

2012 EDITION

HIGH-PILED COMBUSTIBLE STORAGE

BASED ON THE 2012 INTERNATIONAL FIRE CODE®



APPLICATION GUIDE



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Preface

Consumer demands are diverse, and multiple types and styles of products or goods are constantly being manufactured and updated. As a result, high-piled combustible storage is used so that more individual components are available to fulfill the desires of the consumer. High-piled combustible storage is economical to manufacturers and their logistics or supply chains because more goods can be stored within a given area through the use of solid-pile, palletized, rack or automated carousel storage. This allows more material to be stored within a given building area, which reduces the cost of storage or display for each square foot of Group S (storage) or Group M (mercantile) building area.

Since high-piled combustible storage allows for a greater amount of combustible materials within a given floor area, the increased fuel load increases the potential fire-dollar-loss for each square foot of floor area. Property losses resulting from smoke and fire damage of goods within a building in many cases can surpass the construction cost of the building itself.

It is challenging to verify the adequacy of the automatic sprinkler system in buildings housing high-piled combustible storage. In the past 15 years, the fire protection engineering community has witnessed the proliferation of a variety of new automatic sprinklers that are designed specifically for high-piled combustible storage. The available methods of design have also increased, and the National Fire Protection Association (NFPA) requirements for automatic sprinkler protection continue to be extensively modified.

In addition to the new sprinkler designs, specific design criteria for large retail facilities has been added to NFPA Standard 13 as a result of full-scale fire tests performed in testing laboratories. These criteria are very detailed and are influenced by commodity arrangement, the layout of racks and shelves and the method of commodity storage.

This application guide is intended to familiarize code officials and design professionals with Chapter 32 of the 2012 *International Fire Code*® (IFC®), “High-Piled Combustible Storage” and the requirements in Section 413 of the 2012 *International Building Code*® (IBC®). This guide will also introduce code professionals to the requirements for storage occupancies in the 2010 edition of NFPA 13, *Installation of Sprinkler Systems*. It will include an analysis of the three methods of automatic sprinkler design for storage occupancies and the variables that can affect the performance of an automatic sprinkler system designed for the protection of high-piled combustible storage.

The information and opinions expressed in this application guide are those of the present and past authors and do not necessarily represent the official position of the International Code Council® (ICC®).

Additionally, the opinions may not represent the viewpoint of any enforcing agency. Opinions expressed in this publication are only intended to be a resource in the application of IFC Chapter 32 and NFPA 13, and the code official is not obligated to accept such opinions. The code official is the final authority in rendering interpretations of the code and its adopted standards.

Questions or comments concerning this application guide are encouraged. Please direct any correspondence to applicationguide@iccsafe.org.

About the International Code Council®

The International Code Council (ICC), a membership association dedicated to building safety, fire prevention and energy efficiency, develops the codes and standards used to construct residential and commercial buildings, including homes and schools. The mission of ICC is to provide the highest quality codes, standards, products and services for all concerned with the safety and performance of the built environment. Most United States cities, counties and states choose the *International Codes*®, building safety codes developed by the International Code Council.

The *International Codes* also serve as the basis for construction of federal properties around the world, and as a reference for many nations outside the United States. The International Code Council is also dedicated to innovation and sustainability. ICC Evaluation Service, a subsidiary of ICC, issues Evaluation Reports and Listings for innovative building products as well as environmental documents such as ICC-ES VAR Environmental Reports and ICC-ES Environmental Product Declarations (EPDs).

Headquarters:

500 New Jersey Avenue, NW, 6th Floor,
Washington, DC 20001-2070

District Offices:

Birmingham, AL; Chicago, IL; Los Angeles, CA

Telephone: 1-888-422-7233(ICC-SAFE)

www.iccsafe.org

About the Author

The *High-Piled Combustible Storage Application Guide: 2012 International Fire Code* was originally developed in 1990 by Elley Klausbruckner, P.E., of Klausbruckner and Associates, San Diego, CA. Scott Stookey, Engineering Associate for the City of Austin, Texas Fire Department, provided an extensive updating of the publication to provide consistency with the International Fire Code. This edition has been updated to the current requirements in the I-Codes and NFPA Standards by Kevin H. Scott. He is President of KH Scott & Associates, and has extensive experience in the development of fire safety, building safety and hazardous materials regulations. Kevin has actively worked for over 25 years in the development of fire code, building code and fire safety regulations at the local, state, national and international levels. Kevin has developed and presented many seminars on a variety of technical subjects, including means of egress, high-piled combustible storage, hazardous materials, and plan review and inspection practices.

About the Publication

Description

The High-piled Combustible Storage Application Guide, 2012 edition provides a basic understanding of the hazards associated with high-piled combustible storage and introduces the readers to the provisions in Chapter 32 of the 2012 edition of the *International Fire Code*® (IFC®). This publication places special emphasis on the classification of commodities and understanding the design criteria in NFPA 13 for storage.

Goal

This workbook is intended to familiarize readers with the hazards involved with high-piled combustible storage and to provide a basic understanding of the high-piled combustible storage provisions in Chapter 32 of the 2012 edition of the *International Fire Code*® (IFC®).

Objectives

Upon completion of this publication, readers will be better able to:

- Describe the scope and application of Chapter 32 of the IFC.
- Explain the commodity classification system based on the criteria in Section 3203 of the IFC.
- Apply the requirements of Chapter 32 for high-piled combustible storage.
- Identify the various storage methods for high-piled combustible storage.
- Describe how each storage method contributes to fire behavior.
- Explain the basic requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2010 edition, for storage occupancies.

Target Audience

Building Inspectors, Building Officials, Fire Inspectors, Architects and Engineers

Explanation of Icons

These events will be identified by the following icons in the margin of this publication:



This icon directs you to material in the *International Codes*® (I-Codes®). This will help you become familiar with locating information within the code book. The exact location of the information referenced will be provided below the icon.



This icon indicates when an example is used to reinforce concepts in the publication.



The activities included in the publication, indicated by this icon, provide an opportunity for you to practice applying the code. The activities are designed to enhance your learning experience by presenting reality-based exercises.



Look for this icon to indicate a process or procedure that is important for you to know and to be able to use on the job.



The question-and-answer sections provide questions addressing critical areas.



In addition to examples and question-and-answer sections, this publication may include a case study based on real-world situations.



This icon introduces discussion exercises. The questions in this exercise can be discussed with your peers regarding their importance and application.





This icon introduces the final reflection exercise. The questions in this exercise will help you determine the most important thing you learned from the publication, why the information is important for you to know, and how you will use the information at work.



Code commentary books include code language with explanations and discussions of major issues. This icon refers to an explanation in the associated commentary.

Margin Designation Within Code Book

 Margin lines indicate changes to the code. For example the requirements from the 2009 *International Building Code*[®] (IBC[®]) to the 2012 *International Building Code*[®] (IBC[®]).

 Arrows indicate a section that was in the 2009 code that has been deleted from the 2012 code.

* A single asterisk placed in the margin indicates that text or a table has been relocated within the code.

** A double asterisk placed in the margin indicates that the text or table immediately following it has been relocated there from elsewhere in the code.

Letter designations in brackets adjacent to a code section indicate specific code content that is maintained by a code development committee other than those assigned to the specific code. For example, [F] 903.2 is a code provision that was considered by the International Fire Code Development Committee and may be in other codes. This designation serves to inform the user that the same provision is repeated in another ICC code.

- [A] = Administrative Code Development Committee;
- [E] = International Energy Conservation Code Development Committee;
- [EB] = International Existing Building Code Development Committee;
- [F] = International Fire Code Development Committee;
- [FG] = International Fuel Gas Code Development Committee;
- [M] = International Mechanical Code Development Committee; and
- [P] = International Plumbing Code Development Committee.

Module 3

High-Piled Storage Area Requirements

Introduction

After the commodities are classified and the storage height and high-piled storage area have been identified, the amount and type of protection required for the facility must be determined. These requirements are set forth in IFC Table 3206.2, which contains the general fire protection and life safety requirements for high-piled combustible storage. This table serves as an index to the requirements in Sections 3206.2 through 3206.10, which address the following requirements:

- Section 3206.2: Extent and type of protection
- Section 3206.3: Separation of high-piled storage areas
- Section 3206.4: Automatic sprinklers
- Section 3206.5: Fire detection
- Section 3206.6: Building access
- Section 3206.7: Smoke and heat removal
- Section 3206.8: Fire department hose connections
- Section 3206.9: Aisles
- Section 3206.10: Portable fire extinguishers

Application of Table 3206.2

The requirements in Table 3206.2 are based on five variables, which are the basis for the application of the requirements in Chapter 32 and NFPA 13. The variables are:

- Commodity classification
- Size of high-piled storage area
- Requirements for all storage areas
- solid-piled storage, shelf storage and palletized storage volume
- Height of storage

A basic review of this table reveals that all the requirements are dependent on the classification of the commodity and the size of the high-piled storage area. The table is divided into two basic commodity categories: Classes I through IV and high hazard. For Class I through IV commodities, there are no real differences in the requirements; once the goods, materials and packaging are assigned to one of the four commodity classes, the requirements of Table 3206.2 are primarily based on the size of the high-piled storage area.



Definitions

AUTOMATIC SPRINKLER SYSTEM. An automatic sprinkler system, for fire protection purposes, is an integrated system of underground and overhead piping designed in accordance with fire protection engineering standards. The system includes a suitable water supply. The portion of the system above the ground is a network of specially sized or hydraulically designed piping installed in a structure or area, generally overhead, and to which automatic sprinklers are connected in a systematic pattern. The system is usually activated by heat from a fire and discharges water over the fire area.

FIRE ALARM SYSTEM. A system or portion of a combination system consisting of components and circuits arranged to monitor and announce the status of fire alarm or supervisory signal-initiating devices and to initiate the appropriate response to those signals.

MANUAL STOCKING METHODS. Stocking methods utilizing ladders or other nonmechanical equipment to move stock.

MECHANICAL STOCKING METHODS. Stocking methods utilizing motorized vehicles or hydraulic jacks to move stock.

Key Concept

Table 3206.2 serves as an index for the requirements for the protection of high-piled combustible storage based on the building occupancy, the area of storage, the commodity classification and the type of storage.



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Table 3206.2,
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In high-piled storage areas that contain a mix of commodity classes, Section 3206.2 specifies the minimum requirements for extent and type of required protection. It states:

3206.2 Extent and type of protection. Where required by Table 3206.2, fire detection systems, smoke and heat removal, draft curtains and automatic sprinkler design densities shall extend the lesser of 15 feet (4572 mm) beyond the high-piled storage area or to a permanent partition. Where portions of high-piled storage areas have different fire protection requirements because of commodity, method of storage or storage height, the fire protection features required by Table 3206.2 within this area shall be based on the most restrictive design requirements.

TABLE 3206.2
GENERAL FIRE PROTECTION AND LIFE SAFETY REQUIREMENTS

COMMODITY CLASS	SIZE OF HIGH-PILED STORAGE AREA* (square feet) (see Sections 3206.2 and 3206.4)	ALL STORAGE AREAS (See Sections 3206, 3207 and 3208) ^a					SOLID-PILED STORAGE, SHELF STORAGE AND PALLETIZED STORAGE (see Section 3207.3)		
		Automatic fire-extinguishing system (see Section 3206.4)	Fire detection system (see Section 3206.5)	Building access (see Section 3206.6)	Smoke and heat removal (see Section 3206.7)	Draft curtains (see Section 3206.7)	Maximum pile dimension ^g (feet)	Maximum permissible storage height ^g (feet)	Maximum pile volume (cubic feet)
I-IV	0-500	Not Required ^a	Not Required	Not Required ^e	Not Required	Not Required	Not Required	Not Required	Not Required
	501-2,500	Not Required ^a	Yes ⁱ	Not Required ^e	Not Required	Not Required	100	40	100,000
	2,501-12,000 Public accessible	Yes	Not Required	Not Required ^e	Not Required	Not Required	100	40	400,000
	2,501-12,000 Nonpublic accessible (Option 1)	Yes	Not Required	Not Required ^e	Not Required	Not Required	100	40	400,000
	2,501-12,000 Nonpublic accessible (Option 2)	Not Required ^a	Yes	Yes	Yes ^j	Yes ^j	100	30 ^f	200,000
	12,001-20,000	Yes	Not Required	Yes	Yes ^j	Not Required	100	40	400,000
	20,001-500,000	Yes	Not Required	Yes	Yes ^j	Not Required	100	40	400,000
	Greater than 500,000 ^g	Yes	Not Required	Yes	Yes ^j	Not Required	100	40	400,000
High hazard	0-500	Not Required ^a	Not Required	Not Required ^e	Not Required	Not Required	50	Not Required	Not Required
	501-2,500 Public accessible	Yes	Not Required	Not Required ^e	Not Required	Not Required	50	30	75,000
	501-2,500 Nonpublic accessible (Option 1)	Yes	Not Required	Not Required ^e	Not Required	Not Required	50	30	75,000
	501-2,500 Nonpublic accessible (Option 2)	Not Required ^a	Yes	Yes	Yes ^j	Yes ^j	50	20	50,000
	2,501-300,000	Yes	Not Required	Yes	Yes ^j	Not Required	50	30	75,000
	300,001-500,000 ^{g,h}	Yes	Not Required	Yes	Yes ^j	Not Required	50	30	75,000

For SI: 1 foot = 304.8 mm, 1 cubic foot = 0.02832 m³, 1 square foot = 0.0929 m².

- 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.
- b. For aisles, see Section 3206.9.
- c. Piles shall be separated by aisles complying with Section 3206.9.
- 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 51 and 57 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 Section 706 of 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 3207 and 3208.
- j. Not required when storage areas are protected by early suppression fast response (ESFR) sprinkler systems installed in accordance with NFPA 13.

Table 3206.2 requires automatic sprinkler protection for high-piled combustible storage areas over 12,000 square feet (1114.8 m²) housing Class I through IV commodities or storing high-hazard commodities in an area greater than 2,500 square feet (232.25 m²). For instances where a particular storage area is designed for a lower hazard commodity and a higher hazard commodity is introduced, Section 3206.2 can be used to require improve-

ments to the fire protection systems so the higher hazard commodity can be safely stored.

For buildings containing high-piled combustible storage that is accessible to the public, such as Mercantile (Group M) occupancies, the area thresholds for requiring automatic sprinkler protection are far less than the base values prescribed in the IFC and IBC Section 903.2.7. The requirement for the installation of an automatic sprinkler system is applicable in public accessible buildings storing Class I through IV commodities with a high-piled storage area over 2,500 square feet (232.25 m²) and public accessible high-piled storage areas over 500 square feet (46.5 m²) housing High-hazard commodities. By comparison, IFC and IBC Section 903.2.7 require automatic sprinkler protection when the fire area of a Group M occupancy exceeds 12,000 square feet (111.48 m²). The intent of this provision is to protect the building occupants. Group M occupancies can have large occupant loads and fuel packages. Fires involving high-piled combustible storage can have fast burning rates and high heat release rates. Accordingly, when the Group M occupancy contains high-piled combustible storage, the IFC lowers the area threshold to ensure that design of the automatic sprinkler system can control or suppress a fire.

Consider the example in Figure 3-1. The illustration is a partial view of a Group S-1 occupancy that contains high-piled combustible storage. The automatic sprinkler system for the building is designed for the protection of Class III commodities. A Class IV commodity has been introduced. To comply with Section 3206.2, the automatic sprinkler system in the area storing the Class IV commodities must be extended a minimum of 15 feet (4572 mm) beyond the high-piled storage area or to a permanent partition. Figure 3-1 illustrates the storage boundary for the Class IV commodities and the added 15-foot (4572 mm) perimeter in which the fire protection system must be designed to accommodate this commodity.

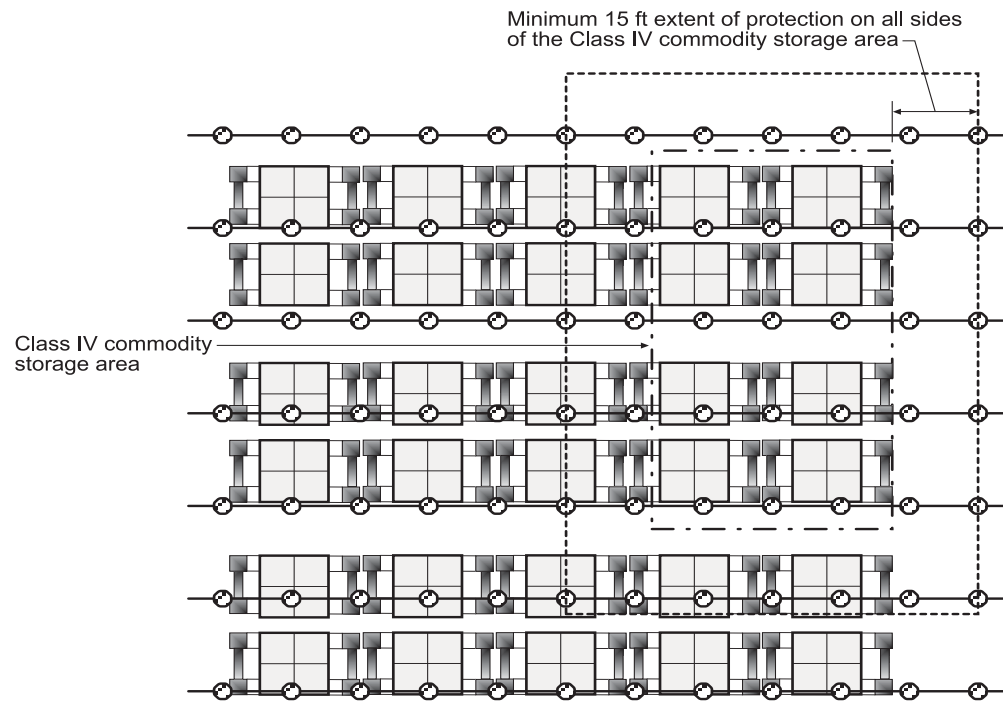


Figure 3-1:
Extent of Protection

In cases where mixed commodities are stored and are not separated, fire code officials should also apply the requirements for Section 3204.2. This requires an engineering analysis of the automatic sprinkler system protecting the commodity that has an increased heat-release rate. Such an analysis will confirm if the automatic sprinkler system can adequately protect the stored commodity.

Separation of High-Piled Storage Areas

In high-piled combustible storage areas that contain multiple classes of commodities, the commodities can be separated using minimum 1-hour fire barriers to isolate the higher hazard from the less challenging commodities. Separating high-hazard commodities, such as expanded or unexpanded Group A plastics or rubber tires, allows the area of the sprinkler system designed to protect these commodities to be limited when the automatic sprinkler system is designed in accordance with either Section 3206.2 or 3204.2.

Section 3206.3 sets forth the requirements for the separation of high-piled storage areas from other occupancies inside a building (i.e., mixed occupancies) and separation of two or more high-piled combustible storage areas within the same building.

Regarding separation of a high-piled storage area from other occupancies within the building, a high-piled storage area generally is limited to one of the following occupancy classifications:

- Group S-1 or S-2
- Group M
- Group H-2, H-3, H-4 or a combination of these hazardous occupancies

While the high-piled storage area may be classified as one of these occupancies, one or more other occupancies may occur within the building. For example, it is not uncommon for a Group S-1 occupancy containing high-piled combustible storage to be located in the same building with an office area classified as Group B. IFC Section 3206.3.1 defers the requirements for the separation of any occupancies containing high-piled combustible storage areas in mixed occupancy buildings to the *International Building Code*.

IBC Section 508 contains the separation requirements in mixed occupancy buildings, including separation based on the method being utilized. The section establishes three methods of dealing with mixed occupancies: accessory occupancies, nonseparated occupancies and separated occupancies. Only the separated occupancies method requires some degree of fire-resistance-rated separation between occupancies, and even then such separations are not required for all occupancy pairings. The method used for regulating mixed occupancies is chosen by the design professional and is then reviewed and approved by the code official. Typically, the nonseparated occupancies method is not chosen since it would mean extending all of the fire protection requirements into the adjacent occupancy, such as smoke removal, building access, etc.

The provisions for separated occupancies in IBC Section 508.4 reference IBC Table 508.4 for the minimum fire-resistance-rated separation required between different occupancies. In reviewing a Group B/F-1/S-1 mixed occupancy condition, building owners have great flexibility for activities in such a building. In buildings where products are manufactured and the materials are stored using high-piled combustible storage methods, the storage area can be anywhere in the building because the Group F-1 and S-1 uses are not required to be separated. As a result, it is important that fire code officials identify where the finished commodities will be stored in the building and ensure that the automatic sprinkler protection is adequate for the area containing high-piled combustible storage. Fire departments should consider developing an administrative policy that addresses the

Key Concept

IBC Section 508 establishes the requirements for separation of mixed uses and occupancies.

design of automatic sprinkler systems in buildings that are speculative in nature and are designed to accommodate mixed occupancies where no fire-resistance-rated separations are required.

**TABLE 508.4
REQUIRED SEPARATION OF OCCUPANCIES (HOURS)**

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	NP	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

S = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.
 NS = Buildings not equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.
 N = No separation requirement.
 NP = Not permitted.

- a. See Section 420.
- b. The required separation from areas used only for private or pleasure vehicles shall be reduced by 1 hour but to not less than 1 hour.
- c. See Section 406.3.4.
- d. Separation is not required between occupancies of the same classification.



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In accordance with IFC Section 3206.3.2, 1-hour fire barriers can be used to create separate high-piled storage areas. Provided the high-piled combustible storage area is no greater than 12,000 square feet (1114.8 m²) for Class I through IV commodities or no greater than 2,500 square feet (232.25 m²) for high-hazard commodities, automatic sprinkler protection is not required by IFC Table 3206.2. When a building contains a Group S-1 fire area exceeding 12,000 square feet (1114.8 m²) the fire area must be sprinklered. An aggregate of Group S-1 fire areas that exceed 24,000 square feet (2229.67 m²) also require automatic sprinkler protection in accordance with IFC Section 903.2.9 unless the Group S-1 occupancy is divided using a fire wall. If a fire wall is used, the area of a nonseparated nonsprinklered building housing high-piled combustible storage is limited to 12,000 square feet (1114.8 m²) in Group S occupancies or 2,500 square feet (232.25 m²) in Group M occupancies, depending on the classification of the commodity.

Automatic Sprinkler Protection

As previously noted, Table 3206.2 requires the installation of an automatic sprinkler system inside a building housing high-piled combustible storage when the area of storage exceeds certain limits. Section 3206.4 refers to other code sections based on the method or methods used to store the commodities:

3206.4 Automatic sprinklers. Automatic sprinkler systems shall be provided in accordance with Sections 3207, 3208 and 3209.

Section 3207 addresses the requirements for solid-piled and shelf storage. Section 3208 addresses the requirements for rack storage, and Section 3209 references the requirements for automated storage. All three sections reference Table 3206.2 for determining when automatic sprinkler protection is required.