NFPA 230
Standard for the Fire Protection of Storage

1999 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 230

Standard for the

Fire Protection of Storage

1999 Edition

This edition of NFPA 230, *Standard for the Fire Protection of Storage*, was prepared by the Technical Committee on General Storage and acted on by the National Fire Protection Association, Inc., at its May Meeting held May 17–20, 1999, in Baltimore, MD. It was issued by the Standards Council on July 22, 1999, with an effective date of August 13, 1999.

This edition of NFPA 230 was approved as an American National Standard on August 13, 1999.

Origin and Development of NFPA 230

The creation of NFPA 230 is the result of a Standards Council directive to consolidate information pertaining to sprinkler systems. The portions of NFPA 231, 231C, 231D, 231E, and 231F containing sprinkler system information were moved into NFPA 13, *Standard for the Installation of Sprinkler Systems*. As part of this effort, nonsprinkler system–related information pertaining to storage operations that was previously located in NFPA 231, 231C, 231D, 231E, and 231F and all of NFPA 46 was redesignated as NFPA 230 and consolidated to minimize duplication of fire protection requirements. A chart, Cross-References to Previous Editions, is provided at the end of this document as a guide to the consolidation of these documents.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on safeguarding general warehousing and commodities stored indoors or outdoors against fire. This Committee does not cover storage specifically covered by other NFPA standards.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

A dagger (†) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix C.

Information on referenced publications can be found in Chapter 12 and Appendix H.

Chapter 1 Introduction

1-1 Scope.

1-1.1 This standard shall apply to the indoor and outdoor storage of materials representing the broad range of combustibles, including plastics, forest products, rubber tires, scrap tires, baled cotton, and roll paper. Storage configurations shall include palletized, solid-piled, in bin boxes, on shelves, or on racks.

1-1.2 This standard shall not apply to the following:

(a) Unsprinklered buildings.

Exception No. 1: Buildings containing baled cotton storage.

Exception No. 2: Rack storage arrangements protected with high-expansion foam systems in accordance with 5-4.1 and 5-4.2.

(b) Storage of commodities that, with their packaging and storage aids, would be classified as noncombustible.

(c) Unpackaged bulk materials such as grain, coal, or similar commodities.

Exception: Wood chips and sawdust are addressed in Appendix E.

(d) Inside or outside storage of commodities covered by other NFPA standards, except where specifically mentioned herein (e.g., pyroxylin plastics).

(e) Storage of high-hazard materials such as flammable liquids. Storage of such commodities shall be protected in accordance with the provisions of NFPA 30, *Flammable and Combustible Liquids Code;* NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products;* NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film;* NFPA 58, *Liquefied Petroleum Gas Code;* NFPA 232, *Standard for the Protection of Records;* NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers;* and NFPA 490, *Code for the Storage of Ammonium Nitrate.*

(f) Storage on plastic shelves on racks.

1-2 Purpose. This standard provides a reasonable degree of protection based upon sound engineering principles, tests, data, and field experience. Nothing in this standard shall be intended to restrict new technologies or alternate arrangements, provided that the level of protection prescribed by the standard is not lowered.

1-3 Retroactivity Clause. The provisions of this document shall be considered necessary to provide a reasonable level of protection from loss of life and property from fire. They shall reflect situations and the state of the art at the time the standard was issued.

Unless otherwise noted, the provisions of this document shall not be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of this document.

Exception: In those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or property, this standard shall apply.

1-4 Definitions.

1-4.1 Storage Definitions. Unless expressly stated elsewhere, for the purpose of this standard, the terms in this section shall be defined as follows.

Aisle Width.* The horizontal dimension between the face of the loads in racks under consideration. *[See Figure A-1-4.1(a).]*

Alleyway. An accessible clear space between storage piles or groups of piles suitable for housekeeping operations, visual inspection of piling areas, and initial fire-fighting operations.

Available Height for Storage.* The maximum height at which commodities can be stored above the floor and still maintain necessary clearance from structural members and the required clearance below sprinklers.

Baled Cotton.* A natural seed fiber wrapped and secured in industry-accepted materials, usually consisting of burlap, woven polypropylene, or sheet polyethylene, and secured with steel, synthetic, or wire bands, or wire; can also include linters (lint removed from the cottonseed) and motes (residual materials from the ginning process).

Baled Cotton Yard. A storage unit consisting of multiple storage blocks subject to bale and clear space limitations.

Banded Storage. Paper rolls provided with a circumferential steel strap [$^3/_8$ in. (9.5 mm) or wider] at each end of the roll.

Banded Tires. A storage method in which a number of tires are strapped together.

Bin Box Storage. Storage in five-sided wood, metal, or cardboard boxes with open face on the aisles that are self-supporting or supported by a structure so designed that little or no horizontal or vertical space exists around boxes.

Block. A basic yard storage unit for baled cotton comprising multiple-row storage with clear spaces on all sides.

Block Storage. The number of bales of cotton closely stacked in cubical form and enclosed by aisles or building sides, or both.

Bulkhead. A vertical barrier across the rack.

Burn-It. A fire-fighting strategy that allows for the free-burn of a tire fire.

Bury-It. A fire-fighting strategy that suggests burying a tire pile with soil, sand, gravel, cement dust, or other cover material.

Cartoned. A method of storage consisting of corrugated cardboard or paperboard containers fully enclosing the commodity.

Ceiling Height. The distance between the floor and the underside of the ceiling above (or roof deck) within the storage area.

Chips. Wood chips of various species used in the manufacture of pulp. These chips are usually $^1/_4$ in. (6.4 mm) to $1^1/_4$ in. (31.8 mm) in size, with nothing finer than what is retainable on a $^1/_4$-in. (6.4-mm) screen; however, blower and conveyor systems can create some fine dust particles after screening.

Clear Space. Any area free of combustible materials. This does not preclude the storage of noncombustible materials that will not transmit an exposure fire.

Clearance. The distance from the top of storage to the ceiling sprinkler deflectors.

Cold Cotton. Baled cotton five or more days old after the ginning process.

Cold Deck. A single ranked pile of logs with individual logs of regular or irregular length usually 20 ft (6.1 m) to 50 ft (15.2 m) long, but greater than 8 ft (2.4 m) in length.

Column (Paper). A single vertical stack of rolls of paper.

Commodity. The combination of products, packing material, and container upon which commodity classification is based.

Compartmented.* The rigid separation of the products in a container by dividers that form a stable unit under fire conditions.

Container (Shipping, Master, or Outer Container).* A receptacle strong enough, by reason of material, design, and construction, to be shipped safely without further packaging.

Conventional Pallets.* A material-handling aid designed to support a unit load with openings to provide access for material-handling devices. *[See Figure A-1-4.1(b).]*

Cordwood. Logs 8 ft (2.4 m) or less in length customarily intended for pulpwood or fuel uses.

Core. The central tube around which paper is wound to form a roll.

Cunit. 100 ft^3 (2.8 m^3) of solid wood or 100 ft^3 (2.8 m^3) of chips or hogged material.

Designated Yard. An area marked by boundary lines intended for outside storage purposes only.

Encapsulated. A method of packaging that consists of a plastic sheet that completely encloses the sides and top of a pallet load that contains a combustible commodity or a combustible package or a group of combustible commodities or combustible packages; combustible commodities that are individually wrapped in plastic sheeting and stored exposed in a pallet load. Totally noncombustible commodities on wood pallets that are enclosed only by a plastic sheet as described are not covered under this definition. Banding (i.e., stretch-wrapping around only the sides of a pallet load) is not considered to be encapsulation. Where there are holes or voids in the plastic or waterproof cover on the top of the carton that exceed more than half the area of the cover, the term *encapsulated* shall not apply. The term encapsulated does not apply to plastic-enclosed products or packages inside a large, nonplastic, enclosed container.

Fire Lane. A clear space suitable for fire-fighting operations by motorized fire apparatus.

Fire-Packed. A cotton bale within which a fire has been packed as a result of a process with ginning being the most frequent cause.

Flameover. A fire that spreads rapidly over the exposed linty surface of the cotton bales. In the cotton industry, the common term is *flashover* and has the same meaning.

Flashover. See definition of *Flameover.*

Forecasting. The ability to predict the fire progression in scrap tire storage location prior to the completion of the inventory fire break using heavy equipment.

Group of Yards. Multiple outdoor storage areas with maximum block and minimum clear space limitations for baled cotton.

Hogged Material. Mill waste consisting mainly of hogged bark but can include a mixture of bark, chips, dust, or other by-products from trees. This also includes material designated hogged fuel.

Horizontal Channel. Any uninterrupted space in excess of 5 ft (1.5 m) in length between horizontal layers of stored tires that can be formed by pallets, shelving, racks, or other storage arrangements.

Horizontal Paper Storage. Paper rolls stored with the cores in the horizontal plane, which is known as on-side storage.

Laced Storage. Tires stored where the sides of the tires overlap, creating a woven or laced appearance. *[See Figure 6-2(g).]*

Lumber. Boards, dimension lumber, timber, plywood, and other similar wood products.

Miscellaneous Storage. Storage that does not exceed 12 ft (3.7 m) in height and is incidental to another occupancy use group as defined in NFPA 13, *Standard for the Installation of Sprinkler Systems.* Such storage shall not constitute more than 10 percent of the building area or 4000 ft^2 (372 m^2) of the sprinklered area, whichever is greater. Such storage shall not exceed 1000 ft^2 (93 m^2) in one pile or area, and each such pile or area shall be separated from other storage areas by at least 25 ft (7.6 m).

Miscellaneous Tire Storage.* The storage of rubber tires that is incidental to the main use of the building in an area not exceeding 2000 ft^2 (186 m^2). On-tread storage piles, regardless of storage method, are not to exceed 25 ft (7.6 m) in the direction of the wheel holes. Acceptable storage arrangements include the following: (1) on-floor, on-side storage up to 12 ft (3.7 m) high; (2) on-floor, on-tread storage up to 5 ft (1.5 m) high; (3) double-row or multirow fixed or portable rack storage on-side, or on-tread, up to 5 ft (1.5 m) high; (4) single-row fixed or portable rack storage on-side, or on-tread, up to 12 ft (3.7 m) high; (5) laced tires in racks up to 5 ft (1.5 m) high.

Naked Bale. An unwrapped cotton bale secured with wire or steel straps.

Noncombustible. Commodities, packaging, or storage aids that do not ignite, burn, or liberate flammable gases when heated to a temperature of 1380°F (749°C) for 5 minutes.

On-Side Storage. Tires stored horizontally or flat.

On-Tread Storage. Tires stored vertically or on their treads.

Packaging. A commodity wrapping, cushioning, or container.

Palletized Storage. Storage of commodities on pallets or other storage aids that form horizontal spaces between tiers of storage.

Paper. The general term for all kinds of felted sheets made from natural fibrous materials, usually vegetable but sometimes mineral or animal, and formed on a fine wire screen from water suspension.

Pyramid Storage. On-floor storage in which commodities are formed into a pyramid to provide pile stability.

Quarantine Yard. A segregated area for the storage of baled cotton of known or suspect fire-packed bales.

Rack. Any combination of vertical, horizontal, and diagonal members that supports stored materials. Some rack structures use solid shelves. Racks shall be permitted to be fixed, portable, or movable *[see Figures A-5-3.1(a)(1) through A-5-3.1(a)(4), A-5-3.1(b), A-5-3.1(c)(1) through A-5-3.1(c)(4), A-5-3.1(d), and A-5-3.1(f)]*. Loading shall be permitted to be either manual, using lift trucks, stacker cranes, or hand placement, or automatic, using machine-controlled storage and retrieval systems.

Rack, Double-Row. Two single-row racks placed back-to-back having a combined width up to 12 ft (3.7 m) with aisles at least 3.5 ft (1.1 m) on each side.

Rack, Movable. Racks on fixed rails or guides. They can be moved back and forth only in a horizontal, two-dimensional plane. A moving aisle is created as abutting racks are either loaded or unloaded, then moved across the aisle to abut other racks.

Rack, Multiple-Row. Racks greater than 12 ft (3.7 m) wide or single- or double-row racks separated by aisles less than 3.5 ft (1.1 m) wide having an overall width greater than 12 ft (3.7 m).

Rack, Portable. Racks that are not fixed in place. They can be arranged in any number of configurations.

Rack, Single-Row. Racks that have no longitudinal flue space and that have a width up to 6 ft (1.8 m) with aisles at least 3.5 ft (1.1 m) from other storage.

Ranked Log Piles. Piles of logs evenly arranged by conveyor, crane, or other means.

Roof Height. The distance between the floor and the underside of the roof deck within the storage area.

Row. A minimum yard storage unit comprised of adjoining cotton bales.

Rubber Tires. Pneumatic tires for passenger automobiles, aircraft, light and heavy trucks, trailers, farm equipment, construction equipment (off-the-road), and buses.

Scrap Tire. A tire that can no longer be used for its original purpose due to wear or damage.

Shelf Storage. Storage on structures less than 30 in. (76.2 cm) deep with shelves usually 2 ft (0.6 m) apart vertically and separated by approximately 30-in. (76.2-cm) aisles.

Shredded Tire. A scrap tire reduced in size by a mechanical-processing device, commonly referred to as a shredder.

Solid Shelving. Solid, slatted, and other types of shelving located within racks that obstruct sprinkler water penetration down through the racks.

Stacked Log Piles. Piles of logs where logs are generally conveyed to the center of a pile, presenting a cone-shaped appearance.

Storage Aids. Commodity storage devices such as shelves, pallets, dunnage, separators, and skids.

Tactics. The method of securing the objectives laid out in the strategy through the use of personnel and equipment to achieve optimum results.

Tiered Storage. An arrangement in which cotton bales are stored two or more bales high directly on the floor or ground, usually on dunnage where stored outdoors.

Tire Chip. A classified scrap tire particle that has a basic geometrical shape, which is generally 2 in. (51 mm) or smaller and has most of the wire removed.

Vertical Paper Storage. Rolls stored with the cores in the vertical plane, which is known as on-end storage.

Wrapped Paper Storage.* Rolls provided with a complete heavy kraft covering around both sides and ends.

Yard Storage. The outdoor areas where commodities are stored.

1-4.2 NFPA Definitions.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

Listed.* Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

1-5* Units. Metric units of measurement in this standard shall be in accordance with the modernized metric system known as the International System of Units (SI). The liter unit, which is not part of but is recognized by SI, is commonly used in international fire protection.

1-5.1 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first value shall be considered to be the requirement. The equivalent value could be approximate.

1-5.2 SI units shall be converted by multiplying the quantity by the conversion factor and then rounding the result to the appropriate number of significant digits.

Chapter 2 Classification of Storage

2-1 General.

2-1.1 Classification of storage shall be determined based on the makeup of individual storage units in accordance with this document and NFPA 13, *Standard for the Installation of Sprinkler Systems*.

2-1.2 Changes in the commodities, packaging, or storage methods shall require an evaluation of the existing protection features including sprinkler systems where installed. Protection features shall be in accordance with this standard and NFPA 13 for the changed commodity, packaging, or storage method.

Chapter 3 General Requirements

3-1 Building Construction.

3-1.1* Construction Type. Buildings used for storage of materials that are stored and protected in accordance with this standard shall be of any of the types described in NFPA 220, *Standard on Types of Building Construction.*

3-1.2 Fire-Fighting Access. Adequate access shall be provided to all portions of the premises for fire-fighting purposes.

3-1.3*† Emergency Smoke and Heat Venting. Protection outlined in this standard shall apply to buildings with or without roof vents and draft curtains.

Exception: Where local codes require heat and smoke vents in buildings protected by early suppression fast response (ESFR) sprinklers, the vents shall be manually operated or have an operating mechanism with a standard response fusible element rated no less than 360°F (182°C).

3-2 Storage Arrangement.

3-2.1 Piling Procedures and Precautions.

3-2.1.1 Any commodities that are hazardous in combination with each other shall be stored so they cannot come into contact with each other.

3-2.1.2* Safe floor loads shall not be exceeded. For water-absorbent commodities, normal floor loads shall be reduced to take into account the added weight of water that can be absorbed during fire-fighting operations.

3-2.2 Commodity Clearance.

3-2.2.1 The clearance between top of storage and sprinkler deflectors shall conform to NFPA 13, *Standard for the Installation of Sprinkler Systems.*

3-2.2.2* If the commodity is stored above the lower chord of roof trusses, at least 1 ft (30.5 cm) of clear space shall be maintained to permit wetting of the truss unless the truss is protected with 1-hour fireproofing.

3-2.2.3 Storage clearance from ducts shall be maintained in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* Section 2-18.

3-2.2.4 The clearance between stored materials and unit heaters, radiant space heaters, duct furnaces, and flues shall not be less than 3 ft (0.9 m) in all directions or shall be in accordance with the clearances shown on the approval agency label.

3-2.2.5* Clearance shall be maintained to lights or light fixtures to prevent possible ignition.

3-2.2.6 Sufficient clearance around the path of fire door travel and around fire extinguishing and protection equipment shall be maintained to ensure proper operation and inspection.

3-2.3 Aisles.

3-2.3.1 For the storage of commodities that expand with the absorption of water, such as roll paper, wall aisles at least 24 in. (61 cm) wide shall be provided.

3-2.3.2 Aisles shall be maintained to retard the transfer of fire from one pile to another and to permit convenient access for fire fighting, salvage, and removal of storage. *(See A-4-2.)*

3-2.4* Storage of Idle Pallets.

3-2.4.1* Wood Pallets. Pallets shall be stored outside or in a detached structure.

Exception: Indoor wood pallet storage shall be permitted in accordance with NFPA 13.

3-2.4.2 Plastic Pallets. Plastic pallets shall be stored outside or in a detached structure.

Exception: Indoor plastic pallet storage shall be permitted in accordance with NFPA 13.

3-2.5 Flammable and Combustible Liquids. Flammable or combustible liquids shall be kept in flammable liquid storage cabinets, in cut-off rooms, or in detached buildings. Protection shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code,* Chapter 4.

3-3 Fire Protection — General.

3-3.1* Sprinkler Systems.

3-3.1.1 Sprinkler systems installed in buildings used for storage shall be in accordance with NFPA 13.

3-3.1.2 In warehouses containing storage, the chapter applicable to the storage configuration and commodity type shall apply in addition to the requirements of this chapter.

3-3.2 High-Expansion Foam.

3-3.2.1 High-expansion foam systems installed in addition to automatic sprinklers shall be installed in accordance with NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems.*

Exception: Where modified by this standard.

3-3.2.2 High-expansion foam used to protect the idle pallets shall have a maximum fill time of 4 minutes.

3-3.2.3 High-expansion foam systems shall be automatic in operation.

3-3.2.4 Detectors for high-expansion foam systems shall be listed and shall be installed at the ceiling at no more than one-half listed spacing in accordance with NFPA 72, *National Fire Alarm Code®.*

3-3.2.5 Detection systems, concentrate pumps, generators, and other system components essential to the operation of the system shall have an approved standby power source.

3-3.3 Manual Protection.

3-3.3.1 Portable Fire Extinguishers. Portable fire extinguishers shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

Exception: Up to one-half of the required complement of portable fire extinguishers for Class A fires shall be permitted to be omitted in storage areas where fixed small hose lines [$1^1/_2$ in. (38 mm)] are available to reach all portions of the storage area.

3-3.3.2 Hydrants. At locations without public hydrants, or where hydrants are not within 250 ft (76.2 m), private hydrants shall be installed in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

3-3.4 Fire Organization.

3-3.4.1 Arrangements shall be made to permit rapid entry into the premises by the municipal fire department, police department, or other authorized personnel in case of fire or other emergency.

3-3.4.2 Due to the uniqueness and hazards associated with fighting storage fires *(see Appendixes F and G)*, the following training items shall be considered for facility emergency personnel:

(1) Understanding the severe collapse potential during fire fighting and mop-up operations due to sprinkler water absorption, use of hose streams, and undermining of piles by fire causing a likelihood of material or piles falling (especially roll tissue paper) and the occurrence of injury or worse
(2) Understanding the operation of sprinkler systems and water supply equipment
(3) Knowing the location of the controlling sprinkler valves so that the proper sprinkler system can be turned on or off as necessary
(4) Understanding the proper operation of emergency smoke and heat vent systems where they have been provided
(5) Using material-handling equipment while sprinklers are operating to effect final extinguishment
(6) Summoning outside aid immediately in an emergency
(7) Maintaining security of the premises
(8) Understanding the operation of foam systems, knowing the appropriate evacuation procedures, and being able to apply proper safety precautions during all foam operations

3-3.4.3 A fire watch shall be maintained when the sprinkler system is not in service.

3-3.5 Alarm Service.

3-3.5.1* Automatic sprinkler systems and foam systems, where provided, shall have approved central station, auxiliary, remote station, or proprietary waterflow alarm service.

Exception: Local waterflow alarm service shall be permitted where recorded guard service also is provided or where the storage facilities are occupied on a 24-hour basis.

3-3.5.2 Alarm service shall comply with NFPA 72.

3-4 Building Equipment, Maintenance, and Operations.

3-4.1* Mechanical-Handling Equipment — Industrial Trucks.

3-4.1.1 Power-operated industrial trucks shall comply with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation.*

3-4.1.2† Industrial trucks using liquefied petroleum gas (LP-Gas) or liquid fuel shall be refueled outside of the storage building at a location designated for that purpose.

3-4.2 Building Service Equipment. Electrical equipment shall be installed in accordance with the provisions of NFPA 70, *National Electrical Code®*.

3-4.3 Cutting and Welding Operations.

3-4.3.1 Where welding or cutting operations are necessary, the requirements of NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, shall apply. Where possible, work shall be removed to a safe area.

3-4.3.2* Welding, soldering, brazing, and cutting shall be permitted to be performed on building components or contents that cannot be removed, provided no storage is located below and within 25 ft (7.6 m) of the working area and flameproof tarpaulins enclose this area. During any of these operations, the sprinkler system shall be in service. Extinguishers suitable for Class A fires with a minimum rating of 2A and charged and attended inside hose lines, where provided, shall be located in the working area. A fire watch shall be maintained during these operations and for not less than 30 minutes following completion of open-flame operation.

3-4.4 Waste Disposal. Approved containers for rubbish and other trash materials shall be provided. Rubbish, trash, and other waste material shall be disposed of at regular intervals.

3-4.5 Smoking. Smoking shall be strictly prohibited. "No Smoking" signs shall be posted in prohibited areas.

Exception: Smoking shall be permitted in locations prominently designated as smoking areas.

3-4.6* Maintenance and Inspection.

3-4.6.1 Fire walls, fire doors, and floors shall be maintained in good repair at all times.

3-4.6.2* The sprinkler system and the water supplies shall be inspected, tested, and maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

3-4.7 Refrigeration Systems. Refrigeration systems, if used, shall conform to ASHRAE 15, *Safety Code for Mechanical Refrigeration.*

Chapter 4 Palletized, Solid Pile, Bin Box, and On-Shelf Storage

4-1 Scope and Application. This chapter shall apply to the indoor storage of materials that represent the broad range of combustibles, including plastics, that are stored palletized, solid-piled, in bin boxes, or on shelves.

Exception No. 1: Rubber tires shall be protected in accordance with Chapter 6.

Exception No. 2: Scrap tires shall be protected in accordance with Chapter 11.

Exception No. 3: Baled cotton shall be protected in accordance with Chapter 8.

Exception No. 4: Roll paper shall be protected in accordance with Chapter 7.

4-2* Aisles.

Chapter 5 Rack Storage

5-1† Application and Scope. This chapter shall apply to storage of materials representing the broad range of commodities stored on racks.

Exception: Protection of rubber tires stored on racks shall be protected in accordance with Chapter 6.

5-2 Building Construction.

5-2.1† With sprinkler systems installed in accordance with Section 7-4 of NFPA 13, *Standard for the Installation of Sprinkler Systems*, fire protection of roof steel shall not be required.

5-2.2† Where ceiling sprinklers and sprinklers on racks are installed in accordance with Section 7-4 of NFPA 13, fire protection of steel building columns shall not be required.

5-2.3† For sprinklered buildings with rack storage of over 15 ft (4.6 m) in height and ceiling sprinklers only installed, structural steel components shall have a minimum 1-hour fire resistance rating.

Exception: Where the sprinkler installation meets the requirements of 7-9.8 of NFPA 13.

5-3 Storage Arrangement.

5-3.1* Rack Structure. Rack configurations shall be of a generally accepted arrangement.

5-3.2* Rack Loading. Racks shall not be loaded beyond their design capacity.

5-3.3* Aisle Widths.

5-3.3.1 Aisle widths and depth of racks shall be determined by material-handling methods. The width of aisles shall be considered in the design of the protection system. *(See Section 7-4 of NFPA 13).*

5-3.3.2 This standard contemplates aisle widths maintained either by fixed rack structures or control in placement of portable racks. Any decrease in aisle width shall require a review of the adequacy of the protection system.

5-4 Fire Protection — General.

5-4.1 High-Expansion Foam.

5-4.1.1* Where high-expansion foam systems are installed, they shall be in accordance with NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, and they shall be automatic in operation.

Exception: Where modified by Chapter 5.

5-4.1.2 Where high-expansion foam systems are used in combination with ceiling sprinklers, in-rack sprinklers shall not be required.

5-4.1.3 Detectors shall be listed and shall be installed in one of the following configurations:

(1) At the ceiling only where installed at one-half listed linear spacing (e.g., 15 ft × 15 ft rather than at 30 ft × 30 ft)

Exception: Ceiling detectors alone shall not be used where roof–ceiling clearance from the top of storage exceeds 10 ft (3.1 m) or the height of storage exceeds 25 ft (7.6 m).

(2) At the ceiling at listed spacing and on racks at alternate levels

(3) Where listed for rack storage installation and installed in accordance with ceiling detector listing to provide response within 1 minute after ignition using an ignition source equivalent to that used in a rack storage testing program

5-4.2 High-Expansion Foam Submergence.

5-4.2.1 The following requirements shall apply to storage of Class I, II, III, and IV commodities as defined in NFPA 13 up to and including 25 ft (7.6 m) in height:

(1) * Where high-expansion foam systems are used without sprinklers, the maximum submergence time shall be 5 minutes for Class I, II, or III commodities and 4 minutes for Class IV commodities.

(2) Where high-expansion foam systems are used in combination with ceiling sprinklers, the maximum submergence time shall be 7 minutes for Class I, II, or III commodities and 5 minutes for Class IV commodities.

5-4.2.2 Where high-expansion foam systems are used for the protection of Class I, II, III and IV commodities, as defined in NFPA 13, stored over 25 ft (7.6 m) high up to and including 35 ft (10.67 m) high, they shall be used in combination with ceiling sprinklers. The maximum submergence time for the high-expansion foam shall be 5 minutes for Class I, II, or III commodities and 4 minutes for Class IV commodities.

Chapter 6 Storage of Rubber Tires

6-1 Scope.

6-1.1 This chapter shall apply to the indoor storage of rubber tires.

Exception: Scrap tire storage (see Chapter 11).

6-1.2 The provisions contained in this chapter shall apply to new facilities for tire storage and the conversion of existing buildings to tire storage occupancy. This chapter shall be permitted to be used as a basis for evaluating existing storage facilities.

6-2 Illustrations. Figures 6-2(a) through (g) include some but not necessarily all possible storage configurations.

Figure 6-2(a) Typical open portable rack unit.

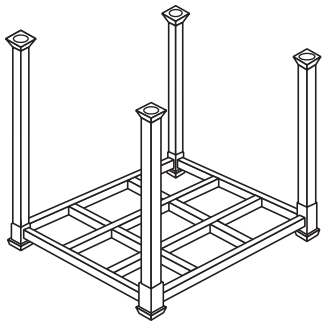


Figure 6-2(b) Typical palletized portable rack units.

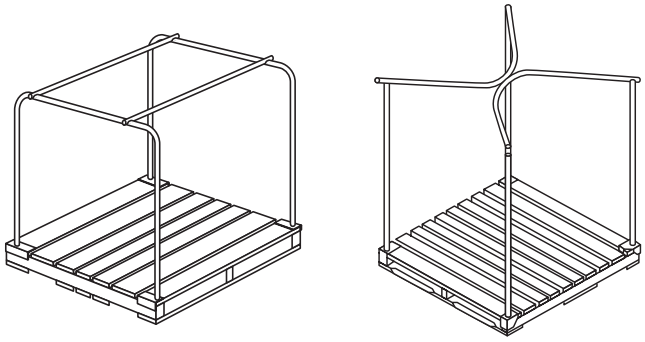


Figure 6-2(c) Open portable tire rack.

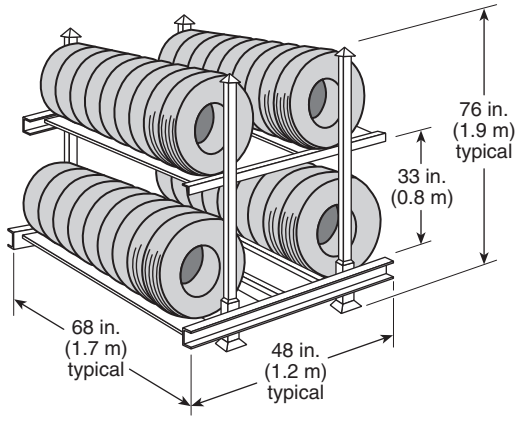
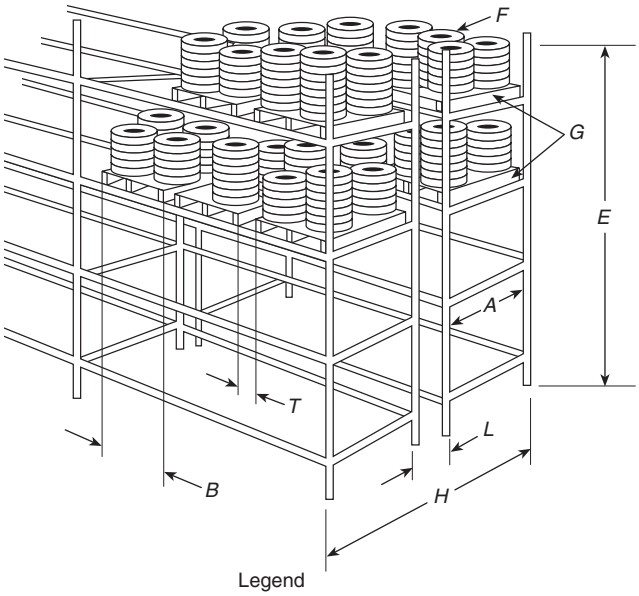


Figure 6-2(d) Double-row fixed rack tire storage.



Legend

A — Load depth
B — Load width
E — Storage height
F — Commodity
G — Pallet
H — Rack depth
L — Longitudinal flue space
T — Transverse flue space

Figure 6-2(e) Palletized portable rack on-side tire storage arrangement (banded or unbanded).

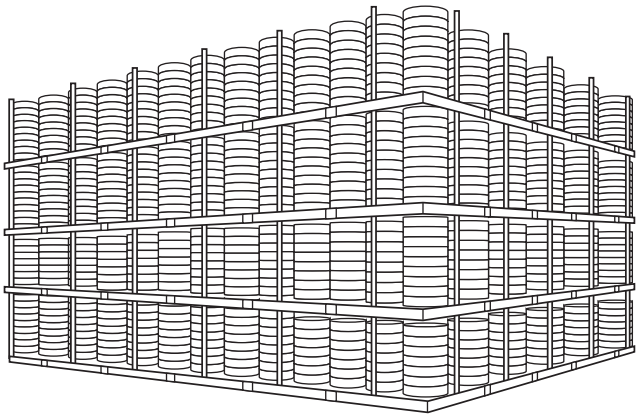


Figure 6-2(f) On-tread, on-floor tire storage arrangement (normally banded).

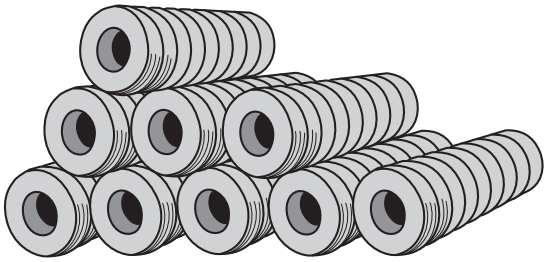
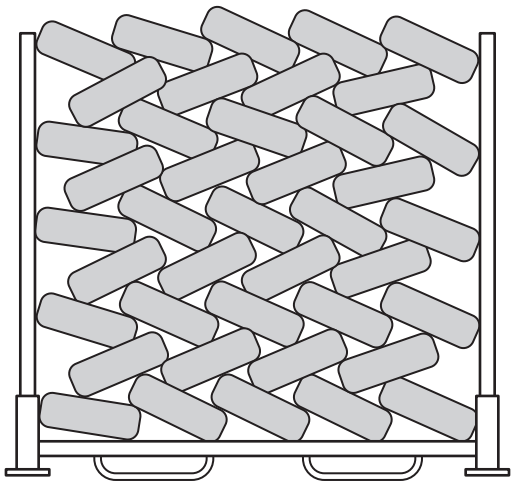


Figure 6-2(g) Typical laced tire storage.



6-3 Building Arrangement.

6-3.1 Steel Columns. Steel columns shall be protected as follows:

(1) For storage exceeding 15 ft through 20 ft (4.6 m through 6 m) in height, columns shall have 1-hour fireproofing.

(2) For storage exceeding 20 ft (6 m) in height, columns shall have 2-hour fireproofing for the entire length of the column, including connections with other structural members.

Exception: The protection required by 6-3.1(1) and (2) shall not be required where the column is protected in accordance with 7-9.8 of NFPA 13.

6-3.2 Fire Walls. Four-hour fire walls shall be provided between the tire warehouse and tire manufacturing areas. Fire walls shall be designed in accordance with NFPA 221, *Standard for Fire Walls and Fire Barrier Walls.*

6-3.3* Travel Distance to Exits. Travel distance to exits in storage occupancies shall be in accordance with NFPA *101®*, *Life Safety Code®*.

6-4 Storage Arrangement.

6-4.1 Piling Procedures.

6-4.1.1* Piles shall not be more than 50 ft (15 m) in width.

Exception No. 1: Where tires are stored on-tread, the dimension of the pile in the direction of the wheel hole shall be not more than 50 ft (15 m).

Exception No. 2: Tires stored adjacent to or along one wall shall not extend more than 25 ft (7.6 m) from that wall.

6-4.1.2 The width of the main aisles between piles shall not be less than 8 ft (2.4 m).

6-4.2 Clearances.

6-4.2.1 Storage clearance in all directions from roof structures shall be not less than 18 in. (0.45 m).

6-4.2.2 Not less than 24-in. (0.6-m) clearance shall be maintained around the path of fire door travel unless a barricade is provided.

6-4.2.3 Mixed Storage. Where protection in accordance with this standard is provided, stored tires shall be segregated from other combustible storage by aisles at least 8 ft (2.4 m) wide.

6-5 Fire Protection.

6-5.1 Fire Emergency Organization. See Appendix F.

Chapter 7 Protection of Roll Paper

7-1† Scope.

7-1.1 This chapter shall apply to the storage of roll paper in buildings or structures.

7-1.2 This chapter shall apply to new facilities or where converting existing buildings to a roll paper storage occupancy. It shall be permitted to be used as a basis for evaluating existing storage facilities.

7-1.3 This chapter shall not apply to the storage of waxed paper, synthetic paper, and palletized roll storage other than on a single floor pallet or raised floor platform.

7-2* Classification of Roll Paper. For the purposes of this standard, the following classifications of paper shall apply. The following classifications shall be used to determine the sprinkler system design criteria:

(a) Heavyweight class includes paperboard and paper stock having a basis weight [weight per 1000 ft^2 (92.9 m^2)] of 20 lb (9.1 kg) or greater.

(b) Mediumweight class includes the broad range of papers having a basis weight [weight per 1000 ft^2 (92.9 m^2)] of 10 lb to 20 lb (4.5 kg to 9.1 kg).

(c) Lightweight class includes all papers having a basis weight [weight per 1000 ft^2 (92.9 m^2)] less than 10 lb (4.5 kg).

(d) Tissue includes the broad range of papers of characteristic gauzy texture, which in some cases are fairly transparent. For the purposes of this standard, tissue is defined as the soft, absorbent type, regardless of basis weight (i.e., crepe wadding and the sanitary class including facial tissue, paper napkins, bathroom tissue, and toweling).

7-3* Building Construction. The protection outlined in this chapter shall apply to buildings with or without fireproofing or other modes of steel protection.

Exception: Where modified by 3-2.2.2.

7-4 Storage Arrangement. The floor load design shall take into account the added weight of water that could be absorbed by certain commodities such as newsprint, corrugating medium, and tissue during fire-fighting operations.

Chapter 8 Protection of Baled Cotton

8-1 General. See Appendix D.

Chapter 9 Protection of Forest Products

9-1 General. See Appendix E.

Chapter 10 Outdoor Storage of a Broad Range of Combustibles Excluding Scrap Tires and Forest Products

10-1 General. See Appendix B.

Chapter 11 Storage of Scrap Tires

11-1 General. See Appendix G.

Chapter 12 Referenced Publications

12-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix H.

12-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1998 edition.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, 1999 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1999 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1995 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 1998 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 1996 edition.

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*, 1998 edition.

NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film*, 1997 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 1999 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 1998 edition.

NFPA 70, *National Electrical Code®*, 1999 edition.

NFPA 72, *National Fire Alarm Code®*, 1999 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, 1999 edition.

NFPA *101®*, *Life Safety Code®*, 1997 edition.

NFPA 220, *Standard on Types of Building Construction*, 1999 edition.

NFPA 221, *Standard for Fire Walls and Fire Barrier Walls*, 1997 edition.

NFPA 232, *Standard for the Protection of Records*, 1995 edition.

NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers*, 1995 edition.

NFPA 490, *Code for the Storage of Ammonium Nitrate*, 1998 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation*, 1999 edition.

12-1.2 Other Publications.

12-1.2.1 ASHRAE Publication. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-2305.

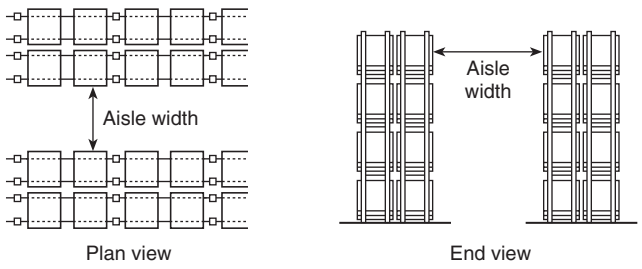
ASHRAE 15, *Safety Code for Mechanical Refrigeration*, 1994.

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-4.1 Aisle Width. See Figure A-1-4.1(a).

Figure A-1-4.1(a) Illustration of aisle width.



A-1-4.1 Available Height for Storage. For new sprinkler installations, maximum height of storage is the height at which commodities can be stored above the floor where the minimum required unobstructed space below sprinklers is maintained. For the evaluation of existing situations, maximum height of storage is the maximum existing height, if space between sprinklers and storage is equal to or greater than required.

A-1-4.1 Baled Cotton. See Table A-1-4.1.

A-1-4.1 Compartmented. Cartons used in most of the Factory Mutual–sponsored plastic tests involved an ordinary 200-lb (90.7-kg) test of outside corrugated cartons with five layers of vertical pieces of corrugated carton used as dividers on the inside. There were also single horizontal pieces of corrugated carton between each layer. Other tests sponsored by the Society of Plastics Industry, Industrial Risk Insurers, Factory Mutual, and Kemper used two vertical pieces of carton (not corrugated) to form an "X" in the carton for separation of product. This arrangement was not considered compartmented, as the pieces of carton used for separations were flexible (not rigid), and only two pieces were in each carton.

A-1-4.1 Container (Shipping, Master, or Outer Container). The term container includes items such as cartons and wrappings. Fire-retardant containers or tote boxes do not of themselves create a need for automatic sprinklers unless coated with oil or grease. Containers can lose their fire-retardant properties if washed. For obvious reasons, they should not be exposed to rainfall.

A-1-4.1 Conventional Pallets. See Figure A-1-4.1(b).

Figure A-1-4.1(b) Typical pallets.

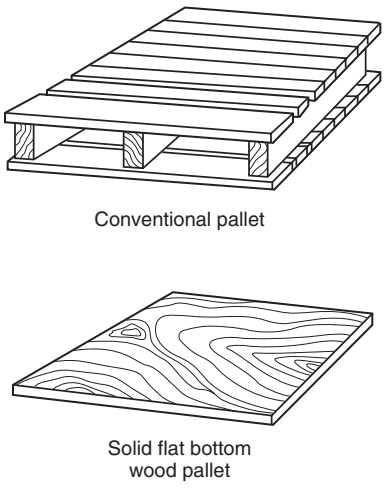
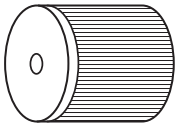
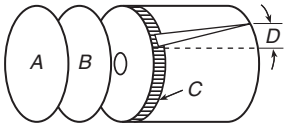
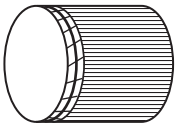


Figure A-1-4.1(c) Wrapping and capping terms and methods.

Wrapper Exterior wrapper Body wrapper	General term for protective wrapping of sides and ends on roll.
Body wrap Sleeve wrap Wrap — do not cap	Wrapper placed around circumference of roll. No heads or caps needed.
	
	
Heads Headers	Protection applied to the ends of the roll (*A* and *B*). Heads do not lap over the end of the roll.
Inside heads	Protection applied to the ends of the roll next to the roll itself (*B*). The wrapper of the roll is crimped down over these heads.
Outside heads	Protection applied to the ends of the roll on the outside (*A*). This head is applied after the wrapper is crimped.
Edge protectors Edge bands	Refers to extra padding to prevent damage to roll edges (*C*).
Overwrap	The distance the body wrap or wrapper overlaps itself (*D*).
Roll cap	A protective cover placed over the end of a roll. Edges of cap lap over the end of the roll and are secured to the sides of the roll.
	

A-1-4.1 Miscellaneous Tire Storage. The limitations on the type and size of storage are intended to identify those situations where tire storage is present in limited quantities and incidental to the main use of the building. Occupancies such as aircraft hangars, automobile dealers, repair garages, retail storage facilities, automotive and truck assembly plants, and mobile home assembly plants are types of facilities where miscellaneous storage could be present. The fire protection sprinkler design densities specified by NFPA 13, *Standard for the Installation of Sprinkler Systems,* are adequate to provide protection for the storage heights indicated. Storage beyond these heights or areas present hazards that are properly addressed by this standard and are outside the scope of NFPA 13.

A-1-4.1 Wrapped Paper Storage. Rolls that are completely protected with a heavyweight kraft wrapper on both sides and ends are subject to a reduced degree of fire hazard. Standard methods for wrapping and capping rolls are outlined in Figure A-1-4.1(c).

In some cases, rolls are protected with laminated wrappers, using two sheets of heavy kraft with a high-temperature wax laminate between the sheets. Where using this method, the overall weight of wax-laminated wrappers should be based on the basis weight per 1000 ft^2 (92.9 m^2) of the outer sheet only, rather than on the combined basis weight of the outer and inner laminated wrapper sheets. A properly applied wrapper can have the effect of changing the class of a given paper to essentially that of the wrapper material. The effect of applying a wrapper to tissue has not been determined by test.

A-1-4.2 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

Table A-1-4.1 Typical Cotton Bale Types and Approximate Sizes

	Dimensions		Average Weight		Volume		Density	
Bale Type	**in.**	**mm**	**lb**	**kg**	**ft^3**	**m^3**	**lb/ft^3**	**kg/m^3**
Gin, flat	55 × 45 × 28	1397 × 1143 × 711	500	226.8	40.1	1.13	12.5	201
Modified gin, flat	55 × 45 × 24	1397 × 1143 × 610	500	226.8	34.4	0.97	14.5	234
Compressed, standard	57 × 29 × 23	1448 × 736 × 584	500	226.8	22.0	0.62	22.7	366
Gin, standard	55 × 31 × 21	1397 × 787 × 533	500	226.9	20.7	0.58	24.2	391
Compressed, universal	58 × 25 × 21	1475 × 635 × 533	500	226.8	17.6	0.50	28.4	454
Gin, universal	55 × 26 × 21	1397 × 660 × 533	500	226.8	17.4	0.49	28.7	463
Compressed, high density	58 × 22 × 21	1473 × 559 × 533	500	226.8	15.5	0.44	32.2	515

A-1-4.2 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-4.2 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-1-5 For conversions and information, see ASTM SI 10, *Standard for Use of the International System of Units (SI): the Modern Metric System.*

A-3-1.1 With protection installed in accordance with this standard, fire protection of overhead steel and steel columns might not be necessary. Consideration should be given to subdividing large-area warehouses in order to reduce the amount of merchandise that could be affected by a single fire.

It is recommended that walls or partitions be provided to separate the storage area from mercantile, manufacturing, or other occupancies to prevent the possibility of transmission of fire or smoke between the two occupancies. Door openings should be equipped with automatic-closing fire doors appropriate for the fire resistance rating of the wall or partition.

A-3-1.3 Since most of the fire tests were conducted without heat and smoke venting and draft curtains, protection specified in NFPA 13 was developed without their use.

Smoke removal is important to manual fire fighting and overhaul. Vents through eave-line windows, doors, monitors, or gravity or mechanical exhaust systems facilitate smoke removal after control of the fire is achieved.

Results of tests organized by the Fire Protection Research Foundation and the Retail Committee on Group A plastics to study the interaction of sprinklers, vents, and draft curtains indicate that the impact of automatic vents on sprinkler performance is neutral when automatic sprinkler discharge is adequate for the hazard and that draft curtains are potentially negative. Test results show that the placement of sprinklers and the thermal sensitivity of sprinklers and vents should be considered. Care should be exercised in the placement of draft curtains. Where required to be installed, draft curtains should be aligned where possible with aisles or other clear spaces in storage areas. Draft curtains where positioned over storage could adversely effect sprinkler operations. The number of operating sprinklers increased and led to a fire that consumed more commodity compared to other tests with fires ignited away from the draft curtains.

A-3-2.1.2 Commodities that are particularly susceptible to water damage should be stored on skids, dunnage, pallets, or elevated platforms in order to maintain at least 4 in. (10.2 cm) clearance from the floor.

A-3-2.2.2 Protection for exposed steel structural roof members could be needed and should be provided as indicated by the authority having jurisdiction.

A-3-2.2.5 Incandescent light fixtures should have shades or guards to prevent the ignition of commodity from hot bulbs where possibility of contact with storage exists.

A-3-2.4 Idle pallet storage introduces a severe fire condition. Stacking idle pallets in piles is the best arrangement of combustibles to promote rapid spread of fire, heat release, and complete combustion. After pallets are used for a short time in warehouses, they dry out and edges become frayed and splintered. In this condition they are subject to easy ignition from a small ignition source. Again, high piling increases considerably both the challenge to sprinklers and the probability of involving a large number of pallets when fire occurs. Therefore, it is preferable to store pallets outdoors where possible.

A fire in stacks of idle plastic or wooden pallets is one of the greatest challenges to sprinklers. The undersides of the pallets create a dry area on which a fire can grow and expand to other dry or partially wet areas. This process of jumping to other dry, closely located, parallel, combustible surfaces continues until the fire bursts through the top of the stack. Once this happens, very little water is able to reach the base of the fire. The only practical method of stopping a fire in a large concentration of pallets with ceiling sprinklers is by means of prewetting. In high stacks, prewetting cannot be done without abnormally high water supplies. The storage of empty wood pallets should not be permitted in an unsprinklered warehouse containing other storage.

A-3-2.4.1 See Table A-3-2.4.1.

A-3-3.1 Wet systems are recommended for storage occupancies. Dry systems are permitted only where it is impractical to provide heat. Pre-action systems should be considered for storage occupancies that are unheated, particularly where in-rack sprinklers are installed or for those occupancies that are highly susceptible to water damage.

A-3-3.5.1 See NFPA 601, *Standard for Security Services in Fire Loss Prevention*.

A-3-4.1 Industrial trucks using gas or liquid fuel should be refueled outside of the storage building at a location designated for that purpose.

A-3-4.3.2 The use of welding, cutting, soldering, or brazing torches in the storage areas introduces a severe fire hazard. The use of mechanical fastenings and mechanical saws or cutting wheels is recommended. Where welding or cutting operations are absolutely necessary, the requirements of NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, should apply.

Locomotives should not be allowed to enter the storage area.

A-3-4.6 Periodic inspections of all fire protection equipment should be made in conjunction with regular inspections of the premises. Unsatisfactory conditions should be reported immediately and necessary corrective measures taken promptly.

Table A-3-2.4.1 Recommended Clearance Between Outside Idle Pallet Storage and Building

Wall Construction		Minimum Distance of Wall from Storage of					
		Under 50 Pallets		50 to 200 Pallets		Over 200 Pallets	
Wall Type	Openings	ft	m	ft	m	ft	m
Masonry	None	0	0	0	0	0	0
	Wired glass with outside sprinklers and 1-hour doors	0	0	10	3.0	20	6.1
	Wired or plain glass with outside sprinklers and $^3/_4$-hour doors	10	3.0	20	6.1	30	9.1
Wood or metal with outside sprinklers		10	3.0	20	6.1	30	9.1
Wood, metal, or other		20	6.1	30	9.1	50	15.2

Notes:
1. Fire-resistive protection comparable to that of the wall also should be provided for combustible eave lines, vent openings, and so forth.
2. Where pallets are stored close to a building, the height of storage should be restricted to prevent burning pallets from falling on the building.
3. Manual outside open sprinklers generally are not a reliable means of protection unless property is attended to at all times by plant emergency personnel.
4. Open sprinklers controlled by a deluge valve are preferred.

A-3-4.6.2 All fire-fighting and safety personnel should realize the great danger in shutting off sprinklers once opened by heat from fire. Shutting off sprinklers to locate fire could cause a disaster. Ventilation, use of smoke masks, smoke removal equipment, and removal of material are safer. *(See NFPA 1620, Recommended Practice for Pre-Incident Planning, for additional information.)*

Sprinkler water should be shut off only after the fire is extinguished or completely under the control of hose streams. Even then, rekindling is a possibility. To be ready for prompt valve reopening if fire rekindles, a person stationed at the valve, a fire watch, and dependable communications between them are needed until automatic sprinkler protection is restored.

The following provides guidelines on pre-fire emergency planning and fire department operations.

(a) *Pre-Fire Emergency Planning.* It is important that such planning be done by management and fire protection personnel, and the action to be taken discussed and correlated with the local fire department personnel.

The critical time during any fire is in the incipient stage, and the action taken by fire protection personnel upon notification of fire can allow the fire to be contained in its early stages.

Pre-emergency planning should incorporate the following:

(1) Availability of hand fire-fighting equipment for the height and type of commodity involved
(2) Availability of fire-fighting equipment and personnel properly trained for the type of storage arrangement involved
(3) Assurance that all automatic fire protection equipment, such as sprinkler systems, water supplies, fire pumps, and hand hose, is in service at all times

(b) *Fire Department Operations.* Sprinkler protection installed as required in this standard is expected to protect the building occupancy without supplemental fire department activity. Fires that occur in rack storage occupancies protected in accordance with this standard are likely to be controlled within the limits outlined in C-5-1, since no significant building damage is expected. Fire department activity can, however, minimize the extent of loss. The first fire department pumper arriving at a rack storage–type fire should connect immediately to the sprinkler system's fire department connection and start pumping operations.

In the test series for storage up to 25 ft (7.6 m), the average time from ignition to smoke obscuration in the test building was about 13 minutes. The first sprinkler operating time in these same fires averaged about 3 minutes. Considering response time for the waterflow device to transmit a waterflow signal, approximately 9 minutes remains between the time of receipt of a waterflow alarm signal at fire department headquarters and the time of smoke obscuration within the building as an overall average.

In the test series for storage over 25 ft (7.6 m), the visibility time was extended. If the fire department facility emergency personnel arrive at the building in time to have sufficient visibility to locate the fire, suppression activities with small hose lines should be started. (Self-contained breathing apparatus is recommended.) If, on the other hand, the fire is not readily visible, hose should be laid to exterior doors or exterior openings in the building and charged lines provided to these points, ready for ultimate mop-up operations. Manual fire-fighting operations in

such a warehouse should not be considered a substitute for sprinkler protection.

Important: The sprinkler system should be kept in operation during manual fire-fighting and mop-up operations.

During the testing program, the installed automatic extinguishing system was capable of controlling the fire and reducing all temperatures to ambient within 30 minutes of ignition. Ventilation operations and mop-up were not started until this point. The use of smoke removal equipment is important.

Smoke removal capability should be provided. Examples of smoke removal equipment include the following:

(1) Mechanical air-handling systems
(2) Powered exhaust fans
(3) Roof-mounted gravity vents
(4) Perimeter gravity vents

Whichever system is selected, it should be designed for manual actuation by the fire department, thus allowing personnel to coordinate the smoke removal (ventilation) with mop-up operations.

See also NFPA 600, *Standard on Industrial Fire Brigades*, and Appendixes F and G.

A-4-2 Storage should be separated by aisles so that piles are not more than 50 ft (15.2 m) wide or 25 ft (7.6 m) wide if they abut a wall. Main and cross aisles should be located opposite window or door openings in exterior walls. This design is of particular importance in buildings where few exterior openings exist. Aisle width should be at least 8 ft (2.4 m). In judging the adequacy of existing sprinkler protection, aisle spacing and frequency should be given consideration.

A-5-3.1 Rack storage as referred to in this standard contains commodities in a rack structure, usually steel. Many variations of dimensions are found. Racks can be single-row, double-row, or multiple-row, with or without solid shelves. The standard commodity used in most of the tests was 42 in. (1.07 m) on a side. The types of racks covered in this standard are as follows.

(a) *Double-Row Racks.* Pallets rest on two beams parallel to the aisle. Any number of pallets can be supported by one pair of beams. *[See Figures A-5-3.1(a)(1) through A-5-3.1(a)(4).]*

(b) *Automatic Storage–Type Rack.* The pallet is supported by two rails running perpendicular to the aisle. *[See Figure A-5-3.1(b).]*

(c) *Multiple-Row Racks More than Two Pallets Deep, Measured Aisle to Aisle.* These include drive-in racks, drive-through racks, flow-through racks, and portable racks arranged in the same manner, and conventional or automatic racks with aisles less than 42 in. (1.07 m) wide. *[See Figures A-5-3.1(c)(1) through A-5-3.1(c)(5).]*

(d) *Movable Racks.* These are racks on fixed rails or guides. They can be moved back and forth only in a horizontal two-dimensional plane. A moving aisle is created as abutting racks are either loaded or unloaded, then moved across the aisle to abut other racks. *[See Figure A-5-3.1(d).]*

(e) *Solid Shelving.* These are conventional pallet racks with plywood shelves on the shelf beams *[see Figures A-5-3.1(a)(3) and A-5-3.1(a)(4)]*. These are used in special cases.

(f) *Cantilever Rack.* The load is supported on arms that extend horizontally from columns. The load can rest on the arms or on the shelves supported by the arms. *[See Figure A-5-3.1(f).]*

Load depth in conventional or automatic racks should be considered a nominal 4 ft (1.22 m). *[See Figure A-5-3.1(a)(2).]*

Figure A-5-3.1(a)(1) Conventional pallet rack.

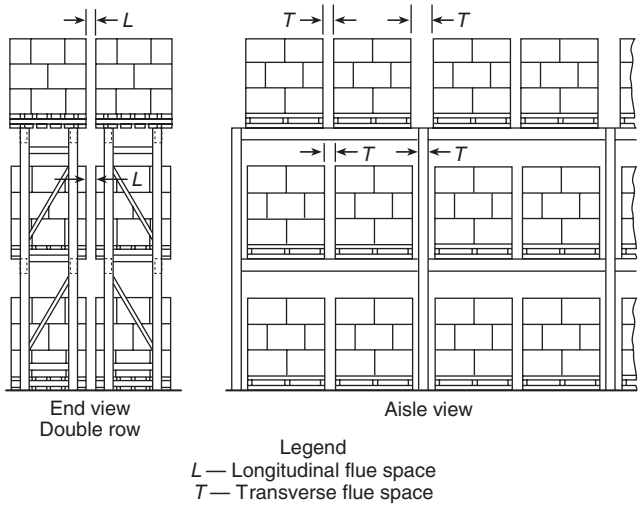


Figure A-5-3.1(a)(2) Double-row racks without solid or slatted shelves.

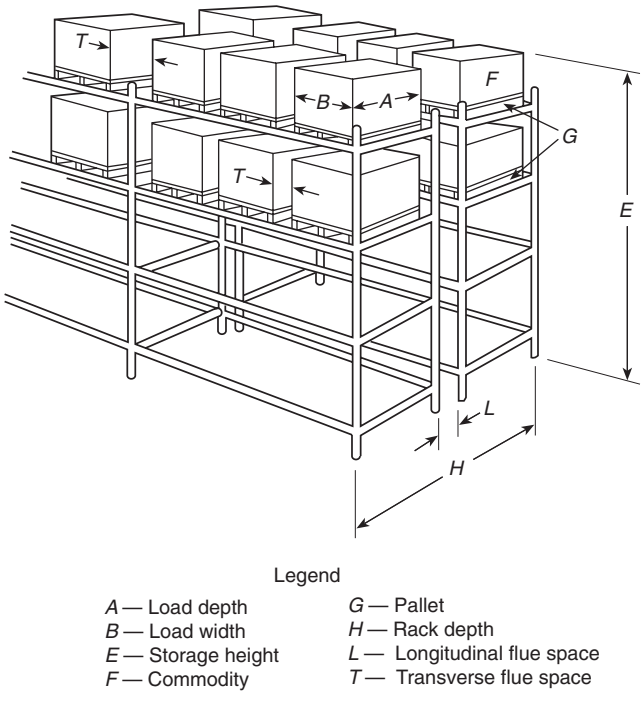
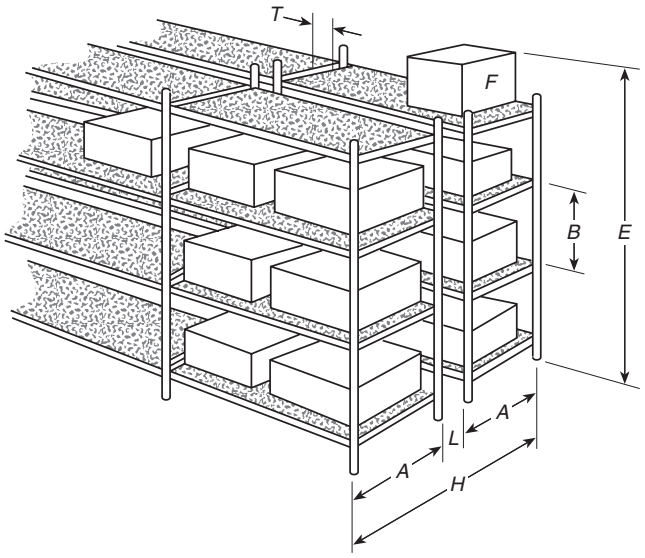


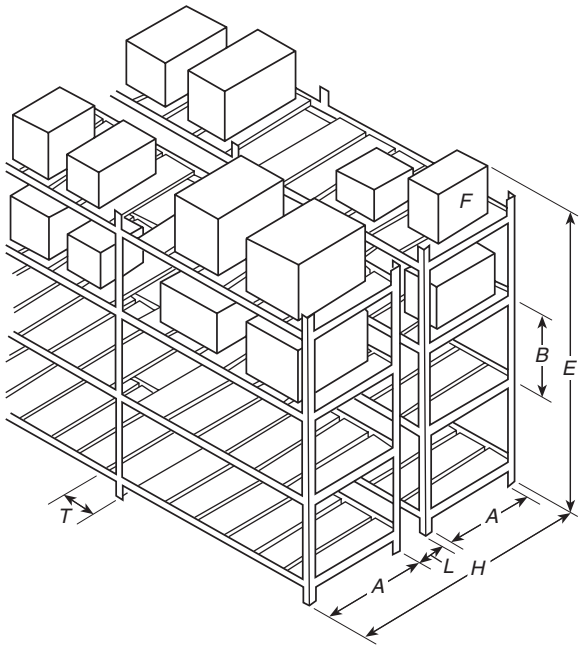
Figure A-5-3.1(a)(3) Double-row racks with solid shelves.



Legend

A — Shelf depth
B — Shelf height
E — Storage height
F — Commodity
H — Rack depth
L — Longitudinal flue space
T — Transverse flue space

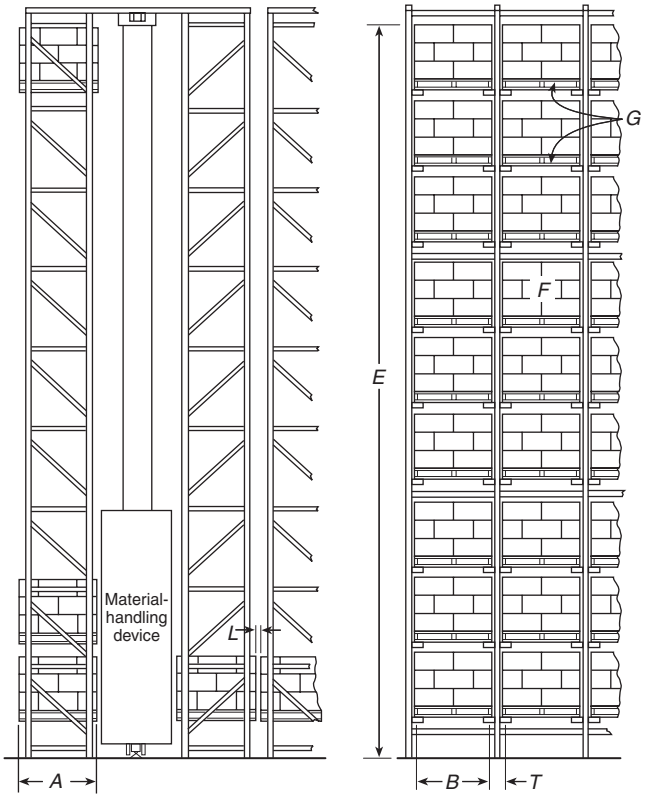
Figure A-5-3.1(a)(4) Double-row racks with slatted shelves.



Legend

A — Shelf depth
B — Shelf height
E — Storage height
F — Commodity
H — Rack depth
L — Longitudinal flue space
T — Transverse flue space

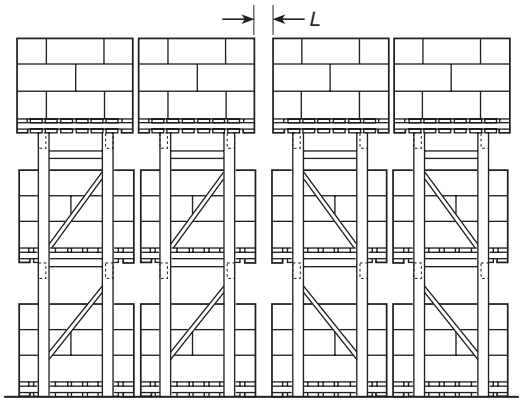
Figure A-5-3.1(b) Automatic storage–type rack.



Legend

A — Load depth
B — Load width
E — Storage height
F — Commodity
G — Pallet
L — Longitudinal flue space
T — Transverse flue space

Figure A-5-3.1(c)(1) Multiple-row rack to be served by a reach truck.



End view

L — Longitudinal flue space

Figure A-5-3.1(c)(2) Flow-through pallet rack.

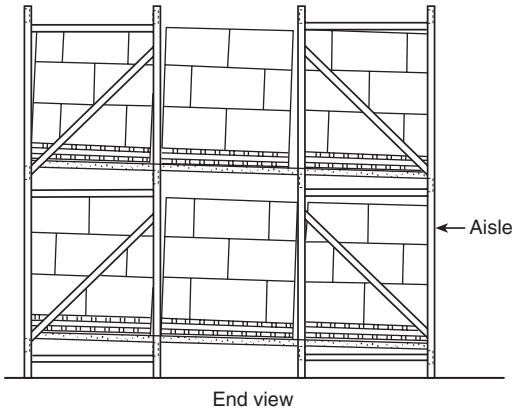


Figure A-5-3.1(c)(3) Drive-in rack — two or more pallets deep (fork truck drives into the rack to deposit and withdraw loads in the depth of the rack).

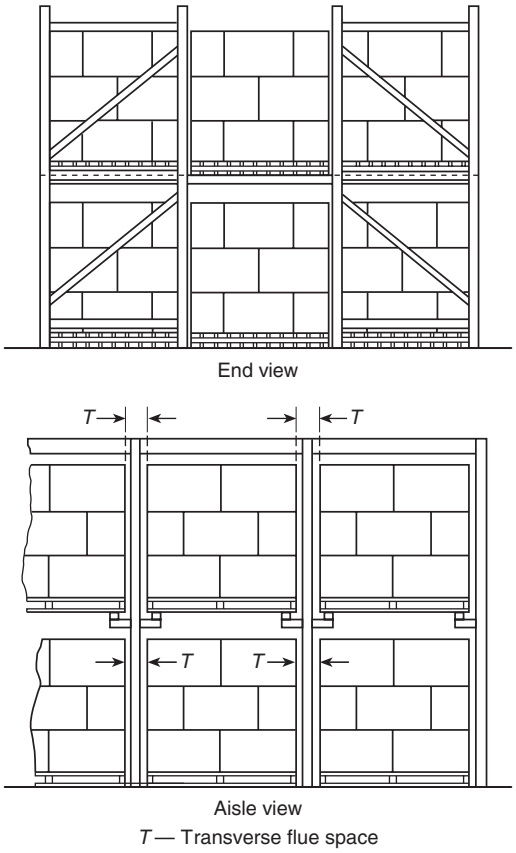


Figure A-5-3.1(c)(4) Flow-through rack.

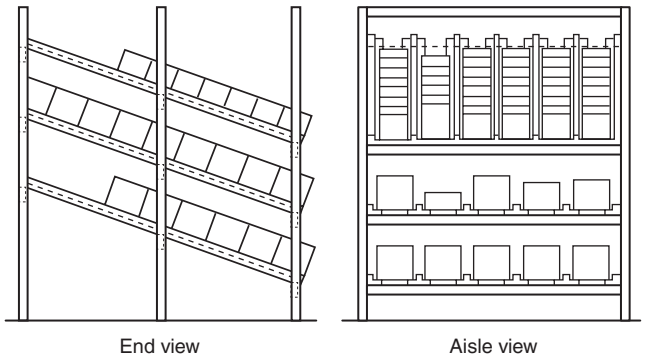


Figure A-5-3.1(c)(5) Portable racks.

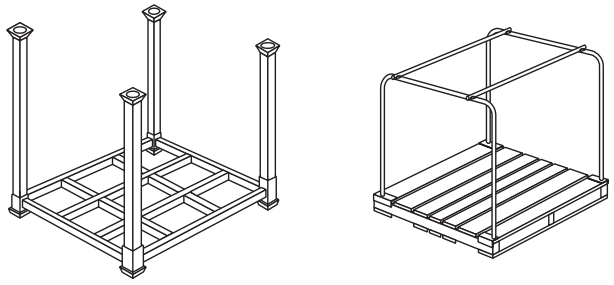


Figure A-5-3.1(d) Movable rack.

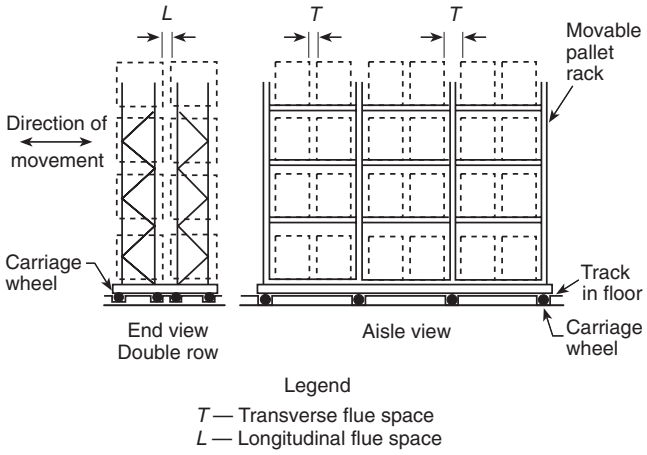
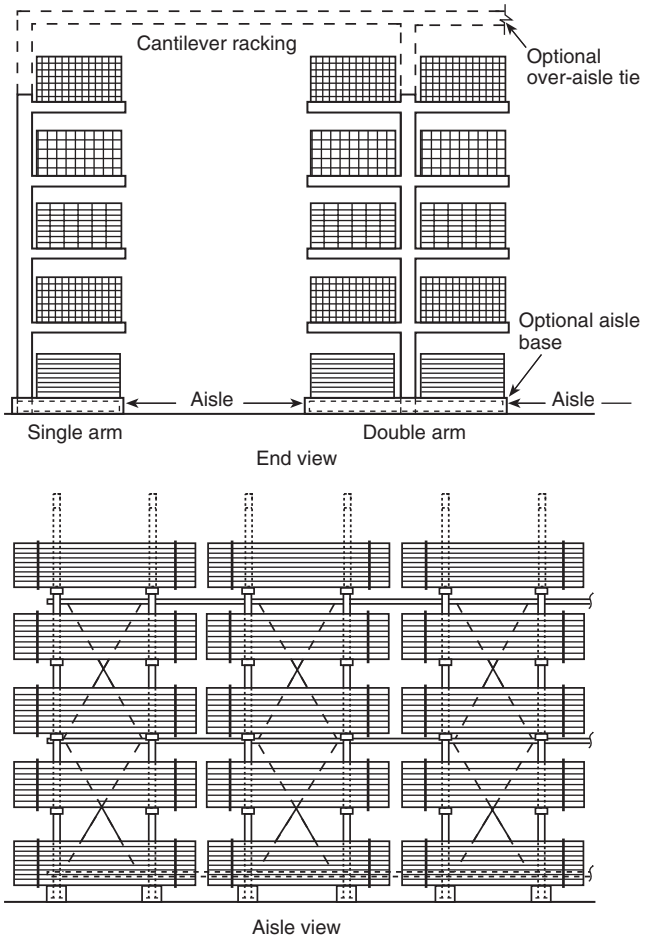


Figure A-5-3.1(f) Cantilever rack.



A-5-3.2 Fixed rack structures should be designed to facilitate removal or repair of damaged sections without resorting to flame cutting or welding in the storage area. Where sprinklers are to be installed in racks, rack design should anticipate the additional clearances necessary to facilitate installation of sprinklers. The rack structure should be anchored to prevent damage to sprinkler lines and supply piping in racks.

Rack structures should be designed for seismic conditions in areas where seismic resistance of building structure is required.

A-5-3.3 Storage in aisles can render protection ineffective and should be discouraged.

A-5-4.1.1 Detection systems, concentrate pumps, generators, and other system components essential to the operation of the system should have an approved standby power source.

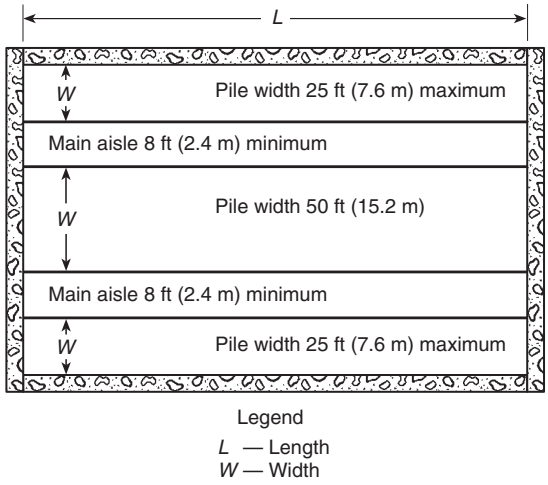
A-5-4.2.1(1) Where high-expansion foam is contemplated as the protection media, consideration should be given to possible damage to the commodity from soaking and corrosion. Consideration also should be given to the problems associated with removal of foam after discharge.

A-6-3.3 NFPA *101®*, *Life Safety Code®*, accurately reflects the travel distance requirements as follows:

(1) Tire storage is classified as ordinary hazard.
(2) Tire fires begin burning slowly. In combination with an acceptable automatic sprinkler system, this slower burning allows time for egress.
(3) Tire storage warehouses have a low occupant load.
(4) Large aisle widths [8 ft (2.4 m) minimum] required in 6-4.1.2 of this standard facilitate egress.

A-6-4.1.1 It is not the intent to limit the pile length. *(See Figure A-6-4.1.1.)*

Figure A-6-4.1.1 A typical tire piling arrangement.



A-7-2 Paper classifications were derived from a series of large-scale and laboratory-type small-scale fire tests. It is recognized that not all paper in a class burns with exactly the same characteristics.

Paper can be soft or hard, thick or thin, or heavy or light and can also be coated with various materials. The broad range of papers can be classified according to various properties. One important property is basis weight, which is defined as the weight of a sheet of paper of a specified area. Two broad cate-

gories of paper are recognized by industry — paper and paperboard. Paperboard normally has a basis weight of 20 lb (9.1 kg) or greater measured on a sheet 1000 ft² (92.9 m²) in area. Stock with a basis weight less than 20 lb/1000 ft² (9.1 kg/92.9 m²) is normally categorized as paper. The basis weight of paper is usually measured on a sheet 3000 ft² (278.7 m²) in area. The basis weight of paper can also be measured on the total area of a ream of paper, which is normally the case for the following types of printing and writing papers:

(1) Bond paper: 500 sheets 17 in. × 22 in. (432 mm × 559 mm) = 1300 ft² (120.8 m²) per ream
(2) Book paper: 500 sheets 25 in. × 38 in. (635 mm × 965 mm) = 3300 ft² (306.6 m²) per ream
(3) Index paper: 500 sheets 25.5 in. × 30.5 in. (648 mm × 775 mm) = 2700 ft² (250.8 m²) per ream
(4) Bristol paper: 500 sheets 22.5 in. × 35 in. (572 mm × 889 mm) = 2734 ft² (254 m²) per ream
(5) Tag paper: 500 sheets 24 in. × 36 in. (610 mm × 914 mm) = 3000 ft² (278.7 m²) per ream

For the purposes of this standard, all basis weights are expressed in lb/1000 ft² (kg/92.9 m²) of paper. To determine the basis weight per 1000 ft² (92.9 m²) for papers measured on a sheet of different area, the following formula should be applied:

$$\frac{\text{Basis weight}}{1000\ \text{ft}^2} = \text{basis weight} \times 1000\ \text{measured area}$$

Example: To determine the basis weight per 1000 ft² (92.9 m²) of 16-lb (7.3-kg) bond paper, the formula would be as follows:

$$\frac{16\ \text{lb}}{1300\ \text{ft}^2} \times 1000 = \frac{12.3\ \text{lb}}{1000\ \text{ft}^2}$$

Large- and small-scale fire tests indicate that the burning rate of paper varies with the basis weight. Heavyweight paper burns more slowly than lightweight paper. Full-scale roll paper fire tests were conducted with the following types of paper:

(1) Linerboard: 42 lb/1000 ft² (19.1 kg/92.9 m²) nominal basis weight
(2) Newsprint: 10 lb/1000 ft² (4.5 kg/92.9 m²) nominal basis weight
(3) Tissue: 5 lb/1000 ft² (2.3 kg/92.9 m²) nominal basis weight

The rate of fire spread over the surface of the tissue rolls was extremely rapid in the full-scale fire tests. The rate of fire spread over the surface of the linerboard rolls was slower. Based on the overall results of these full-scale tests, along with additional data from small-scale testing of various paper grades, the broad range of papers has been classified into three major categories as follows:

(1) Heavyweight: Basis weight of 20 lb/1000 ft² (9.1 kg/ 92.9 m²) or greater
(2) Mediumweight: Basis weight of 10 lb to 20 lb/1000 ft² (4.5 kg to 9.1 kg/92.9 m²)
(3) Lightweight: Basis weight of less than 10 lb/1000 ft² (4.5 kg/92.9 m²) and tissues regardless of basis weight

The following SI units were used for conversion of English units:

1 lb = 0.454 kg
1 in. = 25.4 mm
1 ft = 0.3048 m
1 ft² = 0.0929 m²

The various types of papers normally found in each of the three major categories are illustrated in Table A-7-2.

Table A-7-2 Paper Classification

Heavyweight	Medium-weight	Lightweight	Tissue
Linerboards	Bond and reproduction	Carbonizing tissue	Toilet tissue
Corrugated medium board	Vellum	Cigarette	Towel tissue
Kraft roll wrappers	Offset	Fruit wrap	
Milk carton board	Tablet	Onion skin	
Folding carton board	Computer		
Bristol board	Envelope		
Tag	Book		
Vellum bristol board	Label		
Index	Magazine		
Cupstock	Butcher		
Pulp board	Bag		
	Newsprint (unwrapped)		

A-7-3 With protection installed in accordance with this standard, fire protection of overhead steel and steel columns is not necessary. However, some lightweight beams and joists can distort and necessitate replacement, particularly following fires involving plastic-wrapped rolls stored 20 ft (6.1 m) and higher.

Appendix B Protection of Outdoor Storage

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

B-1 General.

B-1.1 The hazards of exposure to outdoor storage from ignition sources and exposing fires and the infinite variety of conditions under which such exposures can occur render impossible the formulation of any single table, formula, or set of rules that can cover all conditions adequately.

B-1.2 Recommendations contained in this appendix are for the protection of outdoor storage of commodities covered by the standard. *(See Section 1-1.)*

B-1.3 In general, the provision of automatic fire protection is impractical for outdoor storage. As a result, emphasis needs to be placed upon the following:

(1) Control of potential ignition sources, such as from exposing buildings, transformers, yard equipment, refuse burners, overhead power lines, and vandals
(2) Elimination of adverse factors such as trash accumulations, weeds, and brush

(3) Provision of favorable physical conditions, such as limited pile sizes, low storage heights, wide aisles, and possible use of fire-retardant covers (e.g., tarpaulins)
(4) Rapid and effective application of manual fire-fighting efforts by the provision of fire alarms, strategically located hydrants, and adequate hose houses or hose reels

B-1.4 Outdoor storage should be avoided in most cases but is recognized as a necessity in many industries.

B-1.4.1 Outdoor storage is acceptable for materials that are as follows:

(1) Of low fire hazard, not requiring protection even if located indoors
(2) Of sufficiently low value that a potential loss would not justify the utilization of building space
(3) Of such severe fire hazard that indoor protection is impractical when balanced against potential loss
(4) Of large volume and bulk, making it impractical to construct and protect a building to house the storage

B-1.4.2 Where materials that normally would be stored in buildings are stored outdoors in temporary emergencies, it is recommended that special precautions be taken for their safeguard and that they be moved to a storage warehouse as soon as possible.

B-1.5 Standards that address outdoor storage of specific commodities are found in Chapter 12.

B-2 Responsibility of Management.

B-2.1 It is the responsibility of management to properly consider the hazards of the various materials handled. Protection requirements and storage arrangements vary with the combustibility of the materials. Management should determine any special precautions that should be followed for the types of material stored. The care, cleanliness, and maintenance exercised by management determine to a large extent the relative fire safety in the storage area.

B-2.2 Consideration should be given by management to proper storage of materials in order to prevent the undue concentration of quantities of such materials in a single location, subject to one catastrophe. The criteria used to determine the amount of such material that should be stored in a single location are not only dependent upon the dollar value of the commodity but also upon the total supply and availability of the material. The impact of the loss of the storage upon the ability to continue production should be considered.

B-3 Site.

B-3.1 In selecting a site for outdoor storage, preference should be given to a location that can provide the following:

(1) Adequate municipal fire and police protection
(2) Adequate public water system with hydrants suitably located for protection of the storage
(3) Adequate all-weather roads for fire department apparatus response
(4) Sufficient clear space from buildings or from other combustible storage that constitutes an exposure hazard
(5) Absence of flood hazard
(6) Adequate clearance space between storage piles and any highways, bridges, railroads, and woodlands
(7) Topography as level as possible to provide storage stability

B-3.2 The entire site should be surrounded by a fence or other suitable means to prevent access of unauthorized persons. An adequate number of gates should be provided in the surrounding fence or other barriers to permit ready access of fire apparatus.

B-4 Material Piling.

B-4.1 Materials should be stored in unit piles as low in height and small in area as is consistent with good practice for the materials stored. The maximum height should be determined by the stability of pile, effective reach of hose streams, combustibility of the commodity, and ease of pile breakdown under fire or mop-up conditions. Long narrow piles are preferred over large square piles to facilitate manual fire fighting. (The short dimension increases the effectiveness of hose streams and eases pile breakdown.)

B-4.2 Aisles should be maintained between individual piles, between piles and buildings, and between piles and the boundary line of the storage site. Sufficient driveways having the width of at least 15 ft (4.57 m) should be provided to allow the travel of fire equipment to all portions of the storage area. Aisles should be at least twice the pile height to reduce the spread of fire from pile to pile and to allow ready access for fire fighting, emergency removal of material, or salvage purposes.

B-4.3 As the commodity class increases in combustibility or where storage could be ignited easily from radiation, wider aisles should be provided. Smaller unit piles could be an alternative to wider aisles if yard space is limited.

B-4.4 For outdoor idle pallet storage, see 3-2.4 and A-3-2.4 of this standard. Separation between piles of idle pallets and other yard storage should be as specified in Table B-4.4.

Table B-4.4 Pile Separation

Pile Size	Minimum Distance	
	ft	mm
Fewer than 50 pallets	20	6
50–200 pallets	30	9.1
More than 200 pallets	50	15.2

B-4.5 Boundary posts with signs designating piling limits should be provided to indicate yard area, roadway, and aisle limits.

B-5 Buildings and Other Structures.

B-5.1 Yard storage, particularly storage of commodities in the higher heat release category, should have as much separation as is practical from important buildings and structures, but not less than that offered by NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures.*

B-5.1.1 As guidance in using NFPA 80A to establish clear spaces, the following classification of severity with commodity classes of this standard should be used on the basis of 100 percent openings representing yard storage:

(1) Light severity — Commodity Class I
(2) Moderate severity — Commodity Class II
(3) Interpolate between moderate and severe severity for Commodity Class III
(4) Severe severity — Commodity Class IV and Class A plastics

The guidelines of B-5.1.1 apply to the equivalent commodity classes of this standard. The severity of the exposing building or structure also should be a consideration where establishing a clear space.

B-6 Yard Maintenance and Operations.

B-6.1 The entire storage site should be kept free from accumulation of unnecessary combustible materials. Vegetation should be kept cut low. Procedures should be provided for weed control and the periodic cleanup of the yard area.

B-6.2 Adequate lighting should be provided to allow supervision of all parts of the storage area at night.

B-6.3 All electrical equipment and installations should conform to the provisions of NFPA 70, *National Electrical Code®*.

B-6.4 No heating equipment should be located or used within the storage area. Salamanders, braziers, portable heaters, and other open fires should not be used.

B-6.5 Smoking should be prohibited, except in locations prominently designated as smoking areas. "No Smoking" signs should be posted in prohibited areas.

B-6.6 Welding and cutting operations should be prohibited in the storage area, unless in compliance with NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.*

B-6.7 Tarpaulins used for protection of storage against the weather should be of fire-retardant fabric.

B-6.8 Locomotives from which glowing particles could be emitted from exhaust stacks should not be permitted in the yard.

B-6.9 Motorized vehicles using gasoline, diesel fuel, or liquefied petroleum gas as fuel should be garaged in a separate, detached building.

B-6.9.1 Storage and handling of fuel should conform with NFPA 30, *Flammable and Combustible Liquids Code*, and NFPA 58, *Liquefied Petroleum Gas Code.*

B-6.9.2 Repair operations should be conducted outside the yard unless a separate masonry wall building is provided. Vehicles should not be greased, repaired, painted, or otherwise serviced in the yard. Such work should be conducted in conformity with NFPA 88B, *Standard for Repair Garages.*

B-7 Fire Protection.

B-7.1 Provisions should be made for promptly notifying the public fire department and private fire brigade (if available) in case of fire or other emergency.

B-7.2 Hydrants should be spaced to provide a sufficient number of hose streams. *(See NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.)*

B-7.2.1 Provisions should be made to permit the direction of an adequate number of hose streams on any pile or portion of the storage area that could be involved in fire. It is recommended that, unless adequate protection is provided by the municipal fire department, sufficient hose and other equipment should be kept on hand at the storage property, suitably housed, and provision should be made for trained personnel available to put it into operation.

B-7.2.2 Hydrants and all fire-fighting equipment should be accessible for use at all times. No temporary storage should be allowed to obstruct access to fire-fighting equipment, and any accumulation of snow or obstructing material should be removed promptly.

B-7.3 Monitor nozzles should be provided at strategic points where large quantities of highly combustible materials are stored or where average amounts of combustible materials are stored in inaccessible locations.

B-7.4 Fire extinguishers of an appropriate type should be placed at well-marked strategic points throughout the storage area so that one or more portable fire extinguisher units can quickly be made available for use at any point. Where the climate is such that there is a danger of freezing, suitable extinguishers for freezing temperatures should be used. For guidance in the type and use of extinguishers, refer to NFPA 10, *Standard for Portable Fire Extinguishers.*

B-8 Guard Service.

B-8.1 Guard service should be provided and continuously maintained throughout the yard and storage area at all times while the yard is otherwise unoccupied. The responsibilities and the training of guards should be as specified in NFPA 601, *Standard for Security Services in Fire Loss Prevention.* It is recommended that there be some suitable means of supervising guard activities to ensure that required rounds are made at regular intervals.

B-8.2 The value of strategically placed watchtowers in large yards where a guard stationed at an advantage point can keep the entire property under observation should be considered. It is recommended that such watchtowers be connected to the alarm system for prompt notification of fire.

Appendix C Explanation of Rack Storage Test Data and Procedures

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

NOTICE: Appendix C provides an explanation of the test data and procedures that led to the development of the protection for rack storage and roll paper storage. The paragraphs are identified by the same number as the text in this standard to which they apply.

C-3-1.3 Tests were conducted as a part of this program with eaveline window or louvers open to simulate smoke and heat venting. These tests opened 87.5 percent and 91 percent more sprinklers than did comparative tests without windows or louvers open.

C-3-4.1.2 Rack Fire Test 85 was conducted to evaluate the results of a liquid spill fire. Test results indicate it is not practical from an economic standpoint to install sprinkler systems with densities capable of controlling such a fire, and, therefore, industrial trucks should be fueled outside of buildings only.

C-5-1 Chapter 5 uses as a basis the large-scale fire test series conducted at the Factory Mutual Research Center, West Glocester, RI.

The test building is approximately 200 ft × 250 ft (61 m × 76 m) [50,000 ft^2 (4.65 km^2) in area], of fire-resistive construction and contains a volume of approximately 2.25 million ft^3 (63,761.86 m^3), the equivalent of a 100,000-ft^2 (9.29-km^2) building 22.5 ft (6.86 m) high. The test building has two primary heights beneath a single large ceiling. The east section is 30 ft (9.1 m) high, and the west section is 60 ft (18.29 m) high.

The test series for storage height of 20 ft (6.1 m) was conducted in the 30-ft (9.1-m) section with clearances from the top of storage to the ceiling nominally 10 ft (3.1 m). Doors at the lower and intermediate levels and ventilation louvers at the tops of walls were kept closed during the majority of the fire tests, which minimized the effect of exterior conditions. The entire test series was fully instrumented with thermocouples attached to rack members, simulated building columns, bar joists, and the ceiling.

Racks were constructed of steel vertical and horizontal members designed for 4000-lb (1814-kg) loads. Vertical members were 8 ft (2.44 m) on center (O.C.) for conventional racks and 4 ft (1.22 m) O.C. for simulated automated racks. Racks were $3^1/_2$ ft (1.07 m) wide with 6-in. (152.4-mm) longitudinal flue space for an overall width of $7^1/_2$ ft (2.29 m). Simulated automated racks and slave pallets were used in the main central rack in the 4-ft (1.22-m) aisle tests. Conventional racks and conventional pallets were used in the main central rack in the 8-ft (2.44-mm) aisle tests. The majority of the tests were conducted with 100-ft^2 (9.29-m^2) sprinkler spacing.

The test configuration for storage heights of 15 ft (4.6 m), 20 ft (6.1 m), and 25 ft (7.6 m) covered an 1800-ft^2 (167.2-m^2) floor area, including aisles between racks. Tests that were used in producing this standard limited fire damage to this area. The maximum water damage area anticipated in the standard is 6000 ft^2 (557.4 m^2) — the upper limit of the design curves.

The test data shows that, as density is increased, both the extent of fire damage and sprinkler operation are reduced. The data also indicates that, with sprinklers installed in the racks, a reduction is gained in the area of fire damage and sprinkler operations (i.e., water damage).

Table C-5-1 illustrates these points. The information is taken from the test series for storage height of 20 ft (6.1 m) using the standard commodity.

The fact that there is a reduction in both fire damage and area of water application as sprinkler densities are increased or where sprinklers are installed in racks should be considered carefully by those responsible for applying this standard to the rack storage situation.

In the test for storage height of 25 ft (7.6 m), a density of 0.55 gpm/ft^2 [(22.4 L/min)/m^2] produced 42 percent, or 756 ft^2 (70.26 m^2), fire damage in the test array and a sprinkler-wetted area of 1400 ft^2 (130.1 m^2). Lesser densities would not be expected to achieve the same limited degree of control. Therefore, if the goal of smaller areas of fire damage is to be achieved, sprinklers in racks should be considered.

The test series for storage height over 25 ft (7.6 m) was conducted in the 60-ft (18.29-m) section of the test building with nominal clearances from the top of storage to the ceiling of either 30 ft (9.1 m) or 10 ft (3.1 m).

Doors at the lower and intermediate levels and ventilation louvers at the top of walls were kept closed during the fire tests. This minimized the effect of exterior wind conditions.

The purpose of the over-25-ft (7.6-m) series was to accomplish the following:

(1) Determine the arrangement of in-rack sprinklers that can be repeated as pile height increases and that provide control of the fire

(2) Determine other protective arrangements, such as high-expansion foam, that provide control of the fire

Control was considered to have been accomplished if the fire was unlikely to spread from the rack of origin to adjacent racks or spread beyond the length of the 25-ft (7.6-m) test rack. To aid in this judgment, control was considered to have been achieved if the fire did not do the following:

(1) Jump the 4-ft (1.22-m) aisles to adjoining racks

(2) Reach the end face of the end stacks (north or south ends) of the main rack

Control is defined as holding the fire in check through the extinguishing system until the commodities initially involved are consumed or until the fire is extinguished by the extinguishing system or manual aid.

The standard commodity as selected in the 20-ft (6.1-m) test series was used in the majority of over-25-ft (7.6-m) tests. Hallmark products and 3-M products described in the 20-ft (6.1-m) test series report also were used as representative of Class III or IV commodities, or both, in several tests. The results of privately sponsored tests on Hallmark products and plastic-encapsulated standard commodities also were made available to the committee.

A 25-ft (7.6-m) long test array was used for the majority of the over-25-ft (7.6-m) high test series. The decision to use such an array was made because it was believed that a fire in racks over 25 ft (7.6 m) high that extended the full length of a 50-ft (15.24-m) long rack could not be considered controlled, particularly as storage heights increased.

Table C-5-1 Summary of Fire Test Data

Density gpm/ft^2	Fire Damage in Test Array		Sprinkler Operation (165°F) Area ft^2
	Percent	ft^2	
0.30 (ceiling only)	22	395	4,500–4,800
0.375 (ceiling only)	17	306	1,800
0.45 (ceiling only)	9	162	700
0.20 (ceiling only)	28–36	504–648	13,100–14,000
0.20 (sprinklers at ceiling and in racks)	8	144	4,100
0.30 (sprinklers at ceiling and in racks)	7	126	700

For SI units, 1 ft = 0.3048 m; °C = $^5/_9$ (°F – 32); 1 gpm/ft^2 = 40.746 (L/min)/m^2.

One of the purposes of the tests was to determine arrangements of in-rack sprinklers that can be repeated as pile height increases and that provide control of the fire. The tests for storage height of 30 ft (9.1 m) explored the effect of such arrays. Many of these tests, however, produced appreciable fire spread in storage in tiers above the top level of protection within the racks. (In some cases, a total burnout of the top tiers of both the main rack and the target rack occurred.) In the case of the 30-ft (9.1-m) Hallmark Test 134 on the 60-ft (18.3-m) site, the material in the top tiers of storage burned vigorously, and the fire jumped the aisle above the fourth tier. The fire then burned downward into the south end of the fourth tier. In the test on the floor, a nominal 30-ft (9.1-m) clearance occurred between the top of storage and the ceiling sprinklers, whereas on the platform this clearance was reduced to nominal 10 ft (3.1 m). In most cases, the in-rack sprinklers were effective in controlling fire below the top level of protection within the racks. It has been assumed by the Test Planning Committee that, in an actual case with a clearance of 10 ft (3.1 m) or less above storage, ceiling sprinklers would be expected to control damage above the top level of protection within the racks. Tests have been planned to investigate lesser clearances.

Tests 114 and 128 explore the effect of changing the ignition point from the in-rack standard ignition point to a face ignition location. It should be noted, however, that both of these tests were conducted with 30-ft (9.1-m) clearance from the ceiling sprinklers to the top of storage and, as such, ceiling sprinklers had little effect on the fire in the top two tiers of storage. Fire spread in the three lower tiers is essentially the same. A similar change in the fire spread where the ignition point is changed was noted in Tests 126 and 127. Once again, 30-ft (9.1-m) clearance occurred between the top of storage and the ceiling sprinklers, and, as such, the ceiling sprinklers had little effect on the face fire. Comparisons of Tests 129, 130, and 131 in the test series for storage height of 50 ft (15.24 m) indicate little effect of point of ignition in the particular configuration tested.

Test 125, when compared with Test 133, indicates no significant difference in result between approved low profile sprinklers and standard sprinklers in the racks.

C-5-2.1 None of the tests that were conducted with densities in accordance with the design curves produced critical temperatures in bar joists $12^{1}/_{2}$ ft (3.81 m) from the ignition source. Therefore, with sprinkler systems designed in accordance with the curves, fireproofing of roof steel should not be necessary.

C-5-2.2 Temperatures in the test column were maintained below 1000°F (538°C) in all tests where sprinklers in racks were used.

C-5-2.3 Temperatures in the test column were maintained below 1000°F (538°C) with densities, of roof ceiling sprinklers only, of 0.375 gpm/ft^2 (15.3 mm/min) with 8-ft (2.44-m) aisles and 0.45 gpm/ft^2 (18.34 mm/min) with 4-ft (1.22-m) aisles using the standard commodity.

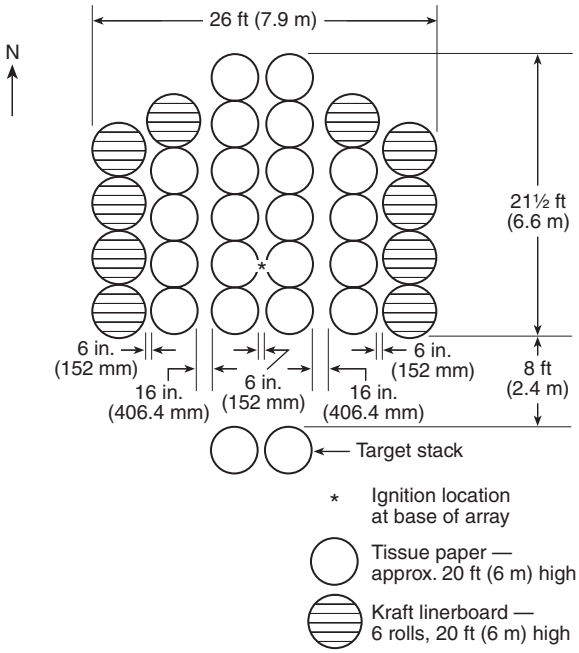
C-7-1 This appendix provides a summary of the data developed from the tissue test series of full-scale roll paper tests conducted at the Factory Mutual Research Center, West Gloucester, RI.

The test building is approximately 200 ft × 250 ft [50,000 ft^2 (4.65 km^2)] in area, of fire-resistive construction, and contains a volume of approximately 2.25 million ft^3 (63,761.86 m^3), the equivalent of a 100,000-ft^2 (9.29-km^2) building 22.5 ft (6.86 m) high. The test building has two primary heights beneath a single large ceiling. The east section is 30 ft (9.1 m) high and the west section is 60 ft (18.29 m) high.

The tissue test series was conducted in the 30-ft (9.1-m) section with clearances from the top of storage to the ceiling nominally 10 ft (3.1 m).

Figure C-7-1 illustrates a typical storage array used in the tissue series of tests.

Figure C-7-1 Plan view of typical tissue storage array.



The basic criteria used in judging test failure included one or more of the following:

(1) Firespread to the north end of the storage array

(2) Gas temperatures near the ceiling maintained at high levels for a time judged to be sufficient to endanger exposed structural steel

(3) Fire reaching the target stacks

Table C-7-1 outlines the tissue test results.

Fire tests have been conducted on 20-ft (6.1-m) and 25-ft (7.6-m) high vertical storage of tissue with 10-ft (3.1-m) and 5-ft (1.5-m) clear space to ceiling in piles extending up to seven columns in one direction and six columns in the other direction. In these tests, target columns of tissue were located directly across an 8-ft (2.4-m) aisle from the main pile. Three tests were conducted using $^{17}/_{32}$-in. (13.5-mm) 286°F (141°C) high temperature sprinklers on a 100-ft^2 (9.3-m^2) spacing and at constant pressures of 14 psi, 60 psi, and 95 psi (97 kPa, 414 kPa, and 655 kPa), respectively. One test was run using 0.64-in. (16.3-mm) 286°F (141°C) high temperature sprinklers on a 100-ft^2(9.3-m^2) spacing at a constant pressure of 50 psi (345 kPa). Two tests were conducted following a scheduled decay from an initial pressure of 138 psi (952 kPa) to a design point of 59 psi (407 kPa) if 40 sprinklers opened.

Table C-7-1 Summary of Roll Paper Tissue Tests

Test Number	B1[a]	B2	B3	B4	B5[b]	B6[b]
Test date	10/4/79	7/23/80	7/30/80	10/15/80	7/28/82	8/5/82
Paper type	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Stack height [ft–in. (m)]	21–10 (6.66)	20–0 (6.1)	21–8 (21.60)	18–6 (6.64)	19–10 (6.05)	25–3 (7.69)
Paper, banded	No	No	No	No	No	No
Paper, wrapped	No	No	No	No	No	No
Fuel array	Std.	Std.	Std.	Std.	Std.	Std.
Clearance to ceiling [ft–in. (m)]	8–2 (2.49)	10–0 (3.05)	8–4 (2.54)	11–6 (3.51)	5–2 (1.58)	4–9 (1.45)
Clearance to sprinklers [ft–in. (m)]	7–7 (2.31)	9–5 (2.87)	7–9 (2.36)	10–9 (3.28)	4–7 (1.40)	4–2 (1.27)
Sprinkler orifice [in. (mm)]	$^{17}/_{32}$ (13.5)	$^{17}/_{32}$ (13.5)	$^{17}/_{32}$ (13.5)	0.64 (16.33)	$^{17}/_{32}$ (13.5)	$^{17}/_{32}$ (13.5)
Sprinkler temp. rating [°F (°C)]	280 (138)	280 (138)	280 (138)	280 (138)	280 (138)	280 (138)
Sprinkler spacing [ft × ft (m × m)]	10 × 10 (3.05 × 3.05)	10 × 10 (3.05 × 3.05)	10 × 10 (3.05 × 3.05)	10 × 10 (3.05 × 3.05)	10 × 10 (3.05 × 3.05)	10 × 10 (3.05 × 3.05)
Water pressure [psi (kPa)]	14 (0.67)[c]	60 (2.87)	95 (4.55)	50 (2.39)	138 (6.61) initial 102 (4.88) final	138 (6.61) initial 88 (4.21) final
Moisture content of paper (%)	9.3	9.3	10.2	6.0	8.2	9.2
First sprinkler operation (min:sec)	0:43	0:32	0:38	0:31	0:28	0:22
Total sprinklers open	88	33	26	64	17	29
Final flow [gpm (L/min)]	2575 (9746)[c]	1992 (7540)	1993 (7544)	4907 (18,573)	1363 (5159)	2156 (8161)
Sprinkler demand area [ft^2 (m^2)]	8800 (817.5)	3300 (306.6)	2600 (241.5)	6400 (595)	1700 (158)	2900 (269)
Avg. discharge density [gpm/ft^2 (L/min·m^2)]	0.29 (11.8)[c]	0.60 (24.4)	0.77 (31.4)	—	0.92 (37.5) initial 0.80 (32.6) final	0.96 (39.1) initial 0.74 (30.2) final
Max. 1 minute avg. gas temp. over ignition [°F (°C)]	1680 (916)[c]	1463 (795)	1634 (890)	1519 (826)	[d]	[e]
Duration of high temp. within acceptable limits	No	Yes	Yes	Marginal	Yes	Yes
Max. 1 minute avg. fire plume gas velocity over ignition [ft/sec (m/sec)]	—	40.7 (12.4)	50.2 (15.3)	47.8 (14.6)	—	—
Target ignited	Yes	Yes	No	No	No	Briefly
Extent of fire damage within acceptable limits	No	No	Marginal	Marginal	Yes	Marginal
Test duration (minutes)	17.4	20	20	25.5	45	45

[a]Phase I Test.
[b]Phase III tests decaying pressure.
[c]Pressure increased to 50 psi (345 kPa) at 10 minutes.
[d]Maximum steel temperature over ignition 341°F (172°C).
[e]Maximum steel temperature over ignition 132°F (56°C).

The significant characteristic of these fire tests was the rapid initial fire spread across the surface of the rolls. Ceiling temperatures were controlled during the decaying pressure tests and during the higher constant pressure tests. With the exception of the 20-ft (6.1-m) high decaying pressure test, the extent of fire spread within the pile could not be clearly established. Aisle jump was experienced, except at the 95-psi (655-kPa) constant pressure, 20-ft (6.1-m) high decaying pressure, and large drop test. Water absorption and pile instability caused pile collapse in all tests. This characteristic should be considered where manually attacking a fire in tissue storage occupancies.

Available fire experience in roll tissue storage occupancies does not correlate well with the constant pressure full-scale fire tests with respect to the number of sprinklers operating and the extent of fire spread. Better correlation is noted with the decaying pressure tests. Thirteen fires reported in storage occupancies with storage piles ranging from 10 ft to 20 ft (3.1 m to 6.1 m) high and protected by wet-pipe sprinkler systems ranging from ordinary hazard design densities to design densities of 0.6 gpm/ft^2 (24.5 mm/min) were controlled with an average of 17 sprinkler heads. The maximum number of wet-pipe sprinkler heads that opened was 45 and the minimum number was five, versus 88 and 26, respectively, in the constant pressure tests. Seventeen sprinkler heads opened in the 20-ft (6.1-m) high decaying pressure test. One actual fire in tissue storage provided with a dry-pipe system opened 143 sprinklers but was reported as controlled.

One fire test was conducted with plastic-wrapped rolls of heavyweight kraft paper. The on-end storage was in a standard configuration, 20 ft (6.1 m) high with $9^1/_2$-ft (2.9-m) clearance to ceiling sprinklers. The prescribed 0.30-gpm/ft^2 (12.2-mm/min) density controlled the fire spread, but protection to roof steel was marginal to the point where light beams and joists could be expected to distort. A lower moisture content in the paper as a result of the protective plastic wrapping was considered to be the reason for the higher temperatures in this test as compared to a similar test where the rolls were not wrapped.

Appendix D Protection of Baled Cotton History of Guidelines

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

D-1 Introduction.

D-1.1 Origin. In the early 1900s, a group of marine underwriters formulated regulations to reduce the frequency of excessive fire loss in baled cotton facilities. In 1916, following a joint conference with the cotton industry, guidelines were established under the title *Specifications and Standards* (also known as *Marine Standards*).

From 1947 through 1969, the sponsorship was through the Cotton Warehouse and Inspection Service (dissolved in 1969). In 1967, interested insurance rating bureaus were added as sponsors, and, in 1969, to prevent conflicts with various rating bureau schedules, the word *Standards* was replaced with *Recommended Good Practices*. However, since 1939, the booklet was commonly referred to as the *Blue Book*.

Numerous revisions were made over the years to keep current, the last made in 1973. Early in 1978, the committee for the *Blue Book* requested that the NFPA consider a standard on baled cotton storage and handling based on the *Blue Book* recommended practices. The NFPA Correlating Committee for Storage expanded the scope to include all fibers in baled form, which were covered in NFPA 44, *Storage of Combustible Fibers*, which was withdrawn many years ago.

Little data was found on fire experience for baled fibers other than cotton, and that data was largely empirical in nature.

Therefrom, the former NFPA 231E, *Recommended Practice for the Storage of Baled Cotton*, was developed by consensus of a test group formed in 1978 that was made up of the cotton warehousing, cotton processing, and insurance industries, under the auspices of the Technical Committee on General Storage. The recommendations were limited to cotton fiber in baled form with the intent to convert to a standard as field experience became available to further substantiate its content.

With the merger of a number of general storage standards in 1999, the information was edited and is now included in this appendix as guidance informance for the user.

D-1.2 Scope.

D-1.2.1 This appendix provides fire protection guidance for the storage of baled cotton in buildings and in yards.

D-1.2.2 None of the provisions outlined should be considered mandatory. However, it is recommended that property owners follow these guidelines as a minimum means of limiting fire spread by the application of the storage methods specified, by the separation of major storages using fire walls or clear spaces, and by the provision of an adequate means of extinguishment.

D-1.2.3 These guidelines can be applied to new or existing facilities.

D-1.2.4 There is no intent to restrict new technologies or alternative arrangements that offer protection features superior to those outlined.

D-1.3 General.

D-1.3.1 Cotton fiber is readily ignitible and burns freely and, when stored in relatively large quantities, poses special fire control problems not generally encountered in other common commodities.

Cotton fiber is compressed to various densities into baled form for transport, storage, and handling and is largely covered by industry-accepted packaging materials and bound by steel, synthetic or wire bands, or wire. The bale surfaces normally are ragged in appearance due to the loose fibrous material not confined by the binding or wrapping. Frequently, this ragged appearance is further aggravated by sampling, which exposes additional fibrous material and can contribute to the rapid spread of fire.

Bale storage in relatively large quantities can pose severe fire control problems due to the potential for flashover and the large area of involvement that could overcome even a well designed and supplied sprinkler system. Therefore, this appendix takes into consideration limits on the number of bales per building or fire division and the size of storage blocks.

Where the bales are tiered or piled in buildings or outdoors, the loose surface fibers are easily ignited in the presence of an ignition source and the fire can spread rapidly over the entire mass or body of the material. This happening commonly is called *flashover*. Fire then can burrow into the bale interiors making detection and extinguishment difficult, particularly in large mass storage. A quick, hot fire then can ensue and spread beyond the control of ordinary extinguishing methods.

In properly arranged storage and with adequate automatic sprinkler protection, fire normally is confined to the pile of

origin, although an aisle fire can be expected to involve more than one tier or pile. Sprinklers usually operate beyond the confines of the fire and wet down bales immediately adjacent to the burning pile.

If adequate sprinkler protection is lacking, if tiers or piles are too large or high, if aisle separation is not properly maintained, or if the bales are otherwise improperly arranged, damage to the section, building, or area of involvement will be more severe, if not totally destructive.

D-1.3.2 Common causes of fire in baled cotton include, but are not limited to the following:

(1) Fire-packed bales from the ginning or other process
(2) Steel bands breaking and striking or rubbing (friction) against each other or other metallic objects causing sparks
(3) Extraneous sparks from sources such as vehicle exhausts and incinerators
(4) Miscellaneous sources such as cutting and welding, electrical and mechanical faults, and smoking

D-2 Building Construction.

D-2.1 Construction. Buildings used for the storage of baled cotton that is stored and protected in accordance with these guidelines are permitted to be of any of the types described in NFPA 220, *Standard on Types of Building Construction.*

D-2.2 Emergency Smoke and Heat Venting. The protection outlined in these guidelines applies to buildings with or without roof vents and draft curtains.

D-2.3 Fire Divisions or Clear Spaces Between Buildings.

D-2.3.1 A fire division is a building, compartment, or section cut off by fire walls or separation.

D-2.3.1.1 Fire divisions or clear spaces between buildings should be in accordance with NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures.*

D-2.3.1.2 Baled cotton storage generally has a fire load in excess of 15 lb/ft^2 (73 kg/m^2), which would place its classification, according to NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, in the "severe" category.

D-2.3.2 Fire walls should be of masonry and rated for at least 4 hours (based on NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials;* ASTM E 119, *Standard Methods of Fire Tests of Building Construction and Materials;* and UL 263, *Standard for Safety Fire Tests of Fire Resistance of Building Construction and Materials*). For a complete description of construction Types I, II, III, IV, and V, see NFPA 220, *Standard on Types of Building Construction.* Such walls should be parapeted as follows:

(a) For wood frame [Type V (111-000)] and ordinary or heavy timber masonry [Type III (211-200) and Type IV (2 HH)], construction parapets should extend at least 5 ft (1.5 m) above the highest point of any adjacent monitor or roof structure within 50 ft (15.2 m) of the fire wall. Where the monitors or the roof structure adjoins a fire wall, the parapet should extend not less than $7\frac{1}{2}$ ft (2.3 m) horizontally from the vertical side of the roof structure. If intersecting end or side walls are other than masonry, the fire wall should extend outward 10 ft (3.1 m) beyond the end or side wall or should be "teed" at the ends 10 ft (3.1 m) from each side of the wall or should be "elled" 20 ft (6.1 m) and of an equivalent fire rating.

(b) For noncombustible construction [Type II (000)] other than that outlined in D-2.3.2(c), parapets should be at least $2\frac{1}{2}$ ft (0.75 m) above the roof. If intersecting side walls are other than masonry, such wall construction should conform to the specifications of D-2.3.2(a).

(c) For noncombustible construction [Type II (222-111)] having masonry walls and with roofs of concrete, gypsum, or Class 1 (UL-classified) metal deck, the parapet should extend at least 12 in. (0.3 m) above the roof.

(d) For walls and roofs of fire-resistive construction [Type I (443-332)], parapets are not necessary.

D-2.3.3 Fire walls should be free of openings. Where openings are necessary, the number should be kept to the minimum necessary, and each side should be protected by an approved and listed 3-hour-rated fire door installed in accordance with NFPA 80, *Standard for Fire Doors and Fire Windows.* Doors should be automatic closing with detectors or fusible links installed on both sides of the opening and interconnected so that the operation of any single detector or fusible link closes both doors simultaneously.

D-2.3.4 Substantial guards of a size to protect fire doors from damage or obstruction should be provided.

D-3 Storage Arrangements.

D-3.1 General. This section applies to buildings protected by a sprinkler system in accordance with Section D-4, or to those not so protected. The tier heights, block sizes, and aisle widths outlined are permitted but represent recommended maximum and minimum limitations. Fire experience and fire tests of high-piled commodities have shown that lower pile heights, smaller block sizes, and wider aisles result in a substantial delay in fire spread and in providing for manual fire fighting. Automatic sprinkler effectiveness is also improved substantially, with a reduction in water demand and a decrease in the quantity of goods damaged.

D-3.1.1 One building, compartment, or section classed as a fire division should not contain more than 10,000 bales of cotton if protected by a sprinkler system in accordance with Section D-4, nor more than 5000 bales if not so protected. *(See D-2.3.)*

D-3.2 Storage Blocks.

D-3.2.1 Storage blocks, tiered or untiered, or in racks, should be limited to 700 bales of compressed cotton or 350 bales of flat cotton. *(See D-3.3.4 for a permitted variation and also Table A-1-4.1 for typical cotton bale types and approximate sizes.)*

D-3.2.2 The height of tiered or rack storage should be limited to a nominal 15 ft (4.6 m). Rack storage, as used in this document, contemplates baled cotton in a skeleton steel pipe or tubular frame, without shelving, and is limited to a single- or double-row configuration not in excess of two bales deep. Any variation could create a serious handicap to automatic sprinklers that is beyond the design capability and should be referred to the authority having jurisdiction.

D-3.2.3 Rack storage should not extend over aisles or doorways.

D-3.2.4 Racks should not be loaded beyond their design capacity and should be designed for seismic conditions in areas where seismic resistance for buildings is required.

D-3.3 Aisles.

D-3.3.1 Aisles should be provided and maintained to minimize the spread of fire and to allow convenient access for fire fighting, removal of storage, and salvage operations.

D-3.3.2 At least one main aisle, 12 ft (3.7 m) or more in width, should be provided in each fire division and arranged to subdivide the storage into two or more approximately equal areas.

D-3.3.3 Cross aisles separating each storage block should be at least 4 ft (1.2 m) in width. The recommended 4-ft (1.2-m) aisles allow sprinkler water to penetrate the lower areas of storage. However, it should be noted that for aisles less than 8 ft (2.4 m) in width, a fire can be expected to communicate readily from one block to another, especially in the case of an easily ignitible commodity such as cotton fiber.

D-3.3.4 Where a 15-ft (4.6-m) cross aisle is provided after every fourth or fifth tiered block, each storage block can be increased to 800 bales of compressed cotton and 400 bales of flat cotton. The purpose of this alternate method of tiered storage is to encourage wider cross aisles at least intermittently, without reducing the recommended storage capacity, as an aid in reducing the flashover fire potential. Because of the increase in block sizes, however, it is recommended that the authority having jurisdiction be consulted prior to practicing this method.

D-3.3.5 Cross aisles separating each single- or double-row rack storage configuration should be at least 10 ft (3.1 m) in width.

D-3.3.6 Aisles should be maintained free of loose cotton fibers.

D-3.4 Freshly Ginned Cotton Bales. See D-5.4.

D-3.5 Storage of Commodities Other than Cotton.

D-3.5.1 Cotton warehouses, in general, can be used for the storage of other commodities, subject to the following:

(1) The storage of other commodities in a building is permitted where baled cotton is not stored.

(2) High-hazard commodities, such as nitrates or similar oxidizing materials, flammable liquids or gases, explosives, or materials of a highly combustible nature, should not be permitted where baled cotton is stored in the fire division.

(3) Any commodities that could be hazardous in combination with each other should be stored so that they cannot come in contact with each other.

D-3.5.2 Where it is necessary to store other commodities with baled cotton storage, a clear space of at least 15 ft (4.6 m) should be maintained between the baled cotton storage and other commodities.

D-3.5.3 Where commodities of different classifications are permitted and stored in the same building, whether on a seasonal or other basis, the protection should be adequate for the most hazardous material. *(For protection of other commodities, refer to the main body of this standard or to the other applicable NFPA storage standards.)*

D-3.6 Clearances.

D-3.6.1 Proper clearances from lights or light fixtures should be maintained to prevent possible ignition. Incandescent light fixtures should have guards to prevent ignition of a commodity from hot bulbs where the possibility of contact exists.

D-3.6.2 No storage should be located within 3 ft (0.9 m) of any electrical switch or panel boards and fuse boxes.

D-3.6.3 Baled cotton storage and other combustibles should be kept at least 4 ft (1.2 m) from fire door openings so that the transmission of fire through a door opening is minimized.

D-3.6.4 At least 2 ft (0.6 m) of clearance should be maintained around all doors (other than as indicated in D-3.6.3), fire protection equipment (including automatic sprinkler risers, controlling valves, hose stations, and portable extinguishers), and telephones for accessibility.

D-3.6.5 A clearance of at least 3 ft (0.9 m) should be maintained between the top of storage and the roof or ceiling construction in order to allow sufficient space for the effective use of hose streams in buildings not equipped with automatic sprinkler protection.

D-4 Fire Protection.

D-4.1 Automatic Sprinkler Systems.

D-4.1.1 Automatic sprinkler protection is not part of the recommendations of this appendix. However, it is unfortunate that, in a fire situation, human response is, in most cases, unreliable in the first critical moments of fire development. Sprinkler protection is, therefore, the most reliable method of fire detection and suppression. Property owners are encouraged to provide sprinkler protection as the best means of minimizing a large loss. *(See D-3.5 for sprinkler protection for other than cotton fiber storage.)*

D-4.1.2 Automatic sprinkler systems, where provided, should be installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

Exception: Where modified by this appendix.

D-4.1.3 Clearance between the top of the storage and the sprinkler deflectors should be at least 18 in. (0.45 m). Building heights should allow for proper clearance between the pile height and sprinkler deflectors. Fire tests of high-piled storage have shown that sprinklers are generally more effective if located $1^1/_2$ ft to $4^1/_2$ ft (0.45 m to 1.4 m) above the storage height.

D-4.2 Water Supplies.

D-4.2.1 The total water supply available should be sufficient to provide the recommended sprinkler discharge density over the area to be protected, plus a minimum of 500 gpm (32 L/sec) for hose streams.

D-4.2.2 Water supplies should be capable of supplying the total demand for sprinklers and hose streams for not less than 2 hours.

D-4.2.3 Recommended water supplies contemplate successful sprinkler operation when installed. However, because of the flashover fire potential and inherent unfavorable features of cotton warehousing, there should be an adequate water supply available for fire department use.

D-4.3 Hydrants. At locations without public hydrants, private hydrants should be provided in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

D-4.4 Manual Inside Protection.

D-4.4.1 Small Hose. In buildings of 15,000 ft^2 (1380 m^2) or larger, small hose [$1^1/_2$ in. (38.1 mm)], with combination water spray nozzle, should be provided to reach any portion of a storage area with due consideration to access aisle configuration with a maximum length of 100 ft (30.5 m) of hose. Such small hose should be supplied from one of the following:

(1) Outside hydrants
(2) A separate piping system for small hose stations in accordance with NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*
(3) Valved hose connections on sprinkler risers where such connections are made upstream of the sprinkler control valves
(4) Adjacent sprinkler systems in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*

D-4.4.2 Portable Fire Extinguishers. Portable listed fire extinguishers should be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*, and as amended by this section. Up to one-half of the required complement of portable fire extinguishers for Class A fires can be omitted in storage areas where fixed small hose lines are installed in accordance with D-4.4.1.

D-4.4.2.1 Cotton and its wrappings represent a Class A fire. Experience has shown that extinguishment using "wet water" — a chemical agent additive to lower the surface tension of water, thus increasing its penetrating and spreading qualities — is the most effective on baled cotton fires.

Plain water is effective on surface fires but lacks the penetrating power of wet water.

Dry chemical extinguishers using sodium bicarbonate, potassium bicarbonate, or potassium chloride base powders have been used to control a surface fire on baled fibers and work mainly by coating the fiber with the fire-retardant powder. However, such chemicals do not affect a smoldering or burrowing fire beneath the surface.

D-4.4.2.2 Additional listed extinguishers, suitable for Class B and C fires, or multipurpose types, should be provided at each press location and for each motorized vehicle or area of hazard other than Class A.

D-4.4.3 Wetting Agent Extinguishing Units.

D-4.4.3.1 Pressurized, wheeled, listed, wetting agent extinguishing units, as specified in NFPA 18, *Standard on Wetting Agents*, can be used subject to the authority having jurisdiction in lieu of Class A conventional types or small hose lines provided the following:

(1) The unit(s) has an equivalent extinguishing effectiveness of 20A for each 15,000 ft^2 (1380 m^2) of floor area or less.
(2) The unit(s) has an equivalent extinguishing effectiveness of 40A or more for each 30,000 ft^2 (2760 m^2) of floor area.

D-4.4.3.2 Placement of extinguishing units should be at locations readily accessible to the main aisles and properly protected from damage.

D-4.4.4 Nonfreezing-Type Extinguishers. Extinguishers should be of the nonfreezing type or protected against freezing where necessary.

D-4.5 Alarm Service.

D-4.5.1 Automatic sprinkler systems should have approved central station, local, auxiliary, remote station, or proprietary waterflow supervised alarm service. Local waterflow alarm service is permitted where standard guard service is provided in accordance with NFPA 601, *Standard for Security Services in Fire Loss Prevention*. Alarm service should comply with NFPA 72, *National Fire Alarm Code*.

D-4.5.2 Valves should be supervised in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

D-4.6 Fire Emergency Planning.

D-4.6.1 Arrangements should be made to allow rapid entry into the premises by the municipal fire department, police department, or other authorized personnel in the case of fire or other emergency.

D-4.6.2 Industrial fire brigades, where provided, should be in compliance with NFPA 600, *Standard on Industrial Fire Brigades*.

D-4.6.3 Manual fire-fighting operations should not be considered to be a substitute for sprinkler operation. The sprinkler system should be kept in operation during manual fire-fighting operations until visibility has improved so that the fire can be clearly seen and the extent of fire has been reduced to a mop-up stage. It is essential that charged hose lines be available before venting is started because of a possible increase in fire intensity. When a sprinkler valve is closed, a designated person should remain at the valve so it can be opened promptly if necessary. The water supply for the sprinkler system should be augmented, where possible, and care should be exercised so that the water supply for the sprinkler system is not rendered ineffective by the use of excessive hose streams.

D-4.6.4 Fire departments should be encouraged to make periodic inspections of the property in cooperation with management and personnel for the purposes of loss prevention and pre-fire planning. For further information, see NFPA 13E, *Guide for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*.

D-4.6.5 A fire watch should be maintained when the sprinkler protection is not in service.

D-5 Yard Storage.

D-5.1 General.

D-5.1.1 This section applies to baled cotton storage yards designated for that purpose. Generally, yards are at or convenient to compression warehouses and gins but can include storage at locations remote from routine operations.

D-5.1.2 This section refers to seed cotton trailers or modules, vehicles, incinerators, and other facilities, or exposures from same, only for the purpose of establishing recommended distances to designated yard storage areas.

D-5.2 Site. Preference should be given to locations having adequate public fire and police protection, adequately supplied fire hydrants for protection of yard areas, good drainage, all-weather roads or driveways for emergency vehicle use, and remoteness from buildings or other combustible storages or facilities that could constitute an exposure hazard.

D-5.3 Storage Arrangements.

D-5.3.1 Tiered storage is not recommended; however, yard or outdoor storage conditions can necessitate storage methods other than those outlined. The authority having jurisdiction should be consulted for approval in such cases.

D-5.3.2 Storage should be arranged to provide reasonable fire breaks and ready access for fire fighting.

D-5.3.3 A row of storage should be limited to 100 bales.

D-5.3.4 Maximum storage limitations should be as follows:

(1) Protected block, 10 rows (1000 bales)
(2) Unprotected block, five rows (500 bales)
(3) Protected yard, five protected blocks (5000 bales)
(4) Unprotected yard, five unprotected blocks (2500 bales)
(5) Protected group yard, four protected yards (20,000 bales)
(6) Unprotected group yard, four unprotected yards (10,000 bales)

D-5.3.5 Minimum clear spaces should be as follows:

(1) 10 ft (3.1 m) between parallel rows and 25 ft (7.6 m) between rows arranged end-to-end
(2) 50 ft (15.2 m) between protected or unprotected blocks
(3) 200 ft (61 m) between protected or unprotected yards
(4) 1000 ft (305 m) between protected or unprotected group yards

D-5.3.6 Rows should be arranged so that prevailing winds blow in the direction of the parallel clear spaces between rows.

D-5.4 Quarantine Yards.

D-5.4.1 Freshly ginned cotton bales, commonly called *fire-packed bales*, are highly subject to insidious fires originating from the ginning operation. Known or suspect fire-packed bales should be marked as such and kept segregated from other contents or buildings for a period of not less than 5 days. If no fire is detected after that period, the bales then can be handled in a normal manner.

D-5.4.2 A clear space of at least 100 ft (30.5 m) from any yard storage and 25 ft (7.6 m) from all buildings should be established as a quarantine area for known or suspect fire-packed bales.

D-5.4.3 Known or suspect fire-packed bales should be separated from each other by at least a 10-ft (3.1-m) clear space.

D-5.5 Unobstructed Clear Space.

D-5.5.1 Except as noted in D-5.5.1 unobstructed clear space to designated yard storage should be maintained as follows:

(1) 100 ft (30.5 m) to any approved sprinklered building
(2) 200 ft (61 m) to any nonapproved sprinklered or nonsprinklered building
(3) 200 ft (61 m) to an approved incinerator
(4) 500 ft (152.5 m) to a nonapproved incinerator or open fire
(5) 100 ft (30.5 m) to vehicle and seed trailer, or module parking areas and trash piles
(6) 50 ft (15.2 m) to roadways and railroad main lines and sidings
(7) 200 ft (61 m) upwind of any reconditioning activity
(8) Clear and clean of loose cotton, dry grass, weeds, and combustible trash for a distance of at least 50 ft (15.2 m) around the yard perimeter

D-5.5.2 In the case of buildings, sprinklered or unsprinklered, the clear space can be reduced up to 50 percent if construction is fire-resistive or if facing walls are masonry and parapeted with adequately protected openings. This area reduction can also be permitted to be applied to noncombustible buildings of a type limited to corrugated iron or asbestos panel walls and roof on a steel frame.

D-5.6 Fire Protection.

D-5.6.1 To qualify as a protected yard, hydrants should comply with D-4.3.

Exception: Where amended by Section D-5.

D-5.6.1.1 All areas of yard storage should be within 500 ft (152.5 m) of a fire hydrant. Adequate clearance should be maintained between storage and hydrants.

D-5.6.1.2 Hydrant equipment for each yard group (20,000 bales) should consist of the following:

(1) 250 ft (76.2 m) of $2^1/_2$-in. (63.5-mm) hose
(2) 300 ft (91.5 m) of $1^1/_2$-in. (38.1-mm) hose with provisions to "Y-connect" to the $2^1/_2$-in. (63.5-mm) hose
(3) Combination water spray nozzles
(4) Proper wrenches for hydrant operation and hose connections

D-5.6.1.3 Water available to the most remote yard hydrants should be capable of delivering at least 500 gpm (1893 L/min) at an effective pressure for at least a 2-hour period.

D-5.6.2 Approved extinguishing units should be provided on the basis of an equivalent 40A rating for each protected or unprotected yard area *(see D-5.3)* or greater fraction thereof.

D-5.6.2.1 Subject to the authority having jurisdiction, a motorized wet water unit(s) can be substituted for that specified in D-5.6.2 provided that a unit of 250 gal (946 L) or greater capacity is provided for each group yard area storing up to 20,000 bales.

D-5.6.2.2 Placement of wheeled or motorized units should be at readily accessible locations within 250 ft (76.2 m) of each yard, protected from damage, and maintained in good operating condition at all times.

D-5.6.3 Water containers and pails, if used, should be distributed at a ratio of one 40-gal (151-L) or greater container with two pails for each 100 bales of storage. However, wheeled wet water pressure extinguishers are permitted in lieu of containers and pails.

D-5.6.4 All motorized vehicles used in designated yard areas should be equipped with a listed multipurpose dry chemical extinguisher of a size appropriate for the anticipated hazard. *(See D-4.4.2 for information on portable fire extinguishers.)*

D-5.6.5 A suitable and reliable means of communication should be available to summon the fire department or other appropriate personnel promptly, to sound a general alarm in the case of fire or other emergency, or both.

D-5.6.6 Reference should be made to D-4.6 for fire emergency planning and procedures that apply to yard storage.

D-5.7 Yard Maintenance and Operations.

D-5.7.1 Smoking. Smoking should be strictly prohibited within 100 ft (30.5 m) of yard storage areas, and "No Smoking" signs should be posted conspicuously. *(See D-6.6.)*

D-5.7.2 Internal Combustion Equipment. All internal combustion equipment used in or around yard storage areas should be equipped with a suitable spark arrester–type muffler properly maintained and otherwise approved by the authority having jurisdiction.

D-5.7.3 Guard Watch Service.

D-5.7.3.1 Guard watch service should be provided throughout all designated yard storage areas during all shutdown periods when fewer than 5 days have passed after cotton bales have been ginned or when the total stock exceeds 1000 bales.

D-5.7.3.2 Hourly rounds should be made and recorded during all nonworking hours using an approved and listed portable clock and having key stations situated to ensure complete coverage of the area of responsibility. Watch service information should be obtained from NFPA 601, *Standard for Security Services in Fire Loss Prevention.*

D-6 Administration, Buildings, Equipment, Maintenance, and Operations.

D-6.1 Administration. The administration of buildings and equipment, and the maintenance thereof, is an important consideration in the reduction of fire incidence and loss. The finest buildings and protective features can be abrogated quickly by neglect of the continuous, necessary maintenance of fire loss prevention programs and protective equipment. Thus, management at all levels plays a critical part in the reduction of fire loss.

In addition to the recommendations outlined in this appendix, the liaison between management and personnel should include a meaningful loss prevention program that provides the following:

(1) Encourages loss prevention habits
(2) Teaches the prompt sounding of alarms
(3) Minimizes panic and effects safe evacuation
(4) Instructs key personnel in the effective utilization of fire-extinguishing equipment and other protective features
(5) Teaches basic salvage and cleanup techniques to minimize the downtime of operations

D-6.2 Mechanical-Handling Equipment.

D-6.2.1 Industrial Trucks. Power-operated industrial trucks and mobile equipment should comply with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation.* Cotton storage and handling areas are defined as Class III, Division 2 hazardous areas and require vehicles designated as types DS, DY, ES, EE, EX, GS, LPS, and GS/LPS.

D-6.2.1.1 Gasoline and diesel fuel should be prohibited in cotton storage areas, on platforms, and in exposing yard areas. Fueling should be done outside at a well-detached location in accordance with NFPA 30, *Flammable and Combustible Liquids Code.*

Exception: Gasoline and diesel fuel contained in the vehicle tanks are permitted.

D-6.2.1.2 Liquefied petroleum gas (LP-Gas) fuel containers shall be exchanged or removed only outdoors. The valve at the fuel container should be closed and the engine allowed to run until the fuel line is exhausted. Tanks should be refueled only at well-detached locations. LP-Gas fuel systems on LP-Gas dual fuel–powered trucks should be in accordance with the applicable provisions of NFPA 58, *Liquefied Petroleum Gas Code.*

D-6.2.1.3 Charging equipment for storage batteries should be in a separate area, room, or building designated for that purpose. If located in a separate room, the room should be lined with substantial noncombustible materials constructed to exclude "fly" or lint. Charging areas should be kept free of extraneous combustible materials and trash. Adequate ventilation should be provided to minimize concentrations of hydrogen gas during charging.

D-6.2.1.4 All mechanical equipment and refueling areas should be kept free of accumulations of fibrous lint, oil, and trash with particular attention paid to the internal areas of vehicles.

D-6.2.2 Maintenance and Operations. The following recommendations should be met prior to the entrance or use of industrial trucks in a cotton storage or handling area:

(1) All traces of fuel should be cleaned from the vehicle before it is started.
(2) Vehicles that have exhausted fuel tanks should be towed to the assigned fueling area for refueling.
(3) Repairs should be prohibited in cotton storage or handling areas.
(4) Alterations of the fire safety features should be prohibited.
(5) Maintenance procedures should comply with those outlined in NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation. (See D-6.2.1.)*

D-6.2.3 Interplant Haulage. Tractors used for interplant hauling should be equipped with a properly maintained, suitable, spark arrester–type muffler.

D-6.2.4 Motorized Vehicles. Motorized vehicles, other than those specified under D-6.2.1, should not be permitted to enter any cotton storage area. A loading platform should be located so that trucks cannot fully enter inside the closing walls of a warehouse with the truck space inclined away from the platform and lower than the platform. The loading area should be closed off from any under-floor building space.

D-6.2.5 Equipment Storage. Mechanical-handling equipment, when not in use, should be stored outside.

D-6.3 Building Service and Equipment.

D-6.3.1 Electrical Installation.

D-6.3.1.1 It is recommended that cotton storage and handling areas be free of electrical installations. However, installations that are necessary should comply with NFPA 70, *National Electrical Code*, for Class III, Division 2 hazardous areas.

D-6.3.1.2 Electrical extension cords should be prohibited in storage areas. If portable lights are necessary, battery-powered lanterns or flashlights can be used.

D-6.3.2 Open-Flame Heating Devices. Open-flame heating devices, permanent or temporary, should be prohibited.

D-6.3.3 Shops and Equipment.

D-6.3.3.1 Repairing and reconditioning and boilers or similar equipment should be prohibited in cotton storage areas. Separate buildings should be provided for such purposes or should be separated from storage areas by a standard 2-hour fire wall.

D-6.3.3.2 The term *reconditioning* applies mainly to cotton and is defined as any opening, drying, cleaning, or picking of bales of loose cotton by any means whatsoever.

Exception No. 1: Air drying (not compressed air) of baled cotton at room temperature where not more than one band is removed from each bale being so dried.

Exception No. 2: The picking of baled cotton by hand where not more than five bales are in the process of being picked on the premises at any one time, and where at least two bands remain on each bale so picked. Removal of more than one band is to be considered part of the picking process.

Exception No. 3: The opening of bales in the press room for pressing or recompressing.

Exception No. 4: The cleaning of baled cotton by brushing (manual only) where the process employed does not remove an appreciable quantity of lint.

Mechanical reconditioning operations should confine lint and "fly" to the reconditioning building and should be separated from cotton storage (or compress) by a standard fire wall without openings or by unobstructed clear spaces as outlined in Section D-2.

D-6.4 Cutting and Welding.

D-6.4.1 Where cutting and welding operations are necessary, the precautions contained in NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*, should be followed.

D-6.4.2 Welding, soldering, brazing, or cutting should be permitted only by the authorization of management. Proper precautions should be observed and should include the following:

(a) A supervisor should be assigned to the operation.

(b) The area should be made fire-safe.

(c) Work should be removed to a safe area, where possible.

(d) Where these operations are performed on equipment or building components that cannot be moved, there should be no storage below or within a 35-ft (10.7-m) radius.

(e) Floors should be swept clean and wooden floors wet down within the 35-ft (10.7-m) radius.

(f) The cutting and welding equipment to be used should be in good operating condition and properly maintained. Personnel operating arc welding or cutting equipment should be protected from possible shock.

(g) Openings and cracks in wood construction should be tightly covered to prevent the passage of sparks.

(h) All cotton bordering the area should be protected by flameproofed covers or otherwise shielded with metal or asbestos guards or curtains. The edges of the covers at the floor should be tight to prevent sparks from escaping. This precaution should extend to where several covers are used to protect a large storage pile.

(i) All fire protection equipment should be in service and ready for immediate use.

(j) A fire watch should be maintained and equipped with a portable extinguisher during these operations for not less than 1 hour following the completion of open-flame operation.

D-6.5 Waste Disposal.

D-6.5.1 Rubbish, trash, and other waste material should be disposed of at regular intervals. Approved waste cans with self-closing covers should be used where needed. Open fires and incinerator operations should be prohibited within 100 ft (30.5 m) of any cotton storage building.

D-6.5.2 For additional details, see NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment.*

D-6.6 Smoking.

D-6.6.1 Smoking should be strictly prohibited. "No Smoking" signs should be posted conspicuously in prohibited areas.

Exception: Smoking is permitted in locations prominently designated as safe smoking areas.

D-6.6.2 The cooperation of employees is more easily secured when a reasonable smoking policy is adopted with smoking allowed in specified locations where there is little hazard, at specified times, and under suitable supervision. Complete prohibition is likely to lead to surreptitious smoking in out-of-the-way locations where the hazard is most dangerous.

D-6.7 Maintenance and Inspection.

D-6.7.1 Fire walls, fire doors, fire door guards, and floors should be maintained in good repair at all times.

D-6.7.2 NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, should be referenced for information on the maintenance and service of sprinkler systems and water supplies.

D-6.7.3 All portable and manual fire-extinguishing equipment should be maintained and serviced.

D-6.7.4 As an aid in maintaining fire protection features and equipment in full service at all times, Figure D-6.7.4 provides a simple self-inspection form that contains a checklist of loss prevention principles. This sample form can be used without change or as a guide in establishing a specialized form to suit individual facilities.

D-6.8 Grass and Weeds. All dried grass and weeds should be kept clear of buildings for at least 50 ft (15.2 m).

D-7 Information on Fighting Fires in Baled Cotton.

D-7.1 Introduction. The information contained in this section is a summary of knowledge gained over the years by cotton warehouse personnel, fire fighters, and insurance authorities in fighting fires in the Cotton Belt.

A baled cotton fire has peculiarities that should be understood and respected if a large loss is to be avoided with minimum danger to personnel. Automatic sprinklers, if properly designed and supplied, can be expected to control a baled cotton fire where storage methods outlined in this standard are followed, but extinguishment should not be expected.

The primary rule for any fire is always to call the responding fire department first. Fighting fires of any type is a profession and, even where a well-trained private fire organization is available, professional aid should be effected as soon as possible, and plant personnel should not be unduly exposed to the peril.

The myriad of small fibers that make up a cotton bale, especially a naked bale or one wrapped in burlap, and cover its surface offer a highly vulnerable source of ignition as well as the potential for a rapid flame spread, also known as *flashover*. A flashover is usually followed by a slower flame spread at the surface, then tenacious burrowing into the pile between bales and penetration of the interiors of individual bales. High-density bales are less vulnerable to a burrowing fire, but the possibility of such a fire should not be ignored.

D-7.2 Causes. Some of the causes of cotton fiber fires include breaking metal bands (ties) that strike other metallic objects resulting in sparks, fire-packed bales, electrical faults, mechanical equipment (e.g., defective lift trucks), friction (e.g., bale ties rubbing together, railroad boxcars), lightning, cutting and welding, and smoking. Sparks from bale ties and fire-packed bales appear to be the most prominent fire cause. Incendiarism and exposures are also a consideration.

Figure D-6.7.4 Sample loss prevention self-inspection form for baled cotton storage.

WAREHOUSE NO. _____	COMPARTMENT NO. _____

	YES	NO
General Housekeeping		
1. Inside Buildings		
(a) Floor and dock areas clean of loose cotton and trash?	☐	☐
(b) Covered metal containers for loose cotton and trash?	☐	☐
2. Outside Buildings		
(a) Surrounding areas free of dried grass, weeds, and combustible trash?	☐	☐
Smoking		
1. Evidence of smoking in unauthorized areas?	☐	☐
2. Signs posted and readily visible?	☐	☐
Electrical Equipment		
1. Extension cords prohibited?	☐	☐
2. Storage in contact with lights or wiring?	☐	☐
3. Wiring properly supported and undamaged?	☐	☐
4. Circuits properly fused?	☐	☐
5. All panels, junction, switch, and receptacle boxes covered?	☐	☐
Mechanical Equipment		
1. Listed for fiber storage (Type DS, DY, ES, EE, EX, GS, or LPS)?	☐	☐
2. Spark-retardant mufflers maintained?	☐	☐
3. Refueled outside at designated area?	☐	☐
4. Stored outside when idle?	☐	☐
5. General condition and maintenance good?	☐	☐
Buildings		
1. Fire walls in good repair, including around fire door openings?	☐	☐
2. Fire doors in proper working condition and tested for ease of closing each week? (Overhead, roll-type doors should be tested at least annually.)	☐	☐
3. Fire door guards in place and maintained?	☐	☐
4. Floor and exterior walls in good repair?	☐	☐
5. Exterior wall openings have doors and windows in place that close properly and lock?	☐	☐
6. Space under grade floor, if any, closed off?	☐	☐
Storage Arrangements		
1. Storage Blocks		
(a) Within prescribed height [15 ft (4.6 m)]?	☐	☐
(b) Sprinkler heads unimpaired [18-in. (457-mm) clearance]?	☐	☐
(c) Block sizes limited to 700 bales pressed or 350 flat?	☐	☐
(d) Tiered storage stable and secure?	☐	☐
2. Aisles		
(a) At least one main aisle 12 ft (3.7 m) or more in width?	☐	☐
(b) Cross or work aisles at least 4 ft (1.2 m) in width?	☐	☐
(c) Any damaged bales, broken bands, or wet stock?	☐	☐

	YES	NO
Fire Department		
1. Phone number prominently displayed at each phone?	☐	☐
2. Personnel instructed on procedure in case of fire?	☐	☐
Watch Service		
1. Making regular rounds?	☐	☐
2. All key stations punched?	☐	☐
3. Records checked, dated, and filed?	☐	☐
Fire Alarm Service		
1. Automatic fire alarm system in service?	☐	☐
2. Manual pull stations clearly marked and accessible?	☐	☐
3. Date last tested?	☐	☐
Manual Extinguishing Equipment Portable Extinguishers		
1. Hand Units		
(a) Properly placed and accessible?	☐	☐
(b) Recharged within the last year?	☐	☐
(c) All in good condition?	☐	☐
2. Containers and Buckets		
(a) Properly distributed?	☐	☐
(b) Kept full?	☐	☐
(c) Two buckets per barrel?	☐	☐
3. Mobile Equipment		
(a) Properly placed and protected from damage?	☐	☐
(b) Charged and ready for service?	☐	☐
Inside Hose		
1. Hose and nozzle attached to each?	☐	☐
2. Racked and in good condition?	☐	☐
3. Easily accessible and ready for use?	☐	☐
4. Valves operate readily?	☐	☐
Yard Hydrants and Hose Houses		
1. Readily accessible?	☐	☐
2. Hose racked or reeled and in good condition?	☐	☐
3. Nozzles, spanners, hydrant wrench available?	☐	☐
4. Hydrants operable?	☐	☐
5. General condition: Good ☐ Poor ☐		

Note: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

REMARKS (Report on any unusual conditions and action taken):

Report by: **Date:**

D-7.3 Incipient Stage. If caught in the incipient stage, control can often be effected, provided the proper procedures are followed. Portable extinguishing equipment, such as containers and pails, or pressurized or pump-type water units, can be used to wet down the exterior of the bale quickly.

If small extinguishers are not successful, portable, wheeled, wetting agent tanks or standpipe hose, or both, should be used. The last resort is hose streams from outside hydrants. Extreme caution should be exercised when using straight hose streams, as the force of the stream could scatter the burning wads or portions of cotton over a wide area. Spray or fog nozzles are recommended, but, if not available, it might be possible to deflect a solid stream off the walls, roof, or other solid object.

Once the exterior of the bale(s) is fully wet down and fire is suppressed, the bales involved then should be removed to an outside, safe location for final extinguishment.

CAUTION

An obviously burning bale should never be dragged or mechanically moved down aisles, as this is likely to spread the fire to bales bordering the aisle. *(See D-7.9.)*

D-7.4 Active Stage in Sprinklered Buildings. If a fire progresses well beyond the incipient stage or involves more than a few bales and further fire spread is likely, the building could readily prove untenable and dense smoke could quickly obscure vision. It then is best to have all personnel vacate the building to a point of safety. As drafts, including early venting through roofs and walls, are undesirable, it is essential to leave the building unventilated and close all doors and cut off all possible drafts to the building or section involved. This reduces available oxygen to the fire, and the dense smoke suppresses fire intensity. Drafts not only provide fresh air to increase fire intensity but also can blow heat away from the fire, opening sprinklers beyond the fire area and possibly overtaxing the available water to the sprinkler system.

The sprinkler system should be given a chance to do its job — do not ventilate! Ventilating a cotton fire can cause it to flash out of control, spread with explosive violence, and open an excessive number of sprinklers.

After the fire is under control of the sprinkler system, the compartment door should be opened only enough to use fire hose or to enter and remove the cotton. The smoldering bales should be removed to the outside as soon as possible for individual attention. Extreme caution should be exercised when entering a fire area. Entry should be on the downwind side, if possible, to avoid creating draft conditions that could cause the fire to reignite. It is important to remain alert for gas explosions. If the fire appears to flare up again, the building should be vacated immediately and the doors again should be closed tightly and the sprinkler system should be allowed to regain control.

D-7.5 Sprinkler Failure. If the sprinkler system fails to maintain fire control, then hose streams should be used, preferably through door openings only large enough for the hose.

Where it is apparent that the fire is beyond the control of the sprinklers and the building is nearing the point of collapse, the control valve(s) to the sprinkler systems in the building or section involved should be shut off to conserve water for hose stream use.

D-7.6 Active Stage in Nonsprinklered Buildings. Immediately on arrival at the fire, all openings to the compartment involved should be closed. As many hose lines as possible, preferably supplied with a wetting agent, should be available. The doors should be opened only enough to allow the use of the hose in a spray-like fashion. Caution should be exercised to open these doors slowly to minimize the chance of an explosion. The doors on the opposite sides of the compartment should not be opened, which would allow a cross-draft. Only the door on the lee side, and not the windward side, of the building should be opened.

D-7.7 Cotton Yard Fires. Conditions in a cotton yard fire are not as controllable as those in a warehouse fire, since draft conditions are almost entirely dependent upon the climatic conditions at the time of the fire. If an adverse wind prevails, a small involvement can easily become a catastrophe. Preplanning is particularly important in this case. Upon arrival at a cotton yard fire, the following steps should be taken immediately:

(1) If available, fire department connection to the hydrants should be utilized.
(2) Hose lines should be laid out.
(3) Using divided stream nozzles, water should be applied ahead and downwind of the fire and then worked toward the fire.
(4) Bales and dunnage should be checked underneath for fire.
(5) It is important to remain alert for flying sparks.
(6) The nearby uninvolved cotton should be removed to create a fire break.
(7) Burned cotton should be removed to a segregated area.

D-7.8 After Watch. Where the fire-involved cotton has been removed and leaves behind undamaged stock, a minute and unobserved spark often causes a rekindling of the previous fire with disastrous results. The involved area should be inspected and carefully cleaned. Hose lines and fire department watch should be maintained until the area is known to be safe. Before leaving the scene of the fire, responsible plant personnel should be advised that after watch should be kept for at least 24 hours. One of the most disastrous fires on record could possibly have been prevented with adequate after watch following a minor involvement.

D-7.9 Salvage Operations. Salvage is important, and every precaution should be taken to protect the salvage. The usual severity of a fire in a cotton warehouse, along with the appearance of the charred bales, is misleading with respect to the amount of remaining salvage.

Water does not damage cotton, and if the charred bales are kept cool with hose streams until proper salvage operation is begun, the quantity of the loss can be reduced substantially.

After the fire is brought under control, all bales involved should be removed to a safe outside location as quickly as possible and practicable. Each bale then should be handled individually in order to effect complete extinguishment. This extinguishment is best accomplished by the use of small hose lines or barrels and buckets, using a wetting agent known as wet water.

WARNING

Do not remove the bands or wires from the bales.

To do so exposes more lint to the fire and threatens the loss of the entire bale.

Salvage crews should be ready to move the cotton out of the involved shed as rapidly as possible. Extreme caution should be exercised in preparing and watching the path along which the burned bales are removed from the involved shed. Burning fibers of cotton are easily blown from the bale, especially in the haste and excitement of moving the bales outside. It could be necessary to move the uninvolved bales away from the exit route

(or from the entire compartment) or even to make a hole in the side of the compartment. The spread of fire along the exit route caused by burning bales is not uncommon. The burning bales should be wetted down and moved to a safe, segregated place as soon as possible for individual attention.

The following are steps to be taken in the salvage operation:

(a) An open area, without exposures, into which the burning bales can be moved should be selected.

(b) A salvage crew should be stationed at the yard.

(c) A good supply of wetting agent should be available.

(d) A good supply of water should be available.

(e) Containers, pails, and stirrup pump–type extinguishers should be available, filled with wet water.

(f) Burning bales should be wetted down and removed from the fire area as soon as possible. They should be placed approximately 3 ft (0.9 m) apart in an open area away from other exposures.

(g) Care should be exercised in removing these bales so as not to start another fire in the process. If the side of the compartment is metal-clad or frame, it could be best to remove a portion of the side so that the cotton can be removed. Some warehouse personnel take the time to remove cotton from those compartments through which the burning bales travel before salvage operations are allowed to start. If there is any question regarding additional exposures, they should be removed, if possible, before moving the burning bales.

(h) Any outside blaze on the bale should be knocked down. The wet water should be applied to each smoldering spot on the bale. Often a handful of cotton soaked in the wet water can be applied directly on or into the smoldering spot. Cotton fires burrow into the bale, so it is necessary to apply the wet water as far into the hole as possible, soaking the area thoroughly. In order to be certain the fire is out, the burned cotton should be removed from each hot spot while applying wet water to the hole. When the area around the spot is no longer warm, it can be assumed that the fire has been extinguished.

(i) The bands from the bales should not be removed. To do so exposes more lint to the fire, and the bale will probably be a complete loss.

(j) Bales involved in a fire should be closely watched for at least 5 days after the last spark is believed to have been extinguished.

D-7.10 Fire-Packed Bales. During the cotton ginning operation, sparks, caused by stones, metal, or other foreign objects in the seed cotton striking metal parts of the gin, can ignite the fibers. Occasionally, a fire immediately erupts, but often the smoldering lint is carried onto the press box where it can be packed, undetected, into the bale. Usually the fire burns through to the outside of the bale within a few hours, but it can remain undetected for several days. Sometimes the odor is noticeable or the bale feels excessively warm. These bales are known as fire-packed bales and are a major cause of fires in baled cotton.

The recommended procedure for handling and extinguishing fire-packed bales is as follows:

(a) All known or suspect fire-packed bales should be stored in the open and segregated from buildings and other storage. They should be separated about 3 ft (0.9 m) from other such bales.

(b) These bales should be under constant surveillance to detect fire as soon as it moves to the surface.

(c) A supply of an approved wetting agent and at least one stirrup pump should be available at all times.

(d) When fire is detected, the area around the hot spot should be wetted immediately to prevent the spread of the fire. The hot spot then should be saturated with wet water. The burned cotton should be removed by hand while constantly applying water to the hole. This procedure should be continued until no warm areas are detected. It is not uncommon for several fires to be packed into a single bale.

(e) Do not remove the bands from the bale, as this exposes more cotton fibers to ignition and usually results in the total loss of the bale.

(f) Fire-packed bales or bales suspected of being fire-packed should remain in quarantine and under surveillance for at least 5 days. After this time, they can be considered to be safe and handled in the regular manner.

NOTICE: There is no set time after which a fire can be considered extinguished in a bale, as this depends on the thoroughness of extinguishment. However, 5 days after the fire is believed to have been extinguished is generally considered to be a rule-of-thumb safe period.

Appendix E Guidelines for Storage of Forest Products

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

E-1 General.

E-1.1 Purpose. The intent of these guidelines is to provide fire protection guidance to minimize the fire hazard in areas used for the storage of forest products, particularly as they are stored outside buildings. These guidelines are not intended to be mandatory requirements. Each individual property will have its own special conditions of stock handling, exposure, and topography. For this reason, only basic fire protection principles are discussed herein, which are intended to be applied with due consideration of all local factors involved. The authority having jurisdiction should be consulted in all cases.

E-1.2 Scope. These guidelines cover the following:

(1) Retail and wholesale lumber storage yards
(2) Outside storage of lumber and timber at other than retail or wholesale yards
(3) Outside storage of ties, poles, piles, posts, and other similar forest products at pressure-treating plant yards
(4) Outside storage of wood chips
(5) Outside storage of logs
(6) Outside storage of hogged material

E-2 Retail and Wholesale Lumber Storage Yards.

E-2.1 Application.

E-2.1.1 The intent of the guidelines contained in this section is to provide fire protection guidance to minimize the fire hazard in the following areas:

(1) Retail lumberyards handling forest products and other building materials
(2) Wholesale lumber storage yards including distribution, holding, and transshipment areas
(3) Buildings in retail and wholesale lumberyards used for storage of forest products or auxiliary operations

E-2.1.2 In addition to the guidelines contained in Section E-2, the provisions outlined in Section E-7 should apply to all retail and wholesale lumber storage yards except as modified herein.

E-2.1.3 The type of operations at properties where these recommendations apply will vary widely. Retail lumber and building material operations are often characterized by large area buildings with minor outside storage areas. On the other hand, wholesale and distribution yards can involve large outside storage areas that present fire protection problems similar to mill yards. The principles outlined in Section E-3 should be used as a further guide for large outside storage areas, and the authority having jurisdiction should be consulted in all cases.

E-2.2 General.

E-2.2.1 Fire loss experience in lumberyards indicates that large undivided stacks, congested storage conditions, delayed fire detection, inadequate fire protection, and ineffective fire-fighting tactics are the principal factors that allow lumberyard fires to reach serious proportions. The fire hazard potential inherent in lumber storage operations with large quantities of combustible material can best be controlled by a positive fire prevention program under the direct supervision of top management and should include the following:

(1) Selection, design, and arrangement of storage yard areas and materials-handling equipment based upon sound fire prevention and protection principles
(2) Facilities for early fire detection, transmission of alarm, and fire extinguishment *(see NFPA 72, National Fire Alarm Code)*
(3) Fire lanes to separate large stacks and provide access for effective fire-fighting operations
(4) Separation of yard storage from yard buildings and other exposing properties
(5) An effective fire prevention maintenance program, including regular yard inspections by trained personnel

E-2.2.2 Cargo yards with lumber stored on piers or wharves and lumber stored on raised platforms present special problems of construction and protection. NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves*, and the authority having jurisdiction should be consulted in each case.

E-2.2.3 It is recognized that retail and wholesale lumber storage yards are normally located within municipal boundaries where there are municipal water supplies available for fire protection. For basic fire protection, the municipal system should be capable of supplying at least four $2^1/_2$-in. (63.5-mm) hose streams simultaneously [1000 gpm (63 L/sec) minimum]. Where large-scale fire-fighting operations can be expected, larger water supplies are needed. Where protection from municipal water supplies and hydrant systems is not present or is not considered adequate by the authority having jurisdiction, a yard fire hydrant system should be provided.

E-2.3 Open Yard Storage.

E-2.3.1 Lumber stacks should be on solid ground, preferably paved or surfaced with materials such as cinders, fine gravel, or stone. Where the danger of underground fire is present, refuse- or sawdust-filled land should not be used.

E-2.3.2 The method of stacking should be solid wherever possible and in an orderly and regular manner.

E-2.3.3 It is recognized that some materials will be stored on pallets in an open yard. As stacks of empty pallets present a severe fire problem, empty pallets should be stored in accordance with the guidelines set out in Table E-2.3.3(a) and Table E-2.3.3(b).

E-2.3.4 The height of stacks should not exceed 20 ft (6.1 m) with due regard for stability. Air-drying stickered stacks are subject to rapid fire spread through the air spaces and should therefore be kept as low as practicable.

E-2.3.5 Where stacks are supported clear of the ground, adequate clearance should be provided for cleaning operations under the stacks.

E-2.3.6 Driveways should be so spaced that a maximum grid system of not over 50 ft × 150 ft (15.2 m × 45.7 m) is produced.

E-2.3.7 Driveways should have a minimum width of 15 ft (4.6 m) and an all-weather surface capable of supporting fire department apparatus.

E-2.3.8 Where the yard has earth or crushed stone drives, boundary posts with signs designating stacking limits should be provided to indicate yard area and alley limits. In paved yard areas, painted boundary limits can be used instead of posts and signs.

E-2.4 Buildings.

E-2.4.1 Automatic sprinklers provide an efficient means of fire detection and extinguishment. Automatic sprinkler protection should be considered for all large storage buildings containing combustible contents and auxiliary buildings containing hazardous operations that can constitute an exposure to outside lumber storage or other property. Automatic sprinkler protection for buildings used for indoor storage of forest products should be designed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

E-2.4.2 Where automatic sprinklers are not installed, large storage buildings should be subdivided by fire walls into compartments not exceeding area limits specified in generally accepted model building codes.

E-2.5 Exposure Protection.

E-2.5.1 Many retail lumberyards sell clay, concrete, and stone products. These and other lesser burnable materials (large-size timbers and flat-stacked stock) should be stored or stacked on the perimeter of the yard to act as a barrier between the yard and adjacent properties or buildings.

E-2.5.2 Exposure to the Yard.

E-2.5.2.1 Except as noted in E-2.5.2.2, open yard stacking should be located with as much clear space to buildings as practicable. Building walls should have sufficient fire resistance to contain a fire that originates in the building, and windows or other openings should be reduced in size or adequately blocked to prevent radiant heat exposure to the open yard stacking. *(See E-7.3.1.)*

E-2.5.2.2 Unsprinklered buildings containing hazardous manufacturing or other operations (e.g., woodworking, glazing, painting, dry kilns, auto repairing, grain or feed milling or grinding, aboveground fuel or gasoline tanks) should have at least 50 ft (15.2 m) of clear space to the nearest lumber stack, shed, or warehouse. Boundary posts with signs designating stacking limits should be provided to designate the clear space to the aforementioned buildings, tanks, and so forth.

Table E-2.3.3(a) Guidelines for Clearance Between Outside Idle Pallet Storage and Building

Wall Construction		Minimum Distance of Wall from Storage of					
		Under 50 Pallets		50 to 200 Pallets		Over 200 Pallets	
Wall Type	Openings	ft	m	ft	m	ft	m
Masonry	None	0	0	0	0	0	0
	Wired glass with outside sprinklers and 1-hour doors	0	0	10	3.0	20	6.1
	Wired or plain glass with outside sprinklers and $^3/_4$-hour doors	10	3.0	20	6.1	30	9.1
Wood or metal with outside sprinklers		10	3.0	20	6.1	30	9.1
Wood, metal, or other		20	6.1	30	9.1	50	15.2

Notes:
1. Fire-resistive protection comparable to that of the wall should also be provided for combustible eave lines, vent openings, and so forth.
2. Where pallets are stored close to a building, the height of storage should be restricted to prevent burning pallets from falling on the building.
3. Manual outside open sprinklers generally are not a reliable means of protection unless property is attended to at all times by plant emergency personnel.
4. Open sprinklers controlled by a deluge valve are preferred.

Table E-2.3.3(b) Guidelines for Clearance Between Outdoor Pallet Storage and Other Yard Storage

Pile Size	Minimum Distance	
	ft	m
Under 50 pallets	20	6
50–200 pallets	30	9.1
Over 200 pallets	50	15.2

E-2.5.3 Exposure from the Yard. Because of the large quantities of material generally involved in lumberyard fires, some form of exposure protection for adjoining properties is recommended. Clear spaces or walls capable of providing fire barriers between yard storage and the exposed properties are desirable. The responsibility for the proper protection of properties adjoining a lumberyard is often a joint one to be worked out by the cooperation of the lumberyard and adjoining property owners. Refer in each case to the authority having jurisdiction.

E-2.6 Special Fire Prevention.

E-2.6.1 All power woodworking machines, except for portable units, should be equipped with refuse removal equipment conforming to NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.*

E-2.6.2 Materials such as hay, coal, grain, and feed should be stored in separate buildings or in the open with adequate clear space between yard buildings or open yard storage.

E-3 Outside Storage of Lumber at Other than Retail or Wholesale Yards.

E-3.1 Application.

E-3.1.1 The intent of the guidelines contained in this section is to provide fire protection guidance to minimize the fire hazard in large yard storage areas containing lumber, timber, and other similar wood products not intended for retail or wholesale distribution at the site. Each individual property will have its own special conditions of yard use, material-handling methods, and topography. For this reason, only basic fire protection principles are discussed herein, which are intended to be applied with due consideration of all local factors involved.

E-3.1.2 In addition to the guidelines contained in this appendix, the provisions outlined in Section E-7 should apply to all large yard storage areas for lumber and timber at other than retail or wholesale yards, except as modified herein.

E-3.2 General.

E-3.2.1 Fire loss experience in lumber storage yards indicates that large undivided stacks, congested storage conditions, delayed fire detection, inadequate fire protection, and ineffective fire-fighting tactics are the principal factors that allow lumberyard fires to reach serious proportions. The fire hazard potential inherent in lumber storage operations with large quantities of combustible material can best be controlled by a positive fire prevention program under the direct supervision of top management and should include the following:

(1) Selection, design, and arrangement of storage yard areas and materials-handling equipment based on sound fire prevention and protection principles
(2) Facilities for early fire detection, transmission of alarm, and fire extinguishment *(see NFPA 72, National Fire Alarm Code)*
(3) Fire lanes to separate large stacks and provide access for effective fire-fighting operations
(4) Separation of yard storage from mill operations and other exposing properties
(5) An effective fire prevention maintenance program, including regular yard inspections by trained personnel

E-3.2.2 Cargo yards with lumber stored on piers or wharves and lumber stored on raised platforms present special problems of construction and protection. NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves*, and the authority having jurisdiction should be consulted in each case.

E-3.3 Basic Lumberyard Protection.

E-3.3.1 For basic fire protection, the hydrant system should be capable of supplying at least four $2^1/_2$-in. (63.5-mm) hose streams simultaneously [1000 gpm (63 L/sec) minimum] while maintaining a positive residual pressure in the fire protection hydrant system of at least 20 psi (138 kPa).

Where large-scale fire-fighting operations can be expected, larger water supplies with adequate mains are needed. *(See E-3.4.)*

For early extinguishment with basic fire protection, hydrants should be spaced with sufficient $2^1/_2$-in. (63.5-mm) hose attached so as to permit rapid hose laying to all parts of the stacking areas. For this reason, the hydrants should be spaced at about 250-ft (76.2-m) intervals so that any part of the yard can be reached with 200 ft (61.0 m) of hose. Hydrants preferably should be located at fire lane intersections. A hydrant hose house with at least 200 ft (61.0 m) of fire hose and auxiliary equipment should be provided at each hydrant. *(See NFPA 13, Standard for the Installation of Sprinkler Systems.)*

E-3.3.2 Access to the plant and yard from public highways should be provided by all-weather roadways capable of supporting fire department apparatus.

E-3.3.3 The storage site should be reasonably level, solid ground, preferably paved or surfaced with material such as cinders, fine gravel, or stone. Refuse- or sawdust-filled land, swampy ground, or areas where the hazard of underground fire is present should not be used.

E-3.4 Special Lumberyard Protection.

E-3.4.1 Yards consisting of single carrier loads of green flat-stacked lumber present a minimum hazard that generally requires only the basic protection provisions of E-3.3 for effective fire control. High stacks of lumber stickered for air drying present a severe hazard that will require effective use of large stream equipment and greatly expanded water supplies for fire control. In yards requiring more than the basic protection provisions of E-3.3 for effective fire control, the following provisions are suggested as a guide. The relative importance of these provisions and the degree to which they might be needed will vary with yard conditions, and the authority having jurisdiction should be consulted in all cases.

E-3.4.2 Powerful water supplies and large mains should be provided where adequate public or private fire department services are available. Large stream equipment, such as portable turrets and deluge sets, requires 750 gpm to 1000 gpm (47 L/sec to 63 L/sec) for each appliance. Monitor towers can require supplies in excess of 1000 gpm (63 L/sec) for each unit. In large yards where the hazard is severe, many of these devices could need to be operated simultaneously.

E-3.4.3 Fire lanes suitable for fire department operations should be provided with storage arranged so that no part of the occupied area is more than 50 ft (15.2 m) in any direction from access by motorized fire-fighting equipment. Where special extinguishing equipment, such as portable turrets, deluge sets, and monitor towers, is available, access distances can be governed by their effective reach with available water supplies. Fire lanes should be kept unobstructed, have an all-weather surface sufficiently strong to support fire apparatus, and should be of sufficient width to permit maneuvering of motorized fire apparatus.

E-3.4.4 Stack heights should be limited. Heights in excess of 20 ft (6.1 m) seriously restrict effective extinguishing operations. Air-drying stickered stacks are subject to a more rapid fire involvement and should be kept as low as possible.

E-4 Outside Storage of Ties, Poles, Piles, Posts, and Other Similar Forest Products at Pressure-Treating Plant Yards.

E-4.1 Application.

E-4.1.1 The intent of the guidelines contained in this section is to provide fire protection guidance to minimize the fire hazard in yard storage areas containing treated and untreated ties, poles, piles, posts, and other similar forest products in yards connected with pressure-treating plants, but not including the treating buildings, processes, or storage of treating materials. Each individual property will have its own special conditions of yard use, stock-handling methods, and topography. For this reason, only basic fire protection principles are suggested herein, which are intended to be applied with due consideration of all local factors involved.

E-4.1.2 Ties, as used herein, includes ties, poles, piles, posts, and other similar forest products. Treated ties are those pressure impregnated with preservatives.

E-4.1.3 In addition to the guidelines contained in this section, the provisions outlined in Section E-7 should apply to all outside storage of ties, poles, piles, posts, and other similar forest products at pressure-treating plant yards, except as modified herein.

E-4.2 General. Fire loss experience in tie storage yards indicates that large undivided stacks, congested storage conditions, delayed fire detection, inadequate fire protection, and ineffective fire-fighting tactics are the principal factors that allow fires to reach serious proportions. The fire hazard potential inherent in tie storage operations with large quantities of combustible material can best be controlled by a positive fire prevention program under the direct supervision of top management and should include the following:

(1) Selection, design, and arrangement of storage yard areas and materials-handling equipment based upon sound fire prevention and protection principles
(2) Facilities for early fire detection, transmission of alarm, and fire extinguishment *(see NFPA 72, National Fire Alarm Code)*
(3) Fire lanes to separate large stacks and provide access for effective fire-fighting operations
(4) Separation of yard storage from mill buildings and other exposing properties
(5) An effective fire prevention maintenance program, including regular yard inspections by trained personnel

E-4.3 Basic Tie Yard Protection.

E-4.3.1 Unobstructed alleyways of sufficient width for hand or cart fire hose laying operations should be provided between piles. A minimum alleyway width of 4 ft (1.2 m) should be provided. Alleyways should be spaced so that initial fire-fighting operations can be effective. With relatively open stacking (i.e., stacking that will permit penetration of fire-extinguishing streams) this can usually be accomplished by providing a 4-ft (1.2-m) or greater alleyway width between alternate rows of tie stacks *[see Figure E-4.3.1(a)]*. Flat crib-style stacking without space between stacks that forms solid packed rows would require a 4-ft (1.2-m) or greater alleyway width between each row. Where the stacking area does not permit a 4-ft (1.2-m) or

wider alleyway between each such row, the length of the rows (distance between fire lanes) should be held to 75 ft (22.9 m) or less. In no event should such alleyways be reduced to less than 2 ft (0.6 m) in width *[see Figure E-4.3.1(b)]*.

Figure E-4.3.1(a) Relatively open stacking methods.

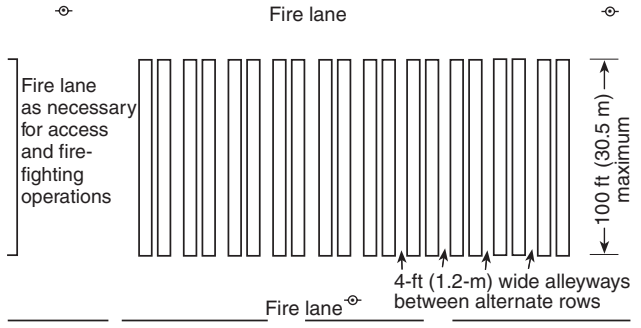
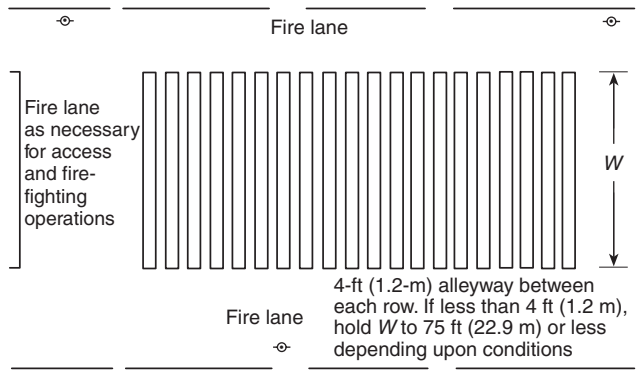


Figure E-4.3.1(b) Crib-style stacking into solid rows.



E-4.3.2 For basic fire protection, the hydrant system should be capable of supplying at least four $2^1/_2$-in. (63.5-mm) hose streams simultaneously [1000 gpm (63 L/sec) minimum] while maintaining a positive residual pressure in the fire protection hydrant system of at least 20 psi (138 kPa).

Where large-scale fire-fighting operations can be expected, larger water supplies with adequate mains are needed. *(See E-4.4.)*

For early extinguishment with basic fire protection, hydrants should be spaced with sufficient $2^1/_2$-in. (63.5-mm) hose attached so as to permit rapid hose laying to all parts of the stacking areas. For this reason, hydrants should be spaced at about 250-ft (76.2-m) intervals so that any part of the yard can be reached with 200 ft (61 m) of hose. Hydrants preferably should be located at fire lane intersections. A hydrant hose house with at least 200 ft (61 m) of fire hose and auxiliary equipment should be provided at each hydrant. *(See NFPA 13, Standard for the Installation of Sprinkler Systems.)*

E-4.3.3 Access to the plant and yard from public highways should be provided by all-weather roadways capable of supporting fire department apparatus.

E-4.3.4 The storage site should be reasonably level, solid ground, preferably paved or surfaced with material such as cinders, fine gravel, or stone. Refuse- or sawdust-filled land, swampy ground, or areas where the hazard of underground fire is present should not be used.

E-4.4 Special Tie Yard Protection.

E-4.4.1 Tie yards containing low-stacked storage, small amounts of treated ties, and well-separated treating facilities present minimum hazards that generally require only the basic protection provisions of E-4.3 for effective fire control. High stacking over extensive areas, congested storage, and large amounts of treated tie storage present increased hazards that require additional safeguards and protection facilities. In yards requiring more than the basic protection provisions of E-4.3 for effective fire control, the following provisions are suggested as a guide. The relative importance of these provisions and the degree to which they might be needed will vary with yard conditions, and the authority having jurisdiction should be consulted in all cases.

E-4.4.2 Powerful water supplies and large mains should be provided where public or private fire department services are available. Large stream equipment, such as portable turrets and deluge sets, requires 750 gpm to 1000 gpm (47 L/sec to 63 L/sec) for each appliance. Monitor towers can require supplies in excess of 1000 gpm (63 L/sec) for each unit. In large yards where the hazard is severe, many of these devices could need to be operated simultaneously.

E-4.4.3 Fire lanes suitable for fire department operations should be provided with storage arranged so that no part of the occupied area is more than 50 ft (15.2 m) in any direction from access by motorized fire-fighting equipment. Where special extinguishing equipment, such as portable turrets, deluge sets, and monitor towers, is available, access distances can be governed by their effective reach with available water supplies. Fire lanes should be kept unobstructed, have an all-weather surface sufficiently strong to support fire apparatus, and should be of sufficient width to permit maneuvering of motorized fire apparatus.

E-4.4.4 Stack heights should be limited. Heights in excess of 20 ft (6.1 m) seriously restrict effective extinguishing operations.

E-4.4.5 Treated ties should not be intermixed with untreated products. A 100-ft (30.5-m) clear space should be maintained between treated tie storage and untreated storage.

E-5 Outside Storage of Wood Chips and Hogged Material.

E-5.1 Application.

E-5.1.1 The intent of the guidelines contained in this section is to provide fire protection guidance to minimize the fire hazard in yard storage areas containing wood chips and hogged material. Each individual property will have its own special conditions of yard use, handling methods, and topography. It is recognized that climate conditions, wood species, and the age of piles are all factors affecting fire safety. For these reasons, only basic fire protection principles are discussed herein, which are intended to be applied with due consideration of all local factors involved.

E-5.1.2 Except for the surface layer, the moisture content of a pile of wood chips or hogged material is quite high, so surface fires will not generally penetrate more than a few inches into the pile. Fire tests indicate that for areas of average humidity conditions, the flame propagation over the surface is relatively slow. These conditions permit ready extinguishment, provided that there is early detection and good access. It is expected that in areas where long periods of low humidity prevail, faster surface flame spread can be anticipated, increasing the importance of early detection and good access.

E-5.1.3 In addition to the guidelines contained in this section, the provisions outlined in Section E-7 should apply to all outside storage of wood chips and hogged material, except as modified herein.

E-5.2 General.

E-5.2.1 Fire experience and fire tests indicate that two completely different types of fires can occur in storage piles — surface fires and internal fires. Fire prevention activities and fire protection facilities should, therefore, be prepared to cope with both situations. These programs should be under the direct supervision of top management and should include the following:

(1) Selection, design, and arrangement of storage yard areas and materials-handling equipment based upon sound fire prevention and protection principles
(2) Establishing control over the various factors that lead to spontaneous heating, including provisions for monitoring the internal condition of the pile
(3) Facilities for early fire detection and extinguishment *(see NFPA 72, National Fire Alarm Code)*
(4) Fire lanes around the piles and access roads to the top of the piles for effective fire-fighting operations
(5) Facilities for calling the public fire department and facilities needed by them for fire extinguishment
(6) An effective fire prevention maintenance program, including regular yard inspections by trained personnel

E-5.2.2 Internal heating is a hazard inherent to long-term bulk storage of chips and hogged material that will progress to spontaneous combustion under certain pile conditions. Internal fires are difficult to detect and extinguish. Unless provisions are made for measuring internal temperatures, such fires can burn for long periods before emission of smoke at the surface indicates an internal fire. Extinguishment then becomes a lengthy and expensive loss-control and operating problem requiring equipment and manpower to move large portions of the pile, either by digging out the burning portions or removing the unburned portions of the pile. Experience has shown that these conditions create very large losses and special attention should be given to the prevention of spontaneous combustion and to pre-fire planning as how best to handle an imminent or actual fire in a particular pile.

E-5.2.3 Prevention of internal fires requires an understanding of the factors that cause exothermic oxidation so that steps can be taken to minimize this hazard and to provide means of monitoring temperature conditions inside the pile. The following are some of the important items that should be considered when establishing operating procedures:

(a) All refuse and old chips should be avoided in the chip pile base.

(b) The storage site should be reasonably level, solid ground, or should be paved with blacktop, concrete, or other hard-surface material that has been thoroughly cleaned before starting a new pile.

(c) Operating plans for the buildup and reclaiming of the pile should be based upon a maximum turnover time of 1 year under ideal conditions. Piles containing other than screened chips made from cleaned and barked logs (e.g., whole-tree chip piles containing bark, leaves, and other extraneous or hogged material) can be subject to greater degrees of spontaneous heating and thermal degradation and should be reclaimed more frequently.

(d) The pile size should be limited. Fundamentally, several small piles are better than one large pile. Pile heights should be kept low, particularly for piles that inherently carry a larger percentage of fines and are subject to greater compaction. For example, veneer chip piles should be limited to 50 ft (15.2 m) in height.

(e) Thermocouples should be installed during pile buildup, or other means for measuring temperatures within the pile should provided with regular (normally weekly) reports to management.

(f) The quality of chip supplies should be controlled in terms of percentage of fines.

(g) The concentration of fines should be avoided during pile buildup. Pneumatic systems produce an air classification of stored materials that should be recognized, and appropriate steps should be taken to minimize concentration of fines. It is preferable to spread new stored materials in a relatively even layer over the pile.

(h) The pile should be wetted regularly to help keep fines from drying out and help maintain the moisture content of the surface layer of the pile. It is important to minimize the diffusion of water from wet, stored material into dry fires to reduce exothermic heating caused by sorption effects. It is also important to maintain surface moisture content so as to reduce the hazard of surface fires during periods of hot, dry weather.

(i) Vehicles used on all piles should be of a type that minimizes compaction.

E-5.3 Pile Protection.

E-5.3.1 Piles should be constructed with an access roadway to the top of the pile in order to reach any part of the pile. For very large piles, two or more access roadways should be provided on opposite sides of the pile. This recommendation applies only to storage in excess of 30 days.

E-5.3.2 Narrow, low piles facilitate fire extinguishment; therefore, piles should not exceed 60 ft (18.3 m) in height, 300 ft (91.4 m) in width, and 500 ft (152.4 m) in length. Where pile height and width are such that all portions of the pile cannot be reached by direct hose streams from the ground, arrangements should be made to provide fire-fighting service in these areas, and small fire stream supplies should be available on the top of the pile for handling small surface fires and for wetting the pile in dry weather. When piles exceed 500 ft (152.4 m) in length, they should be subdivided by fire lanes having at least 30 ft (9.1 m) of clear space at the base of the piles. Low barrier walls around piles should be provided to clearly define pile perimeters, prevent creeping, and facilitate cleanup of fire lanes.

E-5.3.3 Where suitable, a small, motorized vehicle amply equipped with portable extinguishing equipment or a water tank and pump should be provided. Lightweight ladders that can be placed against the side of the pile should be placed at convenient locations throughout the yard for use by the plant emergency organization. Training of the plant emergency organization should also include procedures and precautions to be observed by yard crews employing power equipment in fighting internal fires. *(See E-7.4.6.)*

E-5.3.4 Due to the size and configuration of piles, it is not practical to provide portable fire extinguishers within 75 ft (22.9 m) of travel distance to any point. At a minimum, however, portable fire extinguishers suitable for Class A fires should be provided on all vehicles operating on the pile, in addition to the normal Class B units for the vehicle. Where

hydrant hose houses are provided, a Class A extinguisher of at least a 2-A rating should be provided. *(See NFPA 10, Standard for Portable Fire Extinguishers.)*

E-5.3.5 Fire hydrants connected to yard mains should be provided so that any part of the pile(s) can be reached by hose equipment provided in each hydrant hose house. Each hydrant hose house should be equipped with a complement of $2^1/_2$-in. (63.5-mm) and $1^1/_2$-in. (38.1-mm) hose, a $2^1/_2$-in. × $1^1/_2$-in. (63.5-mm × 38.1-mm) gated wye, and $1^1/_2$-in. (38.1-mm) combination nozzles.

Hydrants should be spaced at about 250-ft (76.2-m) intervals so that any part of the yard can be reached with 200 ft (61 m) of hose.

Where pile configurations are such that all parts of the pile cannot be reached by the hose, a fire hose cart(s) equipped with an ample supply of hose and nozzles should be strategically placed in the storage area.

E-5.3.6 The amount of water needed to control a pile fire will vary substantially depending upon the size of the pile. Weather conditions, operating methods, geographic location, the type of material stored, and the degree to which wetting can be employed affect the potential for a large area surface fire. Experience indicates that exposure to long periods of hot, dry weather with no regular surface wetting creates conditions under which fast-spreading surface fires, which require many hose streams for control depending on the size of the pile, can occur.

Likewise, the frequency of pile turnover and operating methods affect the potential for serious internal fires. Piles built using methods that allow a concentration of fines and piles stored for long periods of time with no turnover are subject to internal heating that, if undetected, can create intense internal fires.

A minimum flow of 500 gpm (31.5 L/sec) should be provided at any fire hydrant in the pile area. Additional flows should be provided as needed where conditions are likely to produce serious surface fires or large internal fires. Fire mains should be engineered to deliver the recommended gallonage plus allowance for operational uses and special extinguishing equipment at a residual pressure of 60 psi to 100 psi (413.7 kPa to 689.5 kPa) at the hydrants.

E-5.3.7 Standard automatic sprinkler protection should be provided in all tunnels and enclosures under the pile. All other handling and conveyor installations of combustible construction, or elevated ones of noncombustible construction that are hood-enclosed, should also be provided with automatic sprinkler protection. Automatic sprinklers are needed in the above areas due to the difficulty of hand fire fighting in concealed, enclosed, or elevated areas. All motor and switch gear enclosures should be provided with approved, suitable portable fire extinguishers. *(See NFPA 10, Standard for Portable Fire Extinguishers.)*

E-5.3.8 Power-operated, shovel- or scoop-type vehicles, dozers, or similar equipment should be available for use in moving stored material for fire fighting. With the use of this equipment, surface types of pile fires can usually be removed from the affected areas and extinguished.

Where deep-seated fires occur within the pile or under the pile in tunnels or other enclosures, this equipment is invaluable in breaking down the entire pile and spreading it out in a safe yard area, which allows fire fighters using hand hose lines or deluge units to extinguish both the pile and ground-spread stored material.

E-5.3.9 Temporary conveyors and motors on the surface or adjacent to the piles should be avoided.

E-5.3.10 Physical protection should be provided to prevent heat sources such as steam lines, air lines, electrical motors, and mechanical drive equipment from becoming buried or heavily coated with combustible material. A high standard of housekeeping should be maintained around all potential heat sources.

E-5.3.11 Care should be exercised to prevent tramp metal from entering the piles, or sections of blower pipes from being buried in the piles. Tramp metal collectors or detectors, or both, are recommended on all conveyor and blower systems.

E-5.4 Exposure Protection.

E-5.4.1 Experience indicates that radiated heat from exposing fires in storage piles does not ordinarily pose a serious ignition threat to other piles provided that recommended clear spaces are maintained. Flying brands from exposing fires, especially during high winds, do present a hazardous ignition source. Upwind forest or brush fires can also present a problem in relation to flying sparks and brands. Incinerators or open refuse burning should not be permitted in any area where sparks could reach the storage piles.

E-5.4.2 Buildings or other structures near storage piles can pose a serious exposure hazard to the pile. A clear space should be maintained between piles and exposing structures, yard equipment, or stock, depending on the degree of exposure hazard. Pile-to-pile clearance of at least 30 ft (9.1 m) at the base of the pile should be provided. Greater clearance is desirable when piles are high and side slopes are greater than 60 degrees.

E-6 Outside Storage of Logs.

E-6.1 Application.

E-6.1.1 The intent of these guidelines is to provide fire protection guidance to minimize the fire hazard in log yard storage areas containing saw, plywood, or pulpwood logs stored in ranked piles commonly referred to as *cold decks*. These guidelines do not apply to stacked piles of cordwood. However, where such material is stored in ranked piles, these guidelines can be used as a guide, recognizing that pile widths will be substantially narrower than the typical log cold deck contemplated herein.

Each individual property will have its own special conditions for yard use, stock handling methods, and topography. For this reason, only basic fire protection principles are discussed herein, which are intended to be applied with due consideration of all local factors involved.

E-6.1.2 In addition to the guidelines contained in this section, the provisions outlined in Section E-7 should apply to all outside storage of logs, except as modified herein.

E-6.2 General.

E-6.2.1 Fire loss experience in outside storage of logs indicates that large undivided piles, congested storage conditions, delayed fire detection, inadequate fire protection, and ineffective fire-fighting tactics are the principal factors that allow log pile fires to reach serious proportions. The fire hazard potential inherent in log storage operations with large quantities of combustible materials can best be controlled by a positive fire prevention program under the direct supervision of top management and should include the following:

(1) Selection, design, and arrangement of storage yard areas and materials-handling equipment based upon sound fire prevention and protection principles
(2) Facilities for early fire detection, transmission of alarm, and fire extinguishment *(see NFPA 72, National Fire Alarm Code)*

(3) Fire lanes to separate large piles and provide access for effective fire-fighting operations
(4) Separation of yard storage from mill operations and other exposing properties
(5) An effective fire prevention maintenance program, including regular yard inspections by trained personnel

E-6.2.2 Special problems of construction and protection are involved when logs are stored on piers or wharves. NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves*, and the authority having jurisdiction should be consulted in each case.

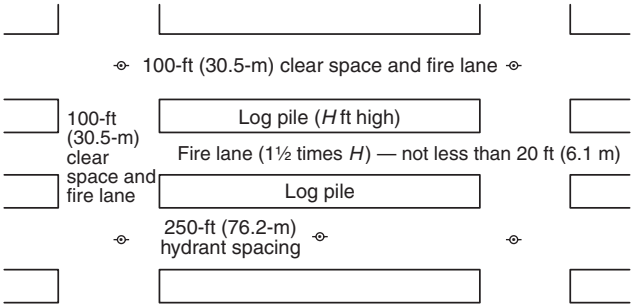
E-6.3 Basic Log Yard Protection.

E-6.3.1 The storage site should be reasonably level, solid ground, preferably paved or surfaced with material such as cinders, fine gravel, or stone. Refuse- or sawdust-filled land, swampy ground, or areas where the hazard of underground fire is present should not be used.

E-6.3.2 Access to the plant and yard from public highways should be provided by all-weather roadways capable of supporting fire department apparatus.

E-6.3.3 All sides of each cold deck should be accessible by means of fire lanes. A fire lane width of $1^1/_2$ times the pile height but not less than 20 ft (6.1 m) should be provided, with fire lanes between alternate rows of two pile groups providing a clear space of at least 100 ft (30.5 m). The length of each cold deck should not exceed 500 ft (152.4 m). Fire lanes for access across each end, providing a clear space of at least 100 ft (30.5 m) to adjacent pile rows or other exposed property, should be provided. Where practical, greater widths are desirable to minimize the effects of radiated heat, particularly in high piled yards. *(See Figure E-6.3.3.)*

Figure E-6.3.3 Layout of log storage yard.



E-6.3.4 For basic fire protection, the hydrant system should be capable of supplying at least four $2^1/_2$-in. (63.5-mm) hose streams simultaneously [1000 gpm (63 L/sec) minimum] while maintaining a positive residual pressure in the fire protection hydrant system of at least 20 psi (138 kPa).

Where large-scale fire-fighting operations can be expected, larger water supplies with adequate mains are needed. *(See E-6.4.)*

For early extinguishment with basic fire protection, hydrants should be spaced with sufficient $2^1/_2$-in. (63.5-mm) hose attached so as to permit rapid hose laying to all parts of the piling areas. For this reason, hydrants should be spaced at about 250-ft (76.2-m) intervals so that any part of the yard can be reached with 200 ft (61 m) of hose. Hydrants preferably should be located at fire lane intersections. A hydrant hose house with at least 200 ft (61 m) of fire hose and auxiliary equipment should be provided at each hydrant. *(See NFPA 13, Standard for the Installation of Sprinkler Systems.)*

E-6.3.5 Dynamite should never be used as a means to reclaim frozen log piles.

E-6.3.6 During dry weather, piles should be wet down periodically. The installation of a portable piping system equipped with irrigation or lawn-type sprinklers on the top of each log pile is recommended.

E-6.4 Special Log Yard Protection.

E-6.4.1 Small log yards containing a single cold deck of low height [10 ft (3 m) or less], having good access and well separated from other property, present minimum hazards that generally require only the basic protection provisions of E-6.3 for effective fire control. Higher piles, multiple piles over extensive areas, congested storage, or serious exposure situations present increased hazards that require additional safeguards and protection facilities. In yards requiring more than the basic protection provisions of E-6.3 for effective fire control, the following provisions should be followed. The relative importance of these provisions and the degree to which they could be needed will vary with yard conditions, and the authority having jurisdiction should be consulted in all cases.

E-6.4.2 Adequate water supplies and large mains should be provided to supply large stream equipment such as portable turrets and deluge sets, which require 750 gpm to 1000 gpm (47 L/sec to 63 L/sec) for each appliance. Monitor towers can require supplies in excess of 1000 gpm (63 L/sec) for each unit. In large yards where the hazard is severe, many of these devices could need to be operated simultaneously.

E-6.4.3 Fire lanes suitable for fire department operations should be provided as outlined in E-6.3.3. Fire lanes should be kept unobstructed. They should have an all-weather surface sufficiently strong to support fire apparatus and should be of sufficient width to permit maneuvering of motorized fire apparatus.

E-6.4.4 Pile heights should be limited. Heights in excess of 20 ft (6.1 m) seriously restrict effective extinguishing operations since successful extinguishment of log pile fires requires penetration of the pile from the side by hose streams. Where pile heights exceed 20 ft (6.1 m), it is recommended that elevated monitor nozzles or mobile elevated nozzles, or both, be provided, and mobile elevated nozzles should be considered when piling height exceeds 12 ft (3.7 m).

E-7 General Fire Protection.

E-7.1 Application.

E-7.1.1 The two key points to reducing fire losses in areas used for the storage of forest products are reduction of the sources of fire ignition and a positive program for early detection and extinguishment of incipient fires. Application of the principles of fire prevention in E-7.2 can reduce fire occurrences. Principles of good fire protection are set forth in E-7.3 and E-7.4.

E-7.1.2 These principles are intended to apply to all facilities as outlined in Sections E-2 through E-6.

E-7.2 Operational Fire Prevention.

E-7.2.1 Weeds, grass, and similar vegetation should be prevented throughout the entire yard and any vegetation growth should be sprayed as often as needed with a satisfactory herbicide or ground sterilizer, or grubbed out. Dead weeds should be removed after destruction. Weed burners should not be used.

E-7.2.2 Good housekeeping should be maintained at all times, including regular and frequent cleaning of materials-

handling equipment. Combustible waste materials such as bark, sawdust, chips, and other debris should not be permitted to accumulate in a quantity or location that will constitute an undue fire hazard.

E-7.2.3 Smoking should be prohibited except in specified safe locations. "No Smoking" signs should be posted in those areas where smoking is prohibited, and signs indicating areas designated as safe for smoking should be posted in those locations. Smoking areas should be provided with approved, noncombustible ash receptacles. Smoking should be specifically prohibited in and around railroad cars.

E-7.2.4 Access into the yard areas by unauthorized persons should be prohibited. Where needed, storage areas should be enclosed with a suitable fence equipped with proper gates located as necessary to allow the entry of fire department apparatus.

E-7.2.5 Miscellaneous occupancy hazards such as vehicle storage and repair shops, cutting and welding operations, flammable liquid storage, liquefied petroleum gas storage, and similar operations should be safeguarded in accordance with recognized good practice. Refer to various NFPA standards applicable to specific occupancy hazards.

E-7.2.6 Vehicles and other power devices should be of an approved type and should be safely maintained and operated. Vehicle fueling operations should be conducted in specified safe locations, isolated from storage areas and principal operating buildings. *(See NFPA 505, Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation.)*

E-7.2.6.1 Diesel- or gasoline-fueled vehicles that operate on hogged material or chip piles, in log storage areas, or in lumber storage areas should be equipped with fixed fire-extinguishing systems of a type approved for off-road vehicles.

E-7.2.7 All electrical equipment and installations should conform to the provisions of NFPA 70, *National Electrical Code*.

E-7.2.8 Salamanders, braziers, open fires, and similar dangerous heating arrangements should be prohibited. Heating devices should be limited to approved-type equipment installed in an approved manner.

E-7.2.9 Suitable safeguards should be provided to minimize the hazard of sparks caused by such equipment as refuse burners, boiler stacks, vehicle exhausts, and locomotives. Burning of shavings, sawdust, and refuse materials should be conducted only in an approved, enclosed refuse burner equipped with an approved spark arrester and located at a safe distance from the nearest point of any yard. See NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment*, for small rubbish burners. The design and location of large burners presents special problems, and the authority having jurisdiction should be consulted.

E-7.2.10 Stacks from solid fuel-burning furnaces and boilers should be equipped with spark-arresting equipment to prevent hot sparks from reaching the ground, and consideration should be given to spark hazard in determining the height of such stacks.

E-7.2.11 Solid fuel-fired steam locomotives, cranes, and similar equipment entering or operating in yards should be equipped with heavy screening and hinged openings between the mud ring and the flare of the ash pan to prevent hot coals from dropping from the ash pan. It is recommended that front-end screens of coal-fired locomotives be examined at frequent intervals. Oil-fired steam equipment should be provided with fully enclosed drip pans to prevent burning oil from escaping. It is recommended that diesel locomotives be equipped with approved spark arresters or other devices to prevent the escape of glowing carbon particles from the exhausts.

E-7.2.12 If yard storage areas are located in regions highly susceptible to lightning strikes, consideration should be given to the installation of lightning protection on masts or towers to provide area protection. *(See NFPA 780, Standard for the Installation of Lightning Protection Systems.)*

E-7.2.13 No cutting, welding, or other use of open flames or spark-producing equipment should be permitted in the storage area unless by an approved permit system.

E-7.3 Exposure Protection.

E-7.3.1 Exposure to the Yard.

E-7.3.1.1 Yard areas should be separated from plant operations and other structures so that fire exposure into the yard will be minimized. Minimum separation should be by means of a clear space permanently available for fire-fighting operations. The width of the clear space should be based upon the severity of exposure, which will vary with the area, height, occupancy, construction, and protection of the exposing structure, and the type of stacking and height of adjacent stacks.

E-7.3.1.2 Unsprinklered manufacturing buildings and other large structures with combustible contents represent a severe exposure to yard storage, unless the exterior walls have the necessary fire resistance to act as a fire separation and are essentially absent of unprotected openings. In general, unsprinklered saw mills, planing mills, treating plants, adzing mills, and similar buildings without essentially blank walls should be separated from yard storage by a clear space, as recommended by NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures.*

E-7.3.1.3 Fully sprinklered structures present a lesser exposure hazard. Automatic sprinkler protection is desirable in all operating and principal storage buildings. Separation consideration between yards and sprinklered buildings will generally be determined by the seriousness of the exposure from the yard. *(See E-7.3.2.)*

E-7.3.1.4 Forest, brush, and grass fire exposure should be minimized by providing adequate clear space that is carefully kept free of combustible vegetation. Clear space of widths at least equivalent to fire lanes should be provided for grass exposures, and clear space of widths at least 100 ft (30.5 m) should be provided for light brush exposures. In forested areas, a wider clear space should be provided.

E-7.3.2 Exposure from the Yard.

E-7.3.2.1 Fire exposure to adjacent structures and nearby property constitutes one of the major fire protection problems of forest products storage operations that can be solved satisfactorily only by cooperation between adjacent property owners. The authority having jurisdiction should be consulted in all cases.

E-7.3.2.2 Special protection provisions discussed in these guidelines furnish a reasonable degree of protection against direct radiated heat through a combination of special protection facilities and controlled storage methods. It should be recognized, however, that these facilities cannot be expected to cope with adverse weather conditions and flying brands. Also, in situations where yard materials and storage methods need special protection facilities but where such protection (which includes adequate water

supplies, fire department manpower, and equipment) is not available, exposure from the yard creates serious conflagration potential. Where these conditions prevail, additional protection against storage yard exposure should be provided, as practicable, by one or more of the following:

(1) Providing greater clear space
(2) Using barrier walls of such fire-resistive properties and stability that the passage of flames and heat can be effectively prevented for a prolonged period of time
(3) Employing perimeter stacking methods that will furnish the equivalent of barrier walls (i.e., materials of greatest thickness and green flat-stacked stock)
(4) Using wall construction for exposed structures having adequate fire resistance
(5) Using automatic sprinkler systems specially designed for protection of the exposed structures

E-7.4 Fire Detection and Extinguishment.

E-7.4.1 In all forest product storage operations, provisions should be made for early fire detection and extinguishment. These activities require watchmen and alarm service, plant emergency organization manpower and extinguishing equipment, and ready access by means of fire lanes into all parts of the storage areas so that fire-extinguishing equipment can be promptly brought to the site of the fire.

E-7.4.2 When a fire is discovered, no matter how small, the public fire department and plant emergency organization should be notified at once. The telephone number of the fire department and the location of the nearest fire alarm box should be posted conspicuously in several locations in the yard and buildings.

E-7.4.3 In storage yards, a reliable means for prompt transmission of fire alarms to public fire departments and plant emergency organizations should be provided at convenient and accessible locations in the yard.

E-7.4.4 Standard, hourly watchman service should be maintained throughout the night and during all nonoperating periods. Watchmen should be competent, and rounds should be supervised by an approved central station watchman's time detector or recorded by a portable watch clock.

E-7.4.5 Watchmen and other employees should be fully instructed in the proper procedure of transmitting a fire alarm and in the use of all fire protection equipment. *(See NFPA 601, Standard for Security Services in Fire Loss Prevention.)*

E-7.4.6 An industrial fire brigade should be organized. It should be well trained and adequately equipped to combat fire while the public fire department is responding to the alarm. *(See NFPA 600, Standard on Industrial Fire Brigades.)*

E-7.4.7 Portable fire extinguishers suitable for the fire hazard involved should be provided at convenient, conspicuously accessible locations in the yard. Where practicable, approved portable fire-extinguishing equipment should be placed so that maximum travel distance to the nearest unit should not exceed 75 ft (22.9 m). *(See NFPA 10, Standard for Portable Fire Extinguishers.)* Approved fire extinguishers of suitable type should be provided on all power vehicles and units, including haulage or private locomotives in the yard.

E-7.4.8 Water Supply. A public or private fire main and hydrant system with ample water supply should be provided. Where adequate public fire protection is not available, private outside fire protection facilities should be provided.

E-7.4.8.1 Private Fire Service Mains and Hydrants. A private fire service main and hydrant system should be installed in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.* Refer to NFPA 13, *Standard for the Installation of Sprinkler Systems.* Hydrants should be of an approved type and located so that any part of the yard can be reached with 200 ft (61 m) of hose. Where practicable, a 50-ft (15-m) separation should be provided between storage and yard hydrants.

E-7.4.8.2 Fire Pumps. Where provided, fire pumps should be installed in accordance with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

E-7.4.8.3 Pressure Tanks. Where provided, pressure tanks should be installed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection.*

E-7.4.8.4 Gravity Tanks. Where provided, gravity tanks should be installed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection.*

E-7.5 Testing and Maintenance of Fire Protection Systems. Water-based fire protection systems, such as fire pumps, storage tanks, fire hydrants, and their related equipment, should be tested and maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

Appendix F Recommendations for Fighting Rubber Tire Fires in Sprinklered Buildings

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

F-1 Introduction. It is essential that the steps necessary for fighting rubber tire fires be understood by both the building occupant and the fire service to prevent unnecessary injury or loss of life and to prevent loss of fire control during overhaul. This activity necessitates emergency preplanning with the local fire department, building occupant, and others as deemed necessary.

Fire tests of rubber tire storage have indicated that smoke can quickly obstruct the visibility within a building and obscure the burning materials. Plans for the attack and extinguishment of the fire should be prepared in advance.

Because the products of combustion are harmful, all personnel assigned to interior functions should use breathing apparatus even before obscuration occurs.

Ventilation efforts should be carefully controlled. Drafts from open doors and windows allow fresh air to reach the fire and make control of the fire difficult. Doors and windows should be closed as soon as possible to limit the air supply to the fire and to allow control by automatic systems to be established.

Fire brigades should be trained and equipped with the necessary tools and equipment to respond to a fire emergency and, if possible, attack the fire prior to the arrival of the fire department.

Review of building and fire protection system plans should be part of the ongoing training of both the on-site personnel and fire departments.

A tire fire can progress quickly through the phases described in the following paragraphs, and each phase presents different conditions to responding emergency personnel. Items for consideration in the emergency preplanning program are provided for inclusion in such plans.

Observations at tire fire tests and accounts of actual fires have indicated that, while automatic sprinklers with adequate densities in approved configurations can control a fire, extinguishment by sprinklers alone normally does not occur. The four tests used also indicate that sprinkler protection can be overcome by the following:

(1) Storage exceeding the heights indicated in this standard
(2) Storage configurations that inhibit the movement of heat to the roof, slowing sprinkler operation, and inhibit the waterflow to the seat of the fire, reducing sprinkler effectiveness

F-1.1 Incipient Stage. This stage occurs within 2 to 5 minutes of ignition.

Important: Drafts from open doors increase the intensity of the fire and make control difficult. Doors should be closed as quickly as possible to isolate the fire area.

Important: Fire tests indicate that smoke obscuration occurs within 6 to 9 minutes of ignition, even when the fire is sprinkler controlled. Breathing apparatus could be needed even before obscuration occurs.

If caught in the incipient stage, control can be achieved using interior hand hose and portable extinguishers. Quick reaction is essential, as this window of opportunity no longer exists within 2 to 5 minutes of actual ignition, since the generation of heat and smoke make the area untenable. Dry chemical extinguishers have been found to be most effective but should be backed up with small hose, as the knock-down is only temporary.

Tires in the affected area should be removed from storage. Tires removed from storage should be taken out of doors, thoroughly soaked, and left where they cannot expose other combustibles. The area where the fire occurred should be closely watched for several hours for rekindling.

While the first sprinkler can be expected to operate within the first 2 to 5 minutes of ignition, the updraft from the fire can disrupt the sprinkler pattern to such an extent that the water might not get to the seat of the fire. After the first 4 minutes, the fire has generally progressed beyond the stage where portable extinguishers are effective and, within minutes, the smoke and carbon monoxide make the area untenable. Vision is obscured, and any personnel without breathing apparatus is at risk.

F-1.2 Active Stage. The active stage of the fire follows the initial stage and is generally defined as that period where the sprinkler system is establishing control over the fire.

Important: Even though the fire is sprinkler controlled, roof temperatures resulting from the tire fires can reach temperatures high enough to cause steel joists to deflect and possibly fail. In recent fire tests, gas temperatures at roof level ranged between 1110°F and 1450°F (593°C and 788°C) for 10 minutes. Roof steel exposed to this high gas temperature could deflect or fail if subjected to additional loading. Do not place personnel on roof to attempt ventilation.

Important: Local fire departments attempting to draft from the sprinkler supply system will decrease the sprinkler effectiveness. If possible, separate municipal hydrants should be identified for fire department use.

Important: As the sprinklers gain control of the fire, the smoke will turn from black to gray. A return to black smoke is an indication that the sprinklers are not controlling the fire. Pump and system pressure also should be monitored. Loss of system pressure is an indication of more sprinklers operating, pump failure, or loss of control.

Responding local fire departments should be arriving by this time. Building personnel should advise arriving fire personnel of the location of all occupants of the building. At this point, there is little for the fire department to do except to connect to the municipal water supply and prepare to supplement the fire protection system through the fire department connection.

Fire department personnel or maintenance personnel, or both, should respond to the fire pump room and work to maintain operation of the fire pump. System discharge pressure should be observed to determine if the pressure is stable. Unstable or decreasing discharge pressure indicates changes in the operating conditions of the fire protection system.

During this stage, the building is untenable, and obscured vision makes the use of hose streams questionable. It should be noted that, in buildings with smoke vents, longer use of fire hose could be possible, but at some risk to personnel. It is best to allow the sprinklers to take control of the fire. Most of the sprinklers will begin to operate within 15 to 20 minutes of ignition, if sprinkler control is effected. Sprinklers should be allowed to operate at least 60 to 90 minutes to gain control. Successful fire tests indicate that waterflow stabilizes within the first 20 minutes of the fire.

The building is best left unventilated at this time. As control is gained, the smoke will change from black to gray and will diminish in intensity. During this period, at least six charged $1^1/_2$-in. (38.1-mm) hose lines should be laid out prepatory to entering the building. Portable flood lights should be secured as well as turn-out gear, breathing apparatus, and forklifts for the overhaul crew.

F-1.3 Critical Stage. The critical stage occurs between the final extinguishment and the ventilation of the building.

Important: Ventilation should be done slowly, and the sprinklers should be left in operation. A return to black smoke is an indication that control is being lost. If this happens, ventilation should cease, the building should be closed, and the sprinkler system should be allowed to regain control. It should be understood that, during the attempt to ventilate the building, the fire intensity can increase due to the addition of outside air. Additional sprinklers can be expected to operate during the ventilation effort. If control has been gained, extra sprinklers might make no difference in overall performance. If control has not been gained or is marginal, this increase in the number of operating sprinklers could make regaining control more difficult due to the overall increase in sprinkler demand. Unless there is a system failure, the sprinklers should regain control. If there is any doubt that control of the fire has been gained, the sprinkler system should be allowed to soak the fire for longer than 90 minutes.

Important: The officer in charge should have a contingency plan if control is lost due to a system failure. In the event that control of the fire is lost, as evidenced by such indicators as increasing smoke generation, loss of pressure at the fire pump discharge (indicating massive sprinkler operation), or collapsing roof, efforts should be directed toward preventing the spread of the fire beyond the area bounded by the fire walls. At this point, consideration should be given to shutting off the sprinklers in the fire area to provide water for protecting the exposures.

After 60 to 90 minutes and when the smoke intensity has diminished, the building should be ventilated around the periphery of the fire area. If control has been gained, the roof temperature will usually have cooled sufficiently to allow roof vents to be opened manually if they have not already opened automatically.

F-1.4 Overhaul. Although visible fire is no longer present, overhaul of the area of the fire should be conducted to be certain of complete extinguishment.

Important: Care should be taken that the hose streams do not lower the pressure or water supply to the sprinkler system. Sprinkler operation should cease only when the fire chief is certain that hoses can control the fire.

Important: Caution should be used, since the tire piles will be unstable.

As soon as the smoke clears to the extent that the building can be entered, entry should be made using small hose streams that should be directed into the burning tires. Sprinklers should be kept in operation during this period.

Forklifts and other means should be used to remove the tires from the fire area to outside the building. It usually is necessary to keep the sprinklers in operation during this procedure at least until there is no evidence of flame. Patrols should be made of the affected area for at least 24 hours following the fire.

Following fire extinguishment, all fire protection systems should be restored to service as quickly as possible. These systems include but are not limited to the following:

(1) Sprinkler systems
(2) Alarm systems
(3) Pumps
(4) Water supplies

F-2 Use of High-Expansion Foam. If a high-expansion foam system is used in connection with automatic sprinklers, sprinklers can be shut off 1 hour after ignition, and foam can soak the fire for an additional hour before the building is opened and overhaul is begun. Limited tests with high-expansion foam indicate that fire extinguishment is largely complete after a period of soaking in foam. As a precautionary measure, charged hose streams should be available when foam is drained away.

After the initial fill, foam generators should be operated periodically during the soaking period to maintain the foam level. This procedure is necessary since sprinklers and products of combustion will cause partial foam breakdown.

Appendix G Guidelines for Outdoor Storage of Scrap Tires

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

G-1 Scope. This appendix applies to the outdoor storage of scrap tires in whole, baled, or processed form, including incidental usage locations.

G-2 Purpose. This appendix has been developed for the purpose of aiding fire officials and authorities having jurisdiction in their effort to both prevent and properly manage fire incidents that occur in whole, baled, or processed scrap tire stockpiles. Each individual property has its own unique conditions of tire handling, exposure, and topography. Thus, in this appendix, basic fire protection principles are applied with due consideration of local factors.

Rubber has a heat combustion of about 15,000 Btu/lb, or roughly twice that of ordinary combustibles (e.g., paper and wood). Once ignited, fire development is rapid, and high temperatures can be expected due to the large exposed surface area of whole tires. In the case of baled or processed-tire fires, high temperatures can also be expected, although the fire behavior differs. Burning is likely to persist for extended periods. In all cases, there is a high probability of rekindling in the tire pile, even if the fire is controlled.

G-3 Definitions.

Burn-It. A fire-fighting strategy that allows for the free-burn of a tire fire.

Bury-It. A fire-fighting strategy in which a tire pile is buried with soil, sand, gravel, cement dust, or other cover material.

Concrete. A composite material that consists essentially of a binding medium within which particles or fragments of aggregate are embedded in hydraulic cement concrete. The binder is formed from a mixture of hydraulic cement and water.

Forecasting. The ability to predict the fire progression location prior to the completion of the inventory fire break using heavy equipment.

Scrap Tire. A tire that can no longer be used for its original purpose due to wear or damage.

Shredded Tire. A scrap tire reduced in size by a mechanical-processing device, commonly referred to as a shredder.

Tactics. The method of securing the objectives laid out in the strategy through the use of personnel and equipment to achieve optimum results.

Tire Chip. A classified scrap tire particle that has a basic geometrical shape, which is generally 2 in. (5.1 cm) or smaller and has most of the wire removed.

G-4 Fire Experience. Fire experience in outdoor storage of scrap tires reveals a number of concerns, including the following:

(1) Lack of fire codes for scrap tire storage
(2) Generation of large amounts of black smoke
(3) Storage is often too close to buildings on the same or adjacent premises, causing fires in the exposed buildings
(4) Generation of oil during a fire where oil contributes to fire or where runoff contaminates the surrounding area
(5) Delays in reporting fires
(6) Lack of fire-fighting capabilities

Fire hazards inherent in scrap rubber tire storage are best controlled by an aggressive fire prevention program that includes a pre-incident plan.

G-5 General. The fire hazard potential inherent in scrap rubber tire storage operations can best be controlled by an aggressive fire prevention program. The method of storage should be solid piles in an orderly manner and should include the following.

(a) Fire lanes to separate piles and to provide access for effective fire-fighting operations should be a minimum of 60 ft (18.3 m) in accordance with Table G-10.

(b) Separation of yard storage from buildings, vehicles, flammable materials, and other exposures should be a minimum of 200 ft (61 m).

(c) The area within 200 ft (61 m) of a pile should be totally void of trees, plants, or vegetation.

(d) Topography is a factor in determining the manner of tire fire tactics and environmental mediation.

(e) Tires should not be stored on wetlands, flood plains, ravines, canyons, or steeply graded surfaces. Scrap tire storage preferably should be on a level area. The preferred surface for the storage area is concrete or hard packed clay, not asphalt or grass.

(f) Smoking should be prohibited within the tire storage area. Other types of potential ignition sources such as cutting and welding, heating devices, and open fires should be prohibited.

Suitable safeguards should be provided to minimize the hazard of sparks from such equipment as refuse burners, boiler stacks, and vehicle exhaust.

(g) Piles should not be permitted beneath power lines or structures.

(h) Lightning protection systems that conform to local and state codes should be located at the facility but away from the tire piles.

(i) Piles should be at least 50 ft (15.2 m) from the fences. Lanes should be kept clear of debris or vegetation.

G-6 Fire Department Access to Site. Each tire storage yard should be provided with fire access routes as follows:

(a) Each tire storage yard or pile should be provided with emergency vehicle access routes, such that no portion of the pile is more than 150 ft (45.7 m) from an access road or fire break.

(b) All roads and accesses should be designed to support the loads imposed by fire-fighting equipment.

(c) All bridges and structures, including drainage structures on access roads, should be capable of carrying a minimum design load of HS-20 in accordance with AASHTO *Standard Specifications for Highway Bridges*. The design and as-built plans for all bridges should be certified by a licensed structural engineer. Routes should be surfaced with material designed to allow accessibility under all climatic conditions.

(d) All emergency vehicle accesses should have an unobstructed vertical clearance of not less than $13^1/_2$ ft (4.1 m), or as is needed to allow for the passage of large fire-fighting equipment, with a minimum outside turning radius of 45 ft (13.7 m) provided for emergency vehicle access.

(e) All dead-end accesses in excess of 150 ft (45.7 m) should be provided with a turn-around area.

(f) Accesses should be well maintained and should remain accessible to the fire department at all times. The fire chief can allow the use of alternative materials or processes to provide equivalent fire protection.

G-7 Site Security. Appropriate steps should be taken to limit access to the tire storage area as follows:

(a) The facility should have a chain-link fence at least 10 ft (3 m) high with intruder controls on top (in accordance with local laws).

(b) Gates should protect each access point (a minimum of one on each side). Such gates should be capable of being locked when the facility is not open for business.

(c) All gates should have a 20-ft (6.1-m) open width and should remain unobstructed at all times.

(d) Gates should have rapid entry design that is compatible with local fire department requirements.

(e) Gates should have an optimum activation system or the equivalent and a compatible system approved by the local government. All electrically activated gates should have the capability to default to the unlocked position.

(f) A certified security attendant or site manager should be on site at all times when the facility is open.

(g) Clearly visible signs that indicate business hours and regulations should be posted near the facility entrance.

G-8 Pre-Incident Planning. Pre-incident plans are developed by fire departments to identify special features and hazards at a particular site or property and to specify the department operational plan. Pre-incident plans are specific to a location. Analytical forecasting of the types of emergencies that can be encountered complement the readiness efforts that are generally employed to manage emergency incidents.

It is strongly recommended that the fire department adopt a model incident management system that is published, taught to all members, and regularly utilized. Neighboring (mutual aid) departments and outside agencies with whom the department interacts should be familiar with the department's model incident management system. Operational drills at the scrap tire facility that involve mutual aid companies and related agencies are useful in evaluating shortfalls in the department's response capability and fireground effectiveness.

A thorough survey of the area under the jurisdiction of the fire department should be undertaken to detect the existence of scrap tire piles. In many areas, piles are remotely and illegally dumped. Once the area has been surveyed and the existence of scrap tire piles has been identified, the magnitude of the problem should be assessed, and an appropriate fire prevention methodology should be developed.

Topographical maps and detailed area plot plans should be compiled, noting all features of the terrain and property, hydrants and water supply sources, accesses, interior lanes or passages, and fuel load configuration. Ingress and egress plans should be developed for apparatus and equipment. The development of additional access points, pre-incident or post-incident, should be analyzed and planned, and the means of maintaining or expanding accesses should be provided. Lists of emergency incident contact personnel (names, addresses, and telephone/pager numbers), appropriate agencies, contractors, mutual aid agreements, and so forth, should be obtained. Such lists should be updated on a semiannual basis. A water supply use plan with the estimated gallons per minute (liters per minute) required should be developed.

G-9 Water Supplies. A public or private fire main and hydrant system should be provided. A water system should be provided to supply a minimum of 1000 gpm (3780 L/min) for less than 20,000 units storage [50,000 ft^3 (1416 m^3)], or 2000 gpm (7560 L/min) for 20,000 units storage or more for a duration of 6 hours. If there is access to a lake, stream, pond, or other body of water in the vicinity of the storage area, a fire department suction connection should be provided.

G-10 Pile Geometry and Spacing. Maximum pile height should be 20 ft (6 m), maximum pile width should be 50 ft (15 m), and maximum length should be 250 ft (76.2 m) without a separation in accordance with Table G-10. *(See Figure G-10.)*

The width limitation of 50 ft (15.2 m) means that, as the exposed face exceeds 100 ft (30.48 m), the pile takes on the appearance of a wind row, and there is little likelihood that the entire face would be burning all at once. Thus, in Table G-10, the minimum exposure separation distances are held constant for exposed face dimensions greater than 100 ft (30.48 m).

For 500 tires or less the minimum separation distance between scrap rubber tires and structures should be 25 ft (7.6 m) or as reduced by Chapter 3 and Chapter 4 of NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures.*

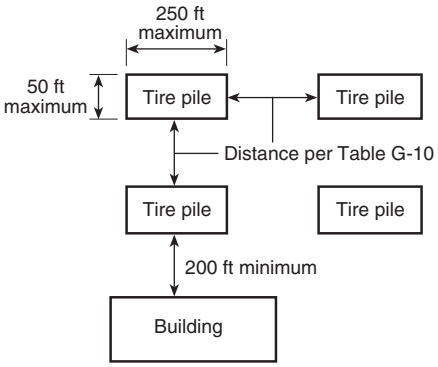
In order for storage piles of more than 500 tires to be considered isolated piles, the minimum separation distance between piles should be in accordance with Table G-10.

The width of the exposing fire should be assumed to be the combined width of piles facing the exposed building, disregarding the nominal separation between piles provided by narrow access aisles and roadways.

Because of the extensive fire expected in scrap tire storage, some form of exposure protection for adjoining properties should

be considered. If the clear space as recommended in Table G-10 cannot be provided, a dirt berm that is one and one-half times the height of the tire storage should be provided, or other protection that meets the requirements of the authority having jurisdiction should be provided. The storage of baled tires should be vertical rather than horizontal. Under fire conditions, the bands release, allowing for sudden, drastic movement of burning tires.

Figure G-10 Pile geometry and spacing.



For SI units, 1 ft = 0.3048 m.

G-11 Outdoor Tire Pile Fire-Fighting Tactics and Strategy. The guidelines contained in this appendix are based on the collective experience of fire service professionals who have managed major scrap tire fires. They are presented as an adjunct to the strategic and tactical practices of an incident command system. Conventional fire suppression tactics are ineffective for scrap tire fires. Fire-fighting tactics and strategies for the suppression of fires in whole tires differ from those for processed tires. The unique shape of whole tires allows the storage of enough air to support combustion throughout the pile, and it is difficult to reach all burning surfaces. Because of such complications, tire fires can continue for weeks, and even months, despite aggressive fire suppression tactics.

The foundation of fire suppression should be based on the data collected before a fire occurs. By establishing a preincident plan that uses a model incident command system, decisions regarding size-up, tactics, strategies, and overhaul can be resolved quickly. Familiarity with plans that have been successful in fighting tire fires throughout the country also aids in the decision-making process. Such decisions should be based on an understanding of the dynamics and behavior of a tire fire.

The environmental consequences of all suppression techniques should be evaluated carefully. Communication between the incident commander and the on-scene environmental specialist is critical. The following provide tactics and strategies for fighting whole-tire and processed-tire fires.

(a) *Tactics/Strategies for Whole-Tire Fires.* Important tactical considerations include protecting exposures, separating burning tires from the rest of the inventory, and forecasting. Forecasting for an effective location for separation should include arrival time of equipment and time necessary to develop the needed firebreak. Heavy equipment can be used to accomplish these tasks.

Protection of exposures is an important tactical decision. The initial approach to a tire fire should be to isolate the tire inventory from the fire. Creating firebreaks in a large pile of scrap tire is a time-consuming process. However, it can be accomplished with heavy machinery and front-end loaders. Bulldozers, front-end loaders, and similar equipment can be used to move tires that are not yet involved in the fire to create breaks in the tire pile or to cover burning tires with soil. Equipment breakdowns — scrap tires caught between the wheels, tracks, and undercarriage of heavy equipment — have been reported. Firelines should be deployed to provide protection to operators and equipment alike.

Recognized strategy options are as follows:

(1) *Let-It-Burn.* Allowing a tire pile to burn has its merits. Factors that influence this decision include, but are not limited to, level of fire involvement, resources available, location of the fire, and environmental and economic impacts. Soil and water pollution, as well as clean-up costs, can be drastically reduced when many of the products of combustion are consumed. A precedent for the let-it-burn strategy appears in fire responses to chemical fires. The fire service is responsible for managing and controlling the burn process. Protecting exposures and separating tires from the burn area is a tactical priority.

(2) *Bury-It.* The decision to bury a tire pile also has merits. Materials as diverse as the soil that is on site, cement kiln dust, sand, gravel, and even crushed coral have been employed to cover the burning material. The bury-it strategy can be employed in areas that have a minimal water supply or in areas that are densely populated. The decision to bury a tire fire should take into consideration reduction of the toxic smoke for the sake of public health. Geological considerations play an important role in the bury-it strategy. While the tire fire is entombed, tires can pyrolize, and oil can be generated and released into the soil or underground water sources.

(3) *Drown-It.* The drown-it strategy is best employed with forethought and careful preplanning. Familiarity with the topography, available water supply, and exposure hazards to aboveground water sources will be critical. Planning for the control and containment will facilitate this tactic. The drown-it strategy also has some drawbacks. Cooling the fire will increase the air emissions as the combustion process is slowed down. An inordinate amount of water runoff combined with pyrolitic oil can result from the drown-it tactic.

(b) *Tactics/Strategies for Processed-Tire Fires.* Important tactical considerations include protecting exposures, separating burning tires from the rest of the inventory, and forecasting. Heavy equipment can be used to accomplish these tasks.

To effectively combat a processed tire fire, a fogging of water or other fire retardant should be applied. Cooling the plane of fire should put the fire out. Using a mist also reduces the amount of water used and the subsequent runoff that can be generated. Under no circumstances should a processed tire pile be broken open or doused with streams of high-pressure water that are directed into the piles. Water actually increases the severity and duration of the fire by introducing oxygen into the pile and by breaking up the pile, causing a burst of flames that emits incompletely burned hydrocarbons and other contaminates to the atmosphere.

Once the surface fire is put out, the cooled chips should be removed, allowing water or fire retardant to reach under layers that are hot and still burning. This process should be repeated until the chips are no longer smoldering or hot.

Table G-10 Representative Minimum Exposure Separation Distances

Exposed Face Dimension (ft)	Tire Storage Pile Height (ft)						
	8	10	12	14	16	18	20
25	56	62	67	73	77	82	85
50	75	84	93	100	107	113	118
100	100	116	128	137	146	155	164
150	100	116	128	137	146	155	164
200	100	116	128	137	146	155	164
250	100	116	128	137	146	155	164

For SI units, 1 ft = 0.3048 m.
Source: Separation distances are based on the "Fire Safety Assessment of the Scrap Tire Storage Methods," by Robert Brady Williamson, PhD and Robert Allen Schroeder, MS.

(c) *Ancillary Issues.* Ancillary issues include fire dynamics, stages of combustion, size-up, and environmental concerns. Refer to *Guidelines for the Prevention and Management of Scrap Tire Fires.*

Appendix H Referenced Publications

H-1 The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not considered part of the requirements of this standard unless also listed in Chapter 12. The edition indicated here for each reference is the current edition as of the date of the NFPA issuance of this standard.

H-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1998 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1999 edition.

NFPA 13E, *Guide for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*, 1995 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 1996 edition.

NFPA 18, *Standard on Wetting Agents*, 1995 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 1999 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 1998 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1995 edition.

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