COLUMBUS
INTERNATIONAL CODE COUNCIL 2017

High-Piled Combustible Storage

Presenters:

Rob Neale & Scott Adams

Tuesday, September 12, 2017

1:30 PM - 4:30 PM

ICC INTERNATIONAL CODE COUNCIL®

Description

At the end of the day, you will recognize:

- high-piled combustible storage hazards, and,
- application of 2015 International Fire Code® (IFC®) Chapter 32.

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Welcome

- Instructor introduction
- Exits/emergency procedures
- Breaks and schedule
- Cell phones
- Student introductions
  - What do you want to learn from the program?
  - What specific questions do you need to have answered?

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Module1:

Introduction: High-piled Combustible Storage

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IFC Chapter 32

- Storage of goods at 12 feet or more above the finished floor.

REFER TO CODE BOOK

Section 202

High-Piled Storage

"Storage of combustible materials in closely packed piles or combustible materials on pallets, in racks or on shelves where the top of storage is greater than 12 feet (3658 mm) in height.

"When required by the fire code official, high-piled combustible storage also includes certain high-hazard commodities, such as rubber tires, Group A plastics, flammable liquids, idle pallets and similar commodities, where the top of storage is greater than 6 feet (1829 mm) in height."

Why High-piled?

- High-piled storage arrays:
  - allow the owner or tenant to maximize amount of goods stored in a smaller footprint,
  - enable rapid construction of large, low-cost warehouses near shifting population and transportation nodes, and,
  - increase efficiency in product handling within the storage configuration.

Fire Challenges

- Increased fuel loads per square foot
- Increased potential fire loss per square foot
- Rapid structural failure
- Losses can surpass the construction value of the building

Fire Dangers

- Storage areas within manufacturing plants
- Shipping and receiving areas of any business
- Speculation warehouses or general storage facilities renting space to individuals
- Consumer retail sales areas

Code Official Challenges

- Determining the adequacy of the fire protection features
  - Sprinkler types and designs have improved protection options
  - Sprinkler designs can be more complicated
- Retailers may have special designs for specific merchandising plans
- When in doubt, seek technical assistance

Chapter 32 Scope/Application

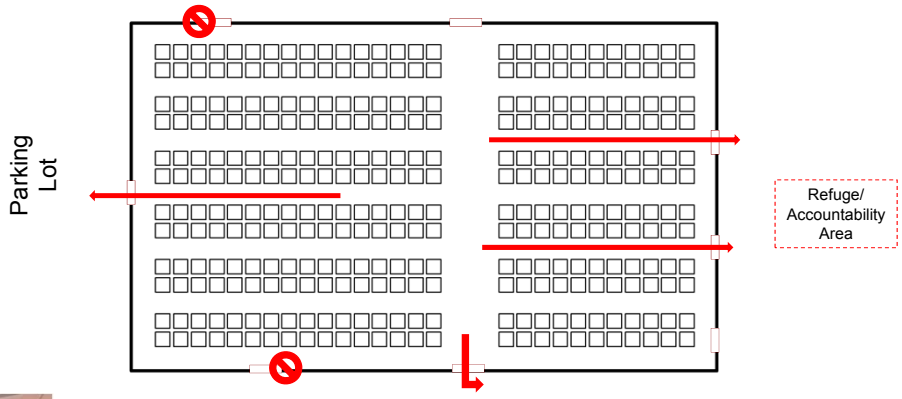
- Chapter 32 references:
  - Aerosols – IFC Chapter 51
  - Flammable & combustible liquids – IFC Chapter 57
  - Hazardous materials – IFC Chapter 50
  - Combustible paper, fibers and miscellaneous storage – Chapter 37
  - General storage – Chapter 3

Construction/Operating Permits

- §105.6.22 Operational permit for buildings containing more than 500 ft² of high-piled storage.
- §105.7 Fire protection system installation.
- §3201.3 Additional details that must be illustrated in the design drawings.

Evacuation Plan

- Fire code official may require evacuation plans for areas accessible to the public



Plan View: Storage Area

Module 2:

Commodity Classification

"Commodity"

REFER TO CODE BOOK

Section 202

"A combination of *products*, *packing materials* and *containers*."

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

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Commodity Classification

Commodities are classified based on estimation and comparison of the heat release rate (HRR) of typical products or goods.

- HRR = Heat of Combustion (Btu/Lb.) x Burning Rate (Lbs./Minute)
- HRR is expressed in Btu/Minute (KW)
- HRR is influenced by the amount of material in a given pile, pallet load or rack

A higher heat release rate (HRR) results in a higher commodity classification

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Relative Fire Hazard

Commodity Class	Fire Hazard Ranking
High-hazard Commodity	Highest Fire Hazard
Class IV Commodity	
Class III Commodity	
Class II Commodity	
Class I Commodity	Lowest Fire Hazard

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REFER TO CODE BOOK

Section 3203.1

Commodity Modification

"Materials listed within each commodity classification are assumed to be unmodified for improved combustibility characteristics.

"Use of flame-retarding modifiers or the physical form of the material could change the classification.

"See Section 3203.7 for classification of Group A, B and C plastics."

Physical form also must be evaluated when classifying commodities

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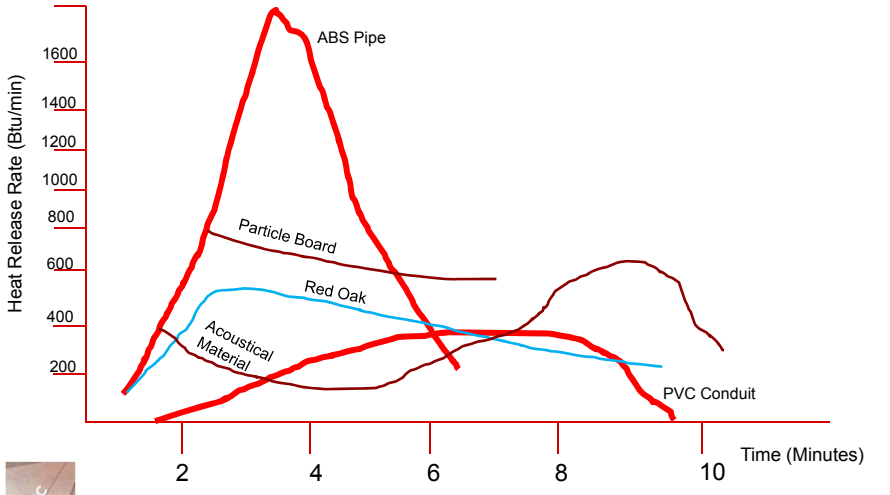
Physical Form Influences

- HRR may evolve differently based on product geometry
- Dimensional wood lumber: Class III
- Cutting and assembling into uniform shapes for fence sections: high hazard

Plastics (Product or Package)

- Plastics are ranked into Groups A, B and C based on their:
  - Heat of combustion
  - Heat Release Rate
- Group A plastics represent the most severe hazard while Group C represent the least severe

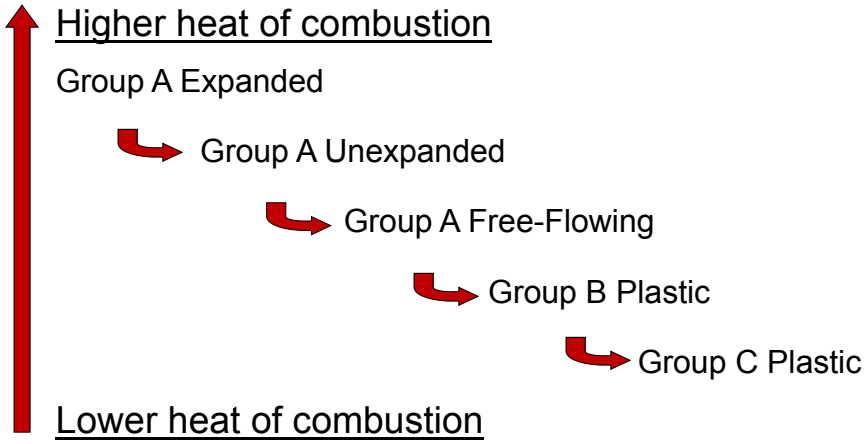
Sample Heat Release Rates



Plastic Hazards

- Some plastics may exhibit faster burning rates compared to ordinary combustibles
  - Plastics can produce 1½ - 3 times as much heat per unit of weight as wood or paper
  - Group A or B
- Some plastics behave similarly to ordinary combustibles
  - Group B or C

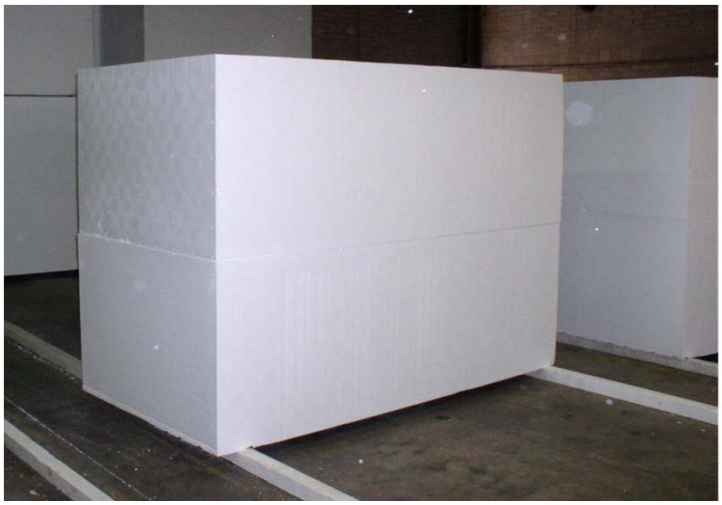
Plastics Classification Examples



Plastic Geometry

- Geometry influences ease of ignition and heat release rate
- Plastics have three basic geometric forms:
  - Expanded (foam coffee cups)
  - Unexpanded (rigid, dense sheets or molds)
  - Free-flowing (pellets or prill)
- Expanded plastics represent the greatest fire hazard while free-flowing plastics represent least

Expanded Group A Plastic



Unexpanded Group A Plastic

Free-flowing Group A Plastic

Pallets

- Influence fire behavior of “unit load”
  - Wood or plastic
  - Solid or open
  - High density, low density plastic

Class I and II Commodities

- Essentially non-combustible commodities
  - Limited amount of Group C plastics
  - No Group A or B plastics
- Difference between Class I and II is amount of combustible packaging

Class III Commodities

- "Ordinary combustibles"
  - Allows more plastics than Class I or II
  - Group A or B plastic limited to 10% by weight or volume
- Group C plastic is Class III commodity

Class IV Commodities

- Can contain Group A plastics
  - 10 - 15% by weight, or
  - 10 - 25% by volume
- Also includes:
  - Group B plastic and
  - Group A free flowing plastic
- Many commodities fall into Class IV classification because of the amount of plastics

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High-hazard Commodities

- While not defined, *High-hazard Commodities* represent a significant fire threat and require specialized fire protection
- These commodities include:
  - Flammable and combustible liquids
  - Group A plastics
    - Unexpanded and expanded
  - Rubber tires
  - Idle pallets

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High-hazard Commodities

- Category unique to IFC for fire protection strategies and operational limitations
  - Neither FM Global nor NFPA utilize this commodity designation
  - NFPA 13 uses “commodity-specific” sprinkler designs
    - Roll paper
    - Plastic motor vehicle components
    - Rubber tires
    - Baled cotton
    - Records storage with catwalk access

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REFER TO CODE BOOK

Limited Amount: Group A Plastics

Section 3203.7.4

- Presence of Group A plastics alone does not require high-hazard commodity classification
  - Some amounts allowed in a package or carton or on a pallet without increasing the commodity classification
  - Figure 3203.7.4 provides guidance to qualified person to assess Group A plastic content

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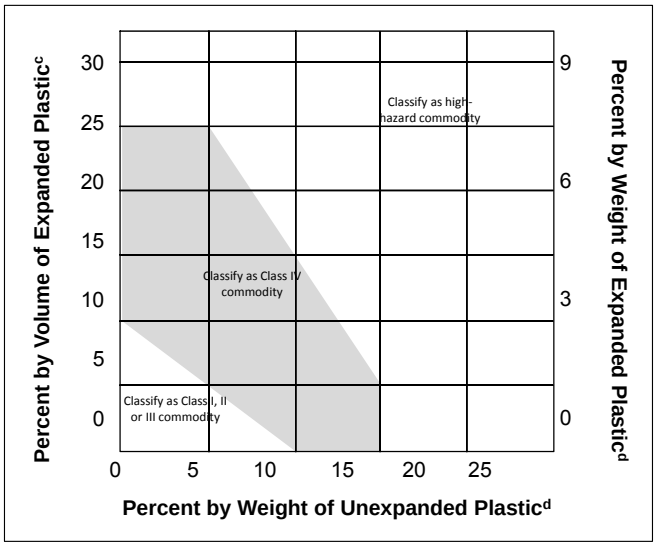
REFER TO CODE BOOK

Figure 3203.7.4, Page 290

Mixed Commodities[a,b]



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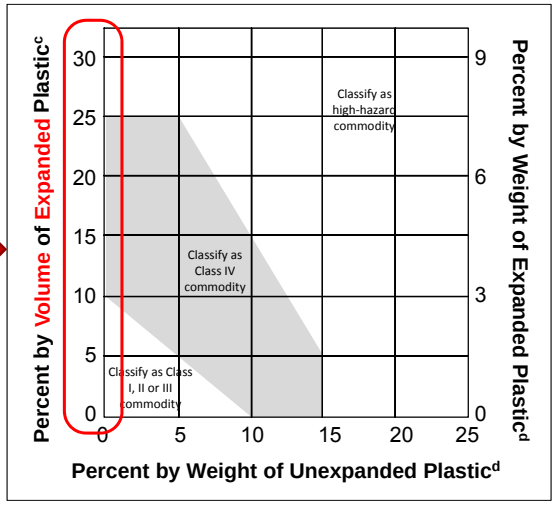
FOR EXAMPLE

Mixed Commodities

Based on volume of expanded plastics

Left vertical axis



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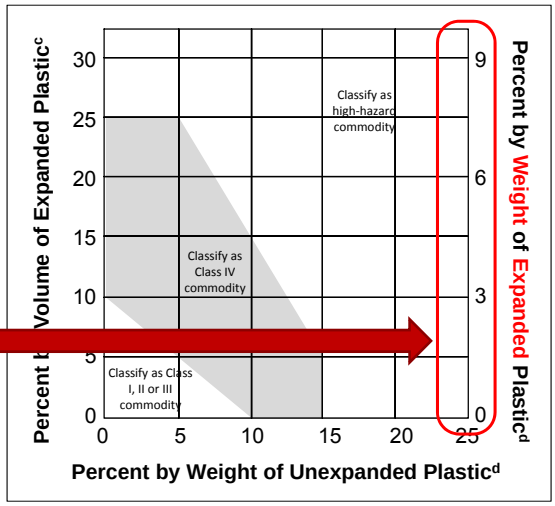
FOR EXAMPLE

Mixed Commodities

Based on weight of expanded plastics

Right vertical axis



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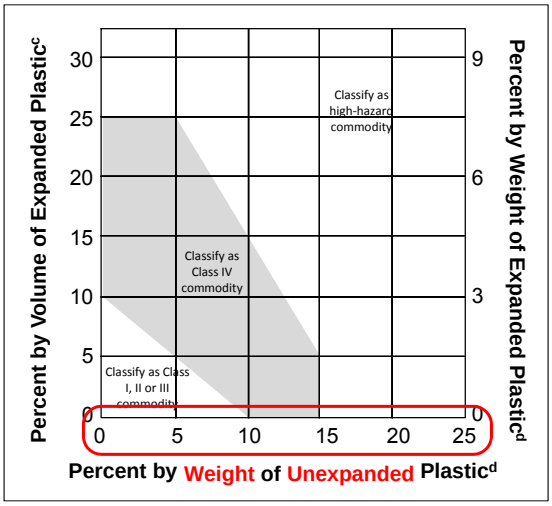
FOR EXAMPLE

Mixed Commodities

Based on weight of unexpanded plastics

Horizontal axis



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FOR EXAMPLE

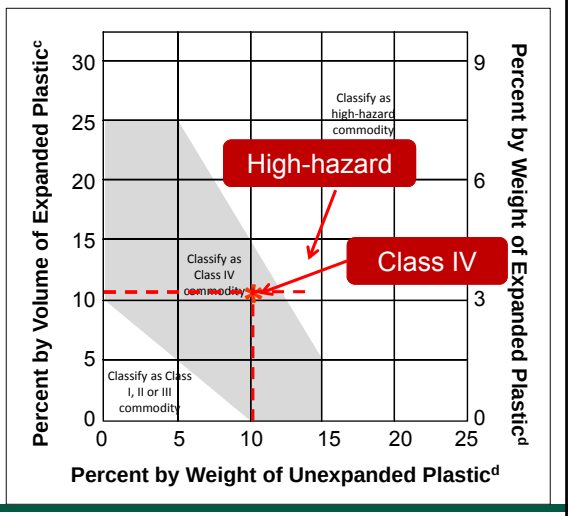
Mixed Commodities

Footnote b.

Unit load containing a Class III commodity has 12% Group A expanded plastic by volume.

The weight of the unexpanded Group A plastic is 10% makes it Class IV commodity.

If weight of the unexpanded plastic is increased to 14%, now a high-hazard commodity.



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Mixed Commodities

Footnote c. Percent by volume =

$$\frac{\text{Volume of plastic in pallet load}}{\text{Total volume of pallet load, including pallet}}$$

Footnote d. Percent by weight =

$$\frac{\text{Weight of plastic in pallet load}}{\text{Total weight of pallet load, including pallet}}$$

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Example 1
Limited Amount Group A Plastics

GIVEN: A pallet load of flat screen TV monitors (Class IV) with the following dimensions and weights:

- Pallet load dimension is 4' by 4' by 4', or a total volume of 64 ft^3
- Each monitor has approximately 0.15 ft^3 of polystyrene foam packing
- Each monitor has approximately 0.75 pounds of unexpanded polyethylene for the outer case and desk supports
- A total of 81 monitors are packed onto each pallet
- The approximate weight of a pallet load is 450 pounds

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Example 1

- Volume of ***expanded*** plastic per pallet load:
  - 0.15 ft^3 of polystyrene per monitor
  - 81 monitors
  - 0.15 x 81 = 12.15 ft^3 of expanded plastic per pallet
- Determine percentage of volume of ***expanded*** plastic:
  - 12.15 ft^3 of expanded plastic per pallet
  - Pallet size is 64 ft^3
  - 12.15 ÷ 64 = 0.1898 x 100% = 18.98% by volume of expanded Group A plastic

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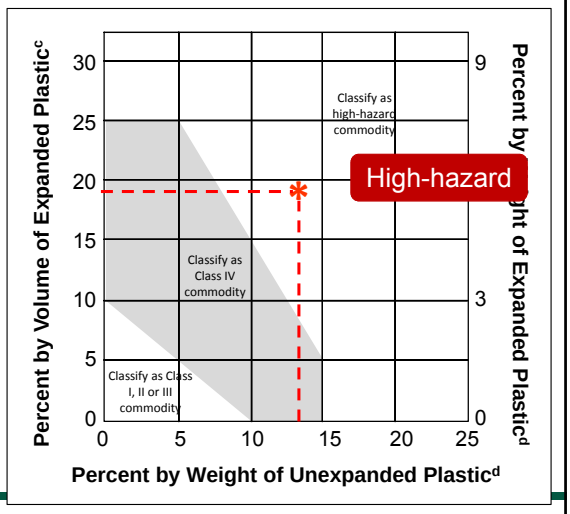
Example 1

- Weight of ***unexpanded*** plastic per pallet load:
  - 0.75 lbs. polyethylene per monitor
  - 81 monitors
  - 0.75 x 81 = 60.75 lbs. of unexpanded plastic per pallet
- Determine percentage of weight of ***unexpanded*** plastic:
  - 60.75 lbs. of unexpanded plastic per pallet
  - Pallet weight is 450 lbs.
  - 60.75 ÷ 450 = 0.135 x 100% = 13.5% by weight of unexpanded Group A plastic

Example 1

- Percent by volume of expanded plastic = 18.98%
- Percent by weight of unexpanded plastic = 13.5%



Example 2: Your Turn

GIVEN: A pallet load of unassembled desktop computer frames and covers (Class III) with the following dimensions and weights:

- Pallet load dimension is 4' by 4' by 4', or a total volume of 64 ft^3
- Each frame has approximately 0.50 pounds of unexpanded polyethylene fasteners for wire harnesses
- A total of 100 frames and covers on each pallet
- The approximate weight of a pallet load is 500 pounds

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Example 2

- Weight of **unexpanded** plastic per pallet load:
  - 0.50 lbs. polyethylene per frame
  - 100 frames
  - 0.50 x 100 = 50 lbs. of unexpanded plastic per pallet
- Determine percentage of weight of **unexpanded** plastic:
  - 50 lbs. of unexpanded plastic per pallet
  - Pallet weight is 500 lbs.
  - 50 ÷ 500 = 0.10 x 100% = 10% by weight of unexpanded Group A plastic

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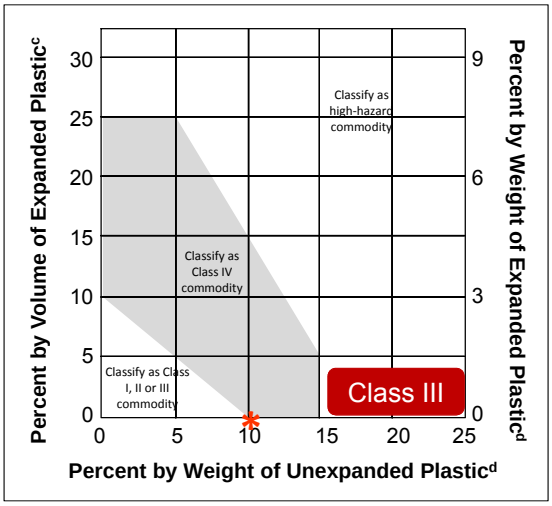
ACTIVITY

Example 2

- Percent by weight of unexpanded plastic = 10%
- What is the commodity class?



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High-piled Combustible Storage Areas

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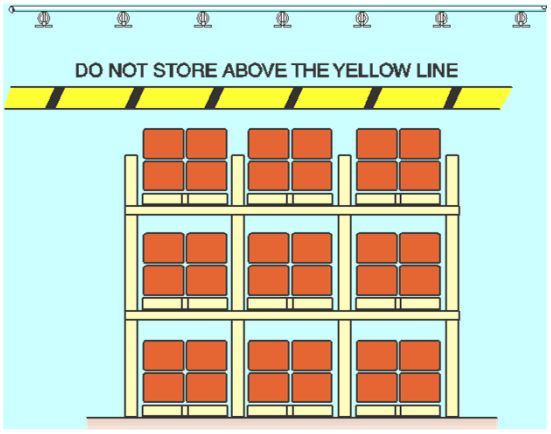
Storage Height Designation

- Fire code official can require visual means to identify maximum allowable storage height
  - Visual marker type is not specified



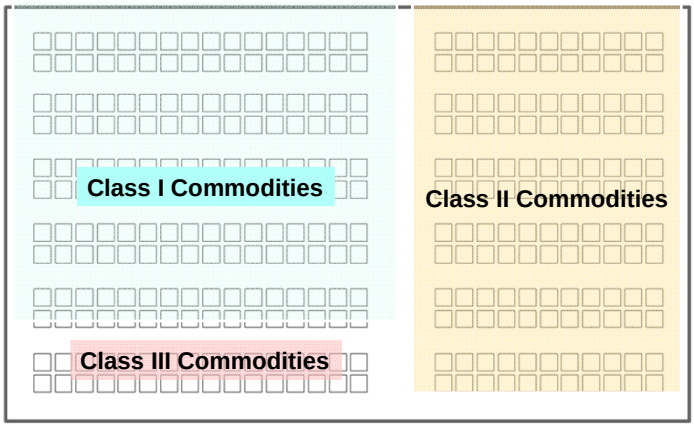
REFER TO CODE BOOK

Section 3204.1

High-Piled Storage Areas

- Storage areas must be assigned a designation based on commodity class
  - Class I-IV or high-hazard
- Designation based on highest hazard class
  - Exception for “engineered analysis option”
- Hazard class establishes fire protection requirements

What Class is This Area? Why?

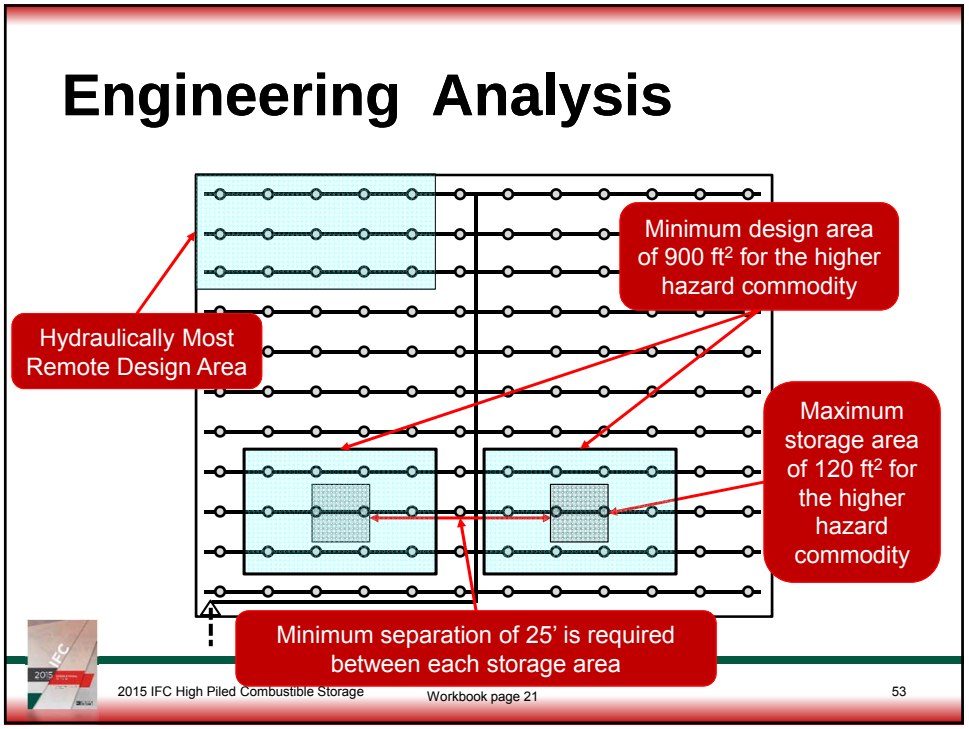


Solid Pile Storage: Plan View

Engineering Analysis Option

Section 3204.2

- §3204.2 can be used to classify High-Piled Storage Area to lower commodity classification when:
  - Higher hazard commodity area is limited,
  - Automatic sprinkler protection design is adequate, and,
  - Storage height restrictions can be maintained


Engineering Analysis
Minimum design area of 900 ft² for the higher hazard commodity
Hydraulically Most Remote Design Area
Maximum storage area of 120 ft² for the higher hazard commodity
Minimum separation of 25' is required between each storage area
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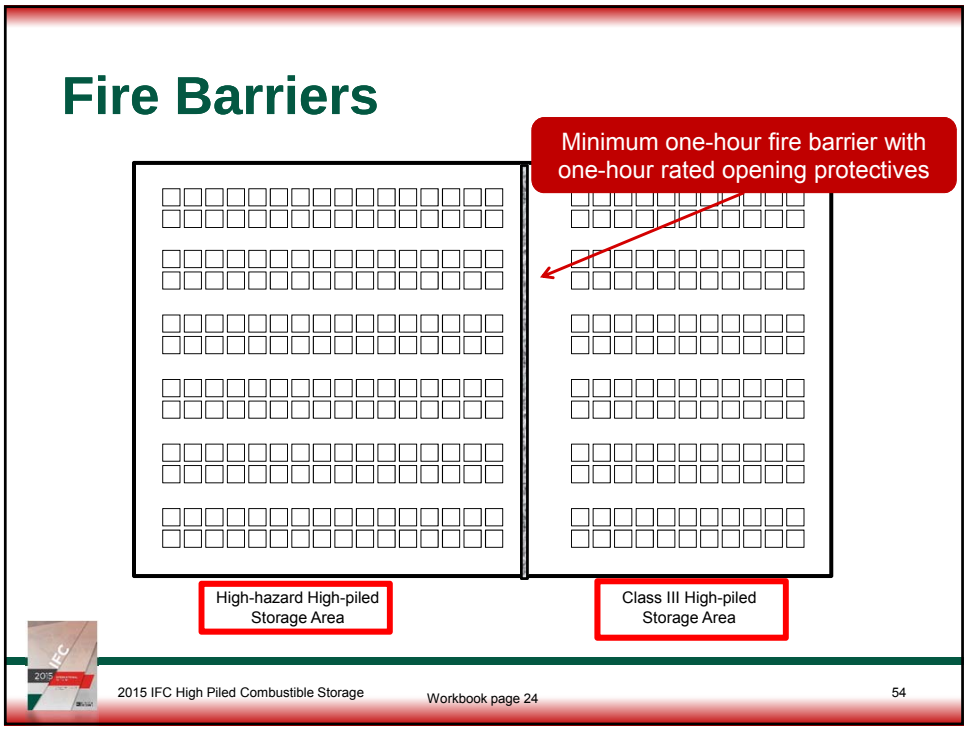
Fire Barriers
Minimum one-hour fire barrier with one-hour rated opening protectives
High-hazard High-piled Storage Area
Class III High-piled Storage Area
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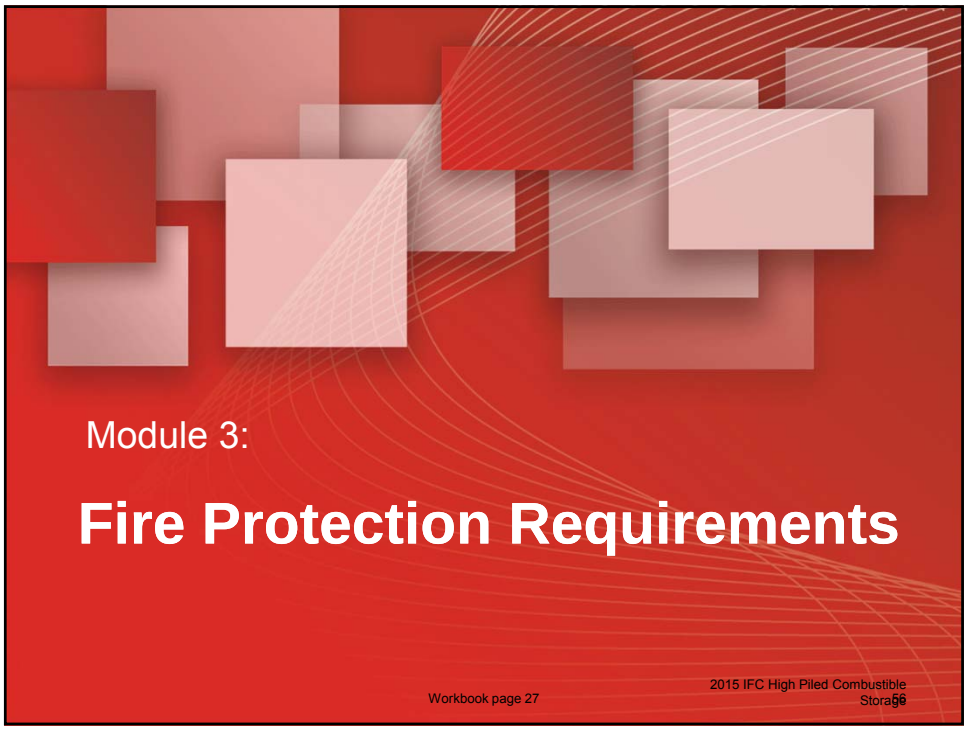

REFER TO CODE BOOK

Fire Protection & Life Safety Requirements

Table 3206.2

1. Commodity classification
2. High-piled storage area size
3. Storage volume
   - Solid-piled storage
   - Shelf storage
   - Palletized storage
4. Storage height

Commodity Class	Size of High Piled Storage Area[a] (square feet)	All Storage Areas[b]					Solid-Piled Storage, Shelf Storage and Palletized Storage		
		Automatic Fire Extinguishing System	Automatic Fire Detection System	Building Access	Smoke and Heat Removal	Draft Curtains	Maximum Pile Dimension[c]	Maximum Permissible Storage Height[d]	Maximum Pile Volume
I – IV	0-500	NR[a]	NR	NR[e]	NR	NR	NR	NR	NR
	501 – 2,500	NR[a]	Yes[j]	NR[e]	NR	NR	100	40	100,000
	2501 – 12,000 Public Accessible	Yes	NR	NR[e]	NR	NR	100	40	400,000
	2501 – 12,000 Non-public Accessible Option 1	Yes	NR	NR[e]	NR	NR	100	40	400,000
	2501 – 12,000 Non-public Accessible Option 2	NR[a]	Yes	Yes	Yes[j]	Yes[j]	100	30[f]	200,000
	12,000 – 20,000	Yes	NR	Yes	Yes[j]	NR	100	40	400,000
	20,001 – 500,000	Yes	NR	Yes	Yes[j]	NR	100	40	400,000
	> 500,000[g]	Yes	NR	Yes	Yes[j]	NR	100	40	400,000

Commodity Class	Size of High Piled Storage Area[a] (square feet)	All Storage Areas[b]					Solid-Piled Storage, Shelf Storage and Palletized Storage		
		Automatic Fire Extinguishing System	Automatic Fire Detection System	Building Access	Smoke and Heat Removal	Draft Curtains	Maximum Pile Dimension[c]	Maximum Permissible Storage Height[d]	Maximum Pile Volume
High-hazard	0-500	NR[a]	NR	NR[e]	NR	NR	50	NR	NR
	501 – 2,500 Public Accessible	Yes	NR	NR[e]	NR	NR	50	30	400,000
	501 – 2,500 Non-public Accessible Option 1	Yes	NR	NR[e]	NR	NR	50	30	400,000
	501 – 2,500 Non-public Accessible Option 2	NR[a]	Yes	Yes	Yes[j]	Yes[j]	50	20	200,000
	2,501 – 300,000	Yes	NR	Yes	Yes[j]	NR	50	30	400,000
	300,001 – 500,000[g,h]	Yes	NR	Yes	Yes[j]	NR	50	30	400,000

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Table 3206.2 – Footnotes

"a. When automatic sprinklers are required for reasons other than those in Chapter 32, the portion of the sprinkler system protecting the high-piled storage area shall be designed and installed in accordance with Sections 3207 and 3208."

For what other reasons might a sprinkler system be required?

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Table 3206.2 – Footnotes

e. Section 503 shall apply for fire apparatus access.

Section 503 allows modifications to fire apparatus access roads when the building is protected by a sprinkler system. What road modifications would you accept for high-piled storage and why?

Table 3206.2 – Footnotes

- For high hazard commodity warehouses from 300,001 to 500,000 sq. ft. the fire code official can require special fire protection provisions including, but not limited to:

What additional fire protection features might you require and why?

- additional in-rack sprinklers, without associated reductions in ceiling sprinkler density; or,
- additional fire department hose connections.

REFER TO CODE BOOK

Protection Extent & Type

Section 3206.2

- Fire protection systems and equipment must:
  - extend 15 feet beyond outer edge of storage or to a permanent partition, and,
  - be based on the highest hazard commodity.

FOR EXAMPLE

Group S-1: Mixed Commodities

Separation of High-Piled Storage Areas

REFER TO CODE BOOK

Section 3206.3.1

"Mixed occupancies shall be separated in accordance with the *International Building Code*."

- IBC addresses separation of mixed occupancies
  - Accessory occupancies – IBC §508.2
  - Non-separated occupancies – IBC §508.3
  - Separated occupancies – IBC §508.4
  - Incidental use – IBC §509

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IBC Table 508.4

OCCUPANCY	A, E		I-1, I-3, I-4		I-2		R[a]		F-2, S-2[b], U		B, F-1, M, S-1		H-1		H-2		H-3, H-4		H-5	
	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS
A, E	N	N	1	2	2	NP	1	2	N	1	1	2	NP	NP	3	4	2	3	2	NP
I-1, I-3, I-4	–	–	N	N	2	NP	1	NP	1	2	1	2	NP	NP	3	N	2	NP	2	NP
I-2	–	–	–	–	N	N	2	NP	2	NP	2	NP	NP	NP	3	NP	2	NP	2	NP
R[a]	–	–	–	–	–	–	N	N	1[c]	2[c]	1	2	NP	NP	3	NP	2	NP	2	NP
F-2, S-2[b], U	–	–	–	–	–	–	–	–	N	N	1	2	NP	NP	3	4	2	3	2	NP
B, F-1, M, S-1	–	–	–	–	–	–	–	–	–	–	N	N	NP	NP	2	3	1	2	1	NP
H-1	–	–	–	–	–	–	–	–	–	–	–	–	N	NP	NP	NP	NP	NP	NP	NP
H-2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	N	NP	1	NP	1	NP
H-3, H-4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1[d]	NP	1	NP
H-5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	N	NP

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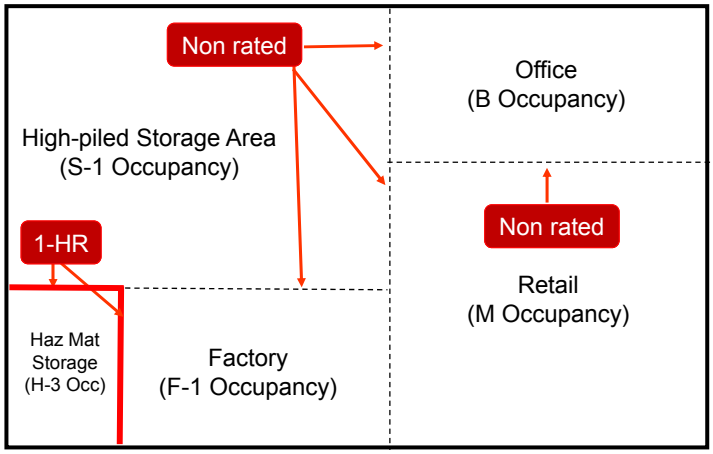
IBC Table 508.4

- Separated mixed occupancy



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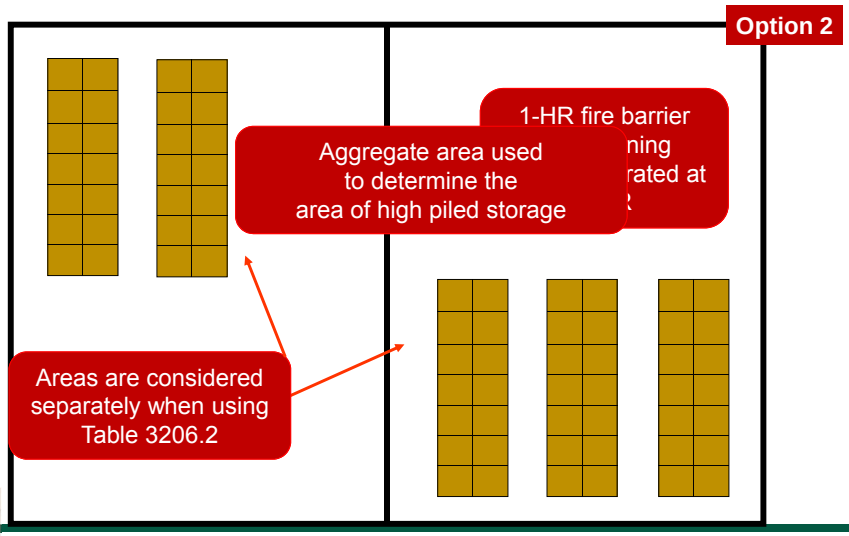
Storage Area Separation



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Automatic Sprinklers

REFER TO CODE BOOK

Section 3206.4

Sprinkler system design and installation must meet NFPA 13 except as provided in Section 903.3.1.1.1 [*Normally exempt locations*].”

Fire Sprinkler Design

- NFPA 13, *Standard for the Installation of Sprinkler Systems*
  - Design and installation guidance
    - Solid-pile and shelf
    - Racks
    - Automated
  - Commodity identification and classification
  - Rack configurations, height and aisle spacing
- Owner or insurance underwriter may require greater protection

Fire Detection Systems

Table 3206.2

- Fire detection system required for non-sprinklered storage areas

Hazard Class	Area	Publicly Accessible
Class I-IV	501-2,500	No
Class I-IV	2,501-12,000	Yes
High Hazard	501-2,500	Yes

Fire Detection Systems

Section 3206.5

- Although smoke detectors are the IFC §907.2.15 recommendation, heat detection may be more appropriate.
- Heat detectors are limited to smooth, beam or sloped ceilings in a building ≤30' in height
  - Ceilings >30' in height require a performance design for spot-type heat detectors, or,
  - Linear cable or pneumatic rate-of-rise heat detection system.

Building Access

- Components of building access:
  - Fire apparatus access roads
  - Fire department access doors
- §503 requires fire apparatus access roads to all buildings
- Table 3206.2 requires fire department access doors for manual suppression

REFER TO CODE BOOK

Section 3206.6

Building Access §3206.6.1

- Doors accessible without a ladder.
- One access door in each 100 lineal feet or fraction of exterior walls facing required fire apparatus access roads.
- Required access doors distributed such lineal distance between adjacent access doors does not exceed 100 feet.

Building Access

Section 3206.6

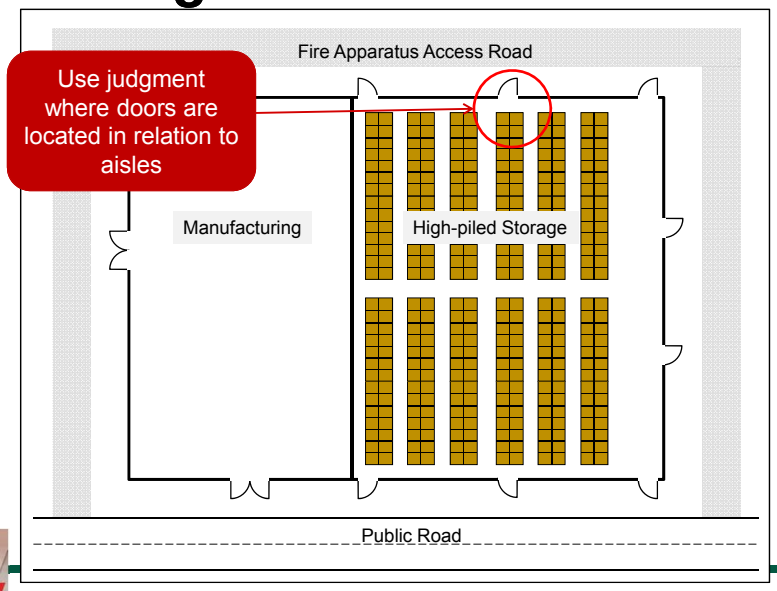
- Access doors at least 3’ wide by 6’ 8’’ high.
- Roll-up doors not to be used unless approved.
- Only approved locking devices.

Building Access

- Fire department access door threshold:

Commodity Classification	Unsprinklered	Sprinklered
Class I – IV	2,501 ft^2	12,001 ft^2
High-hazard	501 ft^2	2,501 ft^2

Building Access



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Smoke/Heat Removal

REFER TO CODE BOOK

Table 3206 & Section 910.2.2

- Provides aid in salvage and overhaul operations by providing post-extinguishment ventilation
- Significant 2015 changes
  - Draft curtains eliminated
  - Smoke and heat vents only in non-sprinklered storage areas
  - Smoke and heat vents *or* mechanical ventilation in sprinklered areas

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Smoke/Heat Removal §910.1

REFER TO CODE BOOK

Section 910.2

Exceptions:

1. Sprinklered frozen food warehouses used solely for storage of Class I and II commodities.

2. Buildings protected by ESFR or fast response Control Mode Specific Application (CMSA) sprinklers.

ESFR courtesy Tyco Fire Protection Products

CMSA courtesy Viking Fire Protection

Smoke and Heat Vents

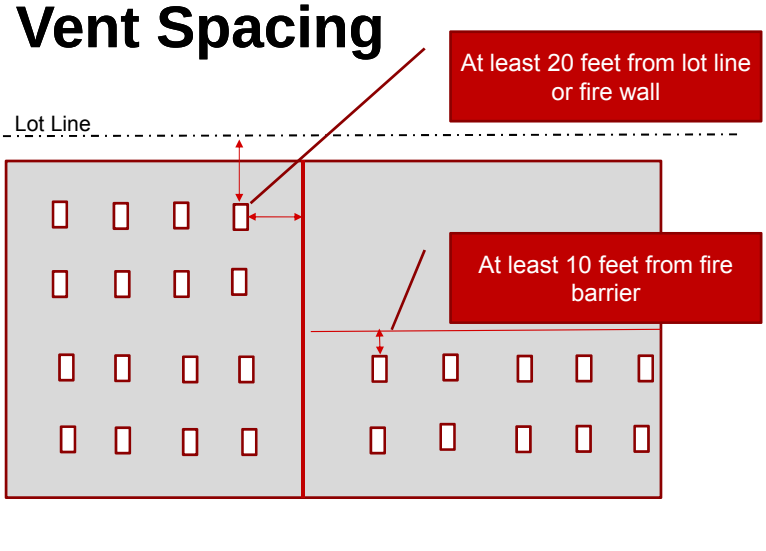
REFER TO CODE BOOK

§910.3

- Vents must be listed and labeled to demonstrate compliance with:
  - UL 793, *Automatically Operated Roof Vents for Smoke and Heat,* or,
  - FM 4430*, Approval Standard for Heat and Smoke Vents.*

FOR EXAMPLE

Vent Spacing



Plan View: High-piled Storage: Class I-IV No Sprinklers

REFER TO CODE BOOK

Section 910.4

Mechanical Smoke Removal

- Mechanical smoke exhaust systems offer firefighters greater control of the smoke removal process
- Building must be sprinklered

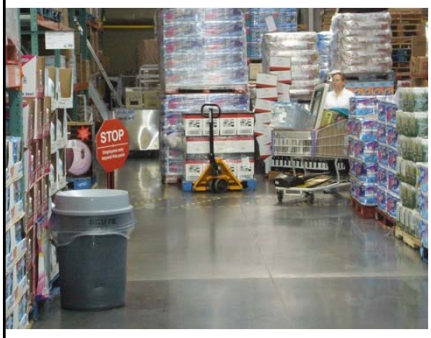
Mechanical Smoke Exhaust

- Mechanical smoke exhaust design for two air changes per hour based on volume.
  - Maximum 30,000 CFM per exhaust fan
  - Automatic or manual make-up air
    - Openings within six feet of floor
    - Min. gross area 8 ft^2/1000 ft^3 of exhaust

Aisles

- Aisles:
  - Limit fire spread
  - Provide egress routes
  - Provide FF access routes

Aisles §3206.9.1.2



- For non-sprinklered buildings, aisles have a minimum width of 8’
- Sprinklered buildings can have aisle widths <8’
- Width is dependent on:
  - Sprinkler system design
  - Commodity classification
  - Storage method
  - Public accessible

Aisle Maintenance §3205.4

- Aisles shall not be obstructed
- Minimum aisle widths must be maintained for manual or mechanical stocking operations
  - Mechanical stocking, minimum 44” aisles are required
  - Manual stocking, 50% of aisle width is required

REFER TO CODE BOOK

Section 3208.3

Flue Spaces

- Flue spaces provided and maintained.
  - Table 3208.3 has not been modified since it was developed
    - Table may conflict with the requirements of NFPA 13, which is adopted by reference
    - As “code” Table 3208.3 takes preference over NFPA “standard”

Flue Requirements: Table 3208.3

Rack Configuration	Automatic Sprinkler Protection		Sprinklers at the Ceiling With or Without Minimum In-Rack Sprinklers			In-Rack Sprinklers at Every Tier	Nonsprinklered
			≤ 25 feet		> 25 feet	Any Height	Any Height
	Storage Height		Option 1	Option 2			
Single-row Rack	Transverse Flue space	Size[b]	3 inches	Not Applicable	3 inches	Not Required	Not Required
		Vertically aligned	Not Required	Not Applicable	Yes	Not Required	Not Required
	Longitudinal Flue space		Not Required	Not Applicable	Not Required	Not Applicable	Not Required
Double-row Rack	Transverse Flue space	Size[b]	6 inches[a]	3 inches	3 inches	Not Required	Not Required
		Vertically aligned	Not Required	Not Required	Yes	Not Applicable	Not Required
	Longitudinal Flue space		Not Required	6 inches	6 inches	Not Required	Not Required
Multi-row Rack	Transverse Flue space	Size[b]	6 inches	Not Applicable	6 inches	Not Required	Not Required
		Vertically aligned	Not Required	Not Applicable	Yes	Not Applicable	Not Required
	Longitudinal Flue space		Not Required	Not Applicable	Not Required	Not Required	Not Required

REFER TO CODE BOOK

Section 3208.5.1

Extra-high-Rack Storage

- Buildings with extra-high-rack combustible storage to be protected with a *specially engineered* automatic sprinkler system.
- When required by code official, extra-high-rack combustible storage shall be provided with additional special fire protection:
  - separation from other buildings,
  - additional built-in fire protection features, and,
  - additional fire department access

Case Study

Group M Occupancy
Austin, Texas

Group M Occupancy Fire

- Background:
  - July, 2000
  - "Big box" Group M home improvement occupancy in Texas
  - Constructed in 1990 using the 1988 Uniform Building and Fire Codes
  - Fire protection features
    - Wet-pipe ceiling sprinklers
    - In-rack sprinklers in high-hazard commodity areas
      - Class I, II and IIIA flammable and combustible liquids
      - Level 2 and 3 aerosols

Building Features

- Fire sprinkler design was:
  - Ceiling: 0.60 GPM/ft² over a 2,000 ft²
  - Two levels of in-rack sprinklers in Class I, II & IIIA storage areas
  - Aerosols protected by two levels of in-rack & face sprinklers
  - Automatic sprinkler systems are supplied by a 1,000 gpm @ 75 psielectric fire pump

Hazardous Materials

- Wholesale/retail exempt amounts* applied

Hazardous Material Classification	Quantity
Class IB & IC flammable liquids	1,850 gallons
Class II & III-A combustible liquids	5,500 gallons
Level 2 & 3 aerosol products	5,000 pounds
Class III solid oxidizers	2,250 pounds
Class II solid oxidizers	4,500 pounds
Corrosive liquids	1,950 gallons
Toxic solids	1,900 pounds

*Now known as “Maximum Allowable Quantities (MAQ)”

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Events Prior to Ignition

- Approximately four months before the fire, employees “reset” the liquid storage area racks
  - When the reset occurred, in-rack sprinkler protection was not extended into the new locations
- Disgruntled employee poured and ignited one gallon of paint thinner in the adjacent aisle which housed a vertical display of wood doors

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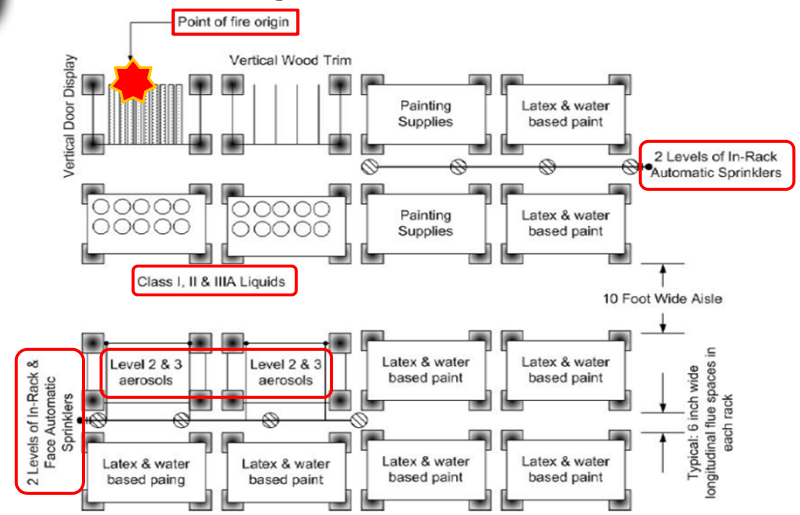
CASE STUDY

Rack Layout



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CASE STUDY

Emergency Response

- First alarm:12:39 am
- First arriving engine reported heavy smoke and sprinkler operation
- Another engine pumped two 3” supply lines to the FDC

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CASE STUDY

Emergency Response

- Interior attack team reported:
  - Sprinklers were operating,
  - Smoke was cold, and,
  - Exploding aerosol cans were striking the roof
- Fire pump was not operating at time of arrival
  - Pump was reset and started using the emergency switch
- By 01:54 am: Five alarms with 90 personnel

CASE STUDY

Post-Fire Observations

- Rack collapse produced larger spill area
- Non-polar solvents flowed under aerosol rack, causing cans to BLEVE
- Aerosol can missing bottom rim found 52’ from collapse area
- 24 ceiling sprinklers and four in-rack sprinklers operated

CASE STUDY

Contributing Factors

- No in-rack sprinklers in flammable and combustible liquid tiers
- "Target" aisle contained more challenging commodities than those used in original fire test to establish sprinkler criteria
- Several containers lacked pressure-relieving features
  - BLEVEs increased the burning rate and fire area
- Initial fire pump failure
  - Fire department unable to determine if this contributed to the number of sprinklers that operated

CASE STUDY

Other Lessons Learned

- When in-rack sprinkler protection is specified, provide protection for the entire rack length
- Aisle plans should be prepared and used by design professionals, regulatory officials, building owners and employees

Questions and Answers

Copyright Materials

Thank you for participating

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