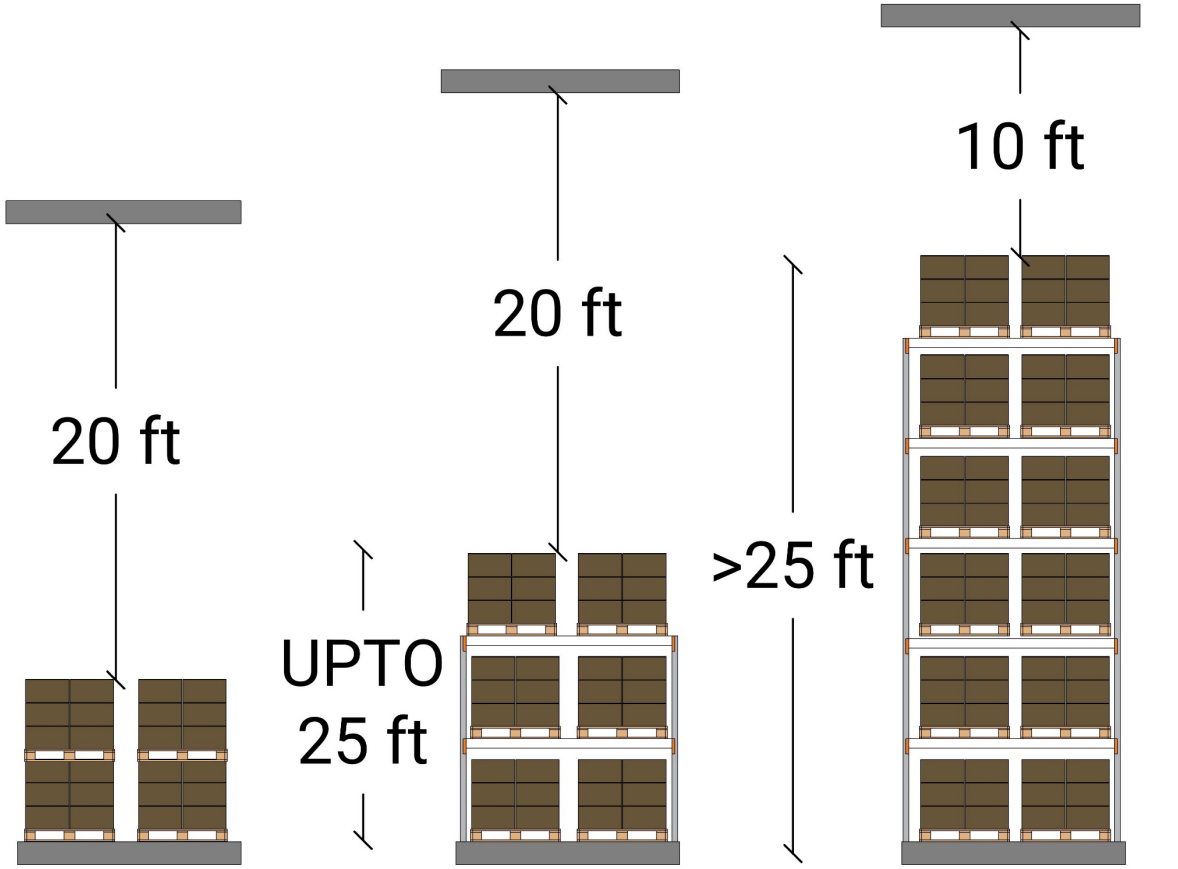


INSULATION SAGGING 6 INCHES

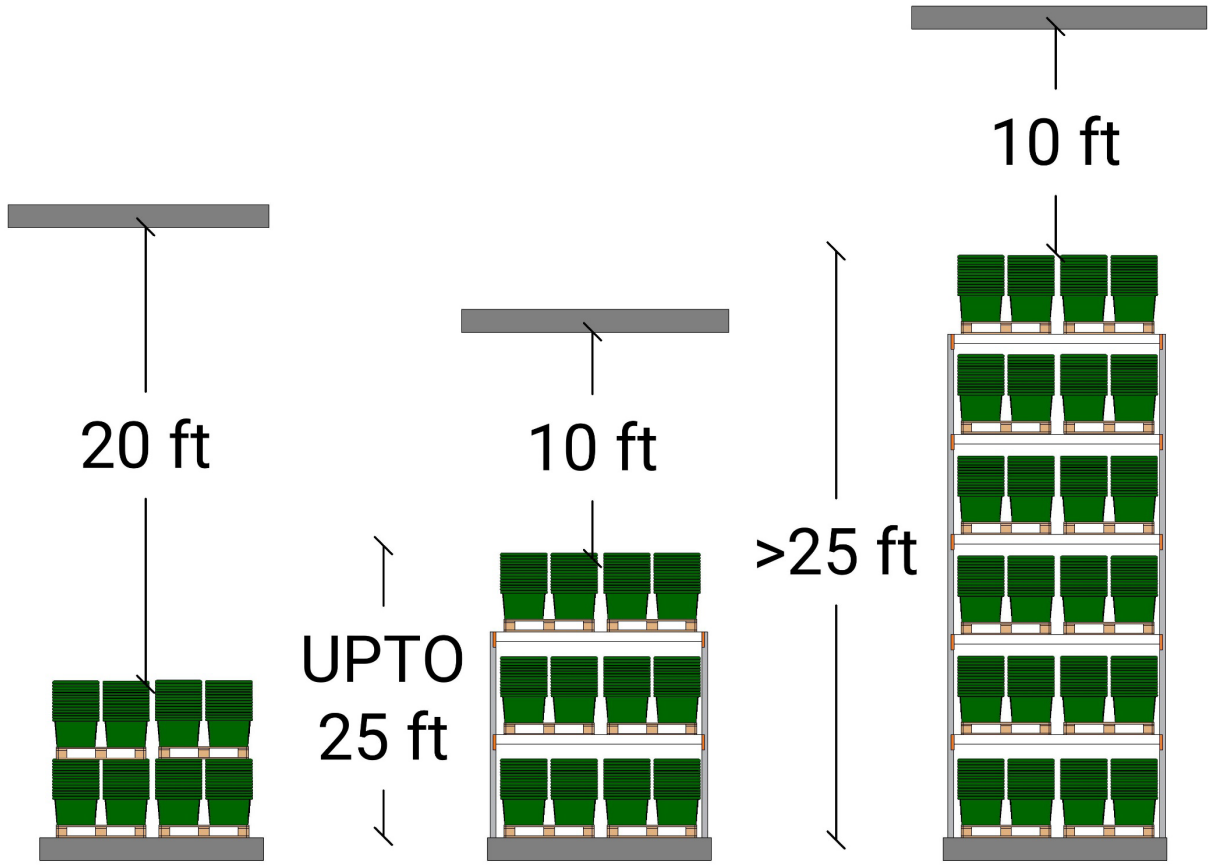


INSULATION SAGGING MORE THAN 6 INCHES


ROOF SLOPE OF 2:12 OR LESS
SPRINKLERS HERE DESIGNED FOR 30 FT CEILING
SPRINKLERS HERE DESIGNED FOR 25 FT CEILING
15 FT
25 FT
30 FT



CLASS I-IV COMMODITIES



GROUP A PLASTICS

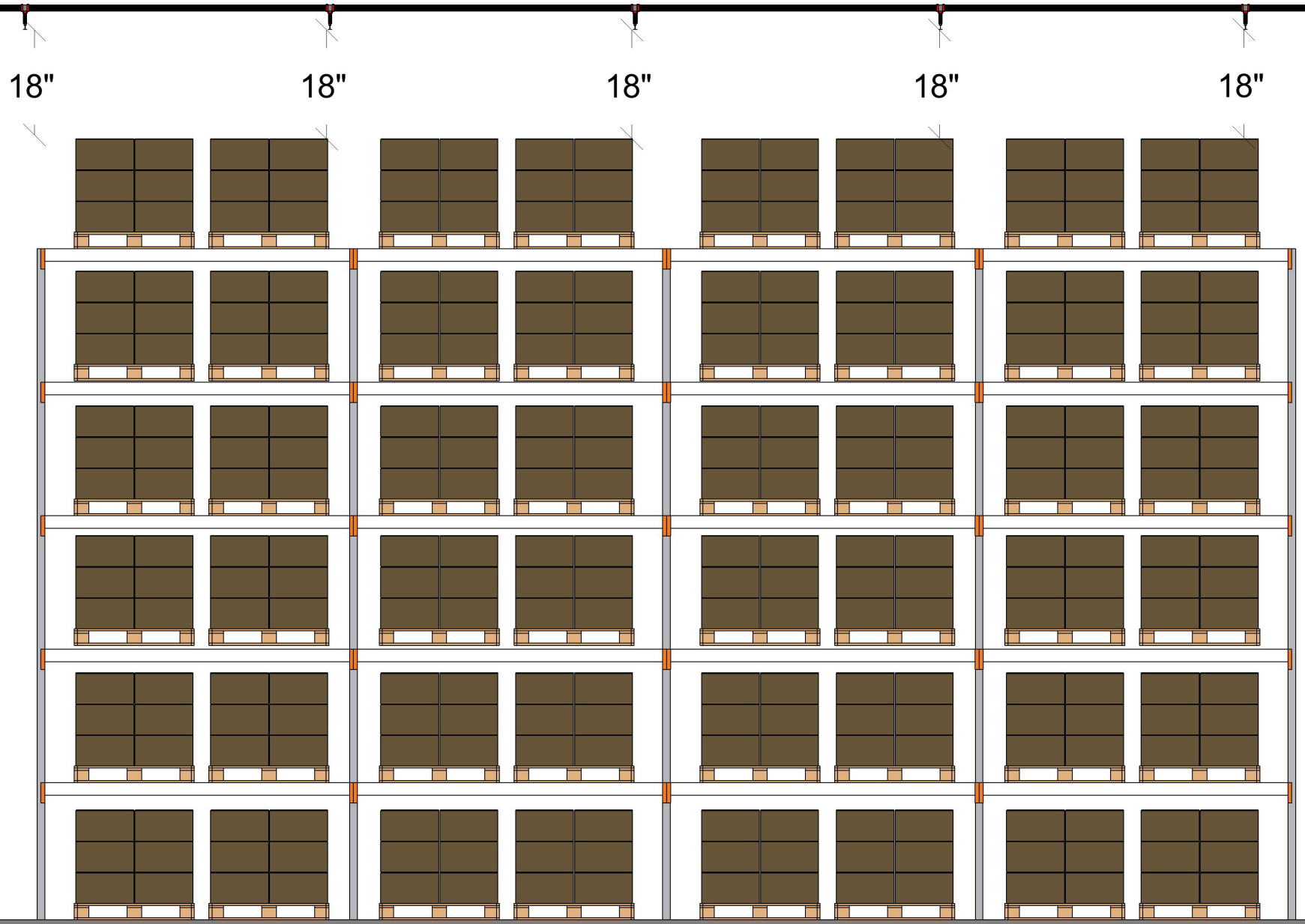
Commodity	Class I – IV	Group A Plastic
Palletized, solid-piled, bin box, shelf, or back-to-back shelf storage	20 ft	20 ft
Rack storage up to 25 ft	20 ft	10 ft
Rack Storage >25ft	10 ft	10 ft

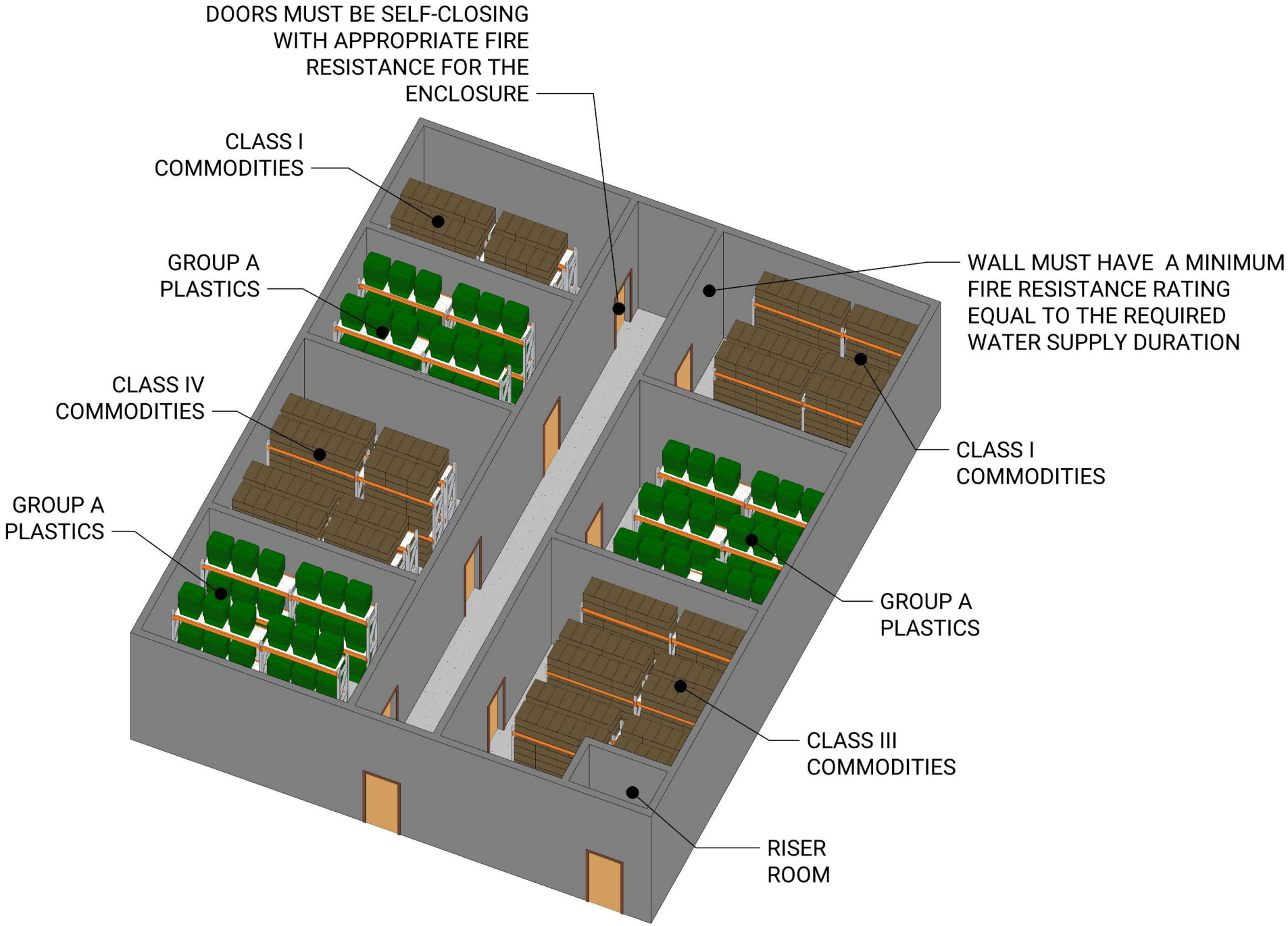
CRITERIA WHEN MAXIMUM CEILING CLEARANCE IS EXCEEDED FOR CLASS I-IV COMMODITIES

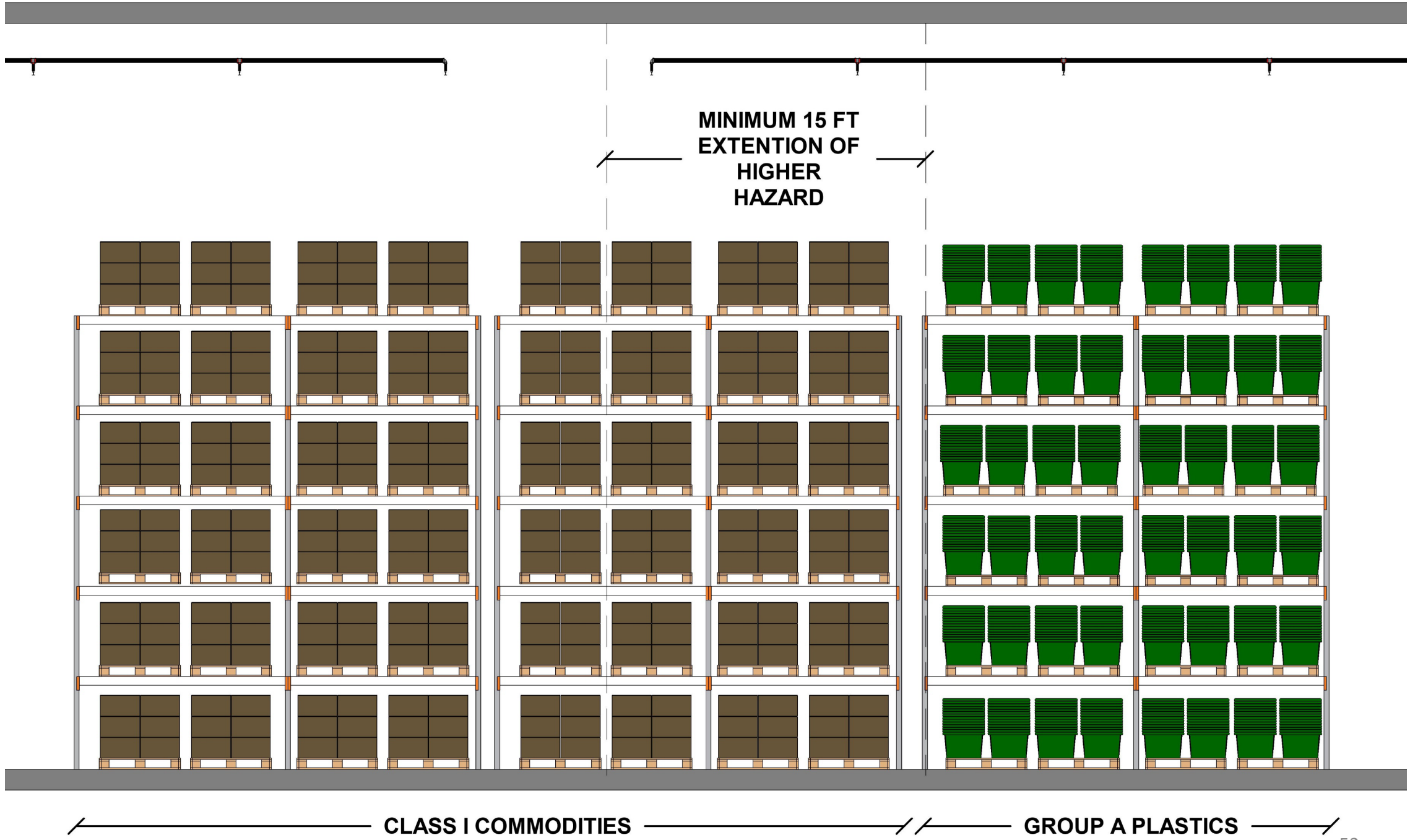
Storage Configuration	Where the clearance to the ceiling exceeds	Protection is based upon the storage height that would result in a clearance to the ceiling of…	In-Rack Sprinklers
Palletized, solid-piled, bin box, shelf, or back-to-back shelf storage	20 ft	20 ft	N/A
Rack storage up to and including 25 ft in height	20 ft	20 ft	Permitted as alternative to presumed clearance of 20 ft
Rack Storage over 25 ft in height	10 ft	10 ft	Permitted as alternative to presumed clearance of 10 ft

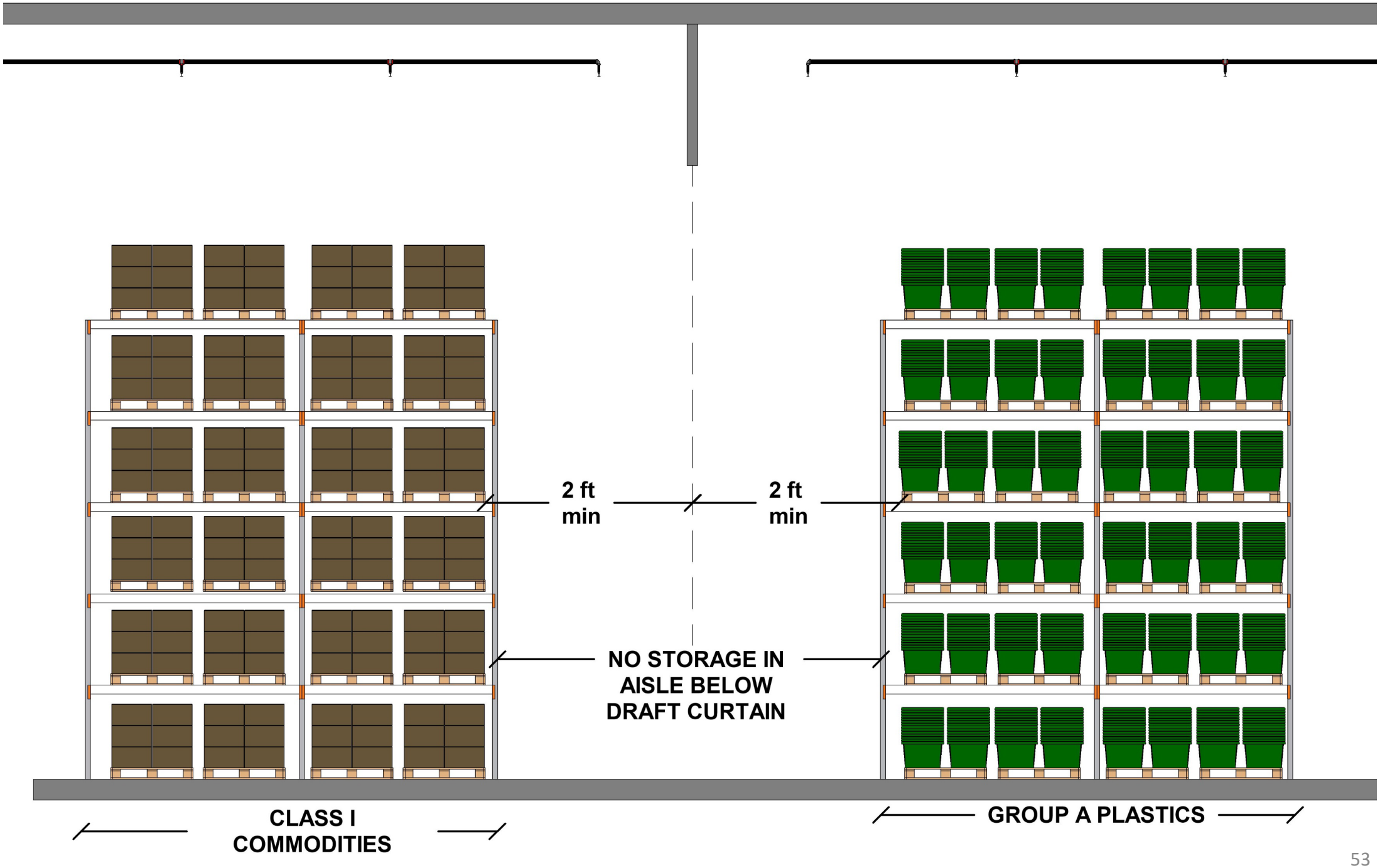
CRITERIA WHEN MAXIMUM CEILING CLEARANCE IS EXCEEDED FOR GROUP A PLASTICS AND TIRES

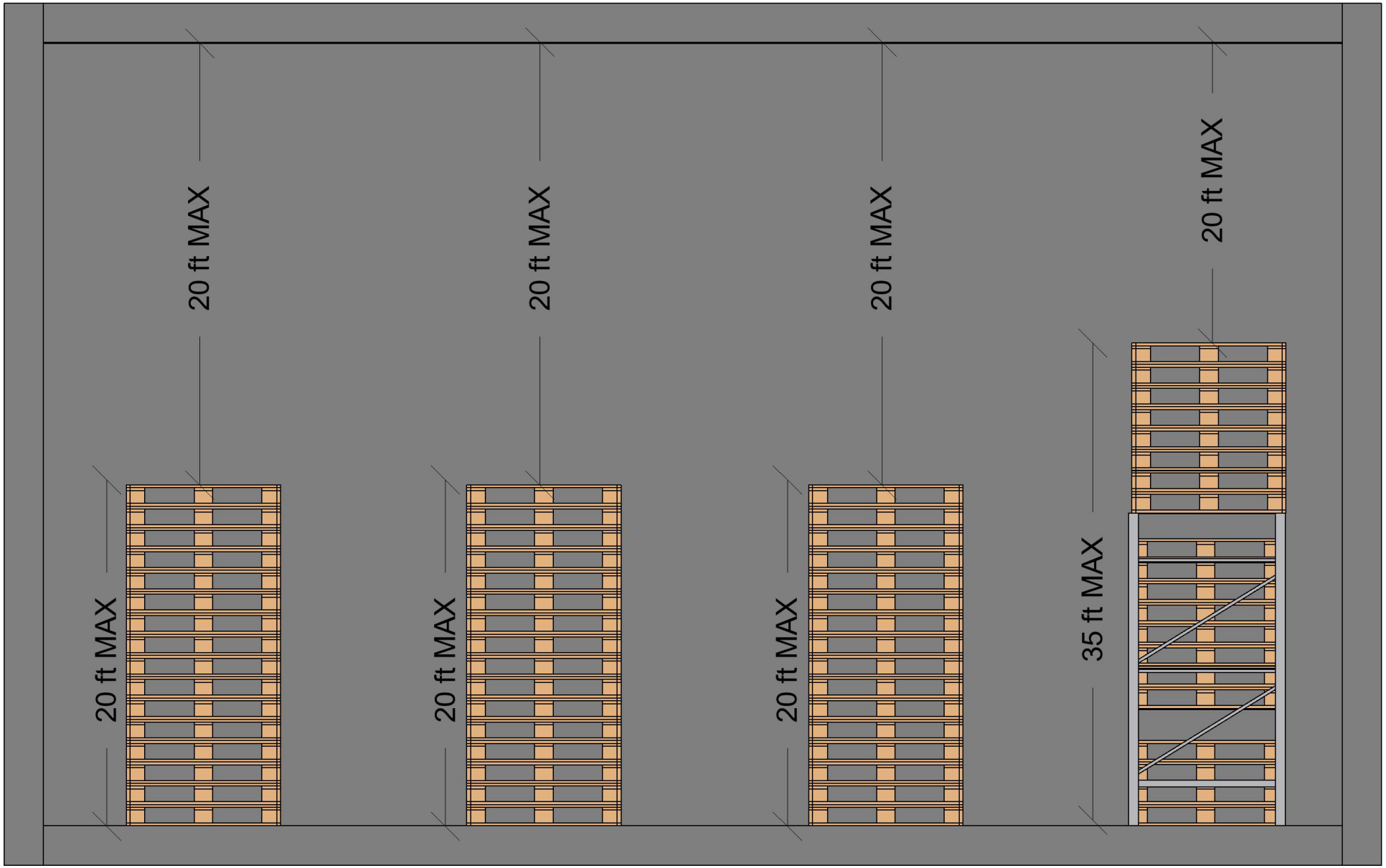
Storage Configuration	Where the clearance to the ceiling exceeds	Protection is based upon the storage height that would result in a clearance to the ceiling of…	In-Rack Sprinklers
General Storage	20 ft	20 ft	N/A
Rack storage up to and including 25 ft in height	20 ft	20 ft	Permitted as alternative to presumed clearance of 10 ft
Rack Storage over 25 ft in height	10 ft	10 ft	Required


18"
18"
18"
18"
18"


DOORS MUST BE SELF-CLOSING WITH APPROPRIATE FIRE RESISTANCE FOR THE ENCLOSURE
CLASS I COMMODITIES
GROUP A PLASTICS
CLASS IV COMMODITIES
GROUP A PLASTICS
WALL MUST HAVE A MINIMUM FIRE RESISTANCE RATING EQUAL TO THE REQUIRED WATER SUPPLY DURATION
CLASS I COMMODITIES
GROUP A PLASTICS
CLASS III COMMODITIES
RISER ROOM


MINIMUM 15 FT
EXTENTION OF
HIGHER
HAZARD
CLASS I COMMODITIES
GROUP A PLASTICS


2 ft
min
2 ft
min
NO STORAGE IN
AISLE BELOW
DRAFT CURTAIN
CLASS I
COMMODITIES
GROUP A PLASTICS



CMDA
TABLE
20.14.1.2(a)

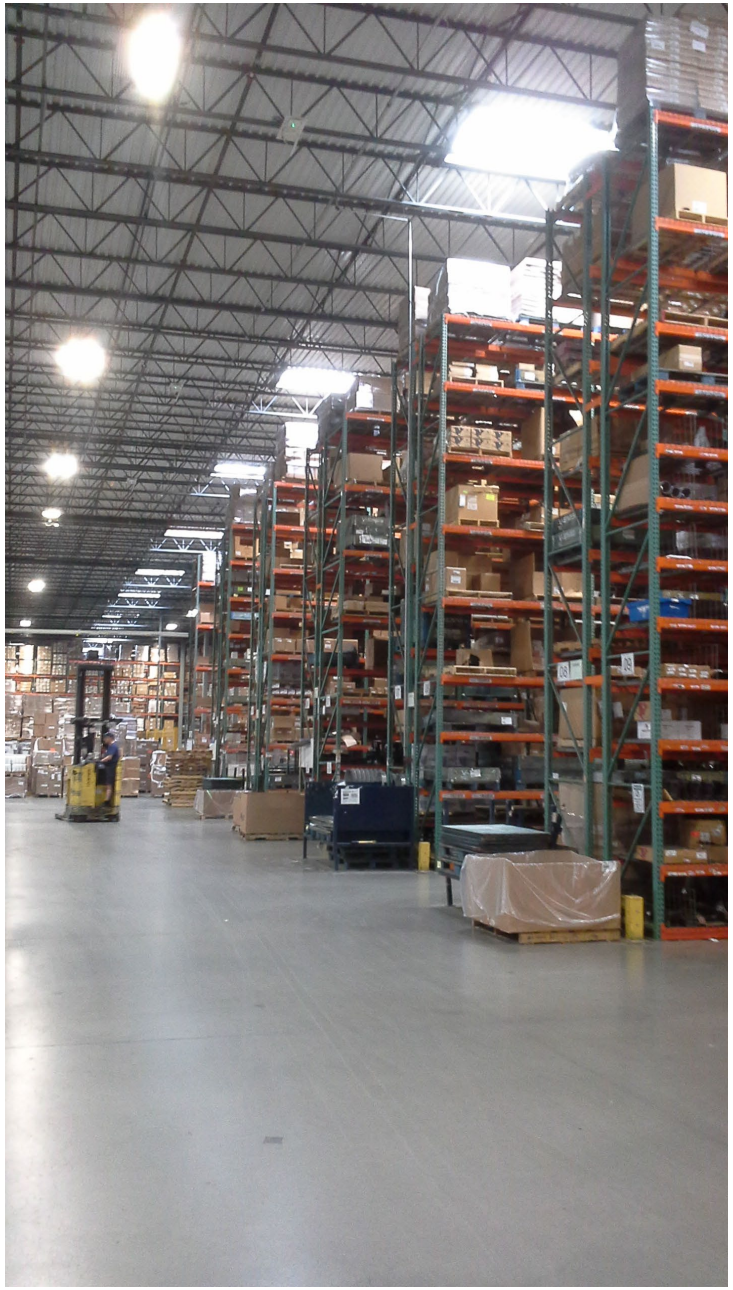
CMSA
TABLE:
20.14.1.2(b)

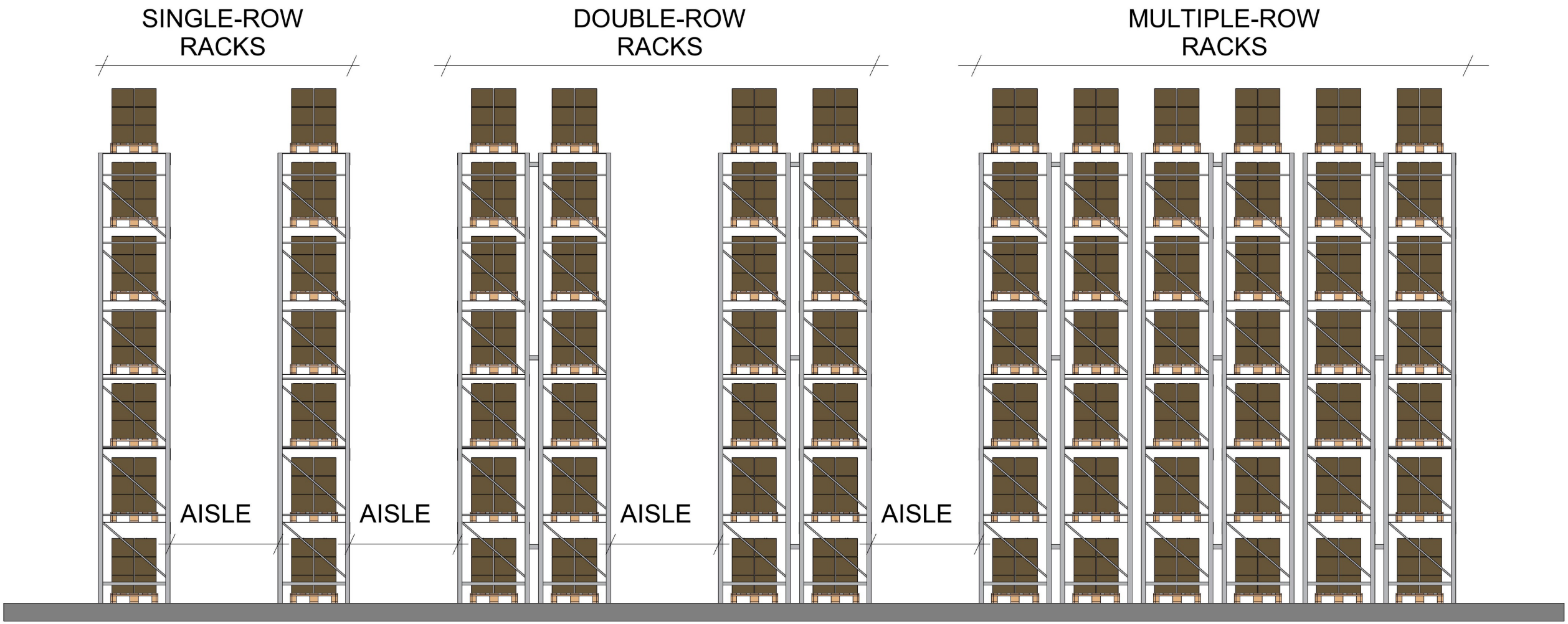
ESFR
(FLOOR)
TABLE:
20.14.1.2(c)

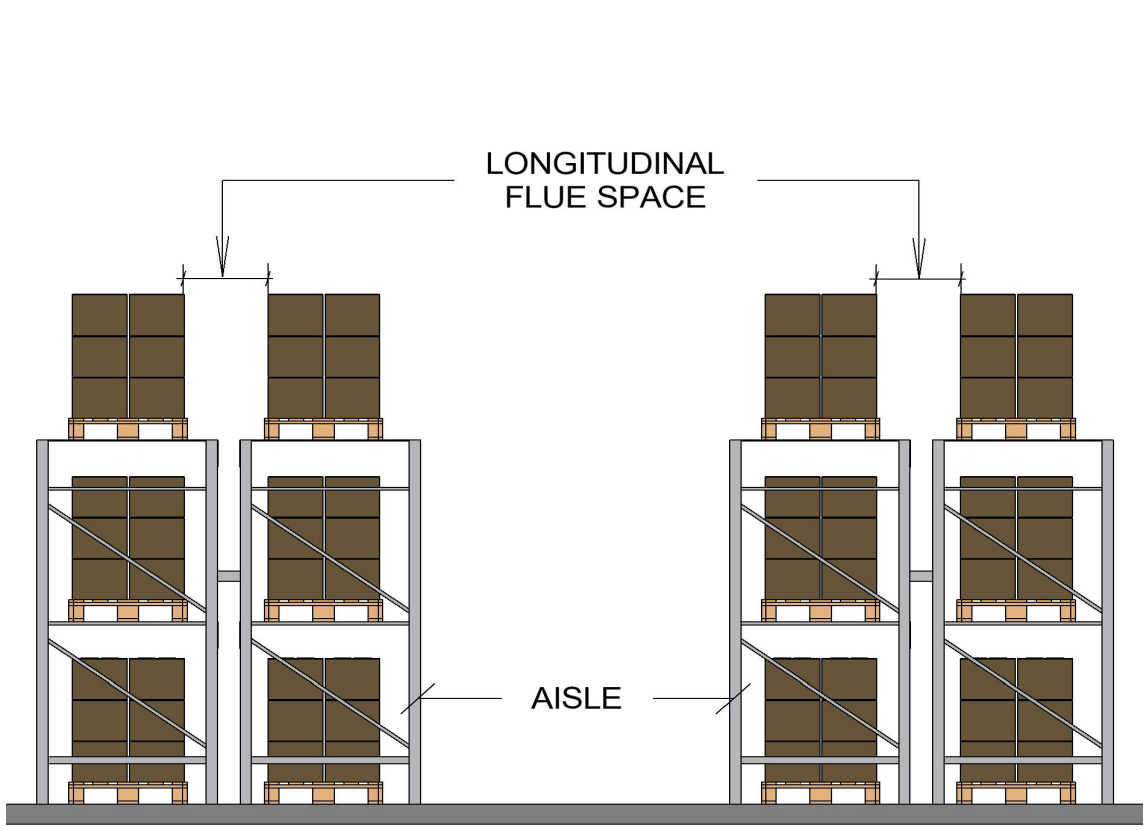
ESFR
(RACK)
TABLE:
20.14.1.2(b)

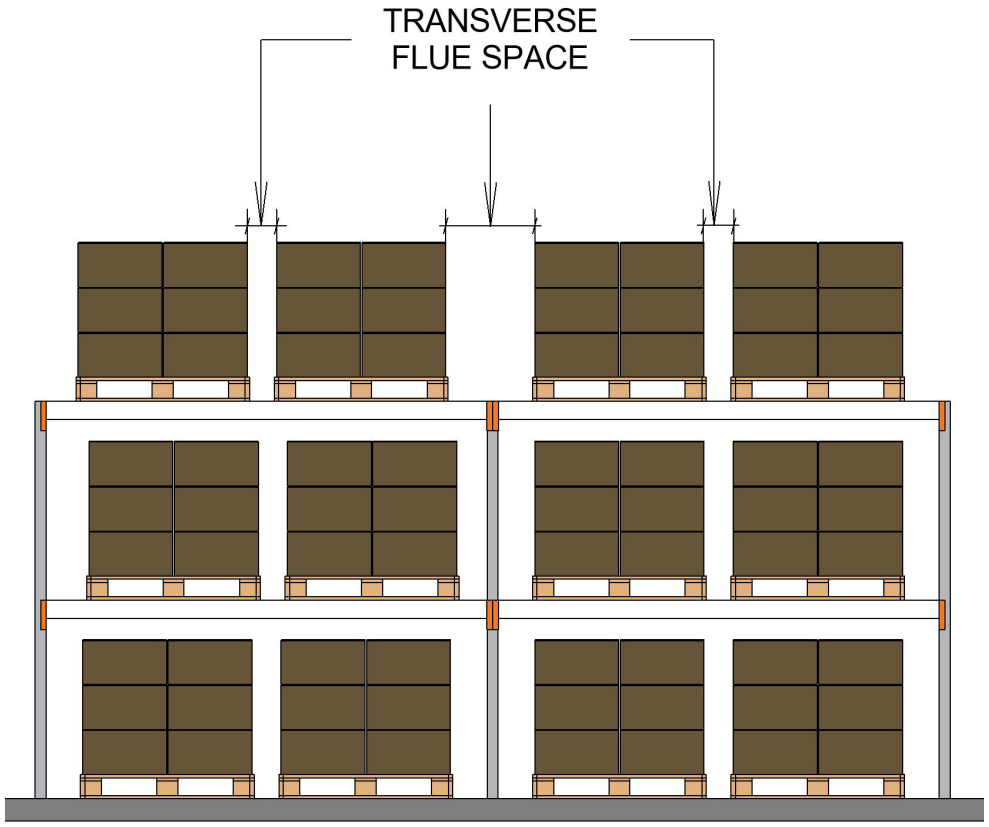
Module Assessment

Provide an example of a high-piled storage project you've worked on. What was being stored and how was the product being stored?

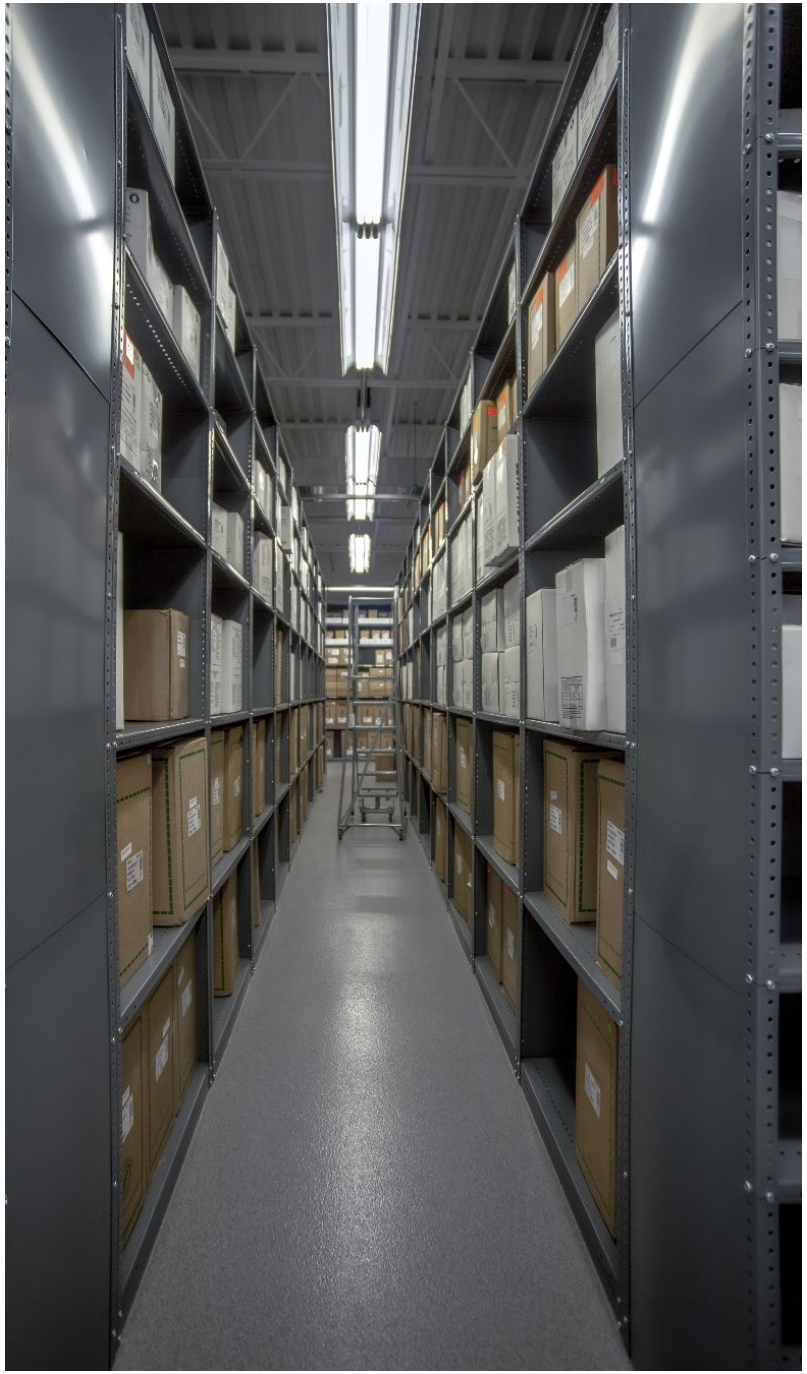



SINGLE-ROW
RACKS
DOUBLE-ROW
RACKS
MULTIPLE-ROW
RACKS
AISLE
AISLE
AISLE
AISLE

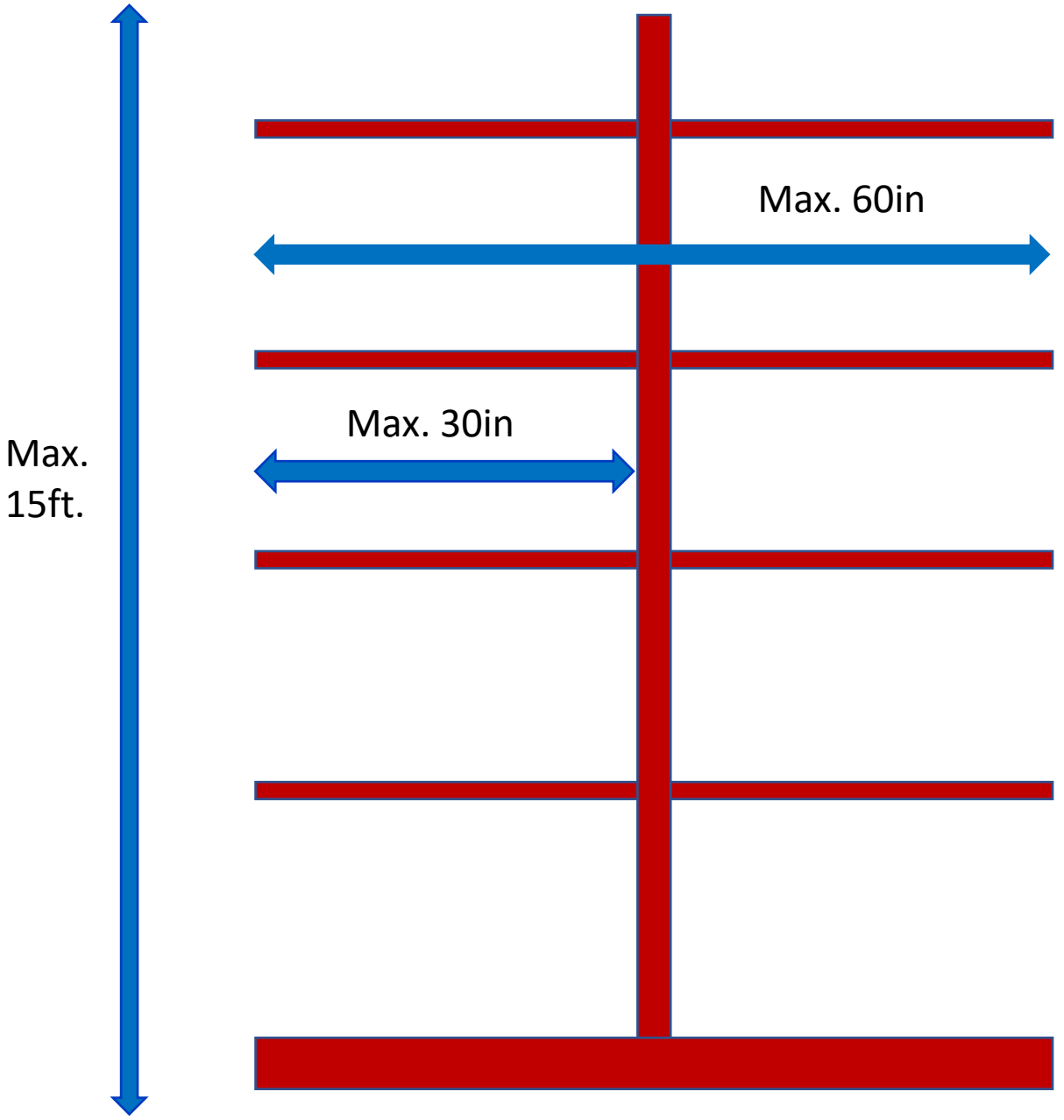

LONGITUDINAL
FLUE SPACE
AISLE


TRANSVERSE
FLUE SPACE

WEST

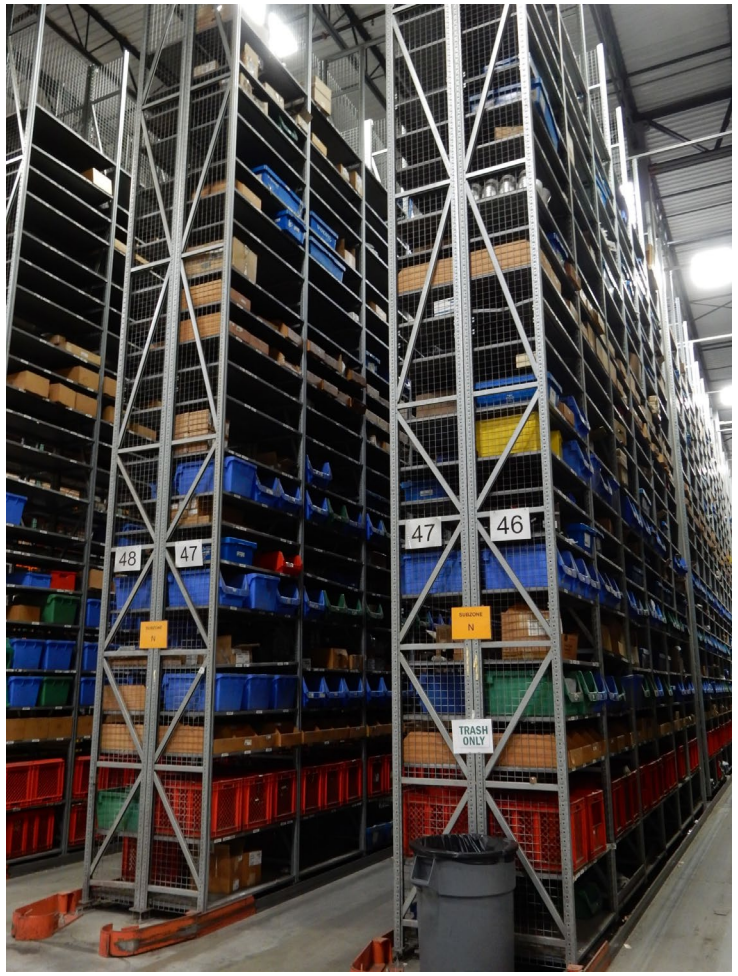


BAR-BEA
BEA-BEL
BEL-BES
BES-BLE


Max.
15ft.
Max. 60in
Max. 30in

THIS SIDE UP
THIS SIDE UP

GOURMET LUMP CHARCOAL
GOURMET LUMP CHARCOAL
GOURMET LUMP CHARCOAL
GOURMET LUMP CHARCOAL
100% HARDWOOD
ALL NATURAL
100% HARDWOOD
ALL NATURAL
GOURMET
LUMP
CHARCOAL


48
47
47
46
TRASH ONLY

Module Assessment

What does CMDA stand for and what does it mean?

0.0
gpm/sqft

0.2
gpm/sqft

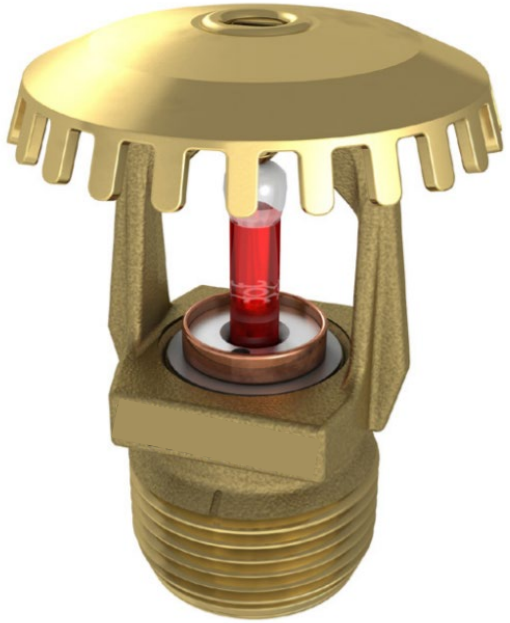
0.34
gpm/sqft

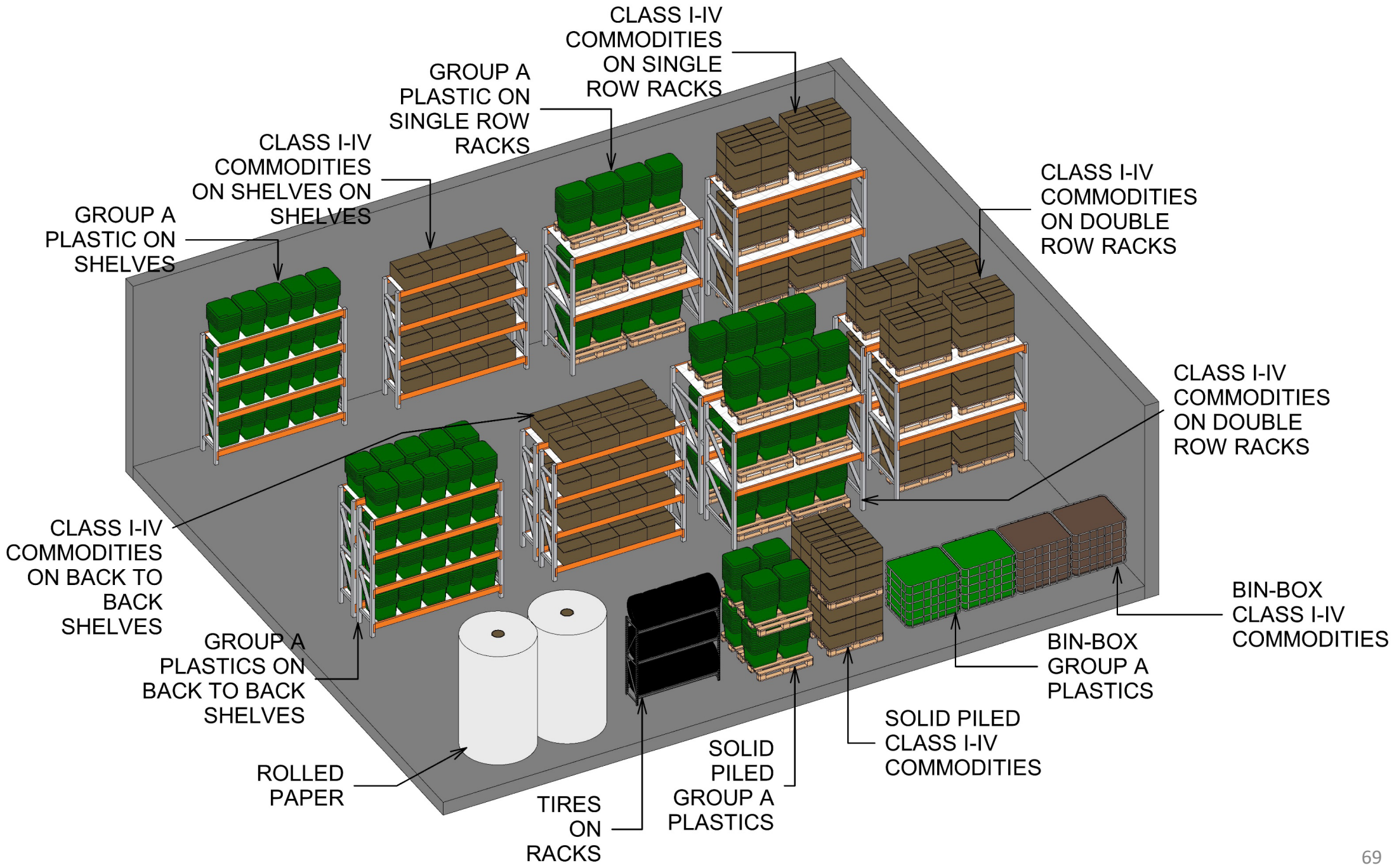
0.8
gpm/sqft

5.6K
Minimum

8.0K
Minimum

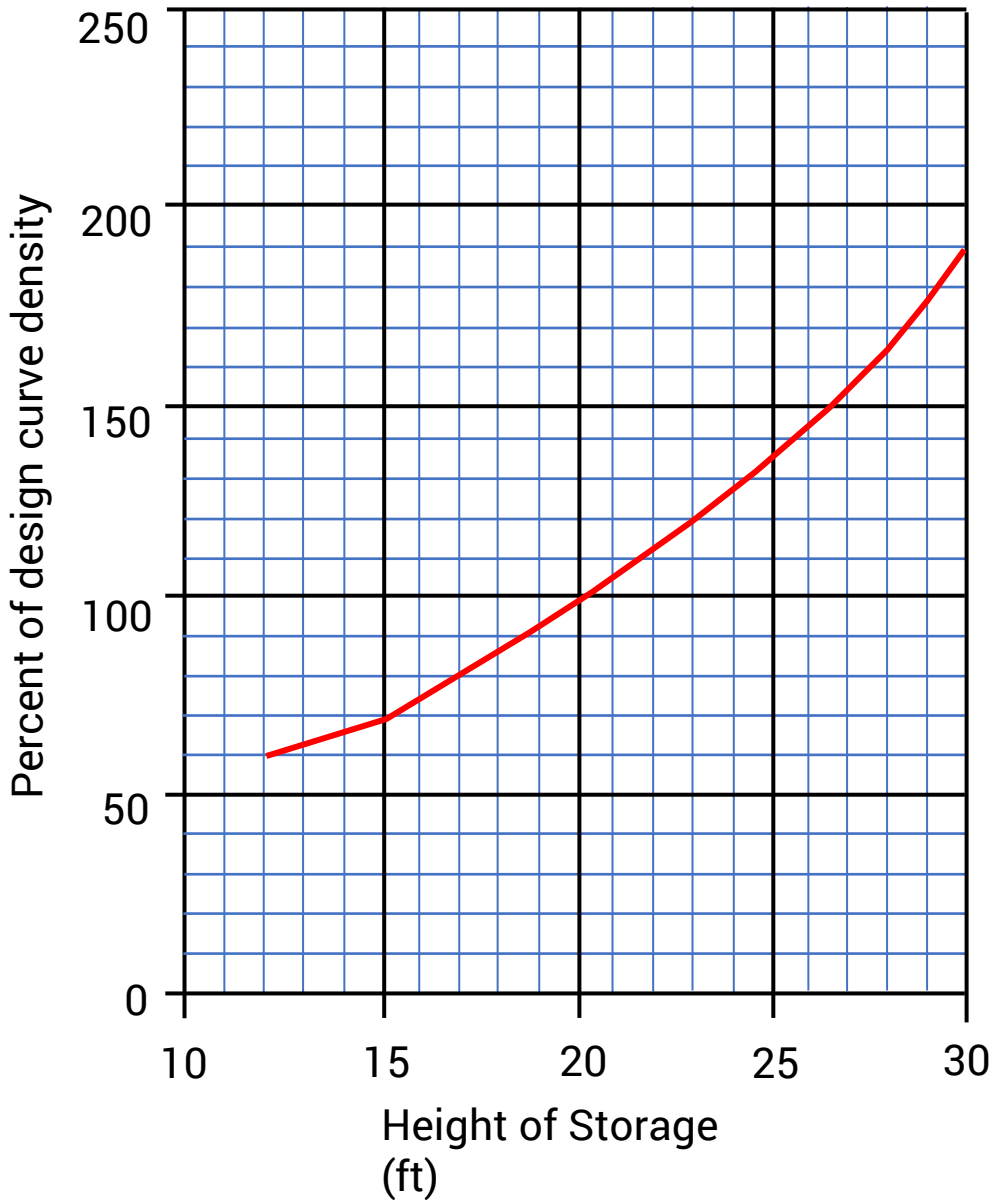
11.2K
Minimum



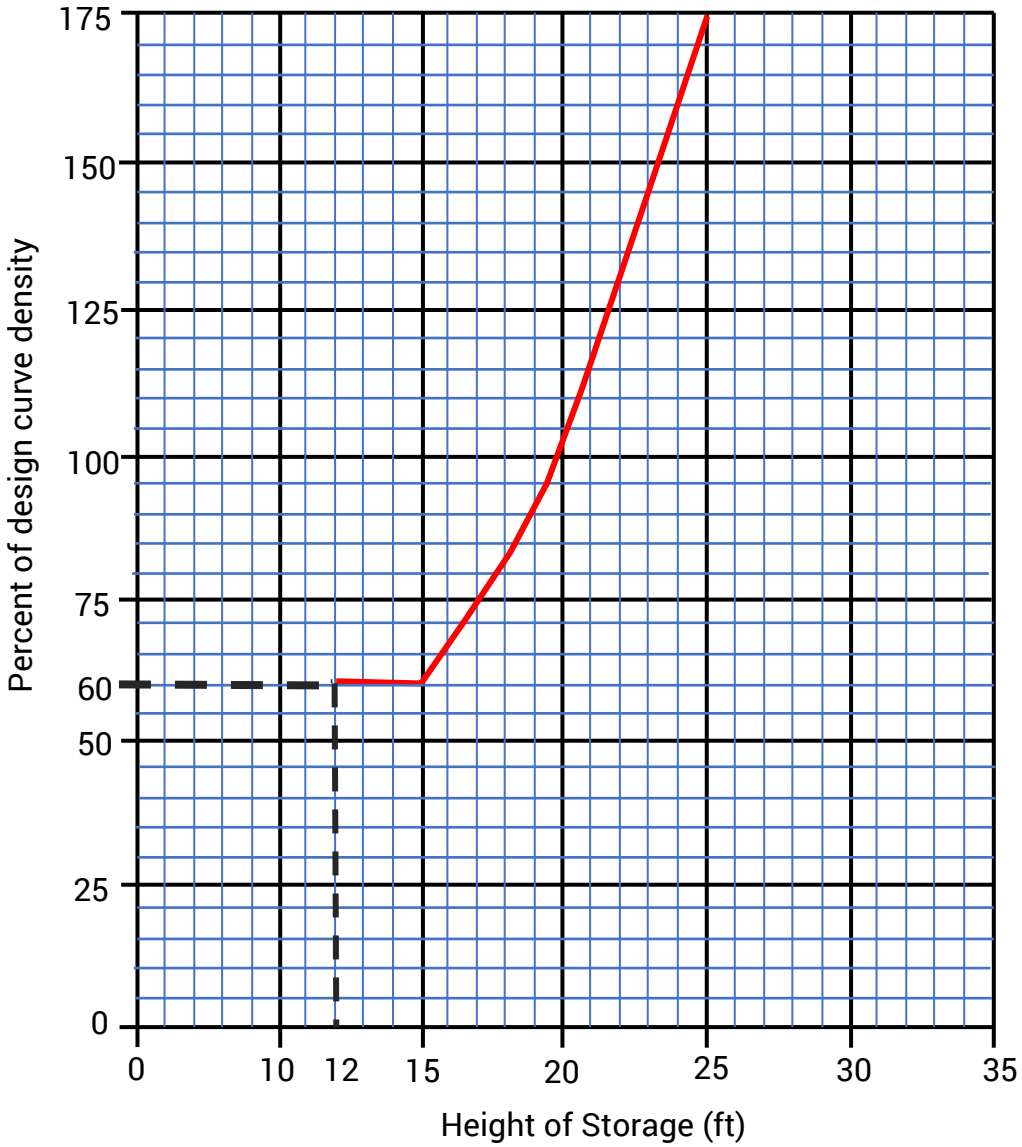

CLASS I-IV COMMODITIES ON SINGLE ROW RACKS
GROUP A PLASTIC ON SINGLE ROW RACKS
CLASS I-IV COMMODITIES ON SHELVES ON SHELVES
GROUP A PLASTIC ON SHELVES
CLASS I-IV COMMODITIES ON DOUBLE ROW RACKS
CLASS I-IV COMMODITIES ON DOUBLE ROW RACKS
CLASS I-IV COMMODITIES ON BACK TO BACK SHELVES
BIN-BOX CLASS I-IV COMMODITIES
GROUP A PLASTICS ON BACK TO BACK SHELVES
BIN-BOX GROUP A PLASTICS
SOLID PILED CLASS I-IV COMMODITIES
ROLLED PAPER
SOLID PILED GROUP A PLASTICS
TIRES ON RACKS

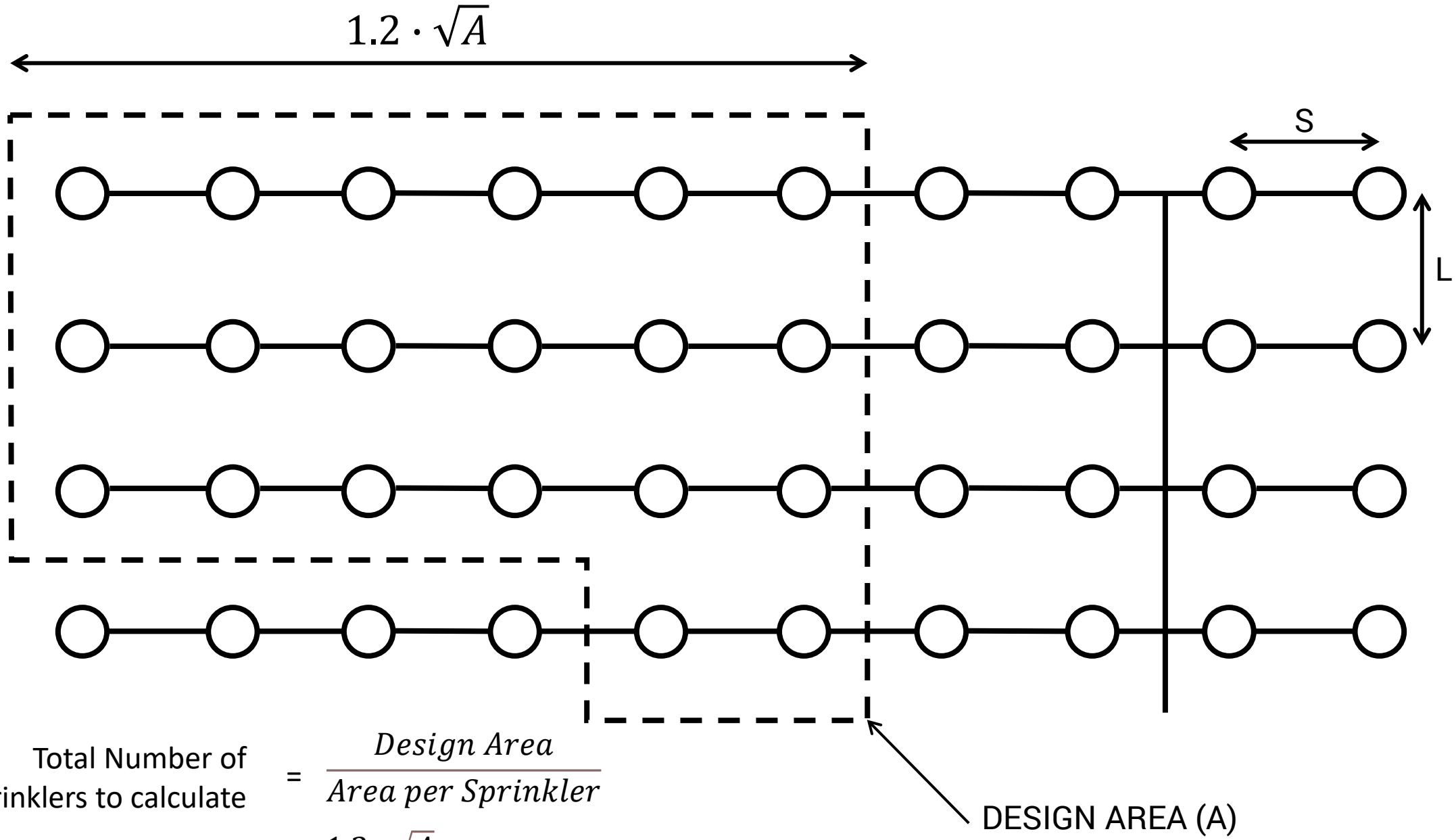
REVIEW NFPA 13 CHAPTER 21

Class I-IV – Paletized, Bin Box, Shelf, Back-to-Back Storage. Figure 21.2.2.3



Class I-IV– Rack Storage. Figure 21.4.1.4.1

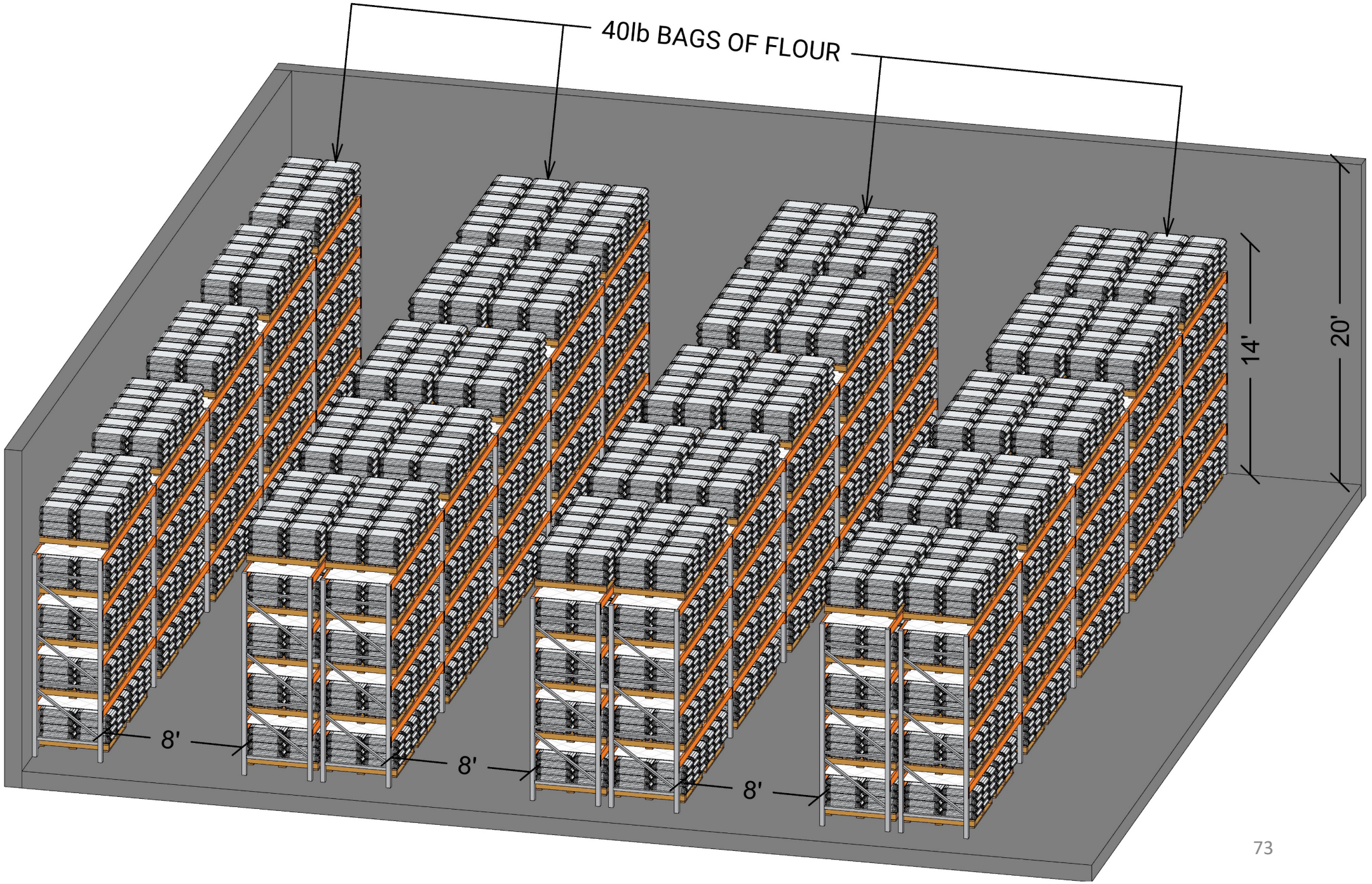




Total Number of sprinklers to calculate $= \dfrac{Design\ Area}{Area\ per\ Sprinkler}$

Number of Sprinklers on branch line $= \dfrac{1.2 \cdot \sqrt{A}}{S}$

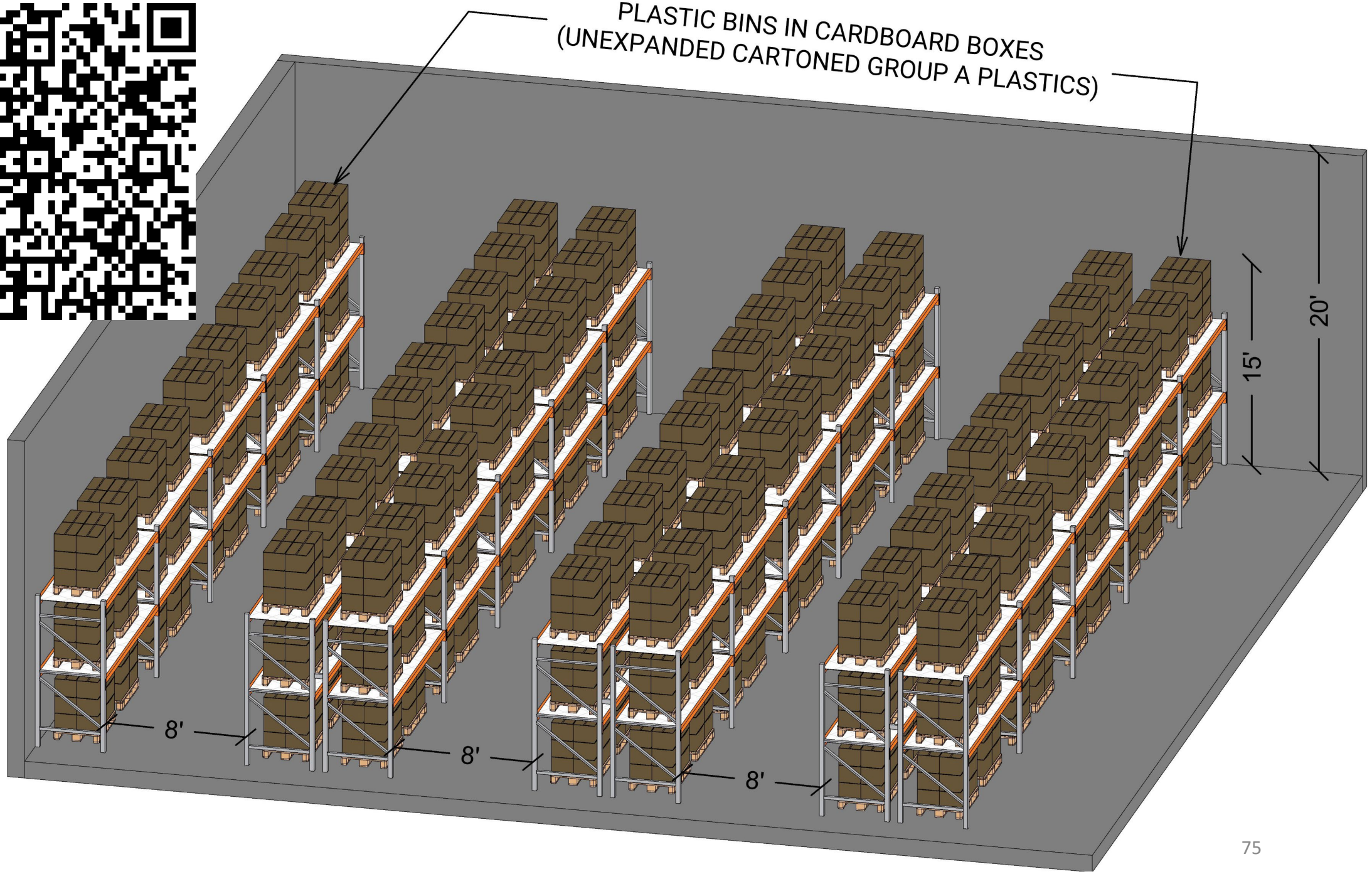
EXAMPLE



ANSWER:

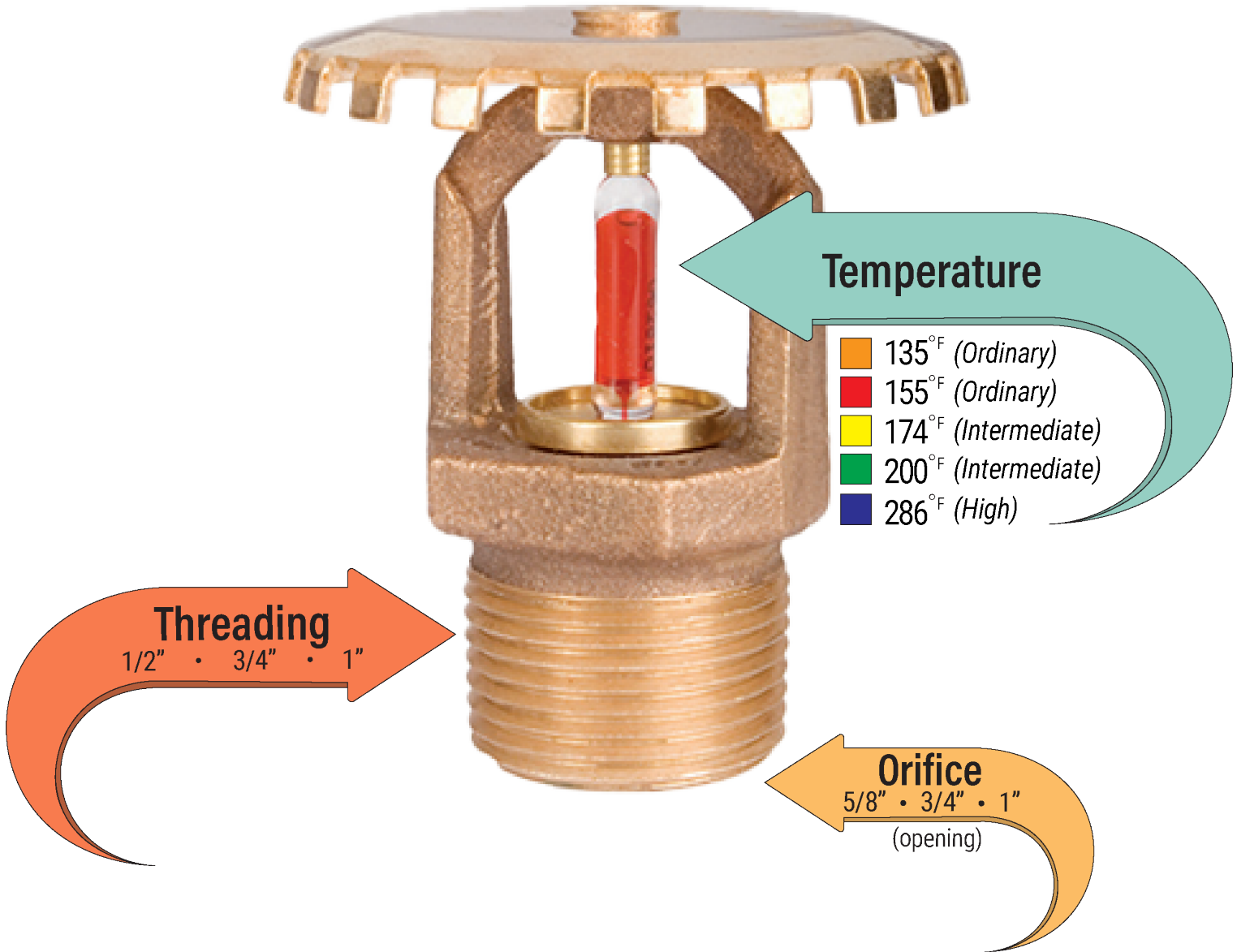
- Table 21.4.1.2
- Figure 21.4.1.2(b)
- Curves A or B
- If Curve A is chosen, why is the density lower when high temperature sprinklers are used?
- .325 gpm/sq ft over 2000 sq ft
- Minimum 11.2K factor
- Total Flow: 650 gpm

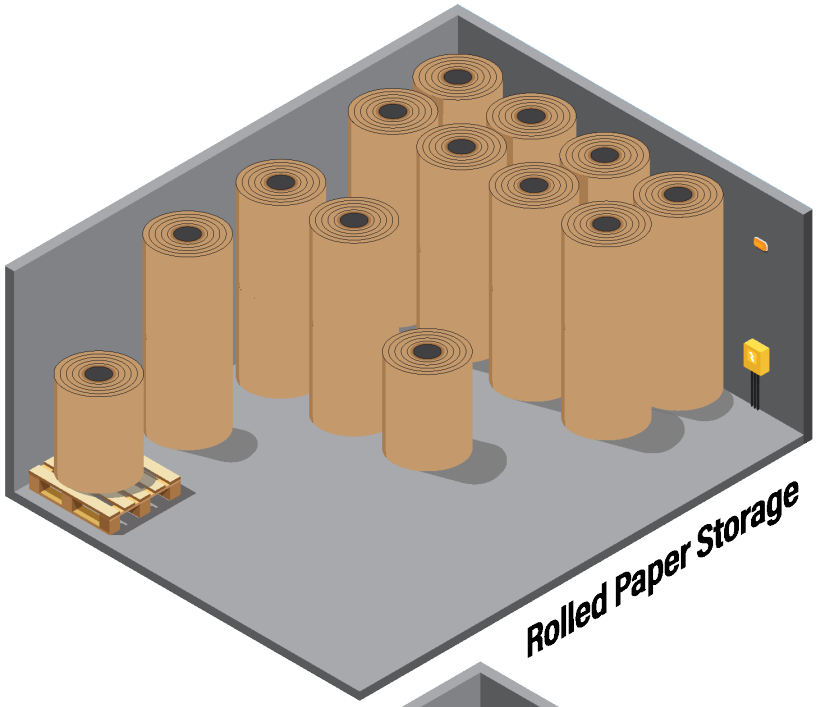
ASSESSMENT


PLASTIC BINS IN CARDBOARD BOXES
(UNEXPANDED CARTONED GROUP A PLASTICS)
20'
15'
8'
8'
8'

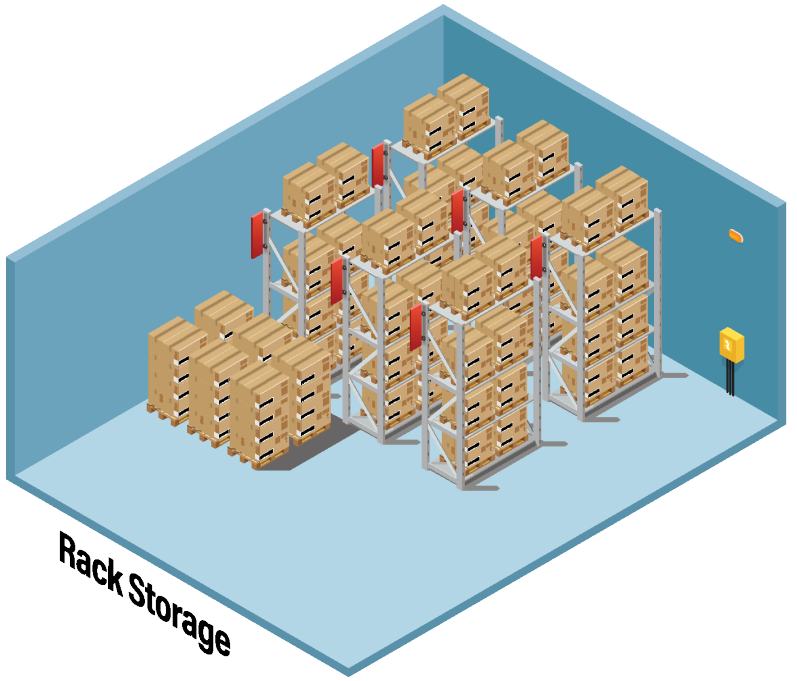
Conversation Quiz

CMSA
fire sprinkler

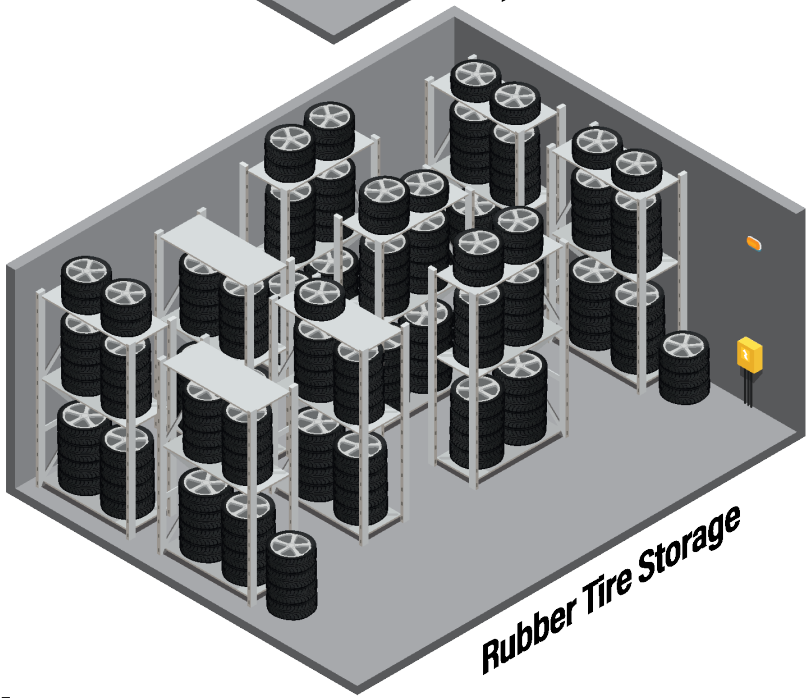




Rolled Paper Storage



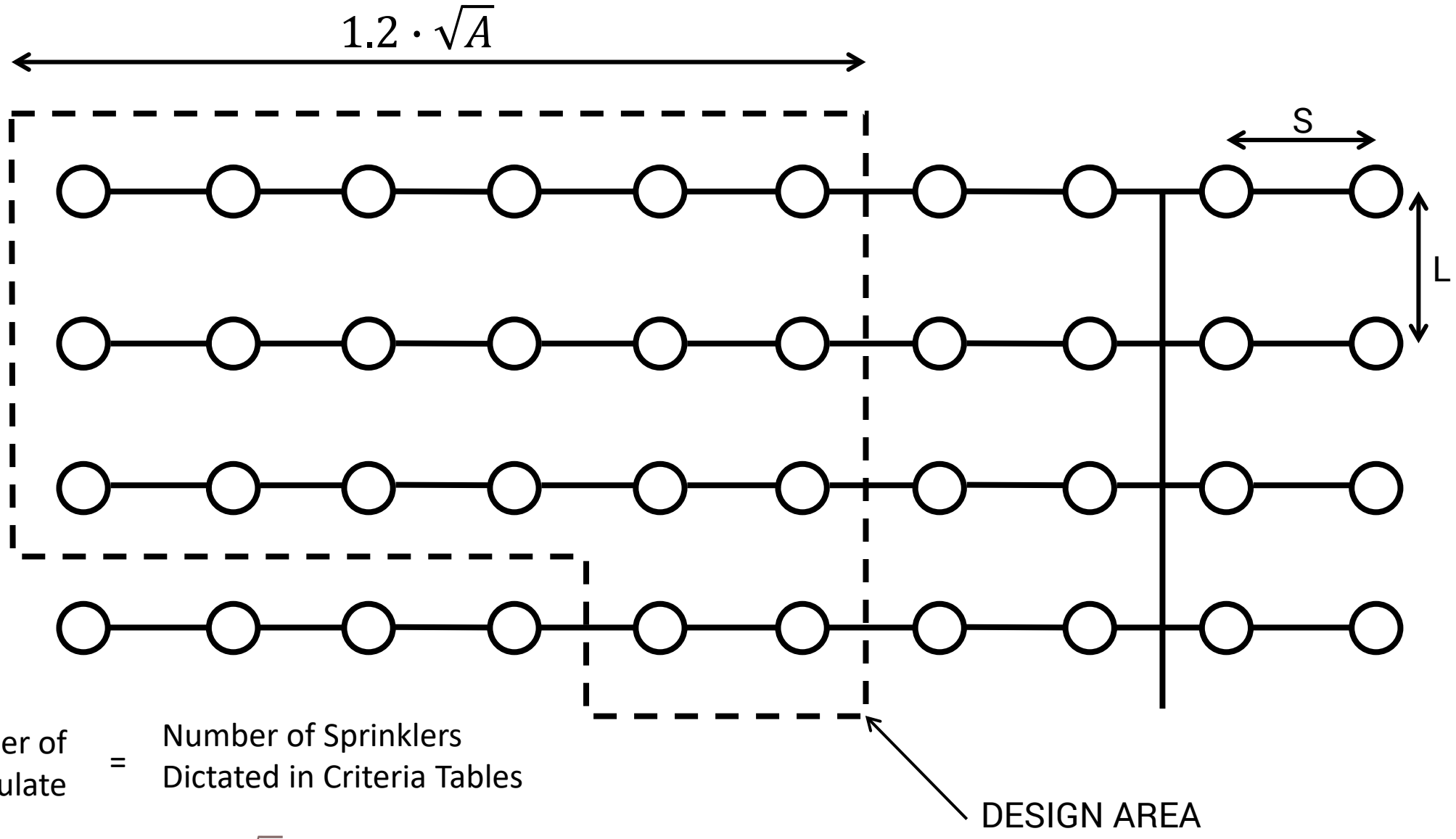
Rack Storage



Rubber Tire Storage

Palletized and solid-piled Storage

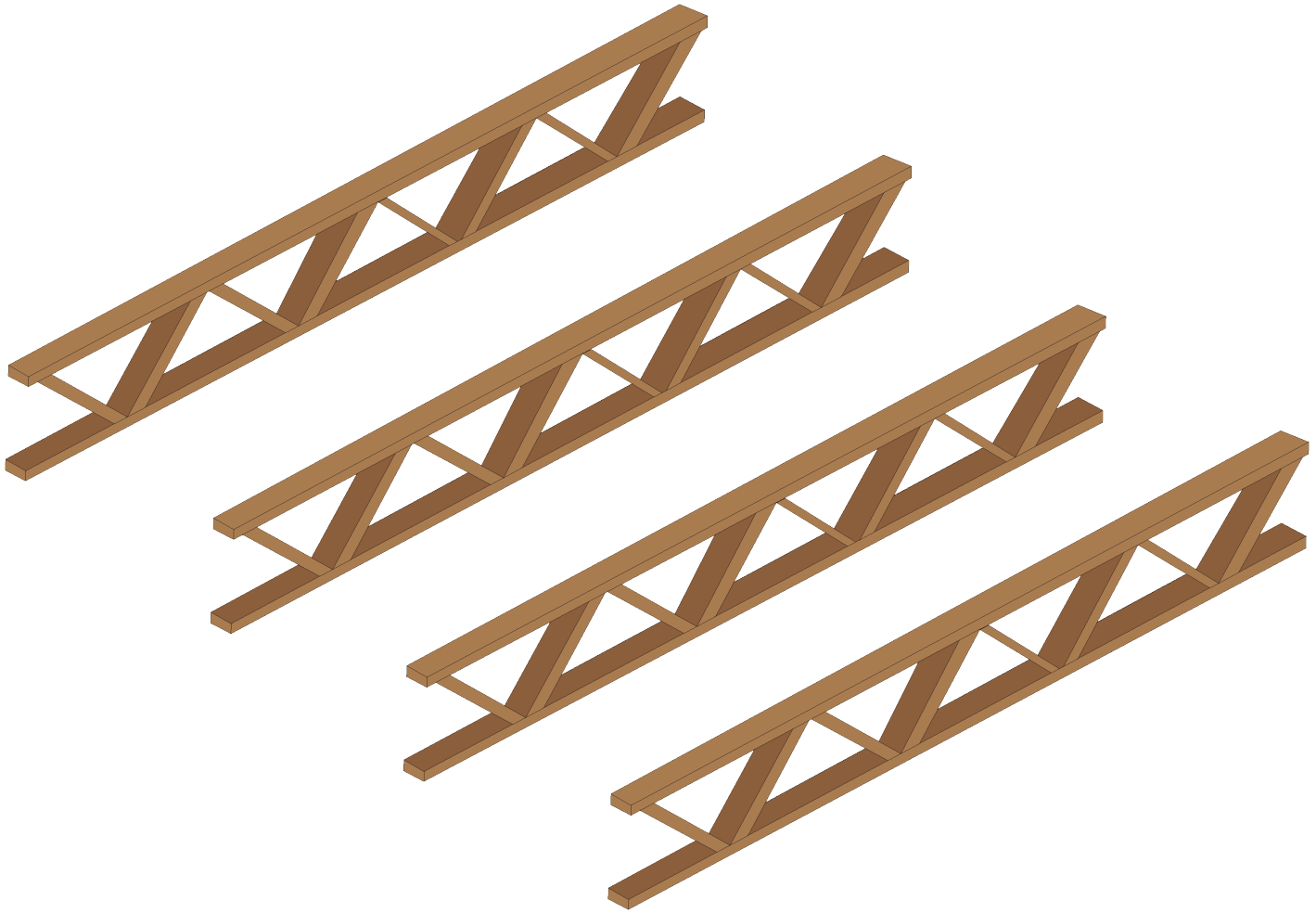
REVIEW NFPA 13 CHAPTER 22



Total Number of sprinklers to calculate = Number of Sprinklers Dictated in Criteria Tables

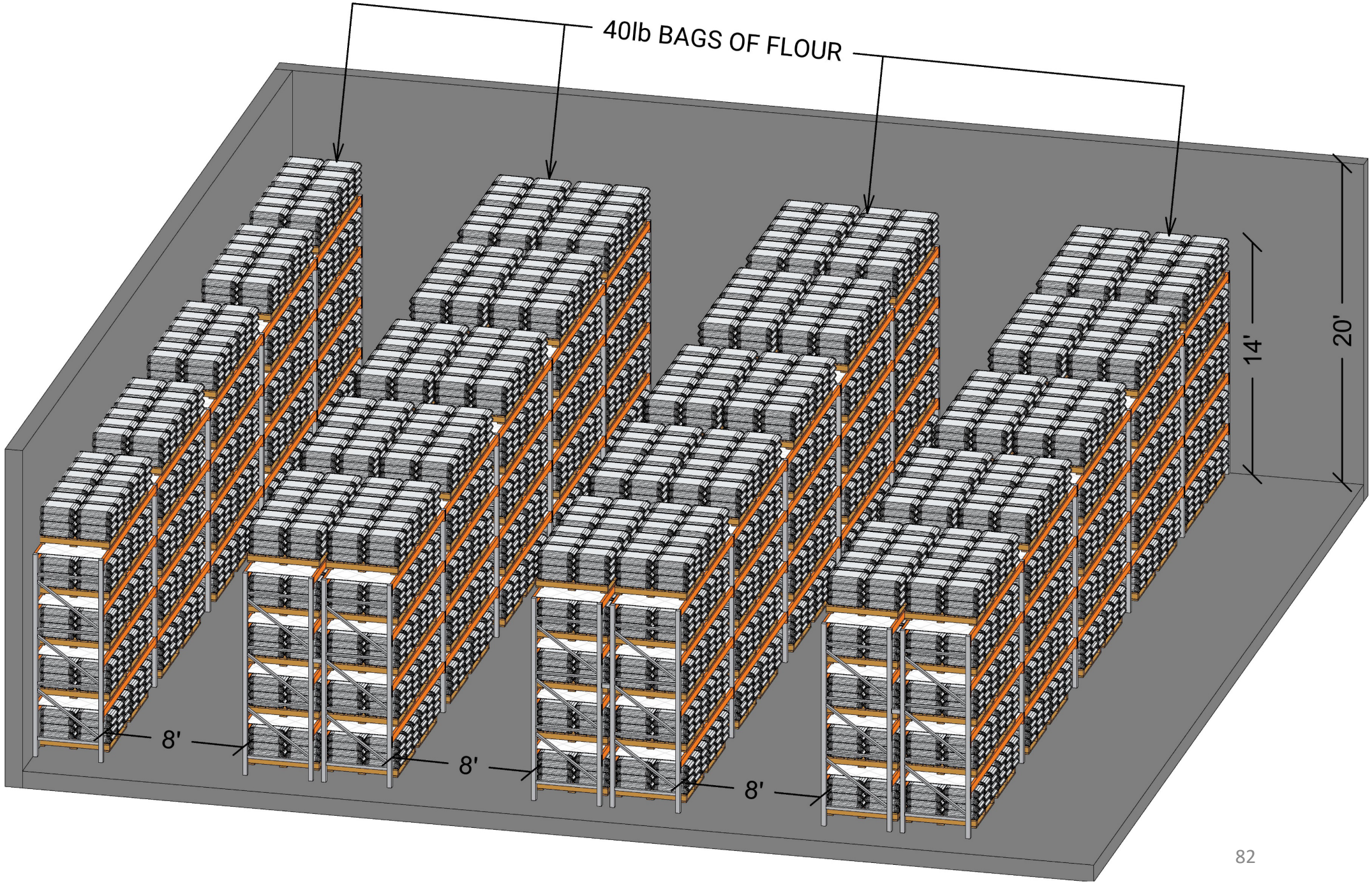
Number of Sprinklers on branch line = $\frac{1.2 \cdot \sqrt{A}}{S}$

A= (Number of Sprinklers Flowing) x (Maximum Allowable area per sprinkler, not actual area per sprinkler)



Sprinkler K Factor	Minimum Operating Pressure
K = 11.2	50
K = 16.8	22
K = 19.6 or larger	Refer to Table 22.4
K= 11.2 or 16.8 *	Refer to Table 22.4

EXAMPLE

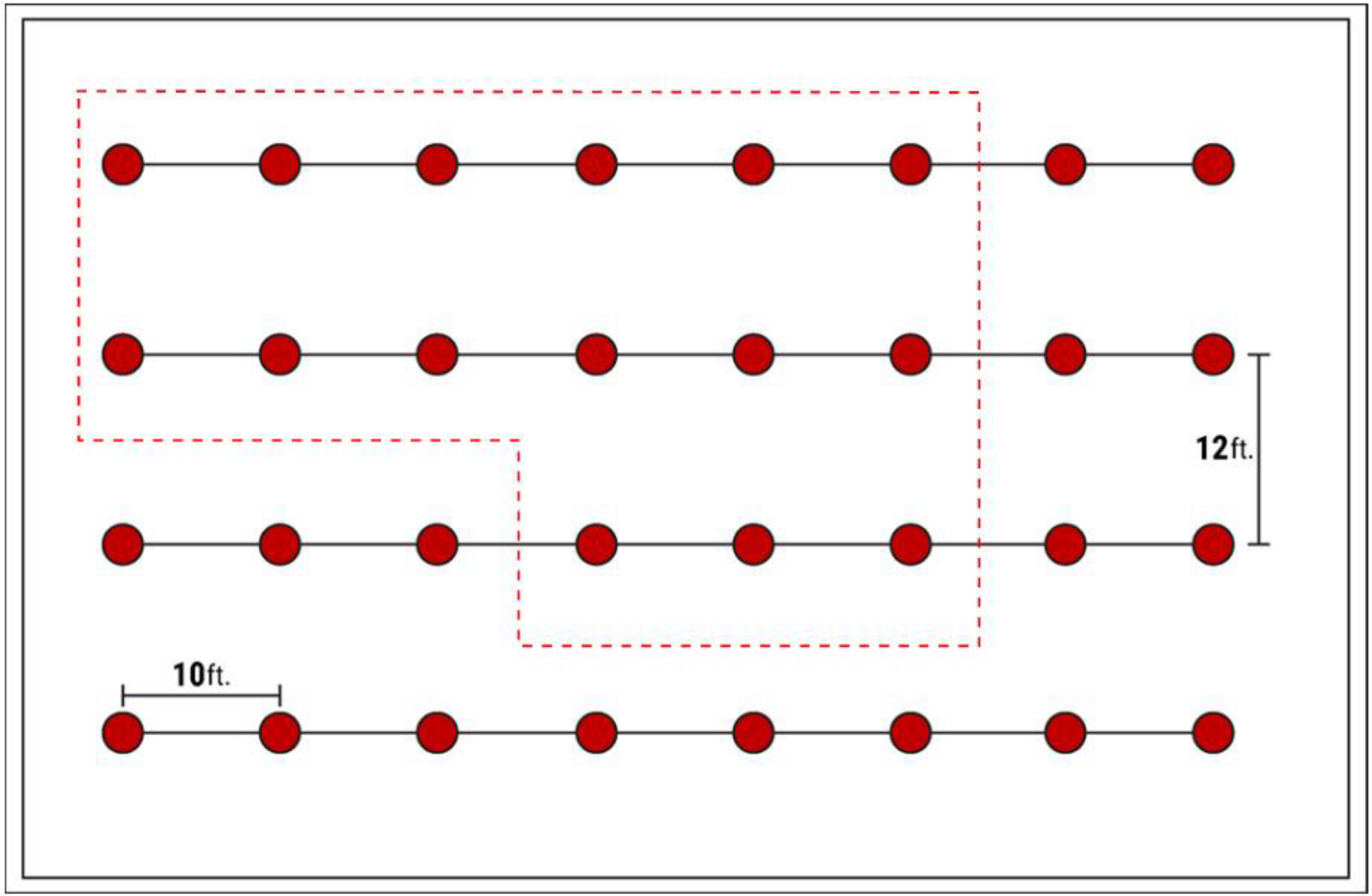


Solution:

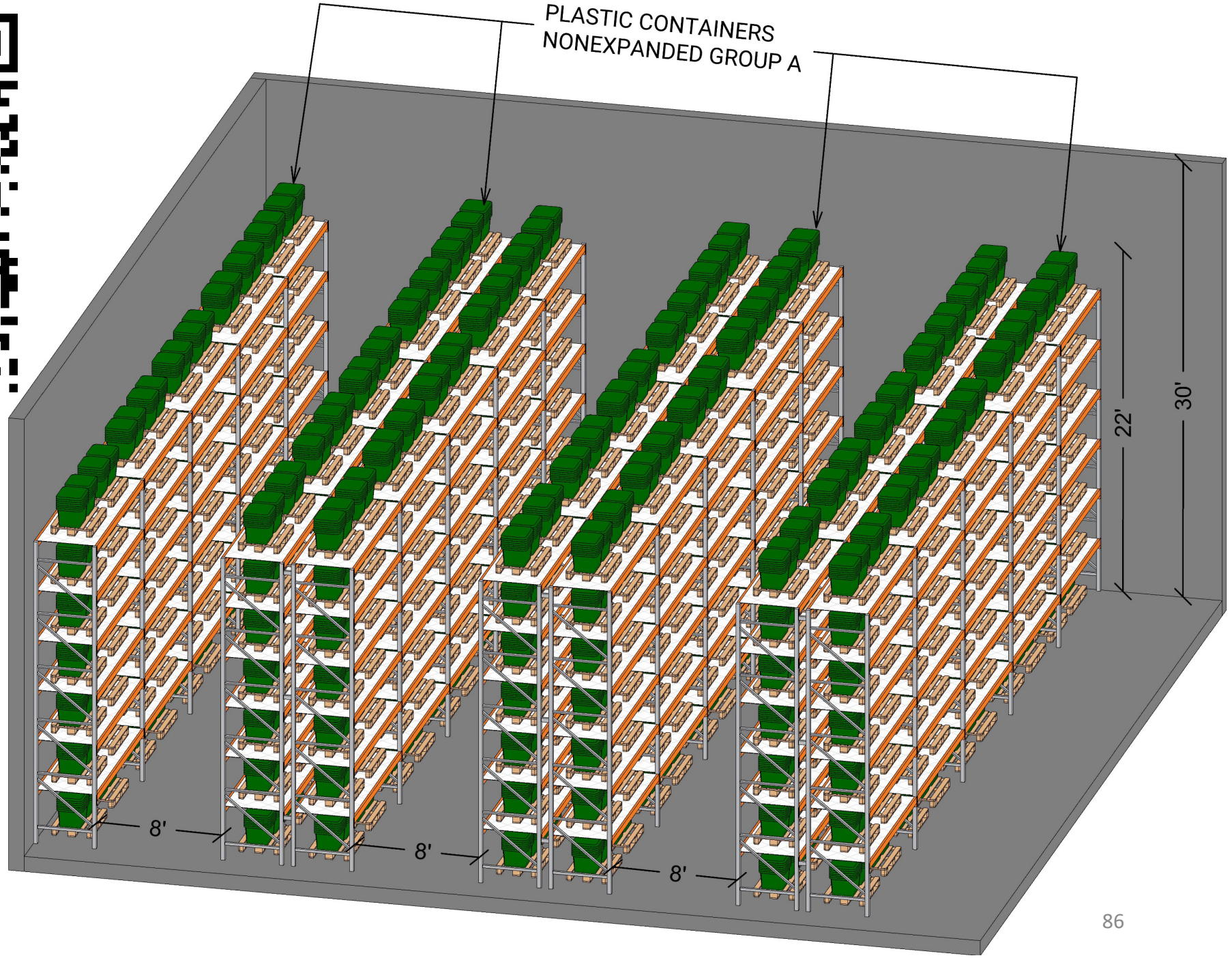
- Chapter:22
- Table 22.4
- Row for:
  - Class I or II
  - 20 ft max storage
  - 30 ft max ceiling
  - Pick 11.2K sprinklers

Results:

- 15 sprinklers
- 25 psi each
- Flow options: Calculate flow for each option using whiteboard
  - For k-11.2: $Q = k\sqrt{P} = 11.2\sqrt{25} = 56gpm$
- Assuming sprinklers are installed on 120 sq ft spacing
  - 10 ft between sprinklers on branch line
  - 12 ft between branch lines
- $Number\ of\ sprinklers\ on\ a\ branch\ line = \frac{1.2\sqrt{Area}}{S} = \frac{1.2\sqrt{(130)(15)}}{10} = 5.3 \approx 6$
  - 6 sprinklers per branch line
  - 15 sprinklers in design area
  - 6 sprinklers on 2 branch lines + 3 sprinklers on 4th

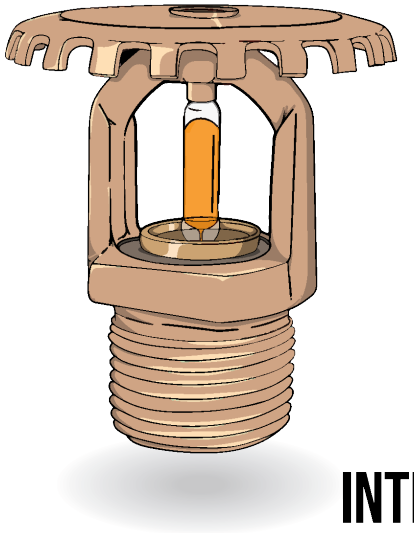

12ft.
10ft.

ASSESSMENT

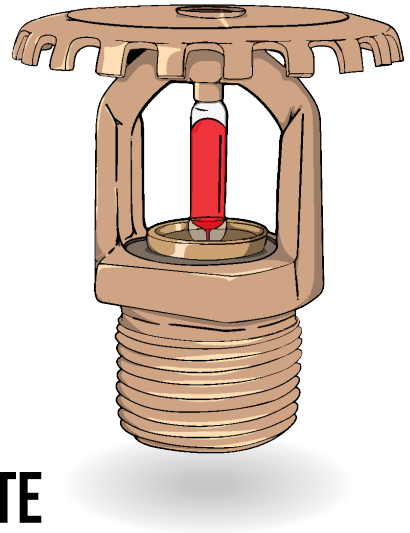


Conversation Quiz

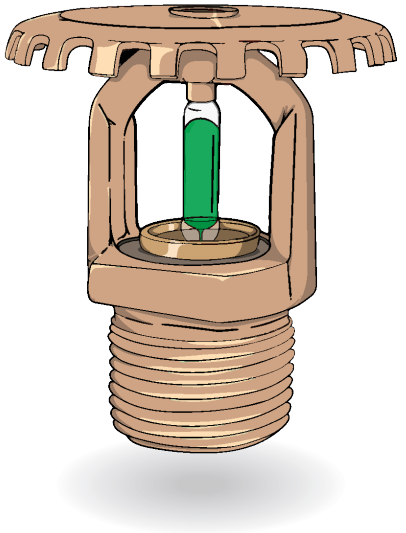
ORDINARY



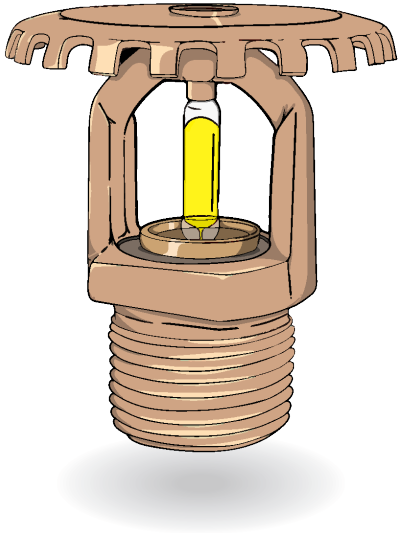
ORDINARY



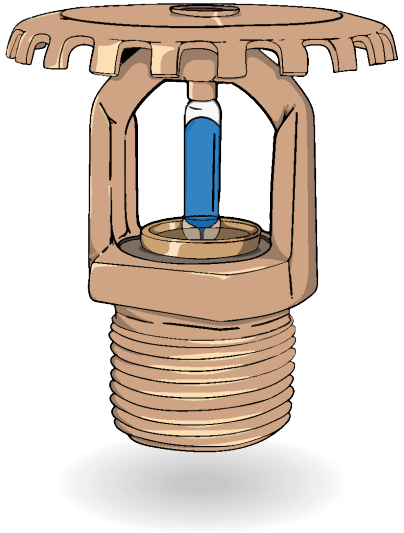
INTERMEDIATE



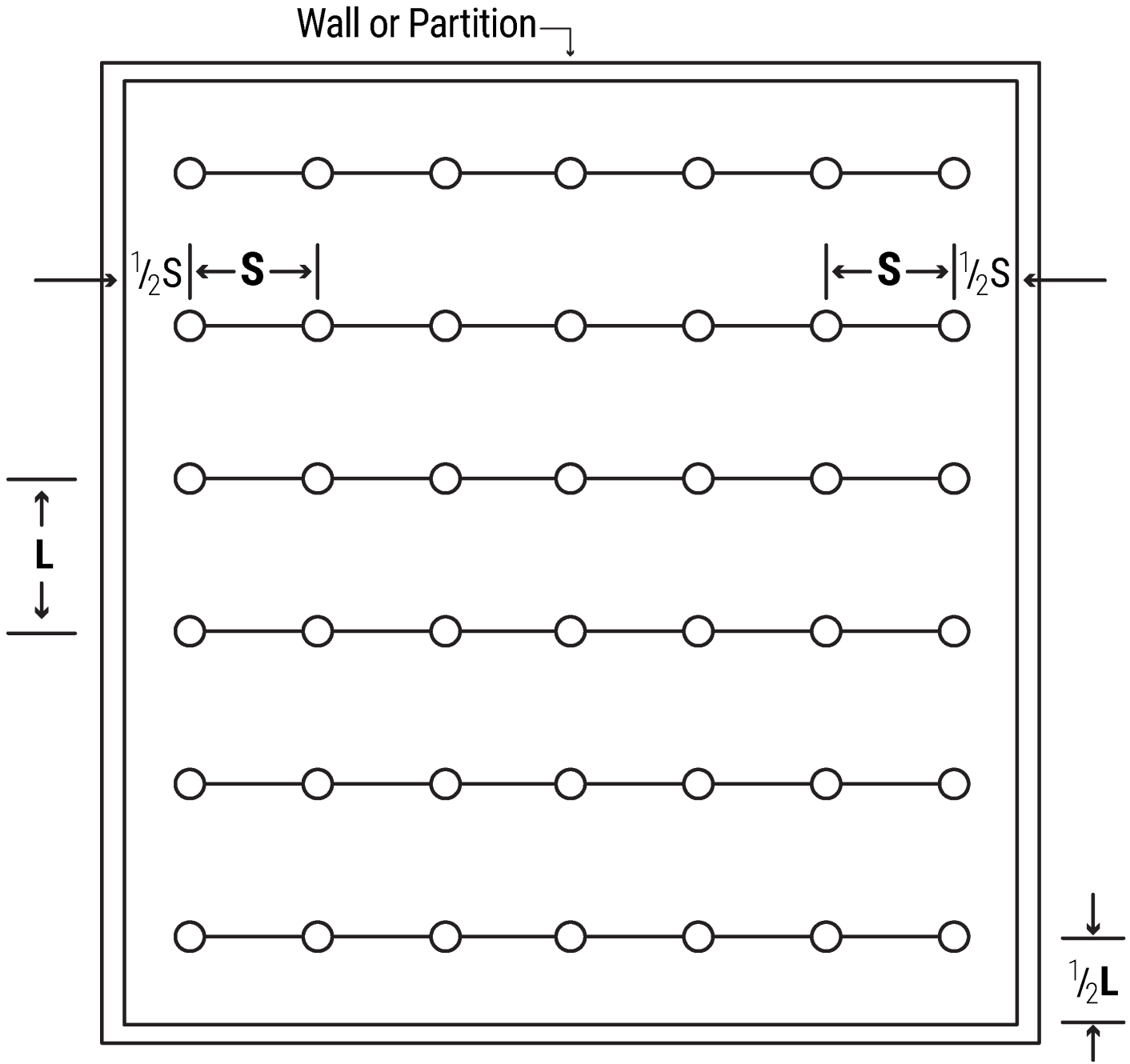
INTERMEDIATE

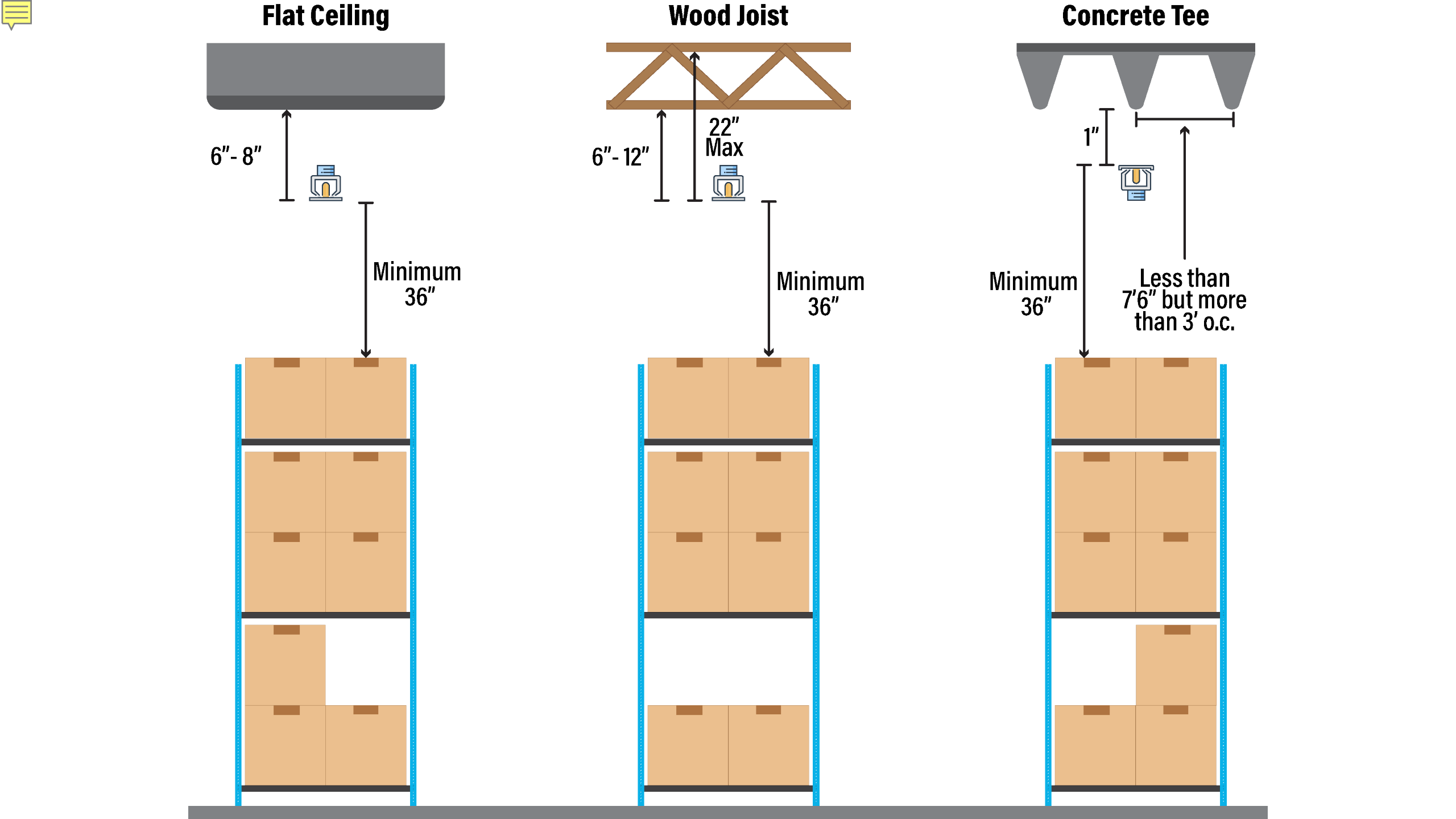


HIGH

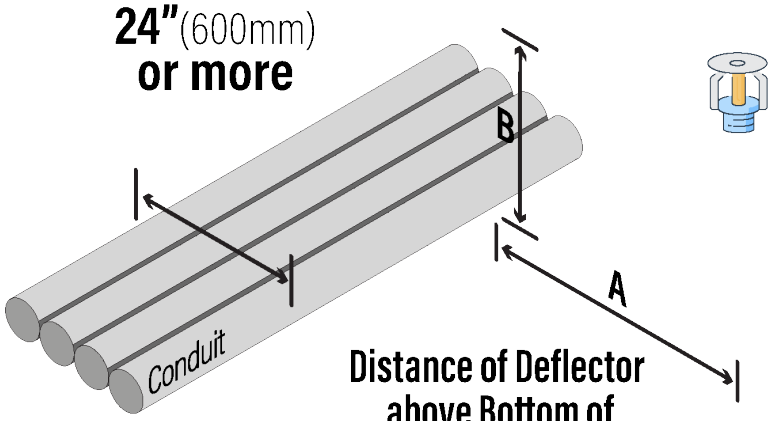


Construction Type	Protection Area	Maximum Spacing
Noncombustible	130 sqft	12 ft
Combustible Unobstructed	130 sqft	12 ft
Combustible Obstructed	100 sqft	10 ft
Rack Storage: All Construction Unobstructed and Noncombustible Obstructed	100 sqft	12 ft


Wall or Partition
½S
S
S
½S
L
½L


Flat Ceiling
6" - 8"
Minimum
36"
Wood Joist
6" - 12"
22"
Max
Minimum
36"
Concrete Tee
1"
Minimum
36"
Less than
7'6" but more
than 3' o.c.

13.2.8.3.



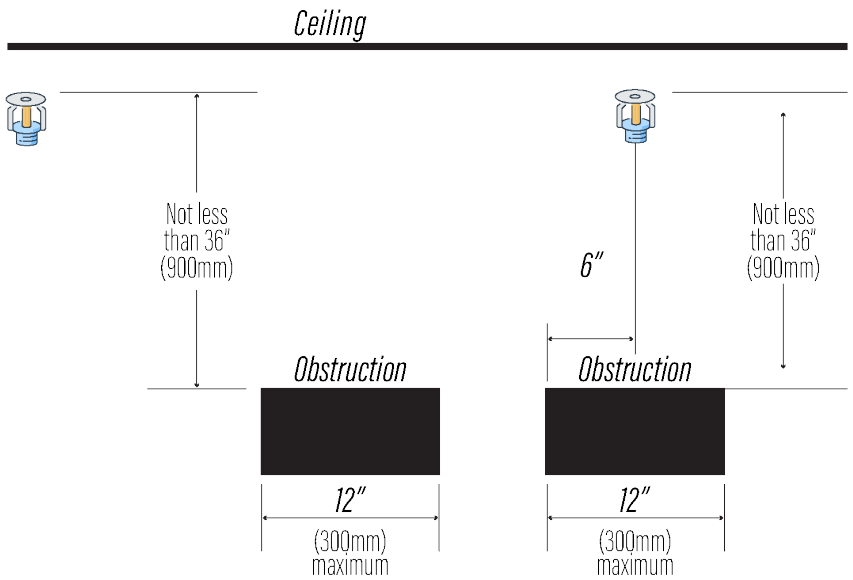
Minimum Distance to Side of Obstruction. (A)

Distance of Deflector above Bottom of Obstruction. (B)

2

Less than 6" (150mm)	1.5" (40mm)
6" (150mm) to less than 12" (300mm)	3" (75mm)
12" (300mm) to less than 18" (450mm)	4" (100mm)
10" (450mm) to less than 24" (600mm)	5" (125mm)
24" (600mm) to less than 30" (750mm)	5.5" (140mm)
30" (750mm) to less than 36" (900mm)	6" (150mm)

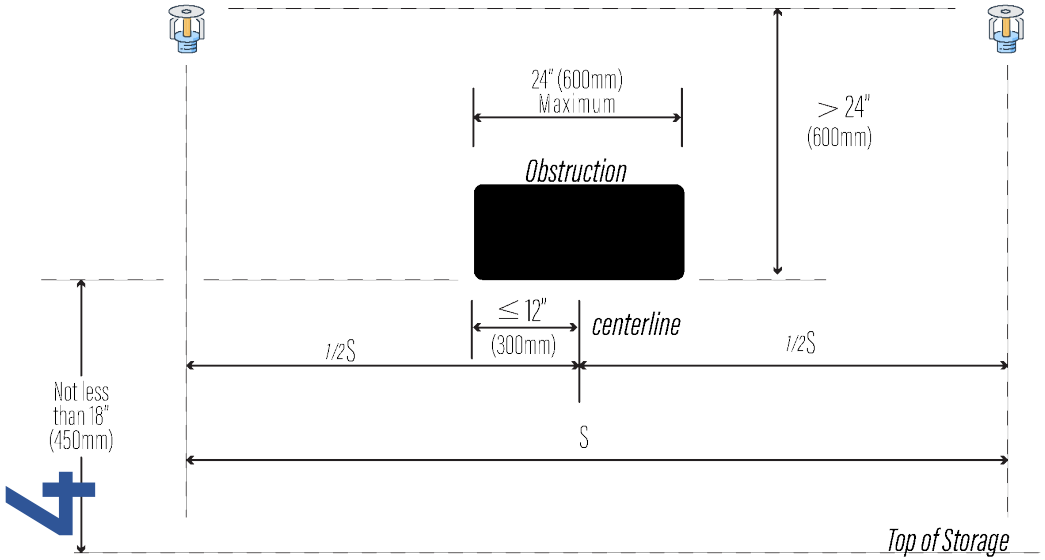
13.2.8.3.



5

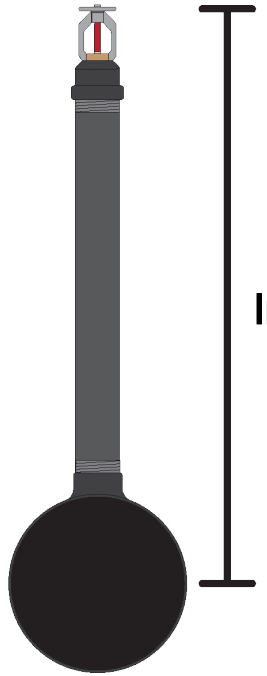
13.2.8.3.

4



13.2.8.2.

Up to 4 Inches



>4 Inch

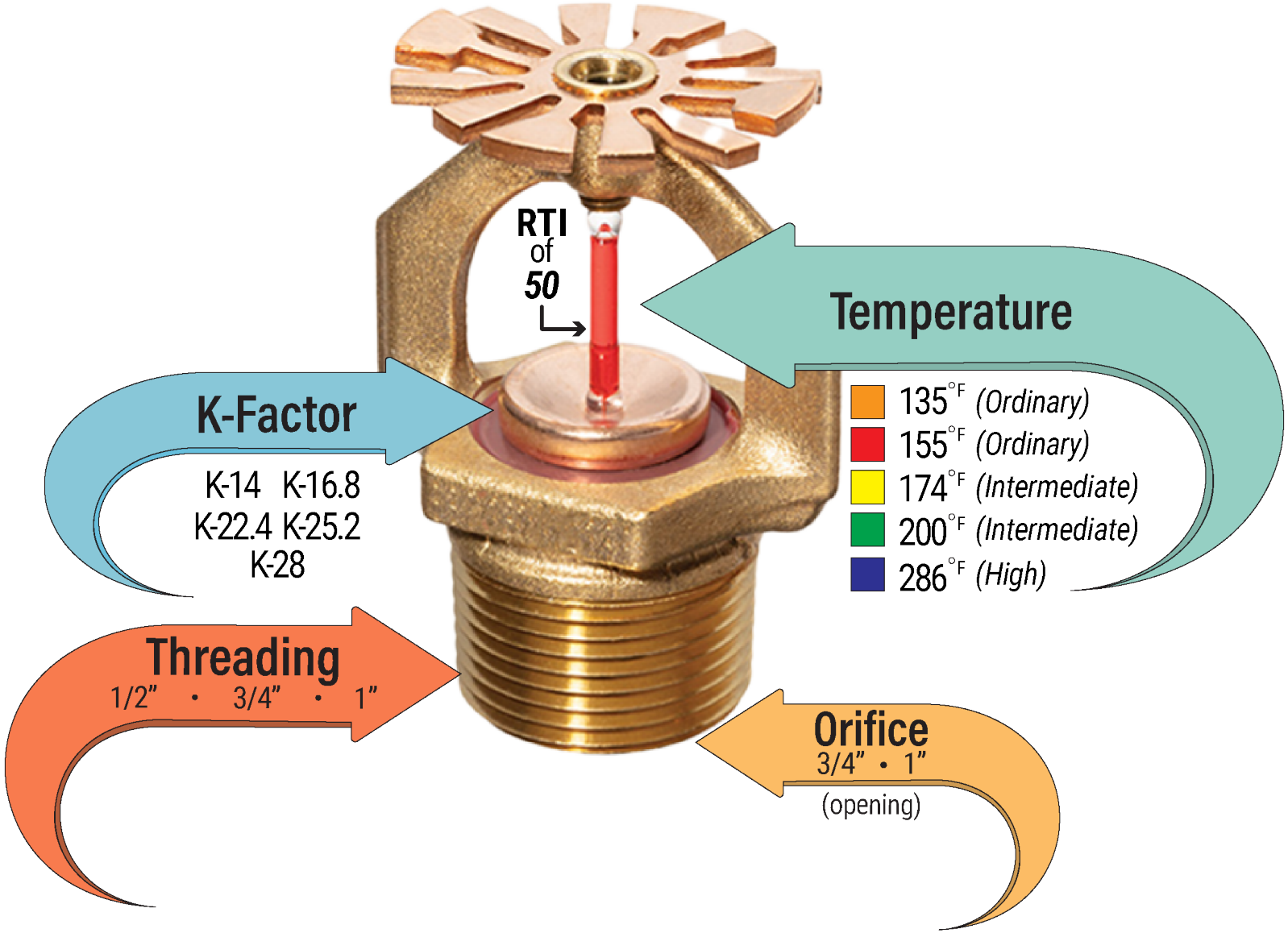
2

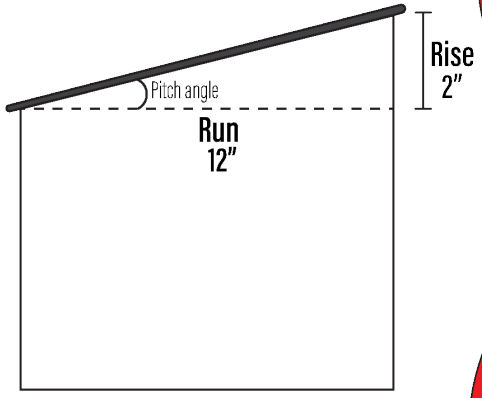
Module Assessment

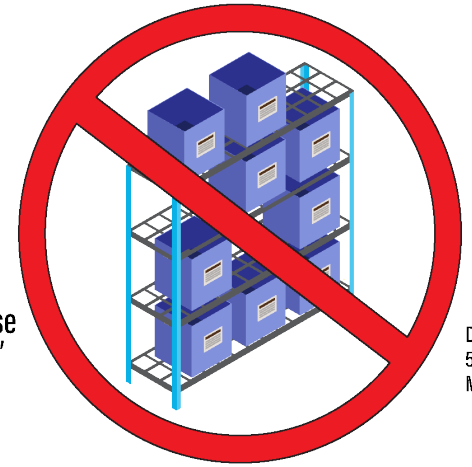
What is the primary different between an ESFR sprinkler And CMDA/CMSA Sprinkler?

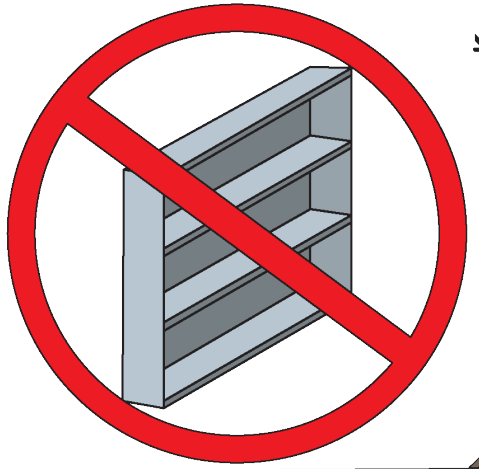
Hint: It’s in the name.

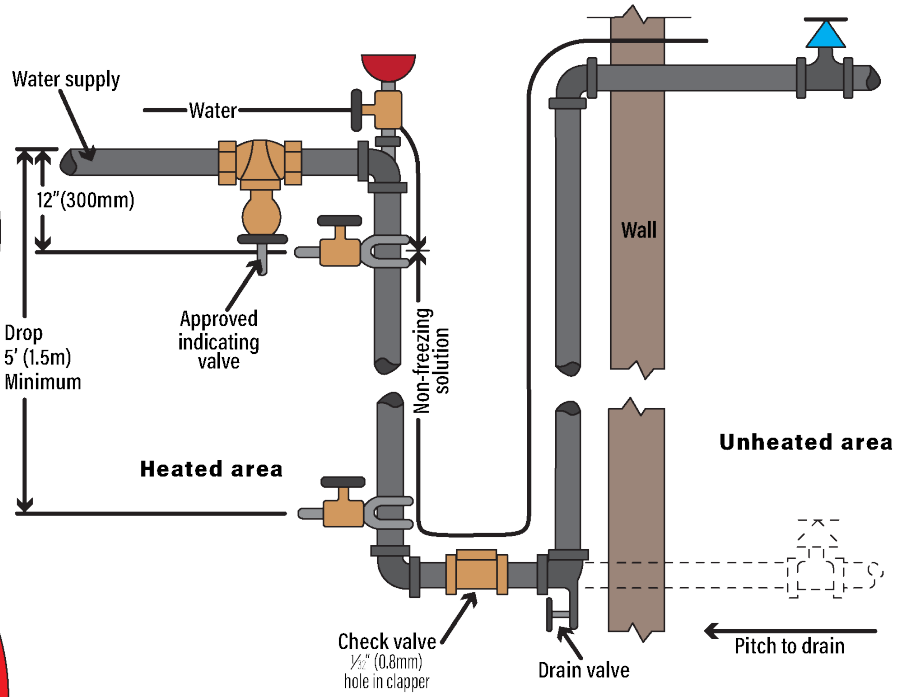
ESFR
fire sprinkler

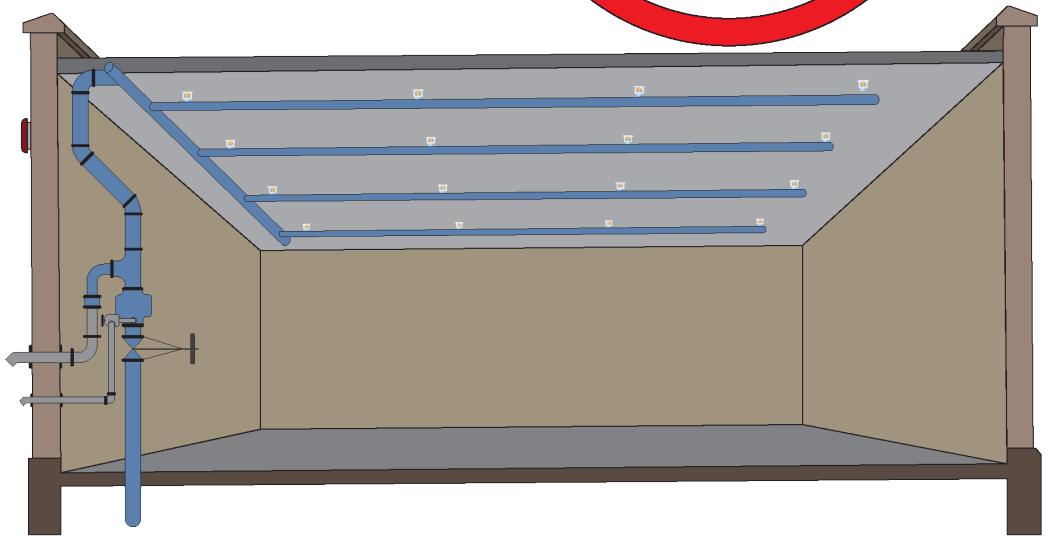


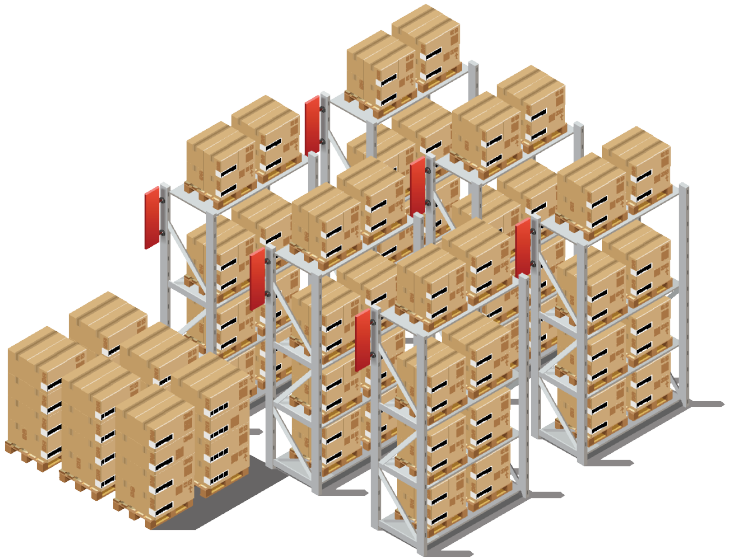






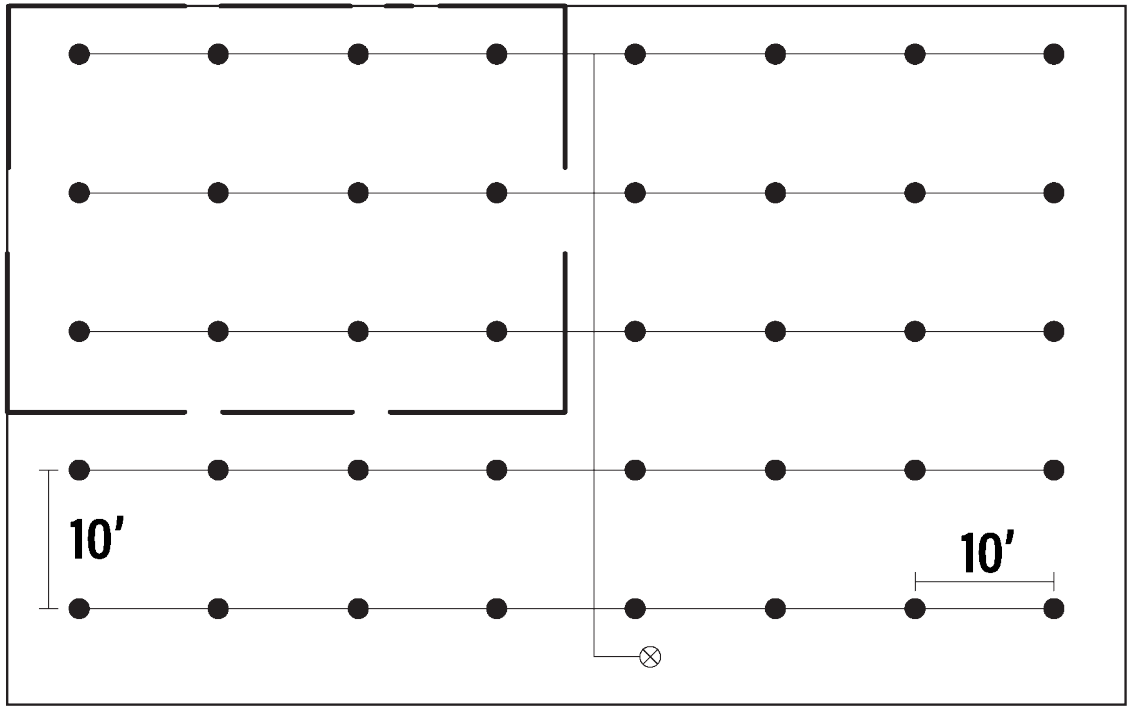






Class I-IV Commodities / Group A Plastics /
Flammable and Combustible Liquids

CHAPTER 23
(OPEN NFPA 13)

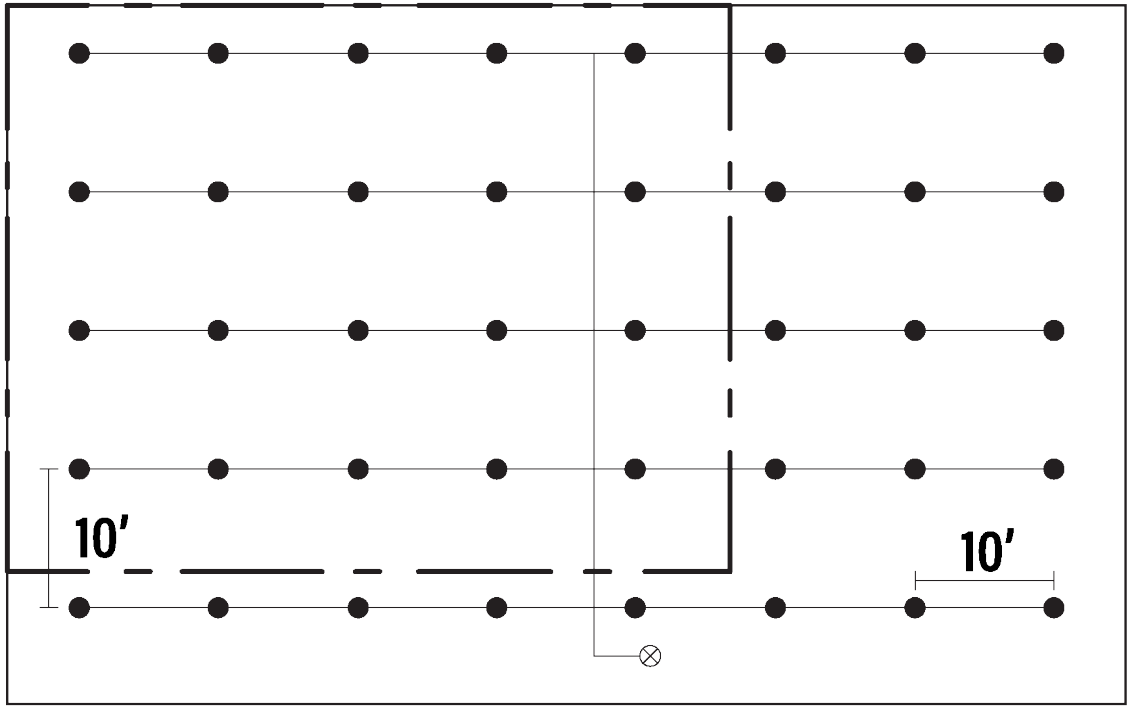


ESFR
Design Area
-Most Criteria

12 Sprinklers

3 Branch Lines

4 Sprinklers per Branch Line



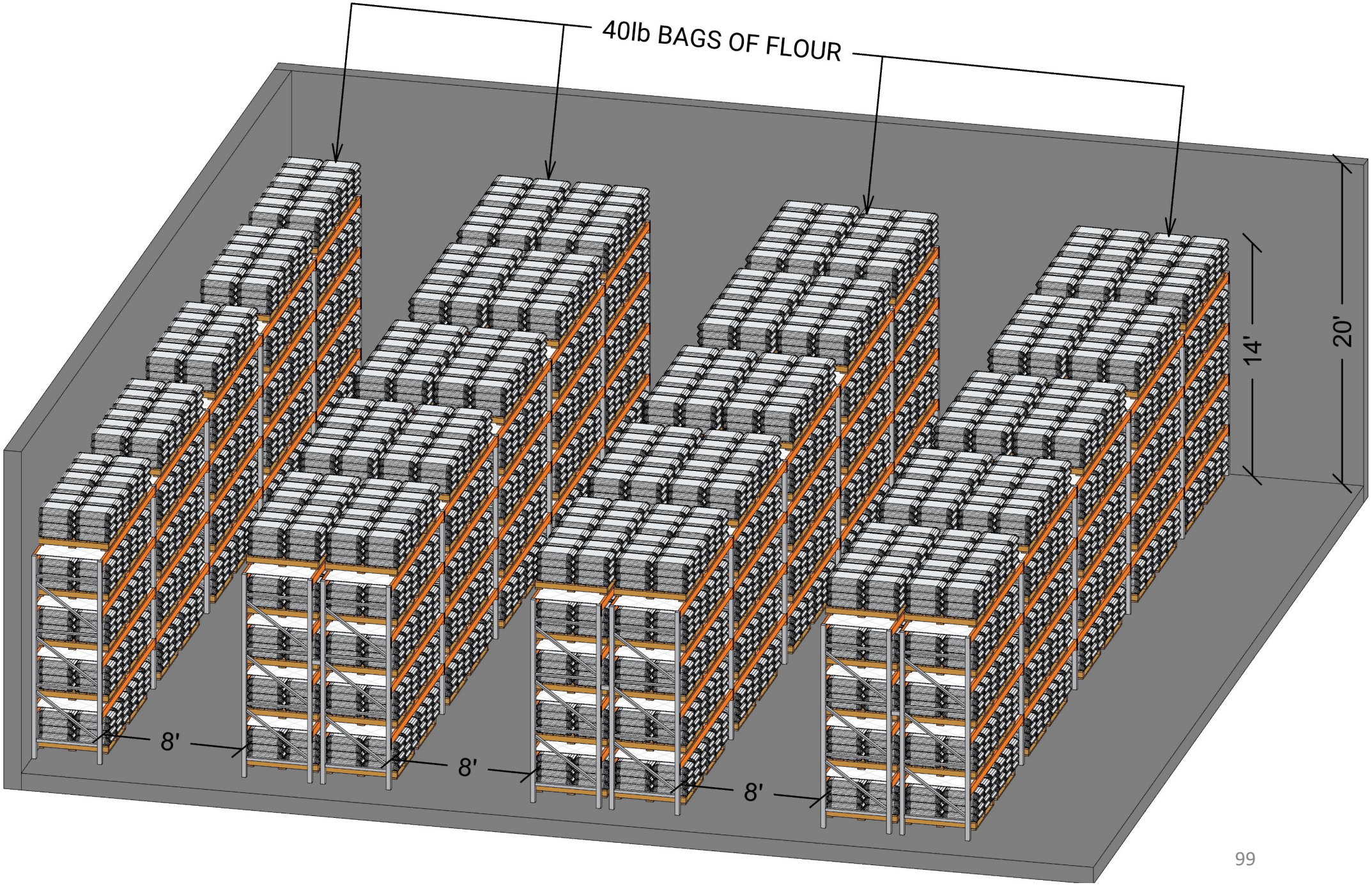
ESFR
Design Area
-Rubber Tires

20 Sprinklers

4 Branch Lines

5 Sprinklers per Branch Line

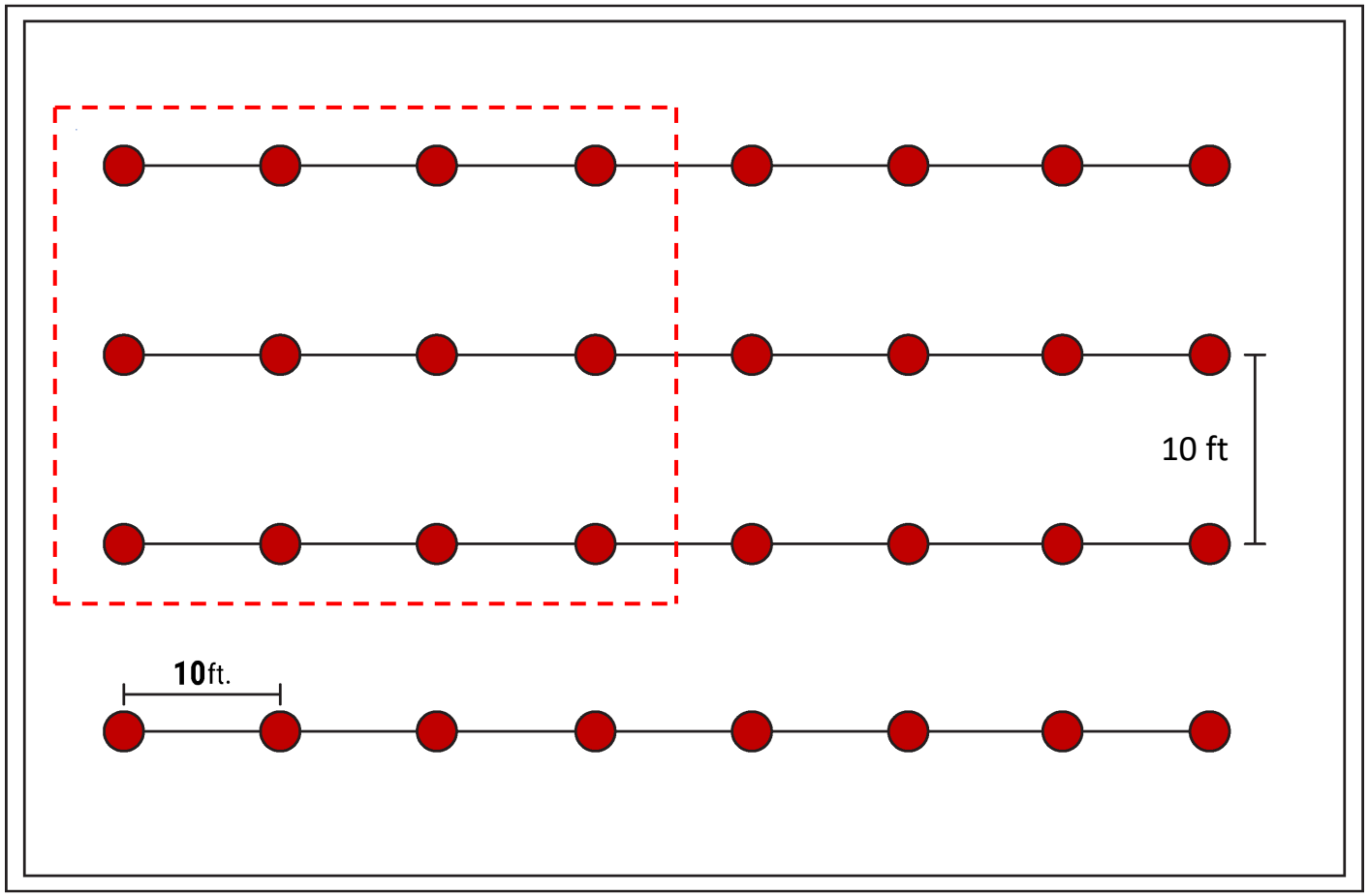
EXAMPLE



SOLUTION

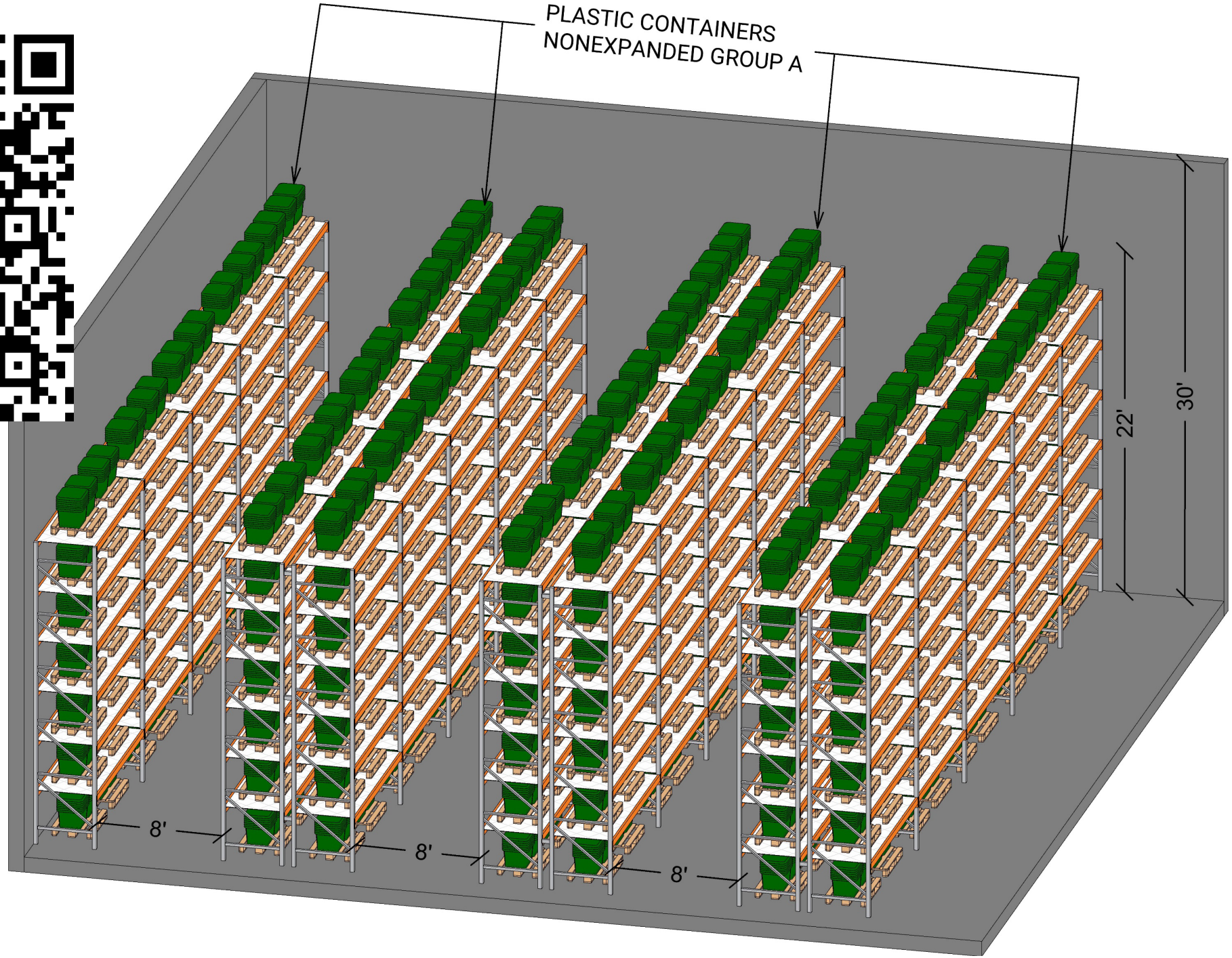
- Chapter:23
- Table 23.5.1
- Row :
  - Class I, II, III, or IV
  - 20 ft max storage
  - 25 ft max ceiling
  - Pick 16.8K sprinklers (14K, 22.4K and 25.2K are also options

RESULTS

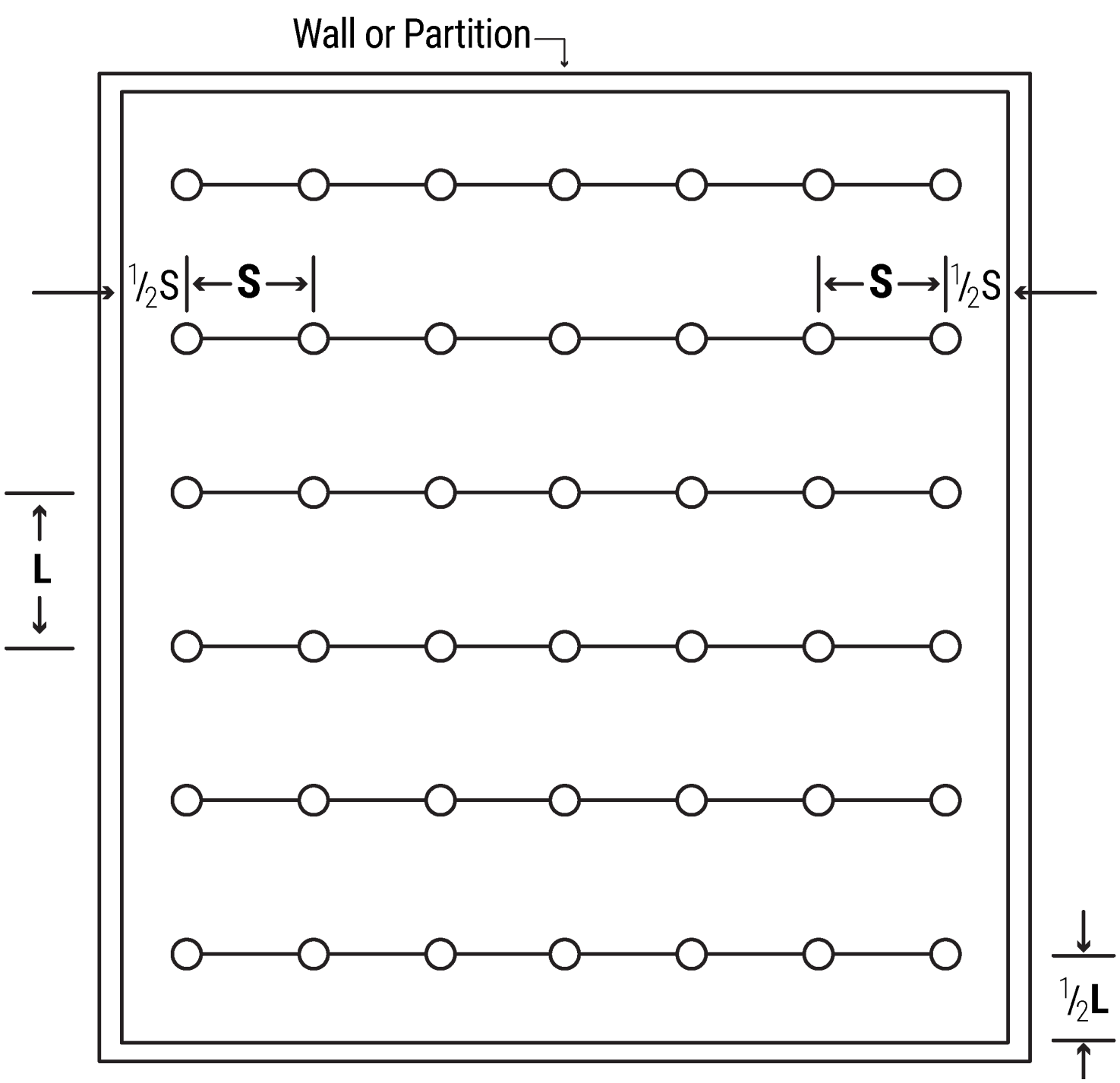


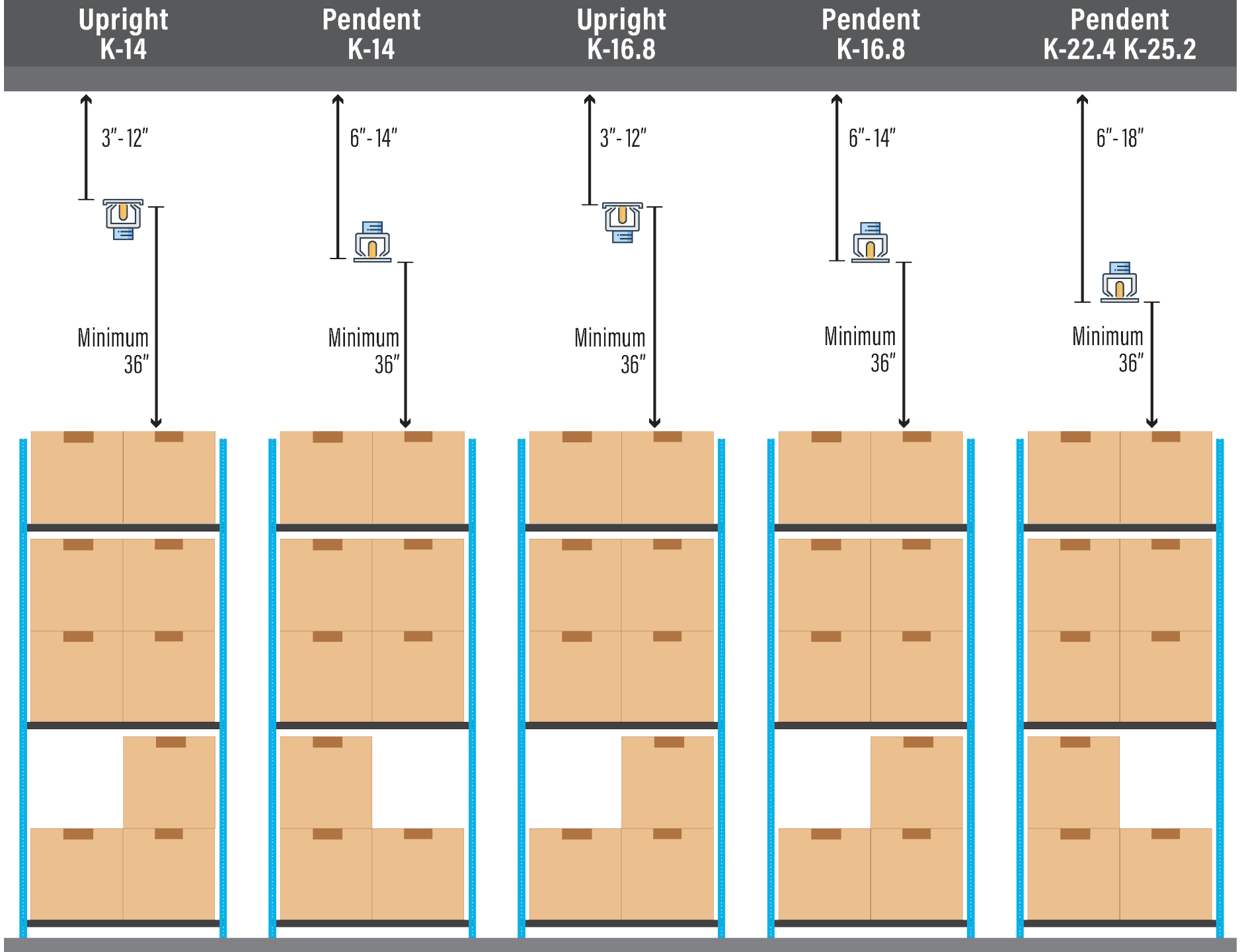
- Each sprinkler flowing at 35 psi
- Per Section 27.2.4.4 we must calculate 12 sprinklers total, 4 sprinklers along 3 different branch lines
- For K-16.8: $Q = k\sqrt{P} = 16.8\sqrt{35} = 99gpm$ per sprinkler

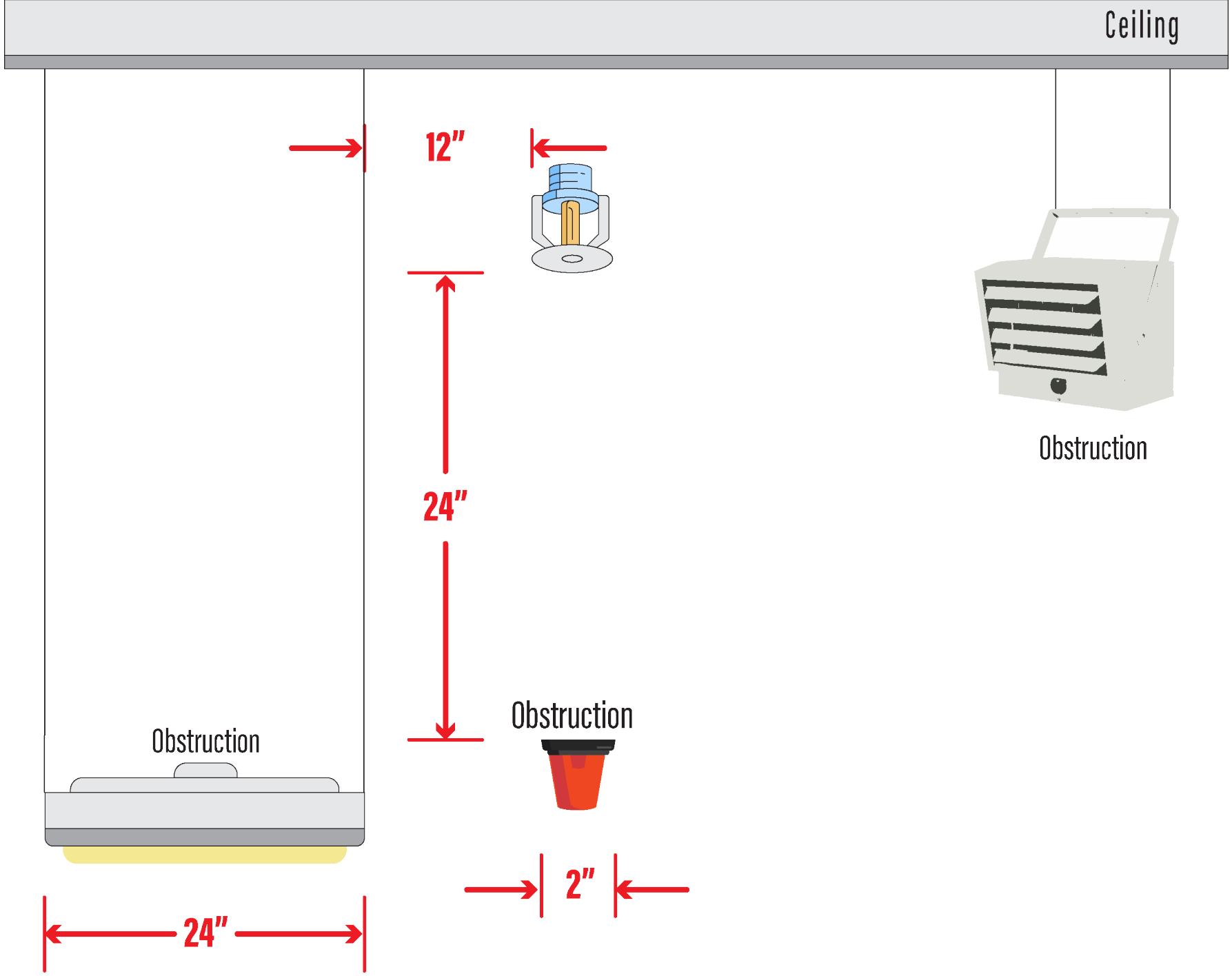
ASSESSMENT

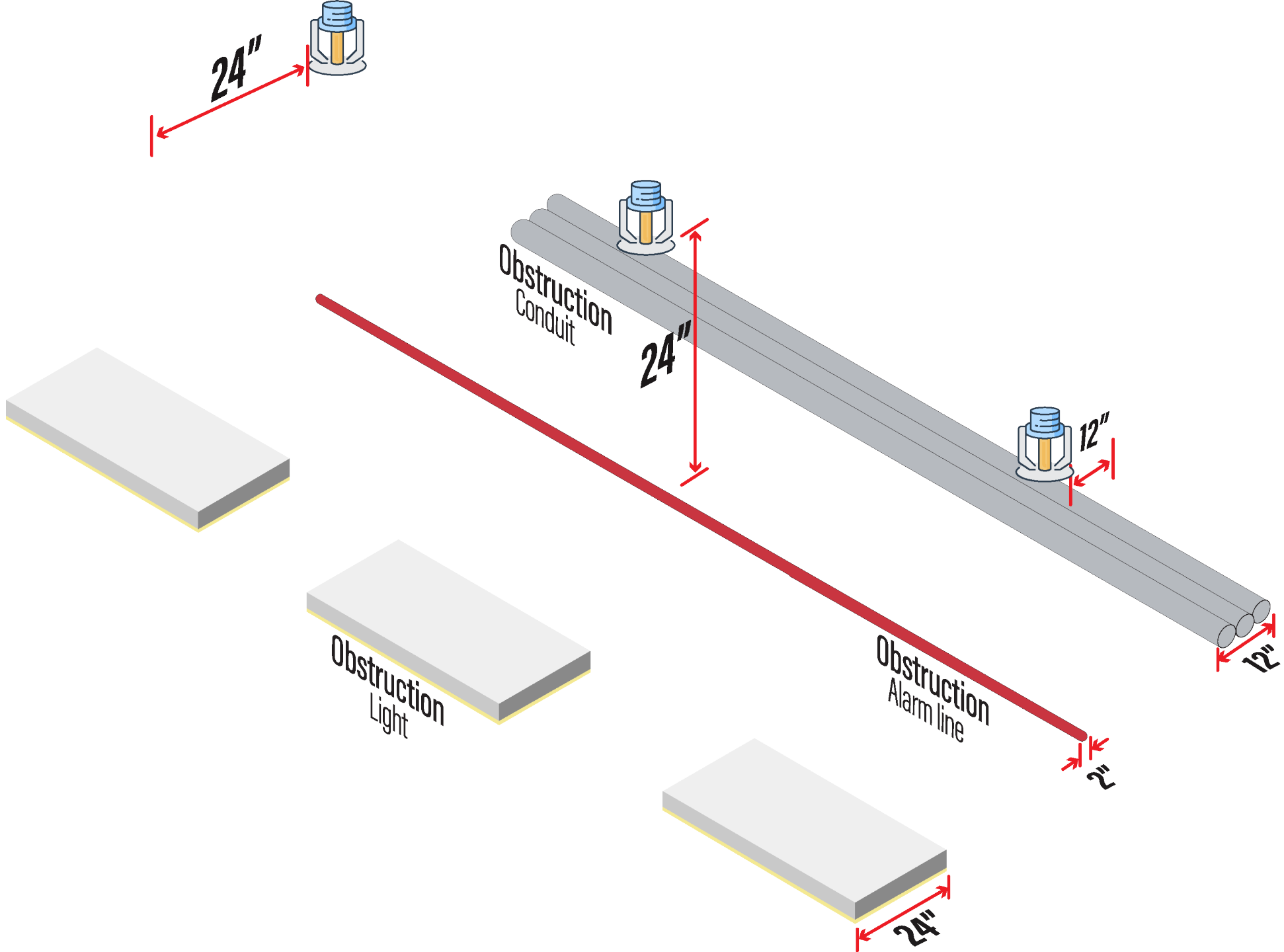


Conversation Quiz

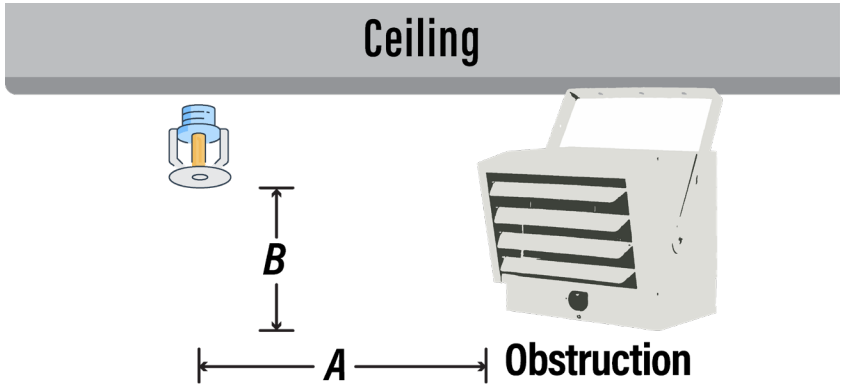

Wall or Partition
½S
S
S
½S
L
½L


Upright
K-14
Pendent
K-14
Upright
K-16.8
Pendent
K-16.8
Pendent
K-22.4 K-25.2
3" - 12"
6" - 14"
3" - 12"
6" - 14"
6" - 18"
Minimum
36"
Minimum
36"
Minimum
36"
Minimum
36"
Minimum
36"


Ceiling
12"
24"
Obstruction
Obstruction
Obstruction
2"
24"

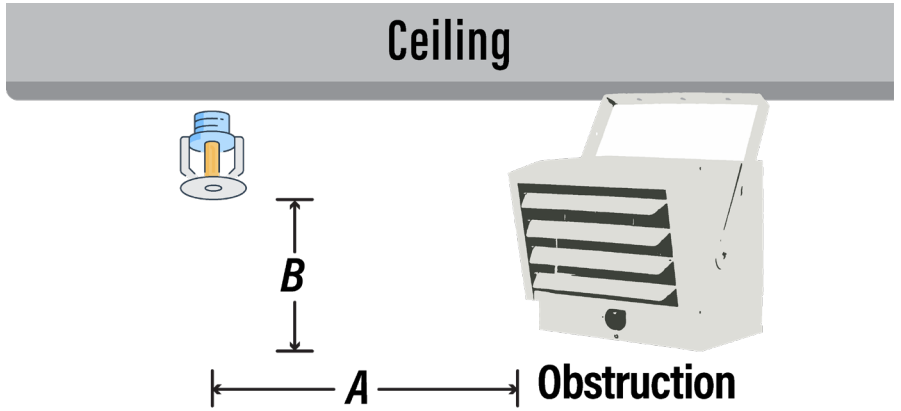

24"
Obstruction
Conduit
24"
12"
12"
Obstruction
Light
Obstruction
Alarm line
2"
24"

STANDARD SPRAY

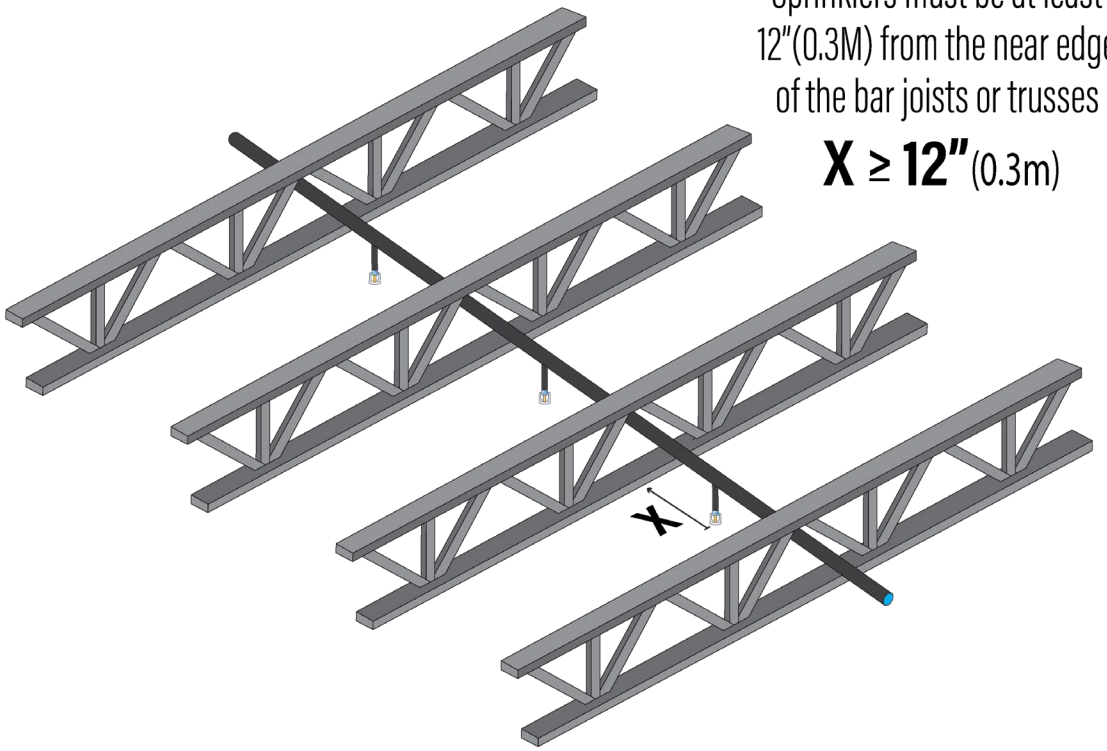


Distance from Sprinkler to Side of Obstruction. (A)	Maximum allowable distance of deflector above bottom of obstruction. (B) *[in. (mm)]*
Less than 1′ (300mm)	0 (0)
1′ (300mm) to less than 1′-6″ (450mm)	2.5 (65)
1′-6″(450mm) to less than 2′ (600mm)	3.5 (90)
2′ (600mm) to less than 2′-6″(750mm)	5.5 (140)
2′-6″(750mm) to less than 3′ (900mm)	7.5 (190)
3′ (900mm) to less than 3′-6″(1.1m)	9.5 (240)
3′-6″(1.1m) to less than 4′(1.2m)	12 (300)
4′ (1.2m) to less than 4′-6″ (1.4m)	14 (350)
4′-6″ (1.4m) to less than 5′ (1.5m)	16.5 (415)
5′ (1.5) to less than 5′-6″ (1.7m)	18 (450)
5′-6″ (1.7m) to less than 6′ (1.8m)	20 (500)
6′ (1.7m) to less than 6′-6″ (2.0m)	24 (600)
6′-6″ (1.7m) to less than 7′ (2.1m)	30 (750)
7′ (1.7m) to less than 7′-6″ (2.3m)	35 (875)

ESFR

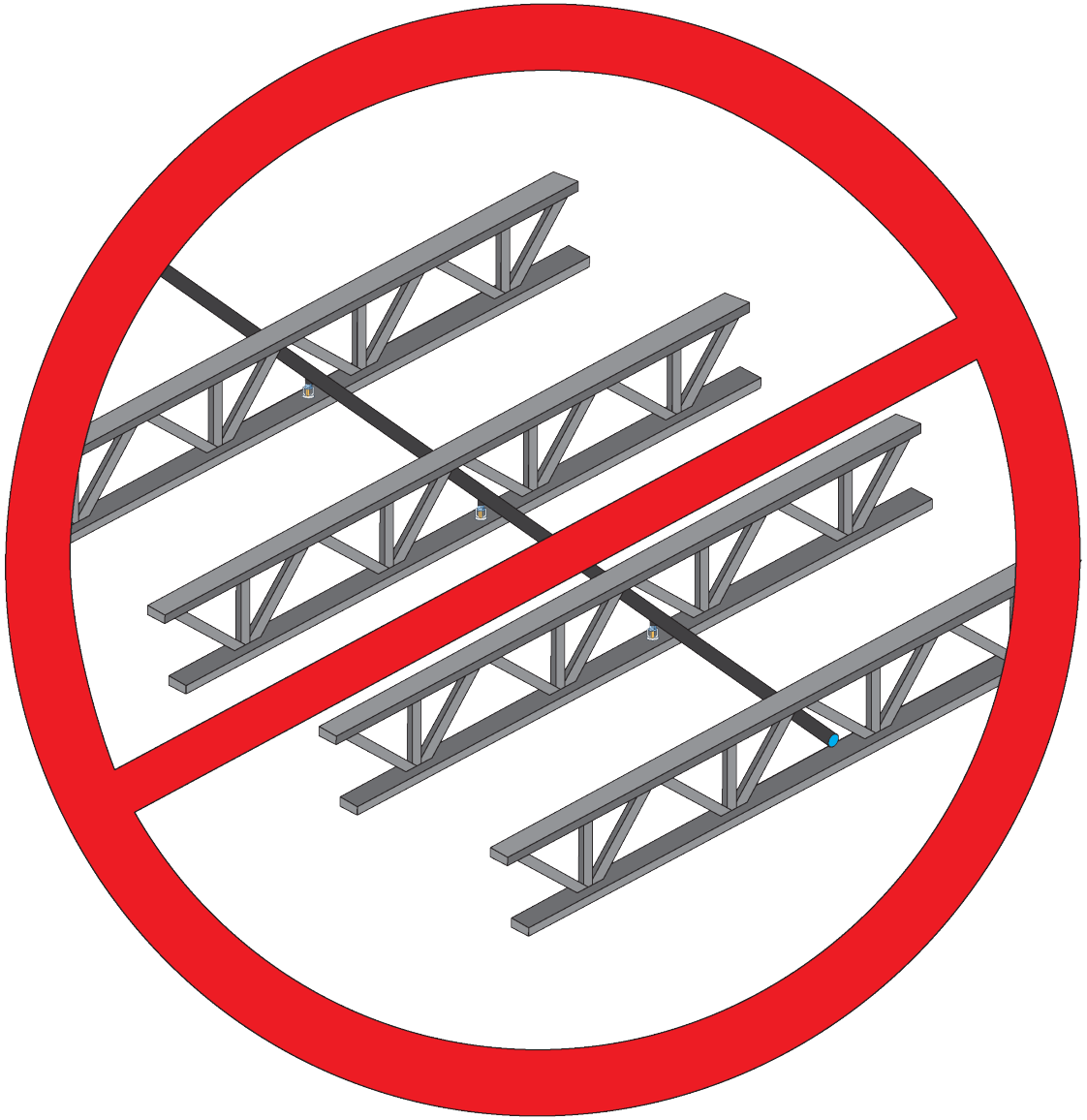


Distance from Sprinkler to Side of Obstruction. (A)	Maximum allowable distance of deflector above bottom of obstruction. (B) *[in. (mm)]*
Less than 1′ (300mm)	0″ (0)
1′ (300mm) to less than 1′-6″ (450mm)	1.5″ (40)
1′-6″(450mm) to less than 2′ (600mm)	3″ (75)
2′ (600mm) to less than 2′-6″(750mm)	5.5″ (140)
2′-6″(750mm) to less than 3′ (900mm)	8″ (200)
3′ (900mm) to less than 3′-6″(1.1m)	10″ (250)
3′-6″(1.1m) to less than 4′(1.2m)	12″ (300)
4′ (1.2m) to less than 4′-6″ (1.4m)	15″ (375)
4′-6″ (1.4m) to less than 5′ (1.5m)	18″ (450)
5′ (1.5) to less than 5′-6″ (1.7m)	22″ (550)
5′-6″ (1.7m) to less than 6′ (1.8m)	26″ (650)
6′ (1.8m)	31″ (775)

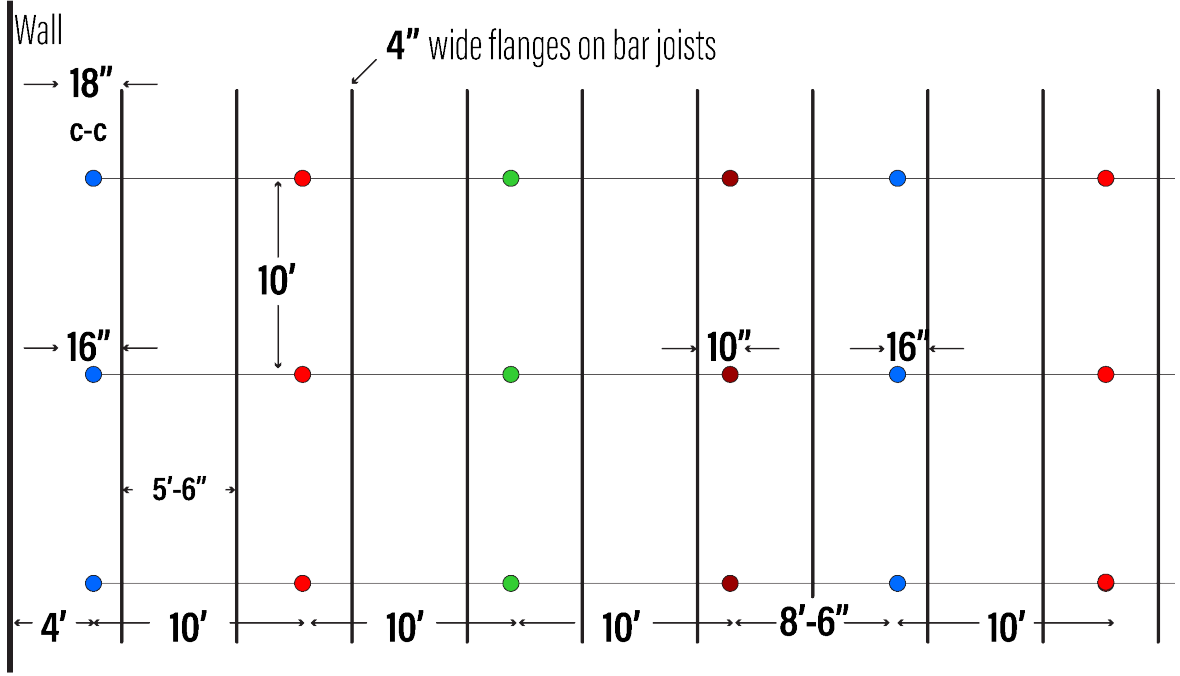


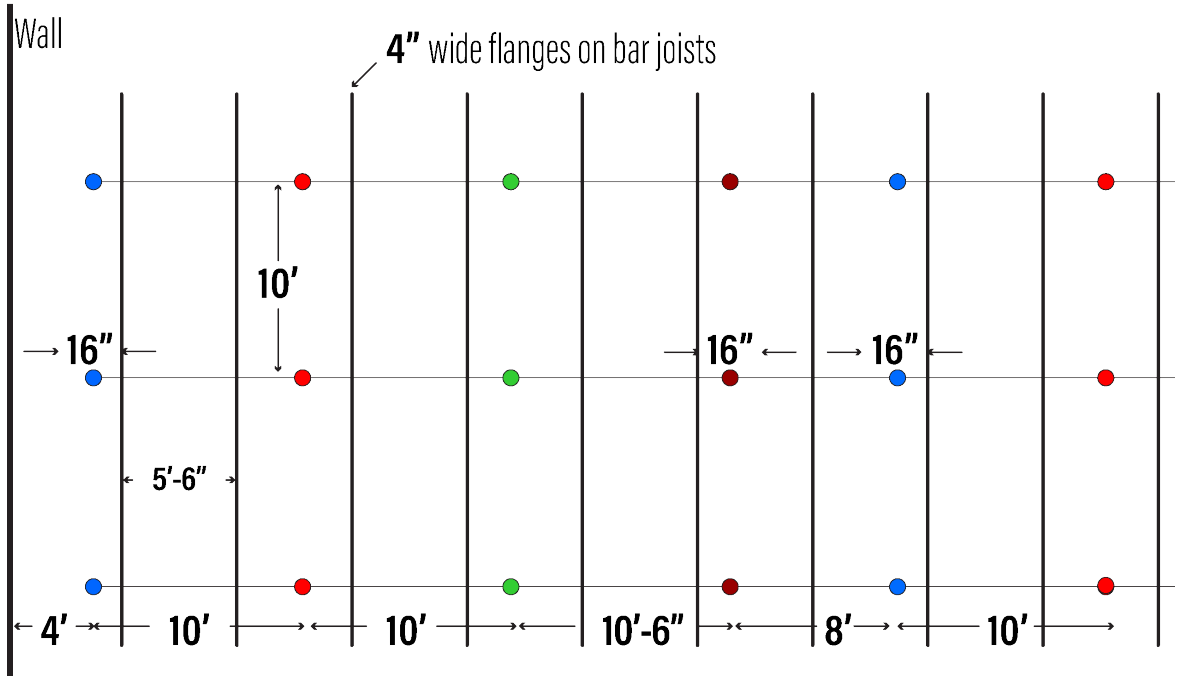
Sprinklers must be at least 12"(0.3M) from the near edge of the bar joists or trusses

X ≥ 12"(0.3m)



ESFR SHIFT RULE





Assessment Quiz

LAST SLIDE

Questions?

Contact: [name here]
[email here]

Complete Course Evaluation to receive certificate
Certificate on website under “My Account”

Course Evaluation

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry