

# NFPA 231F

## Storage of Roll Paper

### 1984



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There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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## **Standard for the Storage of Roll Paper**

**NFPA 231F-1984**

### **1984 Edition of NFPA 231F**

This edition of NFPA 231F, *Standard for the Storage of Roll Paper*, was prepared by the Technical Committee on General Storage, released by the Correlating Committee on Storage, and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 14-17, 1983 in Orlando, Florida. It was issued by the Standards Council on December 8, 1983 with an effective date of December 28, 1983, and supersedes all previous editions.

This 1984 edition of this standard has been approved by the American National Standards Institute.

### **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 there had been 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 formulate a new NFPA 231F, *Standard for the Storage of Roll Paper*. The first edition was 1984.

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**Stephen R. Hoover, Kemper Group**  
(Alternate to W. P. Thomas)

**Fletcher MacGregor, IRM Insurance**  
(Alternate to A. I. Hjertstedt)  
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**Gerald W. O'Rourke, Schirmer Engineering Corp.**  
(Alternate to T. E. Goonan)  
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**Allen D. Walters, American Warehousemen's Assn.**  
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# Standard for the Storage of Roll Paper

NFPA 231F-1984

**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 applies to the storage of roll paper in buildings or structures.

**1-1.2\*** This standard applies to new facilities or when converting existing buildings to roll paper storage occupancy. It may be used as a basis for evaluating existing storage facilities.

**1-1.3** This standard does not apply to:

**1-1.3.1\*** Horizontal Storage.

**1-1.3.2** Storage in unsprinklered buildings and structures.

**1-1.3.3** Storage on racks. (See NFPA 231C, *Standard for Rack Storage of Materials*.)

**1-1.3.4** Incidental storage.

**1-1.3.5\*** Storage of lightweight paper and tissue.

**1-1.3.6\*** Storage in buildings or structures with roofs or ceilings greater than 30 ft (9 m) high.

**1-1.3.7** Storage of waxed paper, synthetic paper, encapsulated rolls and palletized roll storage other than 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 when stored in buildings or structures through 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 providing the level of protection prescribed by the standard is not lowered.

### 1-3 Definitions.

**Approved.** Acceptable to the "authority having jurisdiction."

**NOTE:** 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 or 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 concerned

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

### Array.

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

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

**Note:** The occasional presence of partially used rolls on top of columns of otherwise uniform diameter rolls will not appreciably affect the burning characteristics.

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

**Authority Having Jurisdiction.** The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

**NOTE:** 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, 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 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."

**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 about which paper is wound to form a roll.

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

**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.

**NOTE:** 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.

**Paper (general term).** The name of 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 may be fixed or portable.

**Shall.** Indicates a mandatory requirement.

**Should.** Indicates recommendations or that which is advised but not required.

**Sprinkler Temperature Rating.** A 165°F (74°C) rating includes temperature ratings between 135°F (57°C) and 175°F (80°C), and a 286°F (141°C) rating includes temperature ratings between 250°F (121°C) and 300°F (149°C).

#### **Storage.**

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

**Incidental Storage.** Roll paper that occurs in areas such as manufacturing, shipping, receiving or general warehouses which by virtue of small quantities or storage configuration does not present a hazard beyond the capabilities of the existing sprinkler protection.

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

**NOTE:** The size of rolls and limitations of mechanical handling equipment must be considered in determining maximum storage height.

**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.)

**1-4 Units.** Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). One unit (1 liter) outside of but recognized by SI, is commonly used in international fire protection. For conversions and information, see ASTM E380, *Standard for Metric Practice*.

**1-4.1** If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated is to be regarded as the requirement. A given equivalent value may be approximate.

**1-4.2** The conversion procedure for the SI units has been to multiply the quantity by the conversion factor and then round the result to the appropriate number of significant digits.

## **Chapter 2\* Classification of Roll Paper**

**NOTE:** The following classes 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 will burn with exactly the same characteristics. Presence of a properly applied wrapper has the effect of changing the class of a given paper excluding tissue to essentially that of the wrapper material.

**2-1 Heavy Weight Class.** Includes paperboard and paper stock having a basis weight [weight per 1,000 sq ft (93 m<sup>2</sup>)] of 20 lb (9.1 kg) or greater.

**2-2 Medium Weight Class.** Includes the broad range of papers having basis weight [weight per 1,000 sq ft (93 m<sup>2</sup>)] from 10 lb (4.5 kg) to 20 lb (9.1 kg).

**2-3 Light Weight Class.** Includes all papers having a basis weight [weight per 1,000 sq ft (93 m<sup>2</sup>)] less than 10 lb (4.5 kg) and tissues.

**2-3.1 Tissue.** Includes the broad range of papers of characteristic gauzy texture, in some cases fairly transparent. For the purposes of this standard, tissue is to mean 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 which are stored and protected in accordance with this standard may 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.** Protection outlined in this standard applies to buildings with or without roof vents and draft curtains.

**3-3\* Structural Steel Protection.** Protection outlined in this standard applies to buildings with or without fireproofing or other modes of steel protection except as modified by 4-2.2.

## **Chapter 4 Storage Arrangement**

**4-1\* Piling Procedures and Precautions.** Floor load design shall take into account the added weight of water which could be absorbed during fire fighting operations by certain commodities such as newsprint and corrugating medium.



## 4-2 Commodity Clearance.

4-2.1 The clearance between top of storage and sprinkler deflectors shall conform to NFPA 13, *Standard for the Installation of Sprinkler Systems*, except as 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) clear space shall be maintained to permit wetting of the truss unless the truss is protected with one-hour fireproofing.

4-2.3 Storage clearance from ducts shall be maintained in accordance with NFPA 91, Section 240, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying*.

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 shall be maintained to lights or light fixtures to prevent possible ignition.

4-2.6 Sufficient clearance shall be maintained around the path of fire door travel, and fire extinguishing and protection equipment to assure 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 permit 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, the *Standard for Installation of Sprinkler Systems*, except as modified by this chapter.

5-1.2 Storage of Heavy Weight Class or Medium Weight Class roll paper, as defined by this standard, under 10 ft (3 m) in height shall be protected by sprinklers in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, for Ordinary Hazard Group 3.

5-1.3\* Sprinkler design criteria for vertical storage of roll paper 10 ft (3 m) high and higher in buildings or structures with roofs or ceilings up to 30 ft (9 m) shall be in accordance with Table 5-1.3. For Storage Height see 1-3 Definitions.

5-1.3.1 The 1/2 in. (13.5 mm) nominal orifice sprinkler shall be used for new installations.

5-1.3.2 The minimum discharge pressure from any sprinkler in the design area shall not be less than 15 psig (105 kPa).

5-1.3.3\* 286°F (141°C) temperature rated sprinklers shall be used for installations protecting roll paper stored 15 ft (4.5 m) or higher.

5-1.3.4 The protection area per sprinkler shall not exceed 100 sq ft (9.3 m<sup>2</sup>) or be less than 70 sq ft (6.5 m<sup>2</sup>).

5-1.4 In buildings which are occupied in part for vertical roll paper storage, and only a portion of the sprinkler system is hydraulically designed, the design area shall

Table 5-1.3 Design Density/Area of Application Chart

Storage Height (ft)	Clearance (ft)	Heavy Weight					Medium Weight			
		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	.3/2000	.3/2000	.3/2000	.3/2000	.3/2000	.3/2000	.3/2000	.3/2000	.3/2000
10	> 5	.3/2000	.3/2000	.3/2000	.3/2000	.3/2000	.3/2000	.3/2000	.3/2000	.3/2000
15	≤ 5	.3/2000	.3/2000	.3/2000	.3/2500	.3/3000	.3/2000	.3/2000	.45/2500	.45/2500
15	> 5	.3/2000	.3/2000	.3/2000	.3/3000	.3/3500	.3/2000	.3/2500	.45/3000	.45/3000
20	≤ 5	.3/2000	.3/2000	.3/2500	.45/3000	.45/3500	.3/2000	.45/2500	.6/2500	.6/2500
20	> 5	.3/2000	.3/2500	.3/3000	.45/3500	.45/4000	.3/2500	.45/3000	.6/3000	.6/3000
25	≤ 5	.45/2500	.45/3000	.45/3500	.6/2500	.6/3000	.45/3000	.6/3000	.75/2500	.75/2500

NOTE: Densities and/or areas may be interpolated between any 5 ft storage height increment.

For SI Units: 1 ft = 0.3048 m; 1 gpm/ft<sup>2</sup> = 40.746 (L/min)/m<sup>2</sup>

extend not less than 20 ft (6 m) beyond the area occupied by the roll paper storage.

**5-1.5\*** Where dry pipe systems are used, the areas of operation indicated by Table 5-1.3 shall be increased by 30 percent.

## 5-2 High Expansion Foam.

**5-2.1** When high expansion foam systems are installed in addition to automatic sprinklers, they shall be installed in accordance with NFPA 11A, the *Standard for Medium and High Expansion Foam Systems*, except as modified by this chapter.

**5-2.2** When high expansion foam systems are installed, sprinkler discharge design density can be reduced to not less than 0.25 gpm/sq ft [(10 L/min)/m<sup>2</sup>] with a minimum operating area of 2,000 sq ft (186 m<sup>2</sup>).

**5-2.3** High expansion foam systems shall be automatic in operation.

## 5-3 Water Supplies.

**5-3.1** Water supplies shall be capable of delivering the total demand of sprinklers plus hose streams plus high expansion foam systems where provided for a minimum of 2 hours.

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

## 5-4 Manual Inside Protection.

**5-4.1 Small Hose Systems.** Small hose lines (1 ½ in.) 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, the *Standard for Portable Fire Extinguishers*. Up to one-half of the required complement of portable fire extinguishers for Class A fires may be omitted in storage areas where fixed, 1 ½ in. hose lines are available to reach all portions of the storage area.

**5-5 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 Private Fire Service Mains and Their Appurtenances*.

## 5-6 Fire Organization.

**5-6.1** 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.

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

- (a) Maintaining the security of the premises.
- (b) Means of summoning outside aid immediately, in an emergency.

(c) Use of hand extinguishers and small (1 ½ in.) hose lines 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 system is turned off so that 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.

NOTE: Information on emergency organization is given in the following publications:

NFPA Industrial Fire Brigade Training Manual.

NFPA 27, *Recommendations for the Organization, Training and Equipment of Private Fire Brigades*.

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

**5-7 Alarm Service.** Central station, auxiliary, remote station, or proprietary sprinkler waterflow alarm shall be provided. (See NFPA 71, *Standard for the Installation, Maintenance and Use of Central Station Signaling Systems*; NFPA 72A, *Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems*; NFPA 72B, *Standard for the Installation, Maintenance and Use of Auxiliary Protective Signaling Systems*; NFPA 72C, *Standard for the Installation, Maintenance and Use of Remote Station Protective Signaling Systems*; and NFPA 72D, *Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems*.)

*Exception: Local waterflow alarm may be acceptable where recorded guard service is provided.*

## Chapter 6 Mandatory Referenced Publications

**6-1** This chapter lists publications referenced within this document which, in whole or in part, are part of the requirements of this document.

**6-1.1 NFPA Publications.** This standard makes reference to the following NFPA standards and the year dates shown indicate the latest edition available. They are available from the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 10-1981, *Standard for Portable Fire Extinguishers*

NFPA 11A-1983, *Standard for Medium and High Expansion Foam Systems*

NFPA 13-1983, *Standard for the Installation of Sprinkler Systems*

NFPA 14-1983, *Standard for the Installation of Standpipe and Hose Systems*

NFPA 71-1982, *Standard for the Installation, Maintenance and Use of Central Station Signaling Systems*

NFPA 72A-1979, *Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm and Supervisory Service*

NFPA 72B-1979, *Standard for the Installation, Maintenance and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service*

NFPA 72C-1982, *Standard for the Installation, Maintenance and Use of Remote Station Protective Signaling Systems*

NFPA 72D-1979, *Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems*

NFPA 91-1983, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying*

NFPA 220-1979, *Standard on Types of Building Construction*

### 6-1.2 Other Publications.

ASTM E380-1978, *Standard for Metric Practice, American Society for Testing and Materials*, 1916 Race Street, Philadelphia, PA 19103

## Appendix A

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

**A-1-1.2 Existing Storage Facilities.** Sprinkler systems protecting existing roll paper storage facilities may be evaluated in accordance with Table A-1-1.2. While fire may be controlled by the protection shown in Table A-1-1.2 greater damage may occur where lesser protection is stipulated in Table A-1-1.2 than that specified in Table 5-1.3.

**A-1-1.3.1** Sprinkler design criteria for horizontal storage of roll paper from 10 ft to 30 ft (3 m to 9 m) high in buildings or structures with roof or ceilings up to 35 ft (10.5 m) should be in accordance with Table A-1-1.2, Closed Array.

**A-1-1.3.5** Protection requirements for soft lightweight tissue paper have not yet been developed. Fire tests have been conducted on 20 ft (6 m) and 25 ft (7.6 m) high vertical storage of tissue with 10 ft (3 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 run using  $\frac{1}{2}$  in. 286°F (13.5 mm, 141°C) sprinklers were used on a 100 sq ft (9.3 m<sup>2</sup>) spacing and at constant pressures of 14 psi, 60 psi, and 95 psi (97, 414 and 655 kPa, respectively). One test was run using 0.64 in. 286°F (16.3 mm 141°C) sprinklers on 9100 sq ft (9.3 m<sup>2</sup>) 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 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 constant pressure (655 kPa), 20 ft (6 m) high decaying pressure and large-drop test. Water absorption and pile instability caused pile collapse in all tests. This characteristic must be considered when manually attacking a fire in tissue storage occupancies. A summary of these fire tests can be found in Appendix B. Available fire experience in roll tissue storage occupancies does not correlate well with the constant pressure

Table A-1.1.2 Design Density/Area of Application Chart

Storage Height (ft)	Clearance (ft)	Heavy Weight					Medium Weight			
		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	.2/2000	.2/2000	.2/2000	.25/2000	.25/2000	.2/2000	.25/2000	.3/2000	.3/2000
10	> 5	.2/2000	.2/2000	.2/2000	.25/2500	.25/2500	.2/2000	.25/2000	.3/2000	.3/2000
15	≤ 5	.25/2000	.25/2000	.25/2500	.3/2500	.3/3000	.25/2000	.3/2000	.45/2500	.45/2500
15	> 5	.25/2000	.25/2000	.25/2500	.3/3000	.3/3500	.25/2000	.3/2500	.45/3000	.45/3000
20	≤ 5	.3/2000	.3/2000	.3/2500	.45/3000	.45/3500	.3/2000	.45/2500	.6/2500	.6/2500
20	> 5	.3/2000	.3/2500	.3/3000	.45/3500	.45/4000	.3/2500	.45/3000	.6/3000	.6/3000
25	≤ 5	.45/2500	.45/3000	.45/3500	.6/2500	.6/3000	.45/3000	.6/3000	.75/2500	.75/2500
25	> 5	.45/3000	.45/3500	.45/4000	.6/3000	.6/3500	.45/3500	.6/3500	.75/3000	.75/3000
30	≤ 5	.6/2500	.6/3000	.6/3000	.75/2500	.75/3000	.6/4000	.75/3000	.75/3500	.75/3500

NOTE: Densities and/or areas may be interpolated between any 5 ft storage height increment.

For SI Units: 1 ft = 0.3048 m; 1 gpm/ft<sup>2</sup> = 40.746 (L/min)/m<sup>2</sup>

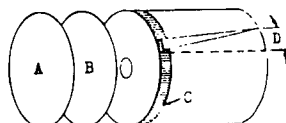
full-scale fire tests regarding the number of sprinklers operating and the extent of fire spread. Better correlation is noted with the decaying pressure tests. Thirteen fires reported in storage occupancies ranging from 10 to 20 ft (3 to 6 m) high and protected by wet pipe sprinkler systems ranging from ordinary hazard to 0.6 gpm per sq ft (2.4 L/M/Min) design densities were controlled with an average of 17 sprinkler heads. The maximum number of wet pipe sprinkler heads opening was 45 and the minimum was 5 vs. 88 and 26, respectively, in the constant pressure tests. Seventeen sprinkler heads opened in the 20 ft (6 m) high decaying pressure test. One actual fire in tissue storage provided by a dry system opened 143 sprinklers but was reported as controlled.

**A-1-1.3.6 Sprinkler design criteria for vertical storage of roll paper from 10 ft to 30 ft (3 to 9 m) high in buildings or structures with roofs or ceilings up to 35 ft (10.5 m) should be in accordance with Table A-1-1.2**

#### Wrapping and Capping Terms

<b>Wrapper</b>	General term for protective wrapping of sides and ends on roll.
Exterior Wrapper	
Body Wrapper	

<b>Body Wrap</b>	Wrapper placed around circumference of roll.
Sleeve Wrap	No heads or caps required.
Wrap — Do Not Cap	



<b>Heads</b>	Protection applied to the ends of rolls (A & B). Heads do not lap over the end of the roll.
Headers	

<b>Inside Heads</b>	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.
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<b>Outside Heads</b>	Protection applied to the ends of the rolls on the outside (A). This head is applied after the wrapper is crimped.
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<b>Edge Protectors</b>	Refers to extra padding to prevent damage to roll edges (C).
Edge Bands	

<b>Overwrap</b>	The distance the body wrap or wrapper overlaps itself (D).
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<b>Roll Cap</b>	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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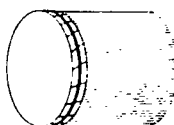


Figure A-1-3

**A-1-3 Wrapped Storage.** Rolls which are completely protected with a heavyweight kraft wrapper both sides and ends will have a reduced degree of fire hazard. Standard methods for wrapping and capping rolls are outlined in Figure A-1-3.

In some cases, rolls are protected with laminated wrappers using two sheets of heavy kraft with a high temperature wax laminate between. When applying this standard, the overall weight of wax laminated wrappers should be based on the basis weight per 1,000 sq ft (93 m<sup>2</sup>) of the outer sheet only rather than the combined basis weight of the outer and inner laminated wrapper sheets combined. The presence of a properly applied wrapper can have the effect of changing the class of a given paper to essentially that of the wrapper material.

**A-2 Paper Classification.** Paper can be soft or hard, thick or thin, 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 or greater measured on a sheet 1,000 sq ft in area. Stock with a basis weight less than 20 lb per 1,000 sq ft is normally categorized as paper. The basis weight of paper is usually measured on a sheet 3,000 sq ft 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<sup>1</sup>/<sub>2</sub>22" = 1,300 sq ft/Ream

Book Paper — 500 Sheets 25<sup>5</sup>/<sub>8</sub>8" = 3,300 sq ft/Ream

Index Paper — 500 Sheets 25.5/30.5" = 2,700 sq ft/Ream

Bristol Paper — 500 Sheets 22.5/35" = 2,734 sq ft/Ream

Tag Paper — 500 Sheets 24<sup>3</sup>/<sub>8</sub>36" = 3,000 sq ft/Ream

For purposes of this standard, all basis weights are given in weight in lb per 1,000 sq ft of paper. To determine the basis weight per 1,000 sq ft for papers measured on a sheet of different area, apply the following formula:

$$\text{Basis weight per 1,000 sq ft} = \frac{\text{Basis weight}}{\text{Measured area}} \times 1,000$$

Example: Determine the basis weight per 1,000 sq ft of 16 lb bond paper.

$$\frac{16 \text{ lb}}{1,300 \text{ sq ft}} \times 1,000 = 12.3 \text{ lb/1,000 sq ft}$$

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/1,000 sq ft Nominal Basis Weight

Newsprint — 10 lb/1,000 sq ft Nominal Basis Weight

Tissue — 5 lb/1,000 sq ft 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:

**Heavy Weight** — Basis weight of 20 lb per 1000 sq ft or greater.

**Medium Weight** — Basis weight of 10 lb to 20 lb per 1000 sq ft.

**Light Weight** — Basis weight of less than 10 lb per 1000 sq ft and tissues regardless of basis weight.

The various types of papers normally found in each of the three major categories are illustrated in the following table:

For SI Units

- 1 lb = 0.454 kg
- 1 in. = 25.4 mm
- 1 ft = 0.3048 m
- 1 ft<sup>2</sup> = 0.0929 m<sup>2</sup>

#### Paper Classes

Heavy Weight	Medium Weight	Light Weight
Linerboards	Bond & Reproduction	Toilet Tissue
Medium	Vellum	Towel Tissue
Kraft Roll Wrappers	Offset	Carbonizing Tissue
Milk Carton Board	Tablet	Cigarette
Folding Carton Board	Computer	Fruit Wrap
Bristol Board	Envelope	Onion Skin
Tag	Book	
Vellum Bristol Board	Label	
Index	Magazine	
Cupstock	Butcher	
Pulp Board	Bag	
	Newsprint (Unwrapped)	

**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.

It is desirable to provide walls or partitions 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, 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.

**A-4-1 Piling Procedures and Precautions.** Floor load design should take into account the added weight of water which could be absorbed during fire fighting operations by commodities such as tissue.

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

**A-4-3.2** Fire tests indicate that fire will not spread between piles which are separated by eight feet or greater aisles when sprinkler protection is provided in accordance with this standard. Main and cross aisles should be located opposite window or door openings in exterior walls. This is of particular importance in buildings where exterior openings are few.

**A-5-1.3** Large drop sprinklers can be used to protect roll paper storage except tissue and other lightweights.

Full-scale fire tests indicate that the following roll paper exposures can be protected by Factory Mutual approved large drop sprinkler systems designed as outlined:

- All classes of paper except tissue and lightweights when stored vertically in a standard array up to 20 ft (6 m) high in a building or structure with a roof or ceiling up to 30 ft (9 m) high.
- All arrays of banded, heavyweight paper stored vertically up to 26 ft (7.8 m) high in a building or structure with a roof or ceiling up to 60 ft (18 m) high.

Large drop sprinkler systems protecting roll paper storage should be wet pipe systems using 286°F (141°C) large drop sprinklers with a maximum spacing of 100 ft<sup>2</sup> (9.3 m<sup>2</sup>) and a minimum spacing of 80 ft<sup>2</sup> (7.5 m<sup>2</sup>).

Large drop sprinkler systems protecting roll paper storage should be hydraulically designed to provide a minimum of 50 psi (350 kPa) with the most hydraulically remote 15 sprinklers operating.

Factory Mutual System Loss Prevention Data Sheet 2-7 installation rules for sprinkler systems using large drop sprinklers can be used as a guideline for the installation of large drop sprinkler systems protecting roll paper storage except as modified above.

**A-5-1.3.3** Generally more sprinklers open in fires involving roll paper storage protected by sprinklers rated below the 286°F (141°C) (high temperature) range. A 67 percent increase in the design area should be considered.

**A-5-1.5** In a dry pipe system the 30 percent area increase should be compounded, i.e., 2000 ft<sup>2</sup> (1.67 for low temperature sprinkler) (1.3 for dry pipe systems) = total area (4343 ft<sup>2</sup>). Where dry pipe systems are used in existing installations, the areas of operation indicated by Table A-1-1.2 should be increased by 30 percent.

## Appendix B

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

Appendix B 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 sq ft (4.65 km sq) in area], of fire-resistive con-

struction, and contains a volume of approximately 2.25 million cu ft (63 761.86 m cu), the equivalent of a 100,000 sq ft (9.29 km sq) 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 (9.15 m) high and the west section is 60 ft (18.29 m) high.

The tissue test series was conducted in the 30 ft (9.15 m) section with clearances from top of storage to ceiling nominally 10 ft (3.05 m).

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

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

- (1) Fire spread 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 jumped to the target stacks.

Figure B-2 outlines the tissue test results.

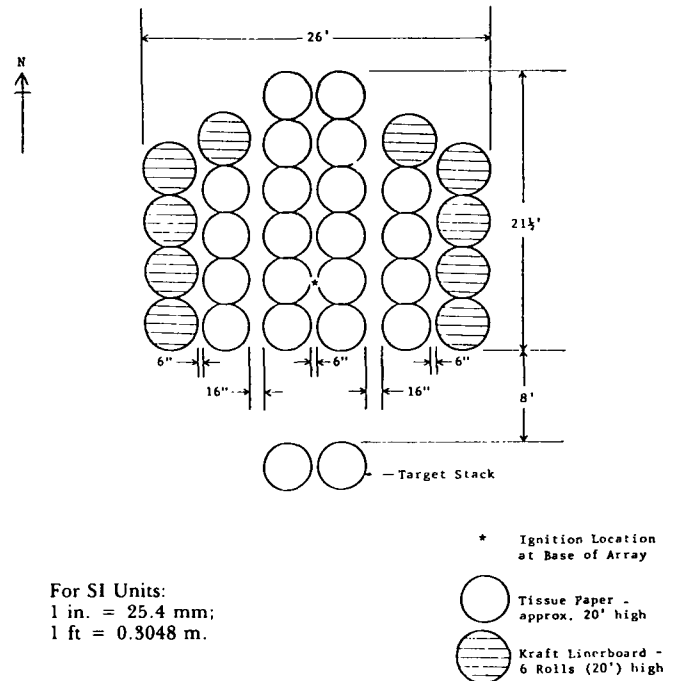


Figure B-1 Plan View of Typical Tissue Storage Array

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.)	21-10	20-0	21-8	18-6	19-10	25-3
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.)	8-2	10-0	8-4	11-6	5-2	4-9
Clearance to Sprinklers (ft-in.)	7-7	9-5	7-9	10-9	4-7	4-2
Sprinkler Orifice (in.)	17/32	17/32	17/32	0.64	17/32	17/32
Sprinkler Temp. Rating (°F)	280	280	280	280	280	280
Sprinkler Spacing (ft × ft)	10 × 10	10 × 10	10 × 10	10 × 10	10 × 10	10 × 10
Water Pressure (psi)	14**	60	95	50	138 Initial 102 Final	138 Initial 88 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)	2575**	1992	1993	4907	1363	2156
Sprinkler Demand Area (ft²)	8800	3300	2600	6400	1700	2900
Avg. Discharge Density (gpm/ft²)	0.29**	0.60	0.77	—	0.92 Initial 0.80 Final	0.96 Initial 0.74 Final
Max. One Min. Avg. Gas Temp. Over Ignition (°F)	1680**	1463	1634	1519	****	*****
Duration of High Temp. Within Acceptable Limits	No	Yes	Yes	Marginal	Yes	Yes
Max. One Min. Avg. Fire Plume Gas Velocity Over Ignition (ft/sec)	—	40.7	50.2	47.8	—	—
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 at 10 min						
***Phase III Tests Decaying Pressure						
****Max. Steel Temp. Over Ignition 341°F						
*****Max. Steel Temp. Over Ignition 132°F						

Figure B-2 Summary of Roll Paper Tissue Tests