



**CITY OF BLAINE**  
**SAFETY SERVICES**  
10801 Town Square Drive,  
Blaine MN 55449  
Business Phone 763-785-6187  
Fax 763-717-2634



## **HIGH-PILED STORAGE**

**General.** An operational permit is required to use a building or portion thereof as a high-piled storage area exceeding 500 square feet. Also, a high-piled storage worksheet must be completed to determine the proper fire protection requirements. High-piled storage areas and facilities shall be in accordance with Minnesota State Fire Code (MSFC) Chapter 23.

**Definition:** High-piled storage is the storage of combustible materials in closely packed piles or combustible materials on pallets, in racks or on shelves where the top of the storage is greater than 12-feet in height. When required by the chief, 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 the storage is greater than 6-feet.

This document is not intended to cover all of the requirements for high-piled storage. The fire code and building code may have additional provisions for egress, building construction, building size, interior finish, and more that will apply but are not covered in this document.

**Classify the Commodity.** The first step in evaluating which fire protection provisions will be required for high-piled storage is to determine the commodity classification for the material to be stored. An accurate classification is essential to determine the appropriate sprinkler system design requirements and to avoid other expensive fire protection upgrades caused by an inaccurate commodity classification. It is important to note that fire protection requirements for high-piled storage are determined by a number of factors including commodity classification, total square footage of storage, shelving or rack type and public accessibility. Use MSFC Section 2303 for commodity classification.

**High-Hazard Commodities.** Special fire protection problems are created by the storage of high-hazard commodities. Some examples include: Aerosols-level 3, alcoholic beverages exceeding 80 percent, alcohol in bottles or cartons, commodities of any class in plastic containers in carousel storage, flammable solids (except solid combustible metals), glycol in combustible containers (50% +), lacquers, which dry by solvent evaporation, in metal cans or cartons, lubricating or hydraulic fluid in plastic containers, mattresses, foamed rubber or foamed plastics, pallets and flats which are idle combustible, paper, asphalt, rolled (vertical or horizontal), paper and pulp, rolled, in vertical storage (unbanded or without approved wrap), pillows, foamed rubber and foamed plastics, plastics, most group A (such as ABS, acetal, acrylic, butyl rubber, EPDM, FRP, natural rubber, nitrile rubber, PET or PETE, polybutadiene, polycarbonate, polyester elastomer, polyethylene, polypropylene, polystyrene, polyurethane and PVC, SAN and SBR), pyroxylin, rubber tires, vegetable oil and butter in plastic containers.

**Other Commodities.** Most other commodities consisting of limited combustible materials, wood, paper, natural fibers, and some low flammability plastics are classified as Class I, II, III or IV commodities. For examples, see MSFC Section 2303. **NOTE:** Some commodity classifications listed in the MSFC differ from those contained in National Fire Protection Association (NFPA) standards. See the MSFC commodity classification tables for more information.

**Class I Commodities** are essentially noncombustible products on wooden or non-expanded polyethylene solid deck pallets. Commodities can be in ordinary corrugated cartons with or without single thickness dividers or in ordinary paper wrappings with or without pallets.

**Class II Commodities** are Class I products (noncombustible) in slatted wooden crates, solid wooden boxes, or multiple-thickness paperboard cartons with or without pallets.

**Class III Commodities** are commodities of wood, paper, natural fiber cloth with or without pallets.

**Class IV Commodities** are Class I, II or III products containing Group A plastics in ordinary corrugated cartons with or without pallets. It also includes Class I, II and III products with Group A plastic packaging in the range of 10-15% by weight or 10- 25% by volume. To determine the exact classification, use MSFC Figure 2303.7.4.

**Plastic Commodities** are divided into three groups; Group A (highest hazard), Group B, and Group C (lowest hazard). If the hazard of the plastic is unknown, a Group A designation should be selected. Group A plastics are considered high hazard commodities as defined above in Section 2.1.

**Mixed Commodities.** When different commodity classes are stored in the same area, the protection required for the storage must be based on the highest class of commodity stored [MSFC Section 2304.1]. For limited storage of commodities with a higher classification than the remainder of the storage, MSFC Section 2304.2 permits designation of the classification based on an engineering analysis. When using such an engineering analysis, the sprinkler protection is still required to be adequate to protect the higher hazard commodity, although over a smaller area of operation.

For commodities that are composed of different materials, one of which is plastic, MSFC Section 2303.7.4 refers to Figure 2303.7.4.

Plastics are manufactured in two basic forms. Unexpanded plastics are high-density materials that may be blown into different shapes such as drums, containers, electronics housings, toys, tote bins etc. Expanded plastics are usually made from the same plastic resins, but during the manufacturing process, small bubbles are trapped in the plastic resulting in a much lower density. These expanded plastics are sometimes called foamed plastics and may include materials such as insulation board, packing beans, polystyrene foam coffee cups/plates, and pipe insulation. Because of their lower density, expanded plastics tend to have a higher heat release rate than expanded plastics.

To use MSFC Figure 2303.7.4, both the percent by volume of expanded plastic and the percent by weight of unexpanded plastic in the commodity must be known. For example, a pallet load with 5% by volume expanded plastic and 10% by weight unexpanded plastic would be considered a class IV commodity. Should the quantity of expanded plastic be increased to 20%, the commodity would be classified as a high hazard (group A plastic). A pallet load with 25% by weight unexpanded plastic and no expanded plastics would also be a high-hazard (group A plastic) commodity.

It is not appropriate to convert percent by weight unexpanded and percent by volume expanded plastic for the purpose apparently reducing the hazard of a commodity to lower the required level of sprinkler protection.

For additional guidance on the storage of multiple classes of commodities, see the 2002 edition of NFPA 13, Chapter 12.

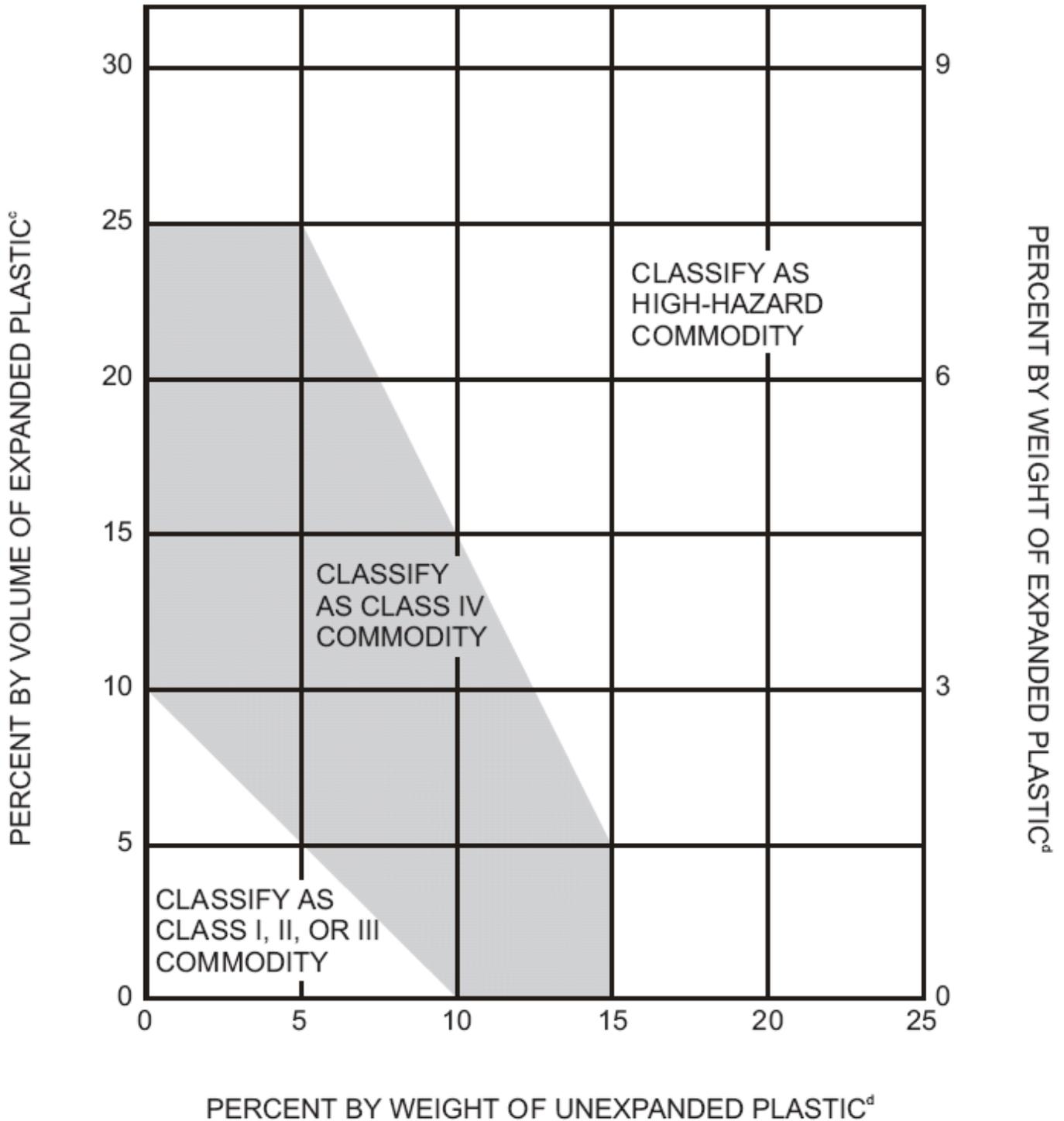


FIGURE 2303.7.4  
MIXED COMMODITIES<sup>a, b</sup>

- a. This table is intended to determine the commodity classification of a mixed commodity in a package, carton or on a pallet where plastics are involved.
- b. The following is an example of how to apply the table: A package containing a Class III commodity has 12-percent Group A expanded plastic by volume. The weight of the unexpanded Group A plastic is 10 percent. This commodity is classified as a Class IV commodity. If the weight of the unexpanded plastic is increased to 14 percent, the classification changes to a high-hazard commodity.
- c. Percent by volume =  $\frac{\text{Volume of plastic in pallet load}}{\text{Total volume of pallet load, including pallet}}$
- d. Percent by weight =  $\frac{\text{Weight of plastic in pallet load}}{\text{Total weight of pallet load, including pallet}}$

**Flammable and Combustible Liquids and Aerosol Containers.** Flammable and combustible liquids in all types of containers, including aerosols require detailed review for proper protection. Any time these types of materials are stored in any quantity, and especially when mixed with other types of storage, expert advice should be obtained. Usually only very small quantities of flammable and combustible liquids are allowed to be stored before the MSFC requires some type of fire suppression system.

**FIRE PROTECTION REQUIREMENTS.** Fire protection for high piled combustible storage is addressed in MSFC Section 2307.2, 2308.2 and 2309.2 and is summarized below in Table 1. Pay particular attention to the requirements for sprinkler protection. For class I-IV commodities, an automatic extinguishing system is required for over 2,500 square feet of storage, although there is one option for nonpublic accessible buildings that would allow up to 12,000 square feet of storage (an alarm system and smoke control are required). For high hazard commodities, an automatic extinguishing system is required for over 500 square feet of storage, although there is one option for nonpublic accessible buildings that would allow up to 2,500 square feet of storage (an alarm system and smoke control are required).

**GENERAL FIRE PROTECTION AND LIFE SAFETY TABLE 2306.2**

COMMODITY CLASS	SIZE OF HIGH-PILED STORAGE AREA <sup>a</sup> (square feet) (see Sections 2306.2 and 2306.4)	ALL STORAGE AREAS (See Sections 2306, 2307 and 2308) <sup>b</sup>					SOLID-PILED STORAGE, SHELF STORAGE AND PALLETIZED STORAGE (see Section 2307.3)		
		Automatic fireextinguishing system (see Section 2306.4)	Fire detection system (see Section 2306.5)	Building access (see Section 2306.6)	Smoke and heat removal (see Section 2306.7)	Draft curtains (see Section 2306.7)	Maximum pile dimension <sup>c</sup> (feet)	Maximum permissible storage height <sup>d</sup> (feet)	Maximum pile volume (cubic feet)
I-IV	0-500	Not Required	Not Required	Not Required <sup>e</sup>	Not Required	Not Required	Not Required	Not Required	Not Required
	501-2,500	Not Required <sup>a</sup>	Yes <sup>i</sup>	Not Required <sup>e</sup>	Not Required	Not Required	100	40	100,000
	2,501-12,000 Public accessible	Yes	Not Required	Not Required <sup>e</sup>	Not Required	Not Required	100	40	400,000
	2,501-12,000 Nonpublic accessible (Option 1)	Yes	Not Required	Not Required <sup>e</sup>	Not Required	Not Required	100	40	400,000
	2,501-12,000 Nonpublic accessible (Option 2)	Not Required <sup>a</sup>	Yes	Yes	Yes <sup>j</sup>	Yes <sup>j</sup>	100	30 <sup>r</sup>	200,000
	12,001-20,000	Yes	Not Required	Yes	Yes <sup>j</sup>	Not Required	100	40	400,000
	20,001-500,000	Yes	Not Required	Yes	Yes <sup>j</sup>	Not Required	100	40	400,000
	Greater than 500,000 <sup>g</sup>	Yes	Not Required	Yes	Yes <sup>j</sup>	Not Required	100	40	400,000
High hazard	0-500	Not Required <sup>a</sup>	Not Required	Not Required <sup>e</sup>	Not Required	Not Required	50	Not Required	Not Required
	501-2,500 Public accessible	Yes	Not Required	Not Required <sup>e</sup>	Not Required	Not Required	50	30	75,000
	501-2,500 Nonpublic accessible (Option 1)	Yes	Not Required	Not Required <sup>e</sup>	Not Required	Not Required	50	30	75,000
	501-2,500 Nonpublic accessible (Option 2)	Not Required <sup>a</sup>	Yes	Yes	Yes <sup>j</sup>	Yes <sup>j</sup>	50	20	50,000
	2,501-300,000	Yes	Not Required	Yes	Yes <sup>j</sup>	Not Required	50	30	75,000

	300,001-500,000 <sup>g, h</sup>	Yes	Not Required	Yes	Yes <sup>j</sup>	Not Required	50	30	75,000
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For SI: 1 foot = 304.8 mm, 1 cubic foot = 0.02832m<sup>3</sup>, 1 square foot = 0.0929m<sup>2</sup>.

a. When automatic sprinklers are required for reasons other than those in Chapter 23, the portion of the sprinkler system protecting the high-piled storage area shall be

designed and installed in accordance with Sections 2307 and 2308.

b. For aisles, see Section 2306.9.

c. Piles shall be separated by aisles complying with Section 2306.9.

d. For storage in excess of the height indicated, special fire protection shall be provided in accordance with Note g when required by the fire code official. See also

Chapters 28 and 34 for special limitations for aerosols and flammable and combustible liquids, respectively.

e. Section 503 shall apply for fire apparatus access.

f. For storage exceeding 30 feet in height, Option 1 shall be used.

g. Special fire protection provisions including, but not limited to, fire protection of exposed steel columns; increased sprinkler density; additional in-rack sprinklers,

without associated reductions in ceiling sprinkler density; or additional fire department hose connections shall be provided when required by the fire code official.

h. High-piled storage areas shall not exceed 500,000 square feet. A 2-hour fire wall constructed in accordance with the *International Building Code* shall be used to

divide high-piled storage exceeding 500,000 square feet in area.

i. Not required when an automatic fire-extinguishing system is designed and installed to protect the high-piled storage area in accordance with Sections 2307 and 2308.

j. Not required when storage areas are protected by early suppression fast response (ESFR) sprinkler systems installed in accordance with NFPA 13.

**Flue Spaces in Racks.** When commodities are stored in racks, openings are created between pallet loads in each direction to facilitate material handling. These flue spaces typically run the full height of the storage and allow fire to rapidly spread throughout the rack. When sprinklers are provided at the ceiling, these same flue spaces allow water to travel into the storage array. Although the buoyant gases from the fire typically prevent the sprinkler water from reaching the seat of the fire, pre-wetting of commodity that is not yet burning slows the spread of fire to yet ignited fuel. One type of sprinklers, Early Suppression Fast Response (ESFR), actually provide sufficient downward momentum to the sprinkler spray that water drops can reach the seat of the fire, virtually suppressing it.

For a double row rack, transverse flue spaces run in the direction of pallet loading and occur at rack uprights or side to side between pallets. Longitudinal flue spaces run the length of the array and are perpendicular to the direction of pallet loading. The longitudinal flue space separates pallets front to back and can easily be blocked when pallet loads are loaded too far back into the storage array.

Developments in sprinkler design have allowed storage well above 20 feet to be protected with ceiling only sprinkler protection. For water to reach burning commodity located within the array, adequate sized flue spaces must be provided as required by MSFC Section 2308. Table 2 details the minimum flue size for single, double and multi-row racks based on MSFC Table 2308.3. When the minimum flue spaces are not provided, then installation of in-rack sprinklers at every tier is usually the only option as outlined in the last column of Table 2.

**TABLE 2308.3  
REQUIRED FLUE SPACES FOR RACK STORAGE**

RACK CONFIGURATION	AUTOMATIC SPRINKLER PROTECTION		SPRINKLER AT THE CEILING WITH OR WITHOUT MINIMUM IN-RACK SPRINKLERS			IN-RACK SPRINKLERS AT EVERY TIER	NONSPRINKLERED
			=< 25 feet		>25 feet		
Single-row rack	Storage height		Option 1	Option 2		Any height	Any height
	Transverse flue space	Size <sup>b</sup>	3 inches	Not Applicable	3 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	
Double-row rack	Transverse flue space	Size <sup>b</sup>	6 inches <sup>a</sup>	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 <sup>b</sup>	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

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

- a. Three-inch transverse flue spaces shall be provided at least every 10 feet where ESFR sprinkler protection is provided.
- b. Random variations are allowed, provided that the configuration does not obstruct water penetration.

When required, longitudinal flue spaces must be provided down the entire length of the array, High density racking may create situations where the backs of pallet loads but up against each other, blocking the longitudinal flue space. In this case, either in-rack sprinklers are necessary, or some type of permanent fixed stop must be installed on the racking to prevent pushing pallets together.

Transverse flue spaces are usually provided at the rack uprights, although this space can become blocked with structural elements used to support the rack. The required transverse flue space need not be provided in one continuous opening, but instead is measured as the sum total of the provided openings. For example, a 4" wide rack upright is provided that creates a transverse flue space, although this area also contains a 1" structural member that runs horizontally down the center. Since two 1 1/2" openings are created, the total transverse flue space is considered to be 3" wide (sum total of all openings). When the space at the rack uprights is obstructed, the transverse flue could also be provided between pallet loads. When vertically alignment of flue spaces is required, permanent pallet guides or stops are typically necessary to keep these spaces open.

**Racks with Shelving That Can Restrict the Passage of Water.** Additional support for pallet loads or cartoned commodities is often proved by including shelves or other forms of material handling surfaces such as slats, mesh, or grates. Unfortunately, shelves also restrict the flow of sprinkler water to burning fuel. When provided with approved flue spaces, shelves, slats or grates with openings not more than 6 inches apart comprising at least 50% of the overall shelf area are treated as racks without shelves. Racks with solid shelving (and shelving not meeting the opening size requirements above) having an area greater than 32 square feet between flue spaces on all four sides shall have sprinkler protection installed as for solid shelves [MSFC Section 2308.2.2]. Basically, this requires sprinklers at every tier within the array.

**Steel Column Protection.** Columns shall be protected according to NFPA 13 ,Chapter 12 Standards. Based on full scale testing of sprinkler protected rack storage, in some cases structural steel reached temperatures leading to failure. In these cases, NFPA 13 requires additional sprinkler protection for structural steel members.

**SUMMARY.** When determining fire protection requirements for a storage facility, the following points should be considered:

- First classify the commodity. Use the information of this fact sheet as a guide, but if a commodity is not listed, do not guess. Contact the State Fire Marshal Division for assistance.
- Use Table 2306.2 in the MSFC for fire protection requirements.
- For materials stored in racks, assure that adequate flue spaces are maintained to allow sprinkler water to penetrate the storage array.
- Watch for obstructions such as solid shelves or slats. Also watch for grates that allow product or cartons to obstruct flue spaces.

