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NFPA 231F

Standard for the

Storage of Roll Paper

1996 Edition

This edition of NFPA 231F, *Standard for the Storage of Roll Paper*, was prepared by the Technical Committee on General Storage and acted on by the National Fire Protection Association, Inc., at its Fall Meeting held November 13-15, 1995, in Chicago, IL. It was issued by the Standards Council on January 12, 1996, with an effective date of February 2, 1996, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of NFPA 231F was approved as an American National Standard on February 2, 1996.

Origin and Development of NFPA 231F

The need for a standard for storage of roll paper was brought to the attention of the Association after the occurrence of several disastrous fires in warehouses containing roll paper. The lack of a national standard had made designing, building, and using a facility for the storage of roll paper an expensive undertaking, sometimes resulting in substandard fire protection. Because of the unique characteristics of roll paper, the Standards Council was petitioned and agreed to have the Technical Committee on General Storage develop NFPA 231F, *Standard for the Storage of Roll Paper*. The first edition was adopted in 1984. A subsequent edition was adopted in 1987.

The 1996 edition of NFPA 231F was revised to incorporate advances in sprinkler technology. Further revisions address miscellaneous storage, retroactivity, and changes to the scope of the document. A number of editorial changes were also incorporated to improve the user friendliness of the document.

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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.

Contents

Chapter 1 Introduction	231F- 4	Chapter 5 Fire Protection	231F- 6
1-1 Scope	231F- 4	5-1 Automatic Sprinkler Systems	231F- 6
1-2 Purpose	231F- 4	5-2 High-Expansion Foam	231F- 6
1-3 Retroactivity Clause	231F- 4	5-3 Water Supplies	231F- 6
1-4 Definitions	231F- 4	5-4 Manual Inside Protection	231F- 7
1-5 Units	231F- 5	5-5 Maintenance	231F- 8
Chapter 2 Classification of Roll Paper	231F- 5	5-6 Fire Organization	231F- 8
2-1 General	231F- 5	5-7 Alarm Service	231F- 8
Chapter 3 Building Construction	231F- 5	Chapter 6 Referenced Publications	231F- 8
3-1 Construction	231F- 5	Appendix A Explanatory Material	231F- 8
3-2 Emergency Smoke and Heat Venting	231F- 5	Appendix B Summary of Test Results	231F-11
3-3 Structural Steel Protection	231F- 5	Appendix C Referenced Publications	231F-13
Chapter 4 Storage Arrangement	231F- 5	Index	231F-13
4-1 Piling Procedures and Precautions	231F- 5		
4-2 Commodity Clearance	231F- 5		
4-3 Aisles	231F- 5		

NFPA 231F

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

Information on referenced publications can be found in Chapter 6 and Appendix C.

Chapter 1 Introduction

1-1 Scope.

1-1.1 This standard shall apply to the storage of roll paper in buildings or structures.

1-1.2* This standard shall apply to new facilities or where converting existing buildings to a roll paper storage occupancy. It can be used as a basis for evaluating existing storage facilities.

1-1.3 This standard shall not apply to:

- (a) Storage in unsprinklered buildings and structures.
- (b) Storage on racks, which shall be in accordance with NFPA 231C, *Standard for Rack Storage of Materials*.
- (c) Miscellaneous storage, which shall be in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.
- (d) Storage of waxed paper, synthetic paper, and palletized roll storage other than on a single floor pallet or raised floor platform.

1-2 Purpose. The purpose of this standard is to provide a reasonable degree of protection for the storage of roll paper where stored in buildings or structures by means of installation requirements based upon sound engineering principles, test data, and field experience. Nothing in this standard is 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 substantial level of protection from fire. They reflect situations and the state of the art at the time the standard was issued.

Unless otherwise noted, it is not intended that the provisions of this document 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.

Approved.* Acceptable to the authority having jurisdiction.

Array.

Closed Array. A vertical storage arrangement in which the distances between columns in both directions are short [not more than 2 in. (50 mm) in one direction and 1 in. (25 mm) in the other].

Open Array. A vertical storage arrangement in which the distance between columns in both directions is lengthy (all vertical arrays other than closed or standard).

*Standard Array.** A vertical storage arrangement in which the distance between columns in one direction is short [1 in. (25 mm) or less], and is in excess of 2 in. (50 mm) in the other direction.

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

Banded Storage. Rolls provided with a circumferential steel strap [$\frac{3}{8}$ in. (9.5 mm) or wider] at each end of the roll.

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

Column. A single vertical stack of rolls.

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

Early Suppression Fast Response (ESFR) Sprinkler. See NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Encapsulated. A method of packaging consisting of a plastic sheet completely enclosing the sides and top of roll paper.

Extra Large Orifice (ELO) Sprinkler. See NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Large Drop Sprinkler. See NFPA 13, *Standard for the Installation of Sprinkler Systems*.

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

Paper (general term). The 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.

Rack Storage. Any combination of vertical, horizontal, or diagonal members that can support roll paper storage. Racks can be fixed or portable.

Shall. Indicates a mandatory requirement.

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

Spray Sprinkler. See NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Sprinkler Temperature Rating.

Ordinary Temperature Rated Sprinklers. Includes temperature ratings of 135°F to 170°F (57°C to 77°C).

Intermediate Temperature Rated Sprinklers. Includes temperature ratings of 170°F to 250°F (77°C to 121°C).

High Temperature Rated Sprinklers. Includes temperature ratings of 250°F to 300°F (121°C to 149°C).

Storage.

Horizontal Storage. Rolls stored with the cores in the horizontal plane (on-side storage).

Miscellaneous Storage. See NFPA 13, *Standard for the Installation of Sprinkler Systems*.

*Storage Height.** The maximum vertical distance above the floor at which roll paper is normally stored.

Vertical Storage. Rolls stored with the cores in the vertical plane (on-end storage).

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

Weight of Paper.* See A-2.

1-5* Units. Metric units of measurement in this standard are 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 might be approximate.

1-5.2 SI units have been 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 Roll Paper

2-1 General. For the purposes of this standard, the following classifications of paper shall apply. These classifications shall be used to determine the sprinkler system design criteria.

2-1.1 Heavyweight Class. Includes paperboard and paper stock having a basis weight [weight per 1000 ft² (92.9 m²)] of 20 lb (9.1 kg) or greater.

2-1.2 Mediumweight Class. Includes the broad range of papers having a basis weight [weight per 1000 ft² (92.9 m²)] of 10 lb to 20 lb (4.5 kg to 9.1 kg).

2-1.3 Lightweight Class. Includes all papers having a basis weight [weight per 1000 ft² (92.9 m²)] less than 10 lb (4.5 kg).

2-1.4 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; specifically, crepe wadding and the sanitary class including facial tissue, paper napkins, bathroom tissue, and toweling.

Chapter 3 Building Construction

3-1 Construction.

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

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

3-2* Emergency Smoke and Heat Venting. The protection outlined in this standard shall apply to buildings with or without roof vents and draft curtains.

3-3* Structural Steel Protection. The protection outlined in this standard shall apply to buildings with or without fireproofing or other modes of steel protection.

Exception: Where modified by 4-2.2.

Chapter 4 Storage Arrangement

4-1 Piling Procedures and Precautions. The floor load design shall take into account the added weight of water that could be absorbed during fire-fighting operations by certain commodities such as newsprint, corrugating medium, and tissue.

4-2 Commodity Clearance.

4-2.1 The clearance between the top of storage and sprinkler deflectors shall be in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Exception: Where modified by this standard.

4-2.2 If the commodity is stored above the lower chord of roof trusses, at least 1 ft (0.3 m) of clear space shall be maintained to allow wetting of the truss unless the truss is protected with 1-hour fireproofing.

4-2.3 Storage clearances from ducts shall be maintained in accordance with NFPA 90B, *Standard for the Installation of Warm Air Heating and Air Conditioning Systems*, and NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*.

4-2.4 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 clearance shown on the approval agency label.

4-2.5* Clearance to lights or light fixtures shall be maintained to prevent possible ignition.

4-2.6 Sufficient clearance around the path of fire door travel and around fire extinguishing and protection equipment shall be maintained to ensure accessibility for inspection and operational use.

4-3 Aisles.

4-3.1 Wall aisles shall be at least 24 in. (600 mm) wide to minimize possible structural damage from roll paper that expands with the absorption of water.

4-3.2* Aisles shall be maintained to retard transfer of fire from one pile to another and to allow convenient access for fire fighting, salvage, and removal of storage.

Chapter 5 Fire Protection

5-1 Automatic Sprinkler Systems.

5-1.1 Sprinkler systems installed in buildings or structures used for the storage of roll paper shall be in accordance with NFPA 13, *Standard for Installation of Sprinkler Systems*.

Exception: Where modified by this chapter.

5-1.1.1 Where buildings are occupied in part for vertical roll paper storage and only a portion of the sprinkler system is hydraulically designed, the design area shall extend not less than 20 ft (6.1 m) beyond the area occupied by the roll paper storage.

5-1.1.2 Wet-pipe systems shall be used in tissue storage areas.

5-1.1.3 Horizontal storage of heavyweight or mediumweight paper shall be protected as a closed array.

5-1.1.4 Mediumweight paper shall be permitted to be protected as heavyweight paper where wrapped completely on the sides and both ends, or where wrapped on the sides only with steel bands.

Wrapping material shall be either a single layer of heavyweight paper with a basis weight of 40 lb (18.1 kg), or two layers of heavyweight paper with a basis weight of less than 40 lb (18.1 kg).

5-1.1.5 Lightweight paper or tissue paper shall be permitted to be protected as mediumweight paper where wrapped completely on the sides and both ends, or where wrapped on the sides only with steel bands.

Wrapping material shall be either a single layer of heavyweight paper with a basis weight of 40 lb (18.1 kg), or two layers of heavyweight paper with a basis weight of less than 40 lb (18.1 kg).

5-1.1.6 For purposes of sprinkler system design criteria, lightweight class paper shall be protected as tissue.

5-1.2 Storage Less than 10 ft (3.1 m) in Height.

5-1.2.1 Storage of heavyweight or mediumweight classes of rolled paper up to 10 ft (3.1 m) in height shall be protected by sprinklers designed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, for Ordinary Hazard, Group 2 densities.

5-1.2.2 Storage of tissue and lightweight classes of paper up to 10 ft (3.1 m) in height shall be protected by sprinklers in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, for Extra Hazard, Group 1 densities.

5-1.3 Spray Sprinklers.

5-1.3.1 Sprinkler design criteria for storage of roll paper 10 ft (3.1 m) high and higher in buildings or structures with roof or ceilings up to 30 ft (9.1 m) shall be in accordance with Tables 5-1.3.1(a) and (b). For definition of storage height, see Section 1-4.

5-1.3.2 Large orifice sprinklers shall be used for new sprinkler system installations.

Exception: The use of extra large orifice sprinklers shall be permitted where listed for such use and where installed at a minimum operating pressure of 10 psi (69 kPa).

5-1.3.3* Where dry-pipe systems are used in Heavyweight Class or Mediumweight Class storage areas, the areas of operation indicated by Tables 5-1.3.1(a) and (b) shall be increased by 30 percent.

5-1.3.4 The minimum discharge pressure from any sprinkler in the design area shall not be less than 15 psi (105 kPa).

5-1.3.5* High temperature sprinklers shall be used for installations protecting roll paper stored 15 ft (4.6 m) or higher.

5-1.3.6 The protection area per sprinkler shall not exceed 100 ft² (9.3 m²) or be less than 70 ft² (6.5 m²).

5-1.4 Large Drop Sprinklers. Where automatic sprinkler system protection utilizes large drop sprinklers, hydraulic design criteria shall be as specified in Table 5-1.4. Design discharge pressure shall be 50 psi (350 kPa) in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*. The number of sprinklers to be calculated is indicated based on storage height, clearance, and system type.

5-1.5 ESFR Sprinklers. Where automatic sprinkler system protection utilizes ESFR sprinklers, hydraulic design criteria shall be as specified in Table 5-1.5. Design discharge pressure shall be applied to 12 operating sprinklers in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

5-2 High-Expansion Foam.

5-2.1 Where high-expansion foam systems are installed in addition to automatic sprinklers, they shall be installed in accordance with NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*.

Exception: Where modified by this chapter.

5-2.2 Where high-expansion foam systems are installed in Heavyweight Class and Mediumweight Class storage areas, sprinkler discharge design densities can be reduced to not less than 0.24 gpm/ft² [(10 lpm)/m²] with a minimum operating area of 2000 ft² (186 m²).

5-2.3 Where high-expansion foam systems are installed in tissue storage areas, sprinkler discharge densities and areas of application shall not be reduced below those provided in Tables 5-1.3.1(a) and (b).

5-2.4 High-expansion foam systems shall be automatic in operation.

5-3 Water Supplies.

5-3.1 The water supply system for automatic fire protection systems shall be designed for a minimum duration of 2 hours.

Exception: For ESFR sprinklers, the water supply duration shall be 1 hour.

5-3.2 At least 500 gpm (1893 lpm) shall be added to the sprinkler demand for large and small hose stream demand.

Exception: For ESFR sprinklers, the hose stream allowance shall be for 250 gpm (947 lpm).

Table 5-1.3.1(a) Automatic Sprinkler System Design Criteria — Spray Sprinklers for Buildings or Structures with Roof or Ceilings up to 30 ft (gpm/ft²)

Storage Height (ft)	Clearance (ft)	Heavyweight					Mediumweight				Tissue
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		Open Array Banded or Unbanded	All Storage Arrays
			Banded	Unbanded	Banded	Unbanded		Banded	Unbanded		
10	≤5	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.45/2000
10	>5	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.45/2500
15	≤5	0.3/2000	0.3/2000	0.3/2000	0.3/2500	0.3/3000	0.3/2000	0.3/2000	0.45/2500	0.45/2500	0.60/2000
15	>5	0.3/2000	0.3/2000	0.3/2000	0.3/3000	0.3/3500	0.3/2000	0.3/2500	0.45/3000	0.45/3000	0.60/3000
20	≤5	0.3/2000	0.3/2000	0.3/2500	0.45/3000	0.45/3500	0.3/2000	0.45/2500	0.6/2500	0.6/2500	0.75/2500
20	>5	0.3/2000	0.3/2500	0.3/3000	0.45/3500	0.45/4000	0.3/2500	0.45/3000	0.6/3000	0.6/3000	0.75/3000
25	≤5	0.45/2500	0.45/3000	0.45/3500	0.6/2500	0.6/3000	0.45/3000	0.6/3000	0.75/2500	0.75/2500	Note 1

NOTE 1: Sprinkler protection requirements for tissue stored above 20 ft have not been determined.

NOTE 2: Densities or areas, or both, shall be permitted to be interpolated between any 5-ft storage height increment.

Table 5-1.3.1(b) Automatic Sprinkler System Design Criteria — Spray Sprinklers for Buildings or Structures with Roof or Ceilings up to 9.1 m [(lpm)/m²]

Storage Height (m)	Clearance (m)	Heavyweight					Mediumweight				Tissue
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		Open Array Banded or Unbanded	All Storage Arrays
			Banded	Unbanded	Banded	Unbanded		Banded	Unbanded		
3.1	≤1.5	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	18.3/185.8
3.1	>1.5	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	18.3/232.3
4.6	≤1.5	12.2/185.8	12.2/185.8	12.2/185.8	12.2/232.3	12.2/278.7	12.2/185.8	12.2/185.8	18.3/232.3	18.3/232.3	24.5/185.8
4.6	>1.5	12.2/185.8	12.2/185.8	12.2/185.8	12.2/278.7	12.2/322.2	12.2/185.8	12.2/232.3	18.3/278.7	18.3/278.7	24.5/278.7
6.1	≤1.5	12.2/185.8	12.2/185.8	12.2/232.3	18.3/278.7	18.3/325.2	12.2/185.8	18.3/232.3	24.5/232.3	24.5/232.3	30.6/232.3
6.1	>1.5	12.2/185.8	12.2/232.3	12.2/278.7	18.3/325.2	18.3/371.6	12.2/232.3	18.3/278.7	24.5/278.7	24.5/278.7	30.6/278.7
7.6	≤1.5	18.3/232.3	18.3/278.7	18.3/325.2	24.5/232.3	24.5/278.7	18.3/278.7	24.5/278.7	30.6/232.3	30.6/232.3	Note 1

NOTE 1: Sprinkler protection requirements for tissue stored above 6.1 m have not been determined.

NOTE 2: Densities or areas, or both, shall be permitted to be interpolated between any 1.5-m storage height increment.

Table 5-1.4 Automatic Sprinkler System Design Criteria — Large Drop Sprinklers (number of sprinklers to be calculated)

Storage Height (ft) (m)		Clearance (ft) (m)		System Type	Heavyweight					Mediumweight					Tissue
					Closed Array	Standard Array		Open Array		Closed Array	Standard Array		Open Array		All Storage Arrays
					Banded or Unbanded	Banded	Unbanded	Banded	Unbanded	Banded or Unbanded	Banded	Unbanded	Banded	Unbanded	
20	6.1	<10	<3.1	W	15	15	15	15	N/A	15	15	15	N/A	N/A	See Note
20	6.1	<10	<3.1	D	25	25	25	N/A	N/A	25	25	25	N/A	N/A	N/A
26	7.9	<34	<10.4	W	15	15	15	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
26	7.9	<34	<10.4	D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

W = wet; D = dry; N/A = not applicable.

For definition of storage height, see Section 1-4.

NOTE: 25 large drop sprinklers @ 75 psi (5.2 bars) for closed or standard array; other arrays N/A.

5-3.3 The water supply design shall include the demand of the automatic sprinkler system plus the hose stream demand plus, where provided, the high-expansion foam system.

5-3.4 Hydrants. At locations without public hydrants, or where hydrants are not within 250 ft (75 m), private hydrants shall be installed in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

5-4 Manual Inside Protection.

5-4.1 Small Hose Systems. Small hoselines [1½ in. (38.1 mm)] shall be available to reach all portions of the storage area.

5-4.2 Portable Fire Extinguishers. Portable fire extinguishers shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

Table 5-1.5 Automatic Sprinkler Design Criteria — ESFR Sprinklers
(maximum height of storage permitted)

ESFR K Factor	System Type	Pressure (psi) (bars)		Building Height (ft) (m)		Heavyweight			Mediumweight			Tissue
						Closed (ft) (m)	Standard (ft) (m)	Open (ft) (m)	Closed (ft) (m)	Standard (ft) (m)	Open (ft) (m)	All Arrays
11.0—11.5	Wet	50	3.4	25	7.6	20	6.1	20	6.1	20	6.1	N/A
13.5—14.5	Wet	50	3.4	30	9.1	25	7.6	25	7.6	25	7.6	N/A
13.5—14.5	Wet	75	5.2	40	12.2	30	9.1	30	9.1	N/A	N/A	N/A

For definition of storage height, see Section 1-4.

Pressure = Operating sprinkler discharge pressure.

Exception: In storage areas where fixed, 1½-in. (38.1-mm) hoselines are available to reach all portions of the storage area, up to ½ of the required complement of portable fire extinguishers for Class A fires shall be permitted to be omitted.

5-5 Maintenance. The fire protection system shall be maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.

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

5-6 Fire Organization.

5-6.1 Arrangements shall be made to allow rapid entry into the premises by the municipal fire department, police department, or other authorized personnel in case of fire or other emergency.

5-6.2 Plant emergency organizations, where provided, shall be instructed and trained in the following procedures:

- (a) Maintenance of the security of the premises;
- (b) Means of summoning outside aid immediately in an emergency;
- (c) Use of hand extinguishers and small [1½-in. (38.1-mm)] hoselines on incipient fires and mop-up operations;
- (d) Operation of sprinkler system and water supply equipment;
- (e) Use of material-handling equipment while sprinklers are operating to effect final extinguishment;
- (f) Supervision of sprinkler valves after the system is turned off so that the system can be reactivated if rekindling occurs;
- (g)* Employee safety during fire-fighting and mop-up operations, including knowledge of the hazard potential of roll paper (i.e., collapse and tumbling);
- (h)* Operation of foam systems and appropriate safety and evacuation procedures.

5-6.3 A fire watch shall be maintained when the sprinkler system is not in service.

5-7 Alarm Service. An approved alarm system including sprinkler system waterflow and supervisory alarms shall be provided in accordance with NFPA 72, *National Fire Alarm Code*.

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

Chapter 6 Referenced Publications

6-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

6-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1994 edition.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, 1994 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1994 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*, 1995 edition.

NFPA 72, *National Fire Alarm Code*, 1993 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air Conditioning Systems*, 1993 edition.

NFPA 91, *Standard for the Exhaust Systems for Air Conveying of Materials*, 1995 edition.

NFPA 220, *Standard on Types of Building Construction*, 1995 edition.

NFPA 231C, *Standard for Rack Storage of Materials*, 1995 edition.

Appendix A Explanatory Material

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

A-1-1.2 Existing Storage Facilities. Sprinkler systems protecting existing roll paper storage facilities should be evaluated in accordance with Tables A-1-1.2(a) and (b). While fire can be controlled by the protection shown in Tables A-1-1.2(a) and (b), greater damage can occur when the densities in Tables A-1-1.2(a) and (b) are used rather than those specified in Tables 5-1.3.1(a) and (b).

A-1-4 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,

Table A-1.1.2(a) Automatic Sprinkler System Design Criteria — Spray Sprinklers for Existing Storage Facilities (gpm/ft²)

Storage Height (ft)	Clearance (ft)	Heavyweight					Mediumweight			
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		Open Array Banded or Unbanded
			Banded	Unbanded	Banded	Unbanded		Banded	Unbanded	
10	≤5	0.2/2000	0.2/2000	0.2/2000	0.25/2000	0.25/2000	0.2/2000	0.25/2000	0.3/2000	0.3/2000
10	>5	0.2/2000	0.2/2000	0.2/2000	0.25/2500	0.25/2500	0.2/2000	0.25/2000	0.3/2000	0.3/2000
15	≤5	0.25/2000	0.25/2000	0.25/2500	0.3/2500	0.3/3000	0.25/2000	0.3/2000	0.45/2500	0.45/2500
15	>5	0.25/2000	0.25/2000	0.25/2500	0.3/3000	0.3/3500	0.25/2000	0.3/2500	0.45/3000	0.45/3000
20	≤5	0.3/2000	0.3/2000	0.3/2500	0.45/3000	0.45/3500	0.3/2000	0.45/2500	0.6/2500	0.6/2500
20	>5	0.3/2000	0.3/2500	0.3/3000	0.45/3500	0.45/4000	0.3/2500	0.45/3000	0.6/3000	0.6/3000
25	≤5	0.45/2500	0.45/3000	0.45/3500	0.6/2500	0.6/3000	0.45/3000	0.6/3000	0.75/2500	0.75/2500
25	>5	0.45/3000	0.45/3500	0.45/4000	0.6/3000	0.6/3500	0.45/3500	0.6/3500	0.75/3000	0.75/3000
30	≤5	0.6/2500	0.6/3000	0.6/3000	0.75/2500	0.75/3000	0.6/4000	0.75/3000	0.75/3500	0.75/3500

NOTE: Densities or areas, or both, can be interpolated between any 5-ft storage height increment.

Table A-1.1.2(b) Automatic Sprinkler System Design Criteria — Spray Sprinklers for Existing Storage Facilities [(lpm)/m²]

Storage Height (m)	Clearance (m)	Heavyweight					Mediumweight			
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		Open Array Banded or Unbanded
			Banded	Unbanded	Banded	Unbanded		Banded	Unbanded	
3.1	≤1.5	0.76/185.8	0.76/185.8	0.76/185.8	0.95/185.8	0.95/185.8	0.76/185.8	0.95/185.8	12.2/185.8	12.2/185.8
3.1	>1.5	0.76/185.8	0.76/185.8	0.76/185.8	0.95/232.3	0.95/232.3	0.76/185.8	0.95/185.8	12.2/185.8	12.2/185.8
4.6	≤1.5	0.95/185.8	0.95/185.8	0.95/232.3	12.2/232.3	12.2/278.7	0.95/185.8	12.2/185.8	18.3/232.3	18.3/232.3
4.6	>1.5	0.95/185.8	0.95/185.8	0.95/232.3	12.2/278.7	12.2/325.2	0.95/185.8	12.2/232.3	18.3/278.7	18.3/278.7
6.1	≤1.5	12.2/185.8	12.2/185.8	12.2/232.3	18.3/278.7	18.3/325.2	12.2/185.8	18.3/232.3	24.5/232.3	24.5/232.3
6.1	>1.5	12.2/185.8	12.2/232.3	12.2/278.7	18.3/325.2	18.3/371.6	12.2/232.3	18.3/278.7	24.5/278.7	24.5/278.7
7.6	≤1.5	18.3/232.3	18.3/278.7	18.3/325.2	24.5/232.3	24.5/278.7	18.3/278.7	24.5/278.7	30.6/232.3	30.6/232.3
7.6	>1.5	18.3/278.7	18.3/325.2	18.3/371.6	24.5/278.7	24.5/325.2	18.3/325.2	24.5/325.2	30.6/278.7	30.6/278.7
9.1	≤1.5	24.5/232.3	24.5/278.7	24.5/278.7	30.6/232.3	30.6/278.7	24.5/371.6	30.6/278.7	30.6/325.2	30.6/325.2

NOTE: Densities or areas, or both, can be interpolated between any 1.5-m storage height increment.

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 concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-4 Array, Standard. The occasional presence of partially used rolls on top of columns of otherwise uniform diameter rolls does not appreciably affect the burning characteristics.

A-1-4 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 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which 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.

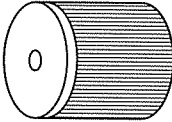
A-1-4 Storage Height. The size of rolls and limitations of mechanical handling equipment should be considered in determining maximum storage height.

A-1-4 Storage Height, Wrapped 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.

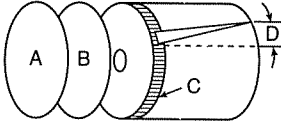
In some cases, rolls are protected with laminated wrappers, using two sheets of heavy kraft with a high temperature wax laminate between the sheets. Where using this method, the overall weight of wax-laminated wrappers should be based on the basis weight per 1000 ft² (92.9 m²) of the outer sheet only, 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.

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 Inside heads Outside heads Edge protectors Edge bands Overwrap	Protection applied to the ends of the rolls (A and B). Heads do not lap over the end of the roll. Protection applied to the ends of the rolls next to the roll itself (B). The wrapper of the rolls is crimped down over these heads. Protection applied to the ends of the rolls on the outside (A). This head is applied after the wrapper is crimped. Refers to extra padding to prevent damage to roll edges (C). The distance the body wrap or wrapper overlaps itself (D).
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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.
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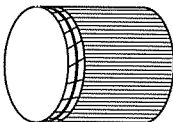


Figure A-1-4 Wrapping and capping terms and methods.

A-1-4 Weight of Paper. See A-2.

A-1-5 For conversions and information, see ASTM E 380, *Standard Practice for Use of the International System of Units (SI)*.

A-2 Paper Classification. These 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 categories 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:

Bond paper — 500 sheets 17 in. × 22 in. (432 mm × 559 mm) = 1300 ft² (120.8 m²)/ream

Book paper — 500 sheets 25 in. × 38 in. (635 mm × 965 mm) = 3300 ft² (306.6 m²)/ream

Index paper — 500 sheets 25.5 in. × 30.5 in. (648 mm × 775 mm) = 2700 ft² (250.8 m²)/ream

Bristol paper — 500 sheets 22.5 in. × 35 in. (572 mm × 889 mm) = 2734 ft² (254 m²)/ream

Tag paper — 500 sheets 24 in. × 36 in. (610 mm × 914 mm) = 3000 ft² (278.7 m²)/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:

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

Example: To determine the basis weight per 1000 ft² (92.9 m²) of 16-lb (7.3-kg) bond paper:

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

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:

Linerboard — 42 lb/1000 ft² (19.1 kg/92.9 m²) nominal basis weight

Newsprint — 10 lb/1000 ft² (4.5 kg/92.9 m²) nominal basis weight

Tissue — 5 lb/1000 ft² (2.3 kg/92.9 m²) nominal basis weight

The rate of firespread over the surface of the tissue rolls was extremely rapid in the full-scale fire tests. The rate of firespread 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:

Heavyweight — Basis weight of 20 lb /1000 ft² (9.1 kg/92.9 m²) or greater

Mediumweight — Basis weight of 10 lb to 20 lb /1000 ft² (4.5 kg to 9.1 kg/92.9 m²)

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-2.

A-3-1.1 Consideration should be given to subdividing large-area warehouses in order to reduce the amount of stock that would be affected by a single fire.

Table A-2 Paper Classification

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

It is recommended that walls or partitions be provided to separate the storage area from manufacturing or other occupancies to prevent the possibility of transmission of fire or smoke between the two occupancies.

A-3-2 Smoke removal is important to manual fire-fighting and overhaul. Since most fire tests were conducted without smoke and heat venting, the protection specified in Section 5-1 was developed without the use of such venting. However, venting through eave-line windows, doors, gravity monitors, or mechanical exhaust systems is essential to smoke removal after control of the fire is achieved. (See NFPA 204M, *Guide for Smoke and Heat Venting*.)

A-3-3 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.

A-4-2.5 Incandescent light fixtures should have shades or guards to prevent the ignition of commodity from hot bulbs where the possibility of contact with storage exists.

A-4-3.2 Fire tests indicate that fire does not spread between piles that are separated by aisles of 8 ft (2.4 m) or greater where sprinkler protection is provided in accordance with this standard. Main aisles and cross aisles should be located opposite window or door openings in exterior walls. This is of particular importance in buildings where there are few exterior openings.

A-5-1.3.3 In a dry-pipe system, the area increase of 30 percent should be compounded [i.e., 2000 ft² (185.8 m²) (1.67 for low temperature sprinklers and 1.3 for dry-pipe systems) = 4343 ft² (403.5 m²) total area]. Where dry-pipe systems are used in existing installations, the areas of operation indicated by Tables A-1-1.2(a) and (b) should be increased by 30 percent.

A-5-1.3.5 Generally, more sprinklers open in fires involving roll paper storage protected by sprinklers rated below the high temperature range. An increase of 67 percent in the design area should be considered.

A-5-6.2(g) Water absorption and pile instability caused pile collapse in all large-scale fire tests of tissue paper. This characteristic should be fully recognized where manually attacking a fire in tissue storage occupancies.

A-5-6.2(h) Information on emergency organization is provided in the following publications:

NFPA *Industrial Fire Brigade Training Manual*
NFPA 600, *Standard on Industrial Fire Brigades*.

Appendix B Summary of Test Results

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

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 ft² (4.65 km²)] in area, of fire-resistive construction, and contains a volume of approximately 2.25 million ft³ (63,761.86 m³), the equivalent of a 100,000-ft² (9.29-km²) 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 B-1 illustrates a typical storage array used in the tissue series of tests.

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

- Firespread to the north end of the storage array;
- Gas temperatures near the ceiling maintained at high levels for a time judged to be sufficient to endanger exposed structural steel;
- Fire reaching the target stacks.

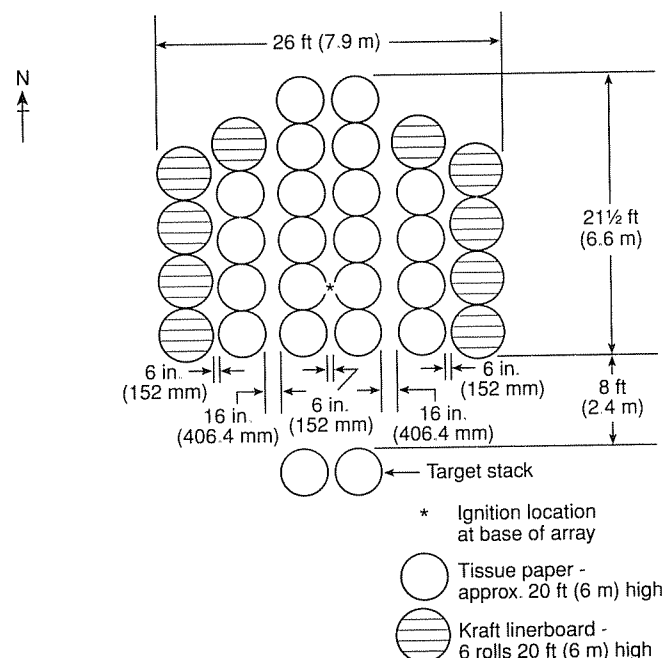


Figure B-1 Plan view of typical tissue storage array.

Table B-1 Summary of Roll Paper Tissue Tests

Test number	B1*	B2	B3	B4	B5***	B6***
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)**	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 (lpm)]	2575 (9746)**	1992 (7540)	1993 (7544)	4907 (18573)	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 [(lpm)/m ²]	0.29 (11.8)**	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 min avg. gas temp. over ignition [°F (°C)]	1680 (916)**	1463 (795)	1634 (890)	1519 (826)	****	*****
Duration of high temp. within acceptable limits	No	Yes	Yes	Marginal	Yes	Yes
Max. 1 min 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 (min)	17.4	20	20	25.5	45	45

*Phase I Test.

**Pressure increased to 50 psi (345 kPa) at 10 min.

***Phase III tests decaying pressure.

****Maximum steel temperature over ignition 341°F (172°C).

*****Maximum steel temperature over ignition 132°F (56°C).

Table B-2 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-ft² (9.3-m²) 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-ft² (9.3-m²) 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. 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 firespread 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 firespread. 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/ft²

[(24.5 lpm)/m²] 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 9½-ft (2.9-m) clearance to ceiling sprinklers. The prescribed 0.30-gpm/ft² [(12.2-lpm)/m²] density controlled the firespread, but protection to roof steel was marginal to the point where light beams and joists might 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 C Referenced Publications

C-1 The following documents or portions thereof are referenced within this document for informational purposes

only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

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

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1994 edition.

NFPA 204M, *Guide for Smoke and Heat Venting*, 1991 edition.

NFPA 600, *Standard on Industrial Fire Brigades*, 1996 edition.

C-1.2 Other Publications.

C-1.2.1 ASTM Publication. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E 380, *Standard Practice for Use of the International System of Units (SI)*, 1993.

C-1.2.2 Installation rules for sprinkler systems using large drop sprinklers are available from Data Sheet 2-7, Factory Mutual Research Corporation, 1151 Boston-Providence Turnpike, Norwood, MA 02062.

Index

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-A-		
Access, fire fighting	4-3.2, A-4-3.2	
Aisles	4-3, A-4-3.2	
Alarm service	5-7	
Approved (definition)	1-4, A-1-4	
Arrays		
Definitions	1-4, A-1-4	
Sprinkler configurations	Tables 5-1.3.1(a) and (b), 5-1.4, 5-1.5, A-1-1.2(a) and (b)	
Authority having jurisdiction (definition)	1-4, A-1-4	
-B-		
Banded storage	5-1.1.4 to 5-1.1.5	
Definition	1-4	
Buildings, construction of	3-1, A-3-1.1	
-C-		
Classification, of roll paper	Chap. 2, A-2	
Clearance		
Commodities	4-2, A-4-2.5	
Definition	1-4	
Closed arrays		
Definition	1-4	
Sprinkler configurations	Tables 5-1.3.1(a) and (b), 5-1.4, 5-1.5, A-1-1.2(a) and (b)	
Columns (definition)	1-4	
Commodity clearance	4-2, A-4-2.5	
Construction, buildings	3-1, A-3-1.1	
Core (definition)	1-4	
-D-		
Doors, fire, clearance from	4-2.6	
Dry-pipe sprinkler systems	5-1.3.3, A-5-1.3.3	
Ducts, clearance from	4-2.3	
-E-		
Early suppression fast response (ESFR) sprinklers	5-1.5, 5-3.1	
Emergency organizations	5-6.2, A-5-6.2	
Encapsulated (definition)	1-4	
Existing storage facilities	1-1.2, A-1-1.2	
Extra large orifice (ELO) sprinklers	5-1.3.2	
Definition	1-4	
-F-		
Fire doors, clearance from	4-2.6	
Fire extinguishers, portable	4-2.6, 5-4.2	
Fire fighting operations		
Access	4-3.2, 5-6.1, A-4-3.2	
Water absorbed during	4-1, 4-3.1, A-5-6.2(g)	
Fire protection	Chap. 5; see also Sprinkler systems	
Alarm service	5-7	
Clearance from equipment	4-2.6	
Emergency organization	5-6.2, A-5-6.2	
High-expansion foam	5-2	

Maintenance	5-5
Manual inside	5-4
Water supplies	5-3
Fire watch	5-5, 5-6.3
Foam, high expansion	5-2

-H-

Heat venting, emergency	3-2, A-3-2
Heating equipment, clearance from	4-2.4
High temperature sprinklers	5-1.3.5, A-5-1.3.5
High-expansion foam	5-2
Horizontal storage	5-1.1.3
Definition	1-4
Hose systems, small	5-4.1

-I-

Incidental storage (definition)	1-4
---------------------------------------	-----

-L-

Large drop sprinklers	5-1.4
Definition	1-4
Lights and light fixtures, clearance from	4-2.5, A-4-2.5
Listed (definition)	1-4, A-1-4

-M-

Manual inside protection	5-4
Measurement, units of	1-5
Miscellaneous storage	1-1.3(a)
Definition	1-4

-O-

Open array	
Definition	1-4

-P-

Paper (general term)	
Definition	1-4
Piling procedures and precautions	4-1, A-4-1
Purpose of standard	1-2

-R-

Rack storage	1-1.3(b)
Definition	1-4
Referenced publications	Chap. 6, App. C
Retroactivity of standard	1-3

-S-

Scope of standard	1-1, A-1-1.2
Shall (definition)	1-4
Should (definition)	1-4
Smoke venting, emergency	3-2, A-3-2
Spray sprinklers	5-1.3, A-5-1.3.3, A-5-1.3.5
Definition	1-4
Sprinkler systems	5-1, A-1-1.2, A-5-1.3, A-5-1.5
Sprinklers	<i>see also</i> Spray sprinklers
Early large orifice (ELO) sprinklers (definition)	1-4
Large drop	5-1.4
Definition	1-4
Temperature rating (definition)	1-4
Standard array	
Definition	1-4, A-1-4
Sprinkler configurations	Tables 5-1.3.1(a) and (b), 5-1.4, 5-1.5, A-1-1.2(a) and (b)
Steel, structural, protection	3-3, A-3-3
Storage	
Arrangements	Chap. 4, A-4-2.5, A-4-3.2
Banded	5-1.1.4 to 5-1.1.5
Definition	1-4
Definitions	1-4
Existing	1-1.2, A-1-1.2
Height (definition)	1-4, A-1-4
Rack	1-1.3(b)
Definition	1-4

-T-

Tests, data from	App. B
Tissue	2-1.4, 5-1.1.2, 5-1.1.5 to 5-1.1.6, 5-1.2.2, Tables 5-1.3.1(a) and (b), 5-2.3, A-5-6.2
Fire tests	App. B
Trusses, clearance from	4-2.2

-V-

Venting, emergency smoke and heat	3-2, A-3-2
Vertical storage	5-1.1.1
Definition	1-4

-W-

Water, absorption by paper of	4-1, 4-3.1, A-5-6.2(g)
Water supplies	5-3
Weight of paper	<i>See</i> Classification, of roll paper
Wet-pipe sprinkler systems	5-1.1.2
Wrapped storage	5-1.1.4 to 5-1.1.5
Definition	1-4
Storage height	A-1-4
Terms and methods	Fig. A-1-4

NFPA 231F**Standard for the Storage of Roll Paper****1996 Edition****Reference: Table 5-1.5
TIA 96-1 (NFPA 231F)**

Pursuant to Section 5 of the NFPA Regulations Governing Committee Projects, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 231F, *Standard for the Storage of Roll Paper*, 1996 edition. The TIA was processed by the General Storage Committee, and was issued by the Standards Council on January 14, 1999, with an effective date of February 3, 1999.

A Tentative Interim Amendment is tentative because it has not been processed through the entire standards-making procedures. It is interim because it is effective only between editions of the standard. A TIA automatically becomes a proposal of the proponent for the next edition of the standard; as such, it then is subject to all of the procedures of the standards-making process.

1. Revise Table 5-1.5 to read as follows:

**Table 5-1.5 Table 2: Automatic Sprinkler Design Criteria — ESFR Sprinklers
(maximum height of storage permitted)**

(maximum height of storage permitted)																		
ESFR K Factor	System Type	Pressure (psi) (bars)		Building Height (ft) (m)		Heavyweight						Mediumweight						Tissue
						Closed		Standard		Open		Closed		Standard		Open		All Arrays
						(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)	
11.0–11.5	Wet	50	3.4	25	7.6	20	6.1	20	6.1	20	6.1	20	6.1	20	6.1	20	6.1	N/A
13.5–14.5	Wet	50	3.4	30	9.1	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	N/A
13.5–14.5	Wet	75	5.2	40	12.2	30	9.1	30	9.1	30	9.1	N/A		N/A		N/A		N/A
23.9–26.5	Wet	20	1.4	30	9.1	25	7.6	25	7.6	25	7.6	20	6.1	20	6.1	20	6.1	N/A
23.9–26.5	Wet	40	2.7	40	12.2	30	9.1	30	9.1	30	9.1	20	6.1	20	6.1	20	6.1	N/A
23.9–26.5	Wet	50	3.4	45	13.7	30	9.1	30	9.1	30	9.1	N/A		N/A		N/A		N/A

For definition of storage height, see Section 1-4.

Pressure = Operating sprinkler discharge pressure.

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(M-1000)