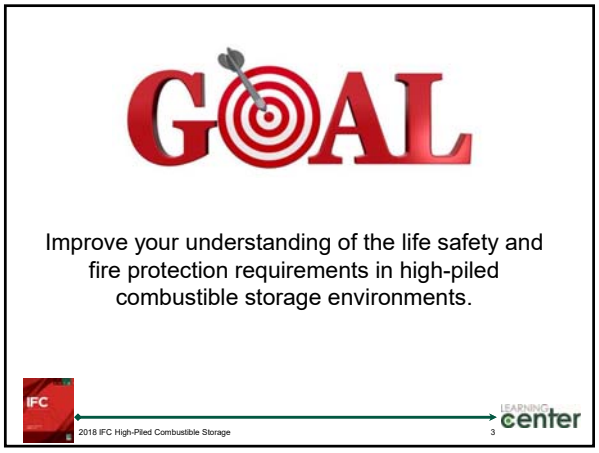

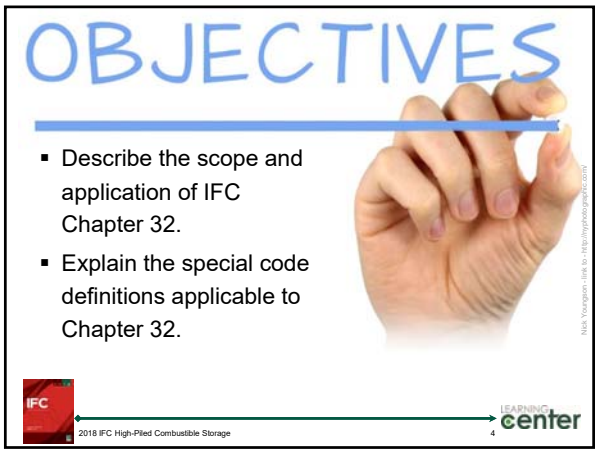

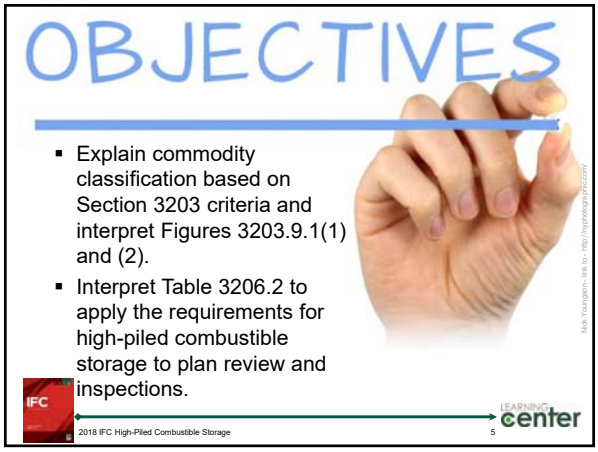

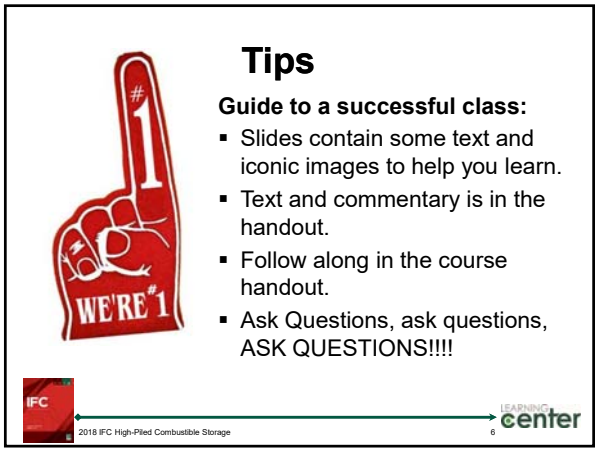

Course Outline

- High-Piled Storage Practices
- General Requirements
- Commodity Classifications
- Storage Areas
- Housekeeping/Maintenance
- Fire Protection/Life Safety
- Array Limits

IFC® Definition: High-Piled Storage

Photo courtesy: The Boeing Company

Photo courtesy: Integra Code Consultants

"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".

High-Piled Storage (cont'd)

Photo courtesy: Integra Code Consultants

"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".

Module #1

High-Piled Storage Practices

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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
  - First responder endangerment
- Losses can surpass the building construction value

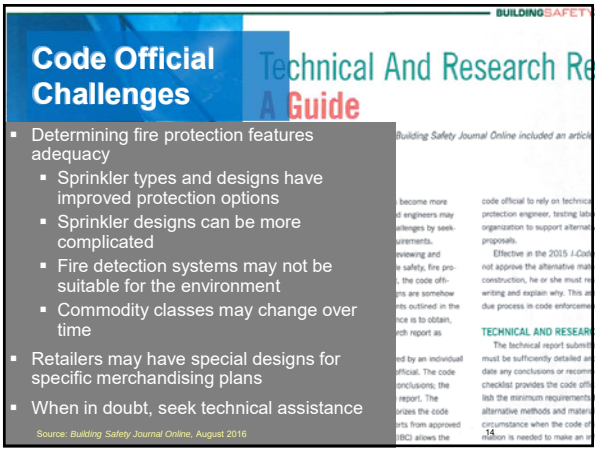
Courtesy: The Boeing Company

Hidden "Watch-outs"

Photo courtesy: Integra Code Consultants

- "Undeclared" high-piled storage areas
- 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 fire protection features adequacy
  - Sprinkler types and designs have improved protection options
  - Sprinkler designs can be more complicated
  - Fire detection systems may not be suitable for the environment
  - Commodity classes may change over time
- Retailers may have special designs for specific merchandising plans
- When in doubt, seek technical assistance

Source: *Building Safety Journal Online*, August 2016

Learning Check

1. The IFC authorizes the code official to use outside resources for technical help.
   True or False

2. Which of the following is **not** a potential consequence of high-piled storage fires?
   a) Product or structural collapse.
   b) Greater dollar losses per square foot.
   c) First responder endangerment.
   d) Increased tax receipts.

Module #2

General Requirements

16

Chapter 32: Scope/Application

- Cross-references:
  - General storage – Chapter 3
  - Hazardous materials – Chapter 50
  - Combustible fibers – Chapter 37
  - Aerosols –Chapter 51
  - Flammable & combustible liquids –Chapter 57
  - Paper records storage – NFPA 13

IFC

2018 IFC High-Piled Combustible Storage 17

LEARNING center

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 Approved construction documents and storage plan – maintained on site.

IFC

2018 IFC High-Piled Combustible Storage 18

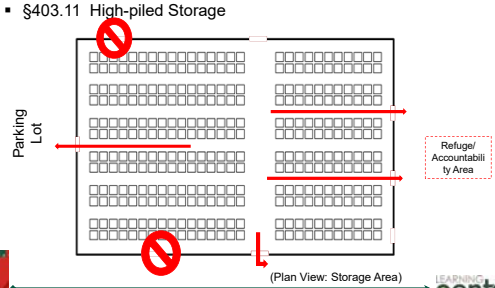
LEARNING center

Documents/Layout Plans

- Rack locations, dimensions and layout
- Design storage height
- Commodity types
- Sprinkler: commodity clearance
- Aisle dimensions
- Pile volume:
  - Solid pile
  - Palletized
- Commodity classes/locations
- Fire department access doors
- Sprinkler control valves

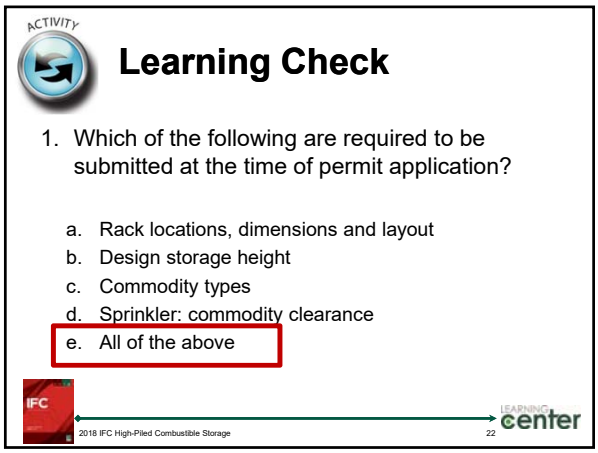
Safety and Evacuation Plan

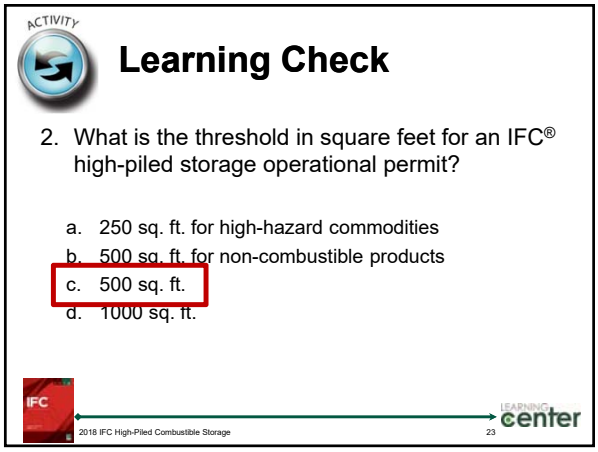
- §3201.4 Plan submitted with permit application
  - §403.11 High-piled Storage

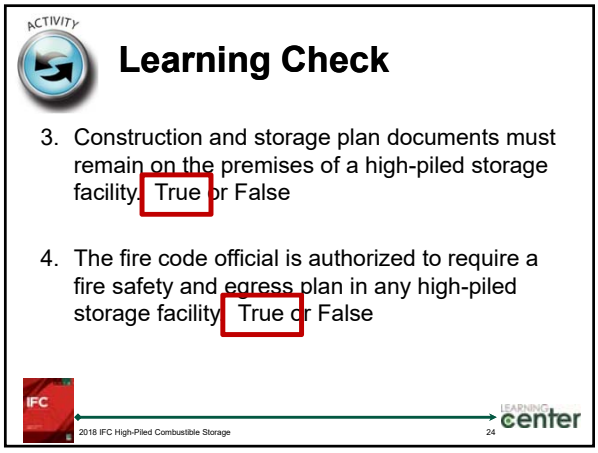


Safety Plan §403.11.5

- Storage area exceeds
  - 500,000 ft^2 Class I-IV commodities
  - 300,000 ft^2 high hazard commodities
- Storage area in Group H occupancy
- Storage area in F or M occupancy
  - Occupant load > 500, or,
  - More than 100 above/below level of exit discharge
- Where fire code official requires







Module #3

Commodity Classification

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Commodity Classification

Fire protection requirements' foundation

IFC

2018 IFC High-Piled Combustible Storage 26

LEARNING center

"Commodity"

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

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 product storage method	Wood or plastic pallets, plastic, cardboard or paper bin boxes, crates, wooden spools . . .

IFC

2018 IFC High-Piled Combustible Storage 27

LEARNING center

Commodity Classification

- Class based on estimated or measured heat of combustion and heat release rate (HRR)
  - Influenced by:
    - Material characteristics
    - Material quantity
    - Surface area/density
    - Ventilation

Latent Heat and HRR

- Heat of Combustion (Btu/Lb.)
- Heat Release Rate
  - HRR expressed in
  - Watts,
  - Kilowatts, or,
  - Megawatts.

Relative Hazard § 3203

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

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."

Geometry Influences

- Product geometry affects HRR

Dimensional lumber: Class III

Section and Table 3203.8

PRODUCT CATEGORY	PRODUCT	CLASSIFICATION
Aerosols	Level 1	Class III (See Chapter 51)
	Level 2	Class IV (See Chapter 51)
	Level 3	High-hazard (See Chapter 51)
Batteries	Dry cells (excludes lithium, lithium-ion and other similar exotic metals or combustible electrolyte); without blister packing (if blister packed, refer to the commodity classification definitions)	Class I
	Dry cells (nonlithium or similar exotic metals); in blister packing; cartoned	Class II
	Vehicle; any size (for example, automobile or truck); empty plastic casing	High-hazard (Group A unexpanded)
	Vehicle; large (in other words, truck or larger); dry or wet cells (excludes lithium-ion and other cells containing combustible electrolytes)	High-hazard (Group A unexpanded)
	Vehicle; small (for example, automobile); wet cells (excludes lithium-ion and other cells containing combustible electrolytes)	Class I
Biomass	Circular baled corn stover	Class IV
	Rectangular baled corn stover	Class III
	Rectangular baled switchgrass	High-hazard

Class I and II Commodities

- § 3203.2 and 3203.3
- Essentially *non-combustible* items
  - Difference between Class I and II is amount/nature of combustible packaging
- Limited amount of Group A plastics

Photo courtesy Integral Code Consultants

Class III Commodities

- § 3203.4
- "Ordinary combustibles"
  - Wood
  - Paper
  - Natural fiber
  - Group C plastic
- Limited Group A plastic

Class IV Commodities

- § 3203.5
- Class I, II or III with some Group A plastic
- Group B plastic
- Group A free-flowing plastic

High-hazard Commodities

- § 3203.6
- Includes:
  - Flammable and combustible liquids
  - Group A plastics
    - Unexpanded and expanded
  - Rubber tires
  - Idle pallets

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

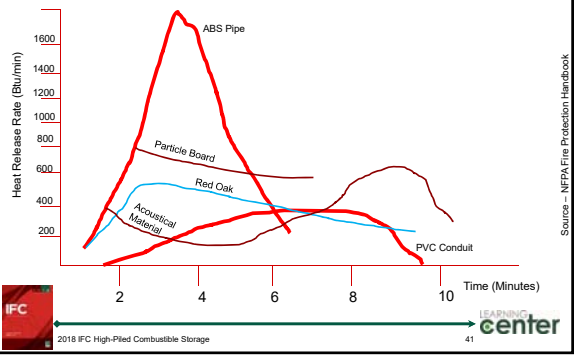
Plastics (Product or Package)

- Plastics are ranked into Groups A, B and C based on:
  - Heat of combustion
    - Potential heat released upon full combustion (Btu/lb.)
  - Heat Release Rate
- Group A plastics represent the most severe hazard while Group C represent the least severe

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

Sample Heat Release Rates



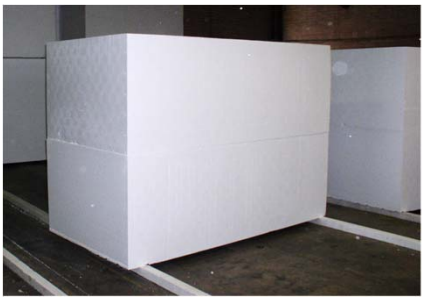
Section and Table 3203.8

PRODUCT CATEGORY	PRODUCT	CLASSIFICATION
Plastic, rubber	ABS (Acrylonitrile-butadiene-styrene copolymer)	High-hazard (Group A unexpanded)
	Acetal (polyformaldehyde)	High-hazard (Group A unexpanded)
	Acrylic (polymethyl methacrylate)	High-hazard (Group A unexpanded)
	Automobile bumpers and dashboards	High-hazard (Group A expanded)
	Butyl rubber	High-hazard (Group A unexpanded)
	Cellulose acetate	Class IV (Group B plastic)
	Cellulose acetate butyrate	High-hazard (Group A unexpanded)
	Chloroprene rubber	Class IV (Group B plastic)
	Containers: Nonexpanded plastic gridded or solid; collapsed or nested with no air spaces	High-hazard (Group A unexpanded)
	ECTFE (ethylene-chlorotrifluoro-ethylene copolymer)	Class IV (Group B plastic)
	EPDM (ethylene-propylene rubber)	High-hazard (Group A unexpanded)
	ETFE (ethylene-tetrafluoroethylene copolymer)	Class IV (Group B plastic)
	Ethyl cellulose	High-hazard (Group A unexpanded)
	FEP (fluorinated ethylene-propylene copolymer)	Class IV (Group B plastic)

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

Limited Amount: Group A Plastics

Presence of Group A plastics alone does not result in high-hazard commodity classification

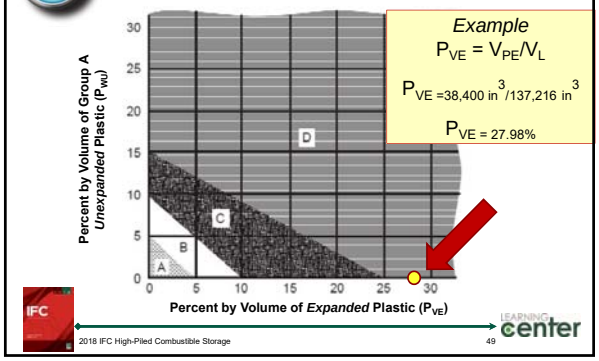
- Some amounts allowed in a package or carton or on a pallet without increasing the commodity classification.
- Figures 3203.9 (1) and (2) provide a qualified person guidance to assess Group A plastic content by volume or weight.
  - Compare both: assign commodity classification on higher value

Limited Group A (Example)

- Light fixture in cardboard box
  - Wt. 3.17 lbs
  - 32 per pallet
- Table 3203.8
  - "Housing materials and appliances"
  - "Light fixtures; non-plastic; cartoned"
- Class II

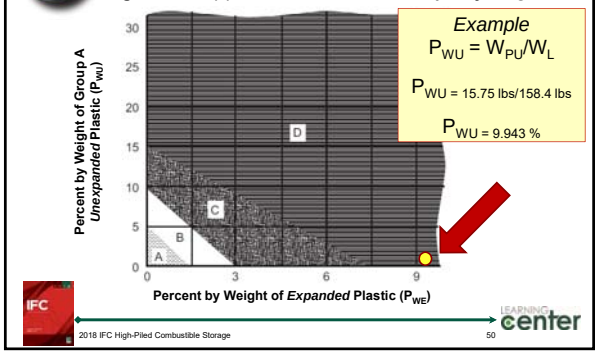
Mixed Commodities

Figure 3203.9(1) Mixed Commodities Group A by *Volume*



Mixed Commodities

Figure 3203.9(2) Mixed Commodities Group A by *Weight*

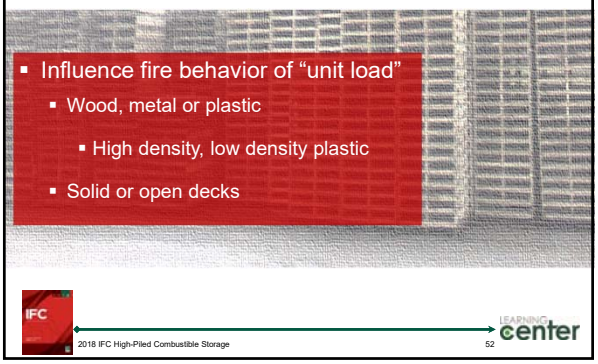


Limited Group A : Outcome (Example)

- Product
  - Originally Class II
  - 27.98% Group A by *volume*
  - 9.43% Group A by weight

- What is the commodity classification?

Pallets §3203.10



- Influence fire behavior of "unit load"
  - Wood, metal or plastic
    - High density, low density plastic
  - Solid or open decks

Commodity Influence §3203.10

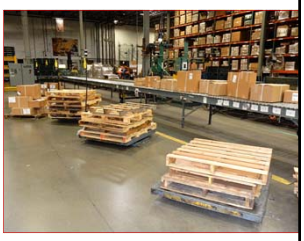
Pallet Composition	Commodity Class	Impact
Unreinforced polypropylene or unreinforced high-density polyethylene	I-IV	Increase one class
Reinforced polypropylene or reinforced high-density polyethylene	I-III	Increase two classes
Reinforced polypropylene or reinforced high-density polyethylene	I-IV	Increase to High Hazard
Others	I-IV	Unless tests prove otherwise, increase two classes

Module # 4

Fire Protection/Life Safety

Fire Protection/Life Safety §3206

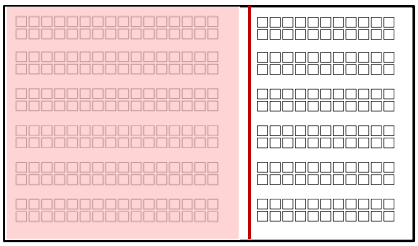
- Fire protection/ life safety requirements
  - Area
  - Commodity class
- Protection extent
  - Multiple areas



Fire Protection Coverage § 3206.2.1

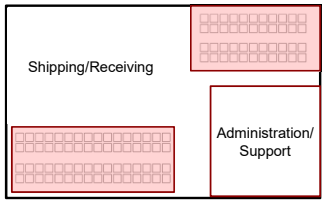
- Protection extent for Table 3206.2
  - "Lesser of" 15 feet *or* full-height wall

Plan view



Fire Protection Coverage § 3206.3.1

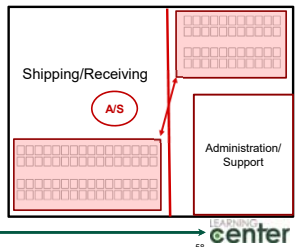
- High-piled storage area size, sum:
  - Footprint of storage, racks, shelves or piles
  - Interior aisles
  - Perimeter aisles
    - 44 or 96 in.



Plan view

Fire Protection Coverage § 3206.3.2

- Multiple high-piled areas
  - Aggregate area, or,
    - One-hour fire barriers, *or,*
    - 100 feet if sprinklered

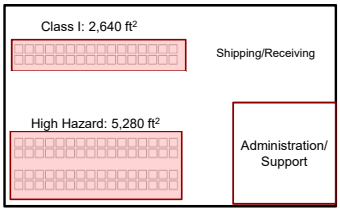


Plan view

Fire Protection Coverage § 3206.2.3.1

- Storage area size – Mixed commodity classes with High-hazard
  - Unless separated: All treated as high hazard
  - Aggregate area

Treat as 7,920 ft^2
High Hazard



Plan view

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[i]	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[i]	Yes[i]	100	30[f]	200,000
	12,000 – 20,000	Yes	NR	Yes	Yes[i]	NR	100	40	400,000
	20,001 – 500,000	Yes	NR	Yes	Yes[i]	NR	100	40	400,000
	> 500,000[g]	Yes	NR	Yes	Yes[i]	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[i]	Yes[i]	50	20	200,000
	2,501 – 300,000	Yes	NR	Yes	Yes[i]	NR	50	30	400,000
	300,001 – 500,000[g,h]	Yes	NR	Yes	Yes[i]	NR	50	30	400,000

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Table 3206 (Extract)

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	2,501 – 12,000 Not open to public Option 1	Yes	NR	NR[e]	NR	NR	100	40	400,000
	2,501 – 12,000 Not open to public Option 2	NR[a]	Yes	Yes	Yes[i]	Yes[i]	100	30[f]	200,000

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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?

2018 IFC High-Piled Combustible Storage 63

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

f. For high hazard commodity warehouses more than 300,000, and Class I-IV more than 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 fire department hose connections.

Automatic Sprinklers §3206.4

Sprinkler system design and installation must meet 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/insurance underwriter may require greater protection

Fire Detection Systems §3206.5

- Required for non-sprinklered storage areas

Hazard Class	Area (ft^2)	Open to Public
Class I-IV	501-2,500	--
Class I-IV	2,501-12,000	No
High Hazard	501-2,500	No

Fire Detection Systems

- Although smoke detectors are preferred by IFC® §907.2.15, 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 §3206.6 and .7

- Access elements:
  - Fire apparatus access roads
  - Fire department access doors
- §503 requires fire apparatus access roads to all buildings
- Table 3206.2 sets fire department access doors for manual suppression requirements

Access Door Exception §3206.7.1

- If wall does **not** face fire apparatus access road, *and*,
  - Opposite wall has access doors
  - Entire interior <150 ft from access door
  - Sprinklered building

Building Access §3206.7.3 – 7.8

- Doors accessible without a ladder.
- One access door in each 125 lineal feet or fraction.
- Access doors at least 3' wide by 6' 8'' high.
  - Roll-up doors not to be used unless approved.
- Only approved locking devices.
  - Key boxes may be required.

Building Access: Table 3206.2

- 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

Smoke/Heat Removal §3206.8

- Provides aid in salvage and overhaul operations by providing post-extinguishment ventilation
- Significant IFC® 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

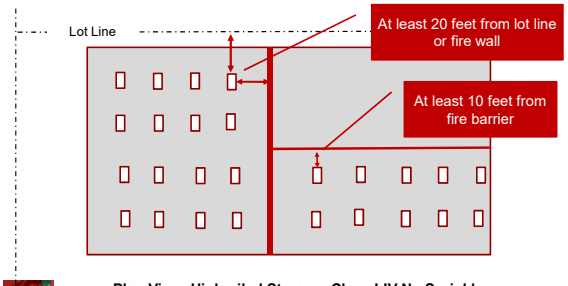
Smoke/Heat Removal §910.2.2

- When required by Table 3206, with 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.

Smoke and Heat Vents §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.*

Vent Spacing §910.3.3



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

Mechanical Smoke Removal §910.4

- If used as alternate to smoke/heat vents, must:
- Sprinklered building
- 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 §3206.10

- Limit fire spread
- Provide egress routes
- Provide firefighter access

- Width is dependent on:
  - Sprinkler system design
  - Commodity classification
  - Storage method
  - Open to public

Aisle Widths §3206.10.1.2

Sprinkler Protection	Hazard Class	Storage Area	Open to Public	Aisle Width (in.)
Yes	Any	Any	Any	44
Yes	High	2,500 sq. ft. or more	Yes	96
Yes	Any	Mechanical stocking	Yes	96
Yes*	High	Mechanical stocking	Yes	44
Yes*	High	Mechanical stocking	No	24
No	Any	Any	Any	96

* If protected for *multiple-row* (> 2 adjacent) racks per § 903.3.1.1.

Solid-Piled and Shelf §3207

- Shelf, piles and bin boxes > 5 feet
  - Shelves 12-15 feet: NFPA 13
  - Shelves > 15: approved protection

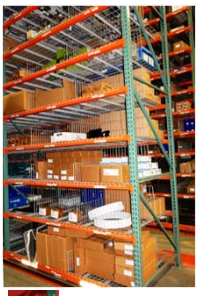
- Pile dimensions per Table 3206.2

Pile Dimensions Table 3206.2

- Given:
  - Class I-IV commodity
  - Storage area: 2,501 to 12,000 sq. ft.
  - Not open to the public

Option	Sprinklers	Max. Dimension (feet)	Max. Height (ft.)	Max. Volume (cu.ft.)
1	Yes	120	40	400,000
2	No	120	30	200,000

Racks §3208



- Racks and bin boxes > 5 feet
  - Plastic shelves/decks
    - Special fire protection
  - Solid shelves/decks
    - 20 sq. ft. or more
  - Open mesh, slatted or grated
    - 50 % open

Flue Spaces

Longitudinal

Transverse

Flue Spaces: Table 3208.3

- Flue spaces provided and maintained.
  - Table may conflict with the requirements of NFPA 13, which is adopted by reference
  - As “code” Table 3208.3 takes preference over NFPA “standard”

Table 3208.3 (Extract)

Rack Configuration	Flue Design		Sprinklers at the Ceiling With or Without Minimum In-Rack Sprinklers		In-Rack Sprinklers at Every Tier
			≤ 25 feet	> 25 feet	Any Height
Double-row Rack (Option 1)	Transverse Flue space	Size	6 inches	3 inches	Not Required
		Vertically aligned	Not Required	Yes	Not Applicable
	Longitudinal Flue space		Not Required	6 inches	Not Required
Double-row Rack (Option 2)	Transverse Flue space	Size	3 inches	6 inches	Not Required
		Vertically aligned	Not Required	Yes	Not Applicable
	Longitudinal Flue space		6 inches	Not Required	Not Required

Extra-high-Rack Storage §3208.5

- Buildings with extra-high-rack combustible storage to be protected with a *specially engineered* automatic sprinkler system.

Commodity Class	Height (feet)
I, II, III, IV	> 40
High-hazard	> 30

Automated Storage §3209

- Carousel storage > 500 ft^2
  - Option 1: Smoke detection system 15 ft beyond perimeter of unenclosed carousel
  - Option 2: Smoke detection in enclosed area
    - Provide local alarm
    - Stop carousel
  - Option 3: Single "dead-man" switch

Final Learning Check

1. If used for smoke removal, the maximum capacity of a single mechanical fan is:

a) Based on the volume of the protected space
b) 15,000 cfm
c) 20,000 cfm
d) 30,000 cfm

Final Learning Check

2. What is the minimum distance between a manual/automatic rooftop smoke/heat vent and a fire barrier?

a) 10 feet
b) 20 feet
c) 30 feet
d) 40 feet

Final Learning Check

3. Class I-IV storage more than 30 feet high is classified as extra-high rack storage. True or False

4. In existing buildings, fire access doors may be spaced _____ feet apart.
   a) 125
   b) 150
   c) 175
   d) 200

Final Learning Check

5. In non-sprinklered Class I-IV storage areas open to the public, what is the area threshold where fire detection is required?

   a. 501 sq. ft.
   b. 2501 sq. ft.
   c. 12,0001 sq. ft.
   d. 500,000 sq. ft.

Summary

- Describe the scope and application of Chapter 32 of the IFC.
- Explain the special code definitions applicable to Chapter 32.
- Explain the commodity classification system based on the criteria in Section 3203 of the IFC and interpret Figures 3203.9.1(1) and (2).
- Interpret Table 3206.2 to apply the requirements for high-piled combustible storage to plan review and inspections.

Final Reflection

Reflect on the day. What will you take back to the job and apply?

- **What?** What happened and what was observed in the training?
- **So what?** What did you learn? What difference did this training make?
- **Now what?** How will you do things differently back on the job as a result of this training?

Resources

Babrauskas, V. (1992). *Heat Release in Fires.* Gosport, Hampshire, UK: Interscience Communications Ltd.

Babrauskas, V. (2003). *Ignition Handbook: Principles and Applications to Fire Safety Engineering, Fire Investigation, Risk Management and Forensic Science*. Bethesda, MD: Society of Fire Protection Engineers.

FM Global (2015). *Commodity Classifications.* Johnston, RI: Author.

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