

ROLL PAPER STORAGE

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1.0 SCOPE

This data sheet provides loss prevention guidelines for the protection of roll paper stored on the floor, on-end, on-side, held horizontally by axial rods on supporting structures, coated with non-wood-based substances, wrapped, on pallets, in racks, and stored outdoors

1.1 Changes

July 2014. The following major changes were made:

- A. Replaced the terms “control-mode density-area (CMDA) sprinkler,” “control-mode specific-application (CMSA) sprinkler” and “suppression-mode sprinkler” with “storage sprinkler.” This terminology is consistent with other FM Global storage data sheets.
- B. Changed all ceiling-level sprinkler protection options to a number of sprinklers at a minimum operating pressure (e.g., 20 sprinklers @ 50 psi [3.4 bar]).
- C. Revised the protection guidelines for heavy-, medium-, and light-weight rolled paper.
- D. Revised the recommendation for banding rolls: the banding of rolls is no longer required when the protection guidelines in this version of DS 8-21 are followed.
- E. Revised the protection recommendations for open array storage of medium-weight and heavy-weight paper.
- F. Revised the protection recommendations for dry sprinklers systems.

1.2 Superseded Information

This version supersedes all previous editions of Data Sheet 8-21.

2.0 LOSS PREVENTION RECOMMENDATIONS

Use FM Approved equipment, materials, and services whenever they are applicable and available. For a list of products and services that are FM Approved, see the *Approval Guide*, an online resource of FM Approvals.

2.1 Construction and Location

2.1.1 Construct storage facilities in accordance with the relevant FM Global property loss prevention data sheets. See the 1-series data sheets for guidelines relevant to the construction features of most storage facilities (e.g., Data Sheet 1-12, *Ceilings and Concealed Spaces*).

2.1.2 See Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, for recommendations related to the use of heat and smoke venting, draft curtains, and sloped ceilings in the presence of storage sprinklers.

2.1.3 Protection of building column and overhead steel is not necessary if all of the protection guidelines in this data sheet are met.

2.2 Protection

2.2.1 General

2.2.1.1 Base the paper classification on weight in lb/1000 ft² (g/m²) and texture, not the paper trade name. See Appendix A for definitions of paper weights and types.

2.2.1.2 Use FM Approved sprinklers. See Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, for installation guidelines for the sprinklers recommended in this data sheet, as well as their compatibility with the facility's construction features such as sloped ceilings, heat and smoke vents, and draft curtains.

Currently, FM Approved ceiling-level storage sprinklers have K-factor values ranging from 11.2 (160) to 25.2 (360). The following sprinklers are not FM Approved as ceiling-level storage sprinklers:

- K8.0 (K115) and smaller
- On-off sprinklers
- Extended-coverage light-hazard (ECLH) sprinklers

- Extended-coverage ordinary-hazard ECOH sprinklers

2.2.1.3 Use wet pipe sprinkler systems whenever possible for all types of roll paper storage

2.2.1.4 Dry Pipe Systems

2.2.1.4.1 When wet systems are impractical, use dry-pipe or preaction systems to protect light-weight paper stored on-side, and heavy-weight or medium-weight paper in any storage array.

2.2.1.4.2 Use 286°F (141°C) temperature-rated, standard response, upright sprinklers for dry sprinkler systems; design the system to have a maximum 40-second water delivery time based on the operation of the most remote four sprinklers (2 sprinklers on 2 lines).

2.2.1.4.3 Unless specified elsewhere, apply a 50% increase to the number of sprinklers recommended for a wet system, not to exceed 70 sprinklers.

2.2.1.4.4 Do not use gridded dry-pipe and gridded preaction systems. These systems result in delayed water delivery times.

2.2.1.4.5 Protect light-weight paper stored on-end with preaction systems when storage in heated areas is not possible. Design preaction systems to provide the same water delivery response as a wet system.

2.2.1.5 Base the protection for the storage area on the type of paper and storage variable that require the most protection within that storage area. If other commodities or a more-hazardous material are present in the same storage area as the roll paper, base the protection on the item requiring the most protection. Protect locations having mixed storage or several different storage arrangements for the greatest storage hazard.

2.2.2 Outdoor Storage of Roll Paper

Recommend separation distances from buildings to outdoor (yard) storage of roll paper using DS 1-20. Use the light/ordinary category in DS 1-20 for on-side roll paper, and the Storage category in DS 1-20 for on-end roll paper.

2.2.3 Roll Paper in Manufacturing Areas

2.2.3.1 Where sprinkler protection for the specific manufacturing occupancy does not meet the recommendations in Section 2.2.4, limit the storage to one of the following (this does not apply to manufacturing occupancies that are not sprinklered):

- A. Limit the in-process storage area of light-weight roll paper to 500 ft² (46 m²). Limit the storage of medium- and heavy-weight roll paper to 1000 ft² (93 m²). Separate these areas of paper from other combustibles by a minimum of 8 ft (2.4 m) wide aisles and limit the height to 5 ft (1.5 m).
- B. Limit the in-process storage area of any type of roll paper to 200 ft² (20 m²). Separate these areas from other combustibles by a minimum of 8 ft (2.4 m) wide aisles and limit the height to 10 ft (3 m).
- C. For stack heights up to 15 ft (4.5 m), limit the footprint to a maximum of four stacks and separate them from other combustibles by a minimum of 15 ft (4.5 m).

Although fire from the burning stacks may cause as many sprinklers to operate as a larger amount of burning paper, the fire spread will be limited unless other combustibles are nearby.

2.2.4 Indoor Roll Paper Stored in a Dedicated Storage Area

2.2.4.1 General Protection Guidelines

This section provides recommendations for determining protection for specialty varieties of paper and methods of paper storage.

2.2.4.1.1 Rolls Wrapped in Plastic

Protect plastic-wrapped roll paper the same as unwrapped paper. Design the sprinkler protection for plastic-wrapped roll paper based on the paper itself, without any adjustment for the plastic wrapping. This also applies where there is a layer (or several layers) of expanded plastic padding between the outer plastic layer and the paper; in most cases, the total thickness of expanded plastic will not exceed 3/8 in. (9.5 mm).

2.2.4.1.2 Special Paper Types

A. Plastic and wax-coated or plastic laminate heavy-weight or medium-weight roll paper require additional protection. "Plastic-coated" means the paper has a thin coating such as that found on a milk carton. Increase the number of sprinklers by 25% (up to a maximum of 70 sprinklers) when plastic or wax-coated or plastic laminate paper is being protected. No increase is required for pendent sprinklers with K-factors greater than 11.2 (160).

B. Treat asphalt-laminated paper as plastic-coated heavy-weight paper. Asphalt-laminated paper is made up of two or more sheets of paper bonded together with one or more layers of asphalt.

C. Treat raw paper-based roofing felt (without asphalt) as a heavy-weight paper. Roofing felt, in this case, is porous, soft paper made from cotton and wool rags and paper stock.

D. Protect solid piled or palletized baled pulp as a Class 3 commodity in accordance with Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*.

2.2.4.1.3 Rack Storage of Roll Paper

2.2.4.1.3.1 Protect rack storage of medium-weight and heavy-weight roll paper as a Class 3 Commodity. Fire in on-end storage of roll paper behaves differently than it does when the rolls are stored in racks. Fire in on-end storage produces a continuous, strong fire plume that may result in many sprinklers operating. Protect rack storage of light-weight paper stored on-end or on-side as a cartoned unexpanded plastic commodity. Refer to Data Sheet 8-9 for protection guidelines.

2.2.4.1.4 Axial Rod or Tambour Storage

A. Protect heavy-weight or medium-weight roll paper on horizontal axial rods as on-end, open array roll paper.

B. Limit storage height to 20 ft (6.1 m). If the storage height exceeds 20 ft (6.1 m), provide FM Approved in-rack sprinklers at not more than 12 ft (3.7 m) vertical intervals. When only one level of in-rack sprinklers is provided, design in-rack sprinkler water demand for eight sprinklers at a minimum of 30 gpm (115 L/min) each. When two or more levels are provided, design in-rack sprinkler water demand for 14 sprinklers at a minimum of 30 gpm (115 L/min) each. When in-rack sprinklers are used, design the ceiling demand based on the height of storage above the highest level of in-rack sprinklers, not to exceed 20 ft (6.1 m). If in-rack sprinklers are used, install them with a horizontal spacing not to exceed 8 ft (2.4 m).

2.2.4.1.5 On-Floor, On-End Storage Using Wood or Plastic Pallets

When roll paper is stored on pallets, base protection on an open array arrangement.

2.2.4.2 Protection of Light-Weight Roll Paper Stored On-Floor

2.2.4.2.1 Refer to Table 1 for wet system protection of light-weight paper using storage sprinklers where the paper is stacked on-side, or on-end in a standard or closed array.

2.2.4.2.2 In addition to the protection recommendations listed in Table 1, on-side storage of light-weight roll paper up to 20 ft (6.0 m) high under a maximum ceiling height of 25 ft (7.6 m) may be protected with the following: 50 K11.2 (K160) sprinklers at 10 psi (0.7 bar) for a wet system, or 65 K11.2 (K160) sprinklers at 10 psi (0.7 bar) for a dry system.

2.2.4.2.3 If the storage is arranged in an open array and the recommended number of sprinklers is 16, increase the number of sprinklers recommended in Table 1 by 100%. When the recommendation is for more than 16 sprinklers increase the number of sprinklers recommended in Table 1 by 50%. In either case do not exceed a maximum of 70 sprinklers.

Example 1: Using Table 1, under a 30 ft (9.1 m) high ceiling, 25 ft (7.6 m) of light-weight paper protected with upright K11.2 (K160) sprinklers requires 60 sprinklers @ 30 psi (2.1 bar) + 50% of the 60 sprinklers = 90 sprinklers @ 30 psi (2.1 bar). In this case, because the design calls for more than 70 sprinklers, the adjusted sprinkler design becomes 70 sprinklers @ 30 psi (2.1 bar) for open array.

Example 2: Using Table 1, under a 30 ft (9.1 m) high ceiling, 25 ft (7.6 m) of light-weight paper protected with pendent K14.0 (K200) sprinklers requires 16 sprinklers @ 75 psi (5.1 bar) + 100% of the 16 sprinklers = 32 sprinklers @ 75 psi (5.1 bar) for open array.

2.2.4.2.4 When wet pipe sprinkler systems are impractical, refer to Section 2.2.1.4 for general dry pipe system guidance and Section 2.2.4.2.5 that recommends adding a layer of heavy weight paper which allows the light weight paper to be treated as heavyweight paper.

2.2.4.2.5 Rolls of light-weight paper can be protected as heavy-weight paper provided one of the following wrapping methods is used:

- A. The sides and ends are wrapped with a minimum of a single layer of heavy-weight paper weighing at least 40 lb/1000 ft² (200 g/m²).
- B. The sides and ends are wrapped with a minimum of two layers of heavy-weight paper weighing at least 20 lb/1000 ft² (100 g/m²).
- C. The sides are wrapped with a minimum of a single layer of heavy-weight paper weighing at least 40 lb/1000 ft² (200 g/m²) and are banded with metal straps
- D. The sides are wrapped with a minimum of two layers of heavy-weight paper weighing at least 20 lb/1000 ft² (100g/m²) and are banded with metal straps.

Table 1. Light-Weight Roll Paper Storage Protection

Protection for On-Side, ¹ On-End in a Standard or Closed Array, Banded or Not Banded ^{2,3,4}							
Maximum Ceiling Height, ft (m)	Maximum Storage Height, ft (m)	Wet Sprinkler System, Number of Sprinklers @ psi (bar) ⁵					
		Pendent, 160°F (70°C), Standard or Quick Response			Upright, 160°F (70°C), Standard or Quick Response		
		K11.2 (K160)	K14.0 (K200)	K16.8 (K240)	K11.2 (K160)	K14.0 (K200)	K16.8 (K240)
30 (9.1)	15 (4.5)	40 @ 30 (2.1)	16 @ 50 (3.4)	16 @ 35 (2.4)	40 @ 30 (2.1)	40 @ 20 (1.4)	40 @ 15 (1.0)
30 (9.1)	25 (7.6)	60 @ 30 (2.1)	16 @ 75 (5.1)	16 @ 50 (3.4)	60 @ 30 (2.1)	60 @ 20 (1.4)	60 @ 15 (1.0)
40 (12.2)	25 (7.6)		25 @ 75 (5.1)	25 @ 50 (3.4)			

¹In addition to the protection recommendations listed in Table 1, on-side storage of light-weight roll paper up to 20 ft (6.0 m) high under a maximum ceiling height of 25 ft (7.6 m) may be protected with the following: 50 K11.2 (K160) sprinklers at 10 psi (0.7 bar) for a wet system, or 65 K11.2 (K160) sprinklers at 10 psi (0.7 bar) for a dry system.

² Refer to Appendix A for definitions of array types.

³ Refer to Section 2.2.4.2.3 for open array recommendations.

⁴ When installing sprinklers with K-factors greater than K16.8 (K240), recommend the same number of sprinklers specified for K16.8 (K240) sprinklers. Recommend a sprinkler pressure with an equivalent flow provided that is recommended with the K16.8 (K240). Make sure the pressure specified does not fall below the minimum pressure for which the sprinkler is FM Approved.

⁵ Refer to Section 2.2.1.4 for dry-pipe sprinkler systems.

2.2.4.3 Protection of Medium-Weight Rolled Paper Stored On-Floor

2.2.4.3.1 Refer to Table 2 for wet system protection of medium-weight paper using storage sprinklers where the paper is stacked on-side or on-end in a standard array or closed array.

2.2.4.3.2 If the storage is arranged in an open array and the recommended number of sprinklers is 12, increase the number of sprinklers recommended in Table 2 by 100%. When the recommendation is for more than 12 sprinklers increase the number of sprinklers recommended in Table 2 by 50%. In either case do not exceed a maximum of 70 sprinklers.

Example 1: Using Table 2, under a 30 ft (9.1 m) high ceiling, 20 ft (6.1 m) of medium-weight paper protected with upright K11.2 (K160) sprinklers requires 40 sprinklers @ 30 psi (2.1 bar) + 50% of the 40 sprinklers = 60 sprinklers @ 30 psi (2.1 bar) for open array.

Example 2: Using Table 2, under a 30 ft (9.1 m) high ceiling, 20 ft (6.1 m) of medium-weight paper protected with pendent K14.0 (K200) sprinklers requires 12 sprinklers @ 75 psi (5.1 bar) + 100% of the 12 sprinklers = 24 sprinklers @ 75 psi (5.1 bar) for open array.

2.2.4.3.3 When wet pipe sprinkler systems are impractical, refer to Section 2.2.1.4 for general dry-pipe system guidance and Section 2.2.4.3.5, which recommends adding a layer of heavy-weight paper that allows the medium-weight paper to be treated as heavy-weight paper.

2.2.4.3.4 If the storage is in an open array protected with a dry sprinkler system, first increase the number of sprinklers recommended in Table 2 by 100% for pendent K14 (K200) or larger, or 50% for all other sprinkler types, then increase the results of that by 50%, not to exceed a maximum of 70 sprinklers.

Example 1: Using Table 2, under a 30 ft (9.1 m) high ceiling, 20 ft (6.1 m) of medium-weight paper requires 40 K11.2 (K160) sprinklers @ 30 psi (2.1 bar) + 50% of 40 sprinklers = 60 sprinklers @ 30 psi (2.1 bar) for

the open array, then 60 sprinklers @ 30 psi (2.1 bar) + 50% of 60 = 90 sprinklers @ 30 psi (2.1 bar) for the dry system. In this case, because the design calls for more than 70 sprinklers, the adjusted sprinkler design becomes 70 sprinklers @ 30 psi (2.1 bar).

Example 2: Using Table 2, under a 30 ft (9.1 m) high ceiling, 20 ft (6.1 m) of medium-weight paper requires 12 K14 sprinklers @ 75 psi (5.1 bar) + 100% of 12 sprinklers = 24 sprinklers @ 75 psi (5.1 bar) for the open array, then 24 sprinklers @ 75 psi (5.1 bar) + 50% of 24 = 36 sprinklers @ 75 psi (5.1 bar) for the dry system.

2.2.4.3.5 Rolls of medium-weight paper can be protected as heavy-weight paper provided one of the following wrapping methods is used.

- A. The sides and ends are wrapped with a minimum of a single layer of heavy-weight paper weighing at least 40 lb/1000 ft² (200 g/m²).
- B. The sides and ends are wrapped with a minimum of two layers of heavy-weight paper weighing at least 20 lb/1000 ft² (100 g/m²).
- C. The sides are wrapped with a minimum of a single layer of heavy-weight paper weighing at least 40 lb/1000 ft² (200 g/m²) and are banded with metal straps (non-metal straps may be used if made from a material that will remain in place if the paper is burning.)
- D. The sides are wrapped with a minimum of two layers of heavy-weight paper weighing at least 20 lb/1000 ft² (100 g/m²) and are banded with metal straps (non-metal straps may be used if made from a material that will remain in place if the paper is burning.)

Table 2. Medium-Weight Roll Paper Storage Protection

Protection for On-Side, On-End in a Standard or Closed Array, Banded or Not Banded ^{1,2,3}							
Maximum Ceiling Height, ft (m)	Maximum Storage Height, ft (m)	Wet Sprinkler System, Number of Sprinklers @ psi (bar) ⁴					
		Pendent, 160°F (70°C), Standard or Quick Response			Upright, 160°F (70°C), Standard or Quick Response		
		K11.2 (K160)	K14.0 (K200)	K16.8 (K240)	K11.2 (K160)	K14.0 (K200)	K16.8 (K240)
20 (6.0)	15 (4.5)	30 @ 15 (1.0)	12 @ 50 (3.4)	12 @ 35 (2.4)	30 @ 15 (1.0)	30 @ 10 (0.7)	30 @ 10 (0.7)
25 (7.6)	20 (6.0)	35 @ 30 (2.1)	12 @ 50 (3.4)	12 @ 35 (2.4)	35 @ 30 (2.1)	35 @ 20 (1.4)	35 @ 15 (1.0)
30 (9.1)	25 (7.6)	40 @ 30 (2.1)	12 @ 75 (5.1)	12 @ 50 (3.4)	40 @ 30 (2.1)	40 @ 20 (1.4)	40 @ 15 (1.0)
35 (10.6)	30 (9.1)	45 @ 30 (2.1)	12 @ 75 (5.1)	12 @ 50 (3.4)	45 @ 30 (2.1)		
40 (12.2)	20 (6.0)		12 @ 75 (5.1)	12 @ 50 (3.4)			
40 (12.2)	30 (9.1)		25 @ 75 (5.1)	25 @ 50 (3.4)			

¹ Refer to Appendix A for definitions of array types.

² Refer to Section 2.2.4.3.2 for open array recommendations.

³ When installing sprinklers with K-factors greater than K16.8 (K240), recommend the same number of sprinklers specified for K16.8 (K240) sprinklers. Use a sprinkler pressure with an equivalent flow provided that is recommended with the K16.8 (K240). Make sure the pressure specified does not fall below the minimum pressure for which the sprinkler is FM Approved.

⁴ Refer to Section 2.2.1.4 for dry-pipe sprinkler systems.

2.2.4.4 Protection of Heavy-Weight Rolled Paper Stored On-Floor

2.2.4.4.1 Refer to Table 3 for wet system protection of heavy-weight paper using storage sprinklers where the paper is stacked on-side or on-end in a standard or closed array.

2.2.4.4.2 If the storage is arranged in an open array and the recommended number of sprinklers is 12, increase the number of sprinklers recommended in Table 3 by 100%. When the recommendation is for more than 12 sprinklers increase the number of sprinklers recommended in Table 3 by 50%. In either case do not exceed a maximum of 70 sprinklers.

Example 1: Using Table 3, under a 30 ft (9.1 m) high ceiling, 25 ft (7.6 m) of heavy-weight paper requires 35 upright K11.2 (K160) sprinklers @ 15 psi (1.0 bar) + 50% of 35 = 53 sprinklers @ 15 psi (1.0 bar).

Example 2: Using Table 3, under a 30 ft (9.1 m) high ceiling, 25 ft (7.6 m) of heavy-weight paper requires 12 pendent K14 (K200) sprinklers @ 50 psi (3.4 bar) + 100% of 12 = 24 sprinklers @ 50 psi (3.4 bar).

2.2.4.4.3 When wet pipe sprinkler systems are impractical, refer to Section 2.2.1.4.

2.2.4.4.4 If the storage is in an open array and protected with a dry sprinkler system, first increase the number of sprinklers recommended in Table 3 by 100% for pendent K14 (K200) or greater, or 50% for all other sprinkler types, then increase the results of that by 50% for the dry system, not to exceed a maximum of 70 sprinklers.

Example 1: Using Table 3, under a 30 ft (9.1 m) high ceiling, 25 ft (7.6 m) of heavy-weight paper requires 35 K11.2 (K160) sprinklers @ 15 psi (1.0 bar) + 50% of 35 sprinklers = 53 sprinklers @ 15 psi (1.0 bar) for the open array, then 53 sprinklers @ 15 psi (1.0 bar) + 50% of 53 = 80 sprinklers @ 15 psi (1.0 bar) for the dry system. In this case because the design calls for more than 70 sprinklers, the adjusted sprinkler design becomes 70 sprinklers @ 15 psi (2.1 bar).

Example 2: Using Table 3, under a 30 ft (9.1 m) high ceiling, 25 ft (7.6 m) of heavy-weight paper requires 12 pendent K14 (K200) sprinklers @ 50 psi (3.4 bar) + 100% of 12 sprinklers = 24 sprinklers @ 50 psi (3.4 bar) for the open array, then 24 sprinklers @ 50 psi (3.4 bar) + 50% of 24 = 36 sprinklers @ 50 psi (3.4 bar) for the dry system.

Table 3. Heavy-Weight Roll Paper Storage Protection

Protection for On-Side, ¹ On-End in a Standard or Closed Array, Banded or Not Banded ^{2,3}							
Maximum Ceiling Height, ft (m)	Maximum Storage Height, ft (m)	Wet Sprinkler System, Number of Sprinklers @ psi (bar) ⁴					
		Pendent, 160°F (70°C), Standard or Quick Response			Upright, 160°F (70°C), Standard or Quick Response		
		K11.2 (K160)	K14.0 (K200)	K16.8 (K240)	K11.2 (K160)	K14.0 (K200)	K16.8 (K240)
20 (6.0)	15 (4.5)	20 @ 7 (0.5)	20 @ 7 (0.5) or 12 @ 50 (3.4)	20 @ 7 (0.5)	20 @ 7 (0.5)	20 @ 7 (0.5)	20 @ 7 (0.5)
25 (7.6)	20 (6.0)	25 @ 7 (0.5)	25 @ 7 (0.5) or 12 @ 50 (3.4)	25 @ 7 (0.5)	25 @ 7 (0.5)	25 @ 7 (0.5)	25 @ 7 (0.5)
30 (9.1)	25 (7.6)	35 @ 15 (1.0)	12 @ 50 (3.4)	12 @ 35 (2.4)	35 @ 15 (1.0)	35 @ 10 (0.7)	35 @ 7 (0.5)
40 (12.2)	25 (7.6)	25 @ 50 (3.4)	12 @ 75 (5.1)	12 @ 50 (3.4)	25 @ 50 (3.4)	25 @ 35 (2.4)	25 @ 25 (1.7)
60 (18.3)	30 (9.1)	Dry sprinkler system only - 30 @ 50 (3.4), K16.8 (K240), 286°F (141°C) temperature rated, standard response, upright sprinklers. Do not apply Note 4.					
60 (18.3)	42 (12.8)			20 @ 50 (3.4)			

¹ Refer to Appendix A for definition of array type.

² Refer to section 2.2.4.4.2 for open array recommendations.

³ When installing sprinklers with K-factors greater than K16.8 (K240) recommend the same number of sprinkler specified for K16.8 (K240) sprinklers. Use a sprinkler pressure with an equivalent flow provided that is recommended with the K16.8 (K240). Make sure the pressure specified does not fall below the minimum pressure for which the sprinkler is FM Approved.

⁴ Refer to section 2.2.1.4 for dry pipe sprinkler systems.

2.2.4.5 Small Hose Connections

2.2.4.5.1 Where trained personnel are allowed to use small hose lines, provide permanent 1.5 in. (38 mm) small hose lines not exceeding 100 ft (30.0 m) in length, and capable of reaching all roll paper storage areas. Supply small hose lines by any of the following means:

- A. A separate piping system for small hose stations
- B. Valved hose connections on sprinkler risers, provided the connections are made upstream from all sprinkler control valves
- C. Adjacent sprinkler systems
- D. Ceiling sprinklers in the protected area when separately controlled in-rack sprinklers are provided

It may be preferable from an operations standpoint to locate hose stations on the ends of racks or storage piles rather than in aisles.

2.2.4.6 Hose Demand and System Duration

Allow at least 500 gpm (1890 L/min) for hose stream demand and a sprinkler system duration of at least 120 minutes. Add the hose stream allowance to the sprinkler demand at the point of connection.

3.0 SUPPORT FOR RECOMMENDATION

3.1 Damage Safeguards

Refer to Data Sheet 1-24, *Protection Against Liquid Damage*.

3.2 Banding of Roll Paper

3.2.1 Protection recommendations given in Section 2.0 are applicable whether or not the rolls are banded when the paper is arranged in an open, closed, or standard array. Metal bands, steel baling wire, or bands of material that will remain in place if the roll catches fire may help keep the outside layers of paper from unwinding and peeling, reducing the overall fire and water damage.

3.3 Quick Response and Standard Response Sprinklers

3.3.1 Wet sprinkler system protection recommended in Section 2.0 notes quick response (QR) and standard response (SR) sprinklers are equal for all paper types stored on-end. QR and SR sprinklers perform similarly in full-scale fire tests with roll paper stored on-end. The rapid rate of fire development combined with the ceiling jet velocities associated with on-end storage of rolled paper indicate there is little difference in performance with similar sprinklers having QR or SR thermal elements.

4.0 REFERENCES

4.1 FM Global

Data Sheet 1-20, *Protection Against Exterior Fire Exposure*

Data Sheet 1-24, *Protection Against Liquid Damage* Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*

Data Sheet 2-81, *Fire Protection Systems Inspection, Testing and Maintenance and Fire Loss Prevention Inspections*

Data Sheet 3-26, *Fire Protection Water Demand for Nonstorage Sprinklered Properties*

Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*

Data Sheet 8-22, *Storage of Baled Waste Paper*

4.2 Other

National Fire Protection Association (NFPA). NFPA 13, *Installation of Sprinkler Systems*.

APPENDIX A GLOSSARY OF TERMS

Banded paper: Roll paper that is provided with one or more circumferential metal straps or wires to prevent unwinding.

Closed array: An on-end storage arrangement of roll paper in which stack spacing in all directions is less than 4 in. (100 mm).

Control-mode density-area sprinkler: Design based on water density over a specified area of coverage. These sprinklers are expected to pre-wet combustibles, cool the ceiling area over the fire, and cool the ceiling area adjacent to the fire to prevent an excessive number of sprinklers from opening. The nominal discharge coefficient (K-factor) of control-mode density-area sprinklers could be 5.6 (80), 8.0 (115), 11.2 (160), or 14.0 (200) gal/min/(psi)^{1/2} (L/min/bar^{1/2}).

Control-mode specific-application sprinkler: Design is based on a specific number of sprinklers and minimum water supply pressure. These sprinklers are expected to pre-wet combustibles, cool the ceiling area over the fire, and cool the ceiling area adjacent to the fire to prevent an excessive number of sprinklers from opening. The nominal discharge coefficient (K-factor) of control-mode specific-application sprinklers could be 11.2 (160) or 16.8 (240) gal/min/(psi)^{1/2} (L/min/bar^{1/2}).

FM Approved: A product or service that has satisfied the criteria for FM Approval. Refer to the *Approval Guide*, an online resource of FM Approvals, for a complete listing of products and services that are FM Approved.

Heavy-weight paper: Paper that weighs 20 lb/1000 ft² (100 g/m²) or more. Examples may include liner board, corrugating medium, Bristol board, vellum Bristol board, index, cup board, tag, folding box board, and kraft roll wrappers.

Heavy-weight wrapped paper: Roll paper that is provided with a heavy-weight wrapper covering the sides and both ends of the roll.

Light-weight paper: Paper with an absorbent, fibrous, or gauzy texture regardless of weight. Examples include toilet tissue, napkins, crepe, facial tissue, and paper towels. Also included is paper with a hard, smooth, or glossy finish that weighs less than 10 lb/1000 ft² (50 g/m²). Examples include onion skin, catalog paper, fruit wrap, carbon paper, and cigarette paper. Some newsprint may weigh as little as 8.6 lb/1000 ft² (40 g/m²).

Medium-weight paper: Paper with a hard, smooth, or glossy finish that weighs less than 20 lb/1000 ft² (100 g/m²) but not less than 10 lb/1000 ft² (50 g/m²). Examples may include, newsprint, tablet, computer, envelope, book, butcher, label, bond, magazine, vellum, and bag paper.

Nonstorage sprinkler: A sprinkler that has been categorized by FM Global as acceptable for protecting nonstorage-type occupancies and/or any other low to moderate heat-release type fires as permitted in an occupancy-specific data sheet.

Open array: An on-end storage arrangement of roll paper in which stack spacing in all directions is 4 in. (100 mm) or more. Open array storage is usually found where rolls are not uniform in diameter, or in locations that use overhead cranes to move the rolls.

Plastic wrapped: A wrapping method consisting of a plastic sheet or bag enclosing the sides and ends of roll paper.

Sprinkler clearance: Clear space maintained between the top of storage and ceiling sprinkler deflectors. Clearance is measured to the sprinklers closest to the peak of sloped roofs.

Standard array: An on-end storage arrangement of roll paper in which uniform diameter rolls are in vertical stacks butted in one direction and separated by 4 in. (100 mm) or more in the other direction. The standard array is usually found where rolls are uniform in diameter and clamp trucks are used.

Storage height: Maximum height of storage measured from the floor to the top-most level of storage. For new or proposed buildings or structures, storage height is the maximum distance above the floor that roll paper can be stored considering the size of the rolls, limitations of mechanical handling equipment, and a minimum 3 ft (0.9 m) clearance between the top of storage and ceiling sprinkler deflectors.

Storage sprinkler: A sprinkler that has been categorized by FM Global as acceptable for protecting storage-type occupancies and/or any other high heat-release type fires as permitted in an occupancy-specific data sheet.

Suppression mode: Design is based on a specific number of sprinklers operating at a minimum water supply pressure. The sprinklers directly over the fire are expected to operate early. Suppression-mode sprinklers are designed to discharge large amounts of water and suppress the fire. The nominal discharge coefficient (K-factor) of suppression mode sprinklers could be 14.0 (200) or 25.2 (360) gal/min/(psi)^{1/2} (L/min/bar^{1/2}).

APPENDIX B DOCUMENT REVISION HISTORY

July 2014. The following major changes were made:

- A. Replaced the terms “control-mode density-area (CMDA) sprinkler,” “control-mode specific-application (CMSA) sprinkler” and “suppression-mode sprinkler” with “storage sprinkler.” This terminology is consistent with other FM Global storage data sheets.
- B. Changed all ceiling-level sprinkler protection options to a number of sprinklers at a minimum operating pressure (e.g., 20 sprinklers @ 50 psi [3.4 bar]).
- C. Revised the protection guidelines for heavy-, medium-, and light-weight rolled paper.
- D. Revised the recommendation for banding rolls: the banding of rolls is no longer required when the protection guidelines in this version of DS 8-21 are followed.

E. Revised the protection recommendations for open array storage of medium-weight and heavy-weight paper.

F. Revised the protection recommendations for dry sprinklers systems.

March 2013. The following major changes were made:

A. The terms “control mode density area (CMDA) sprinkler,” “control mode specific application (CMSA) sprinkler” and “suppression mode sprinkler” have been replaced with “storage sprinkler.” This terminology is consistent with other FM Global storage data sheets.

B. All ceiling-level sprinkler protection options are now given as a number of sprinklers at a minimum operating pressure (e.g., 20 sprinklers @ 50 psi [3.4 bar]).

C. Protection guidelines for heavy, medium and light-weight rolled paper stored in a standard or closed array have been revised.

D. Banding of rolls is not required when the protection guidelines in this 2014 revision of 8-21 are followed.

January 2013 (Interim Revision). A protection option for heavyweight paper stored 42 ft (12.8 m) of on-end, standard array (banded or unbanded) under ceilings up to and including 60 ft (18.3 m) high when installed on a wet pipe system has been added to Section 2.3.5. In addition minor editorial changes and clarifications have been made.

May 2008. Clarification was made to Note 1 in Table 8.

January 2008. Specify storage arrangements that are acceptable for the protection recommendations in Table 8, “Heavyweight Roll Paper Storage Protection, Control Mode, Specific Application Sprinkler.”

January 2003. Recommendations provided for the protection of medium and heavyweight paper with upright suppression mode sprinklers with a K-factor of 16.8 (242). Loss history information was updated.

May 2002. Additional protection guidance was added to Table 7, *Heavyweight Paper Storage Protection*.

May 2001. Recommendations provided for the protection of medium and heavyweight paper with suppression mode sprinklers with a K-factor of 16.8.

January 2001. Additional information is provided to clarify the use of interpolation when determining the design area for heavy and mediumweight paper using control mode, density area sprinklers (sections 2.3.4.2 and 2.3.5.2).

September 2000. This revision of the data sheet includes the following significant changes:

1. Hose stream and total water demand recommendations have been simplified (section 2.3.7).
2. Sprinkler protection tables are subdivided by paper weight and sprinkler type. Within the tables the protection for storage height and building height are listed as a function of sprinkler type (sections 2.3.3, 2.3.4 and 2.3.5).
3. Automatic sprinklers are identified using new classifications. The classifications are: control mode (density/area), control mode (specific application) and suppression mode. Definitions and examples for the classifications are provided in Appendix A.
4. Recommendation for the protection of rack storage of roll paper have been added (section 2.3.1.4).

March 1991. Data Sheet was revised to include protection recommendations using suppression mode sprinklers and large drop (control mode — specific application) sprinklers. Additional guidelines were provided for axial rod storage.

November 1983. Data Sheet revised to include protection criteria based on three different paper classifications. Protection recommendations were provided for rolls wrapped in paper and plastic.

APPENDIX C FIRE BEHAVIOR IN ROLL PAPER STORAGE

C.1 General

The destruction of roll paper warehouses and loss of many tons of roll paper in yard storage have demonstrated that roll paper storage presents a serious fire hazard. The hazards are aggravated by material-handling methods and economic pressures that lead to increased storage heights and reduced aisle spaces.

If roll paper storage is inadequately protected, fire development and spread is unusually severe and rapid. Exposed building steel can quickly heat to temperatures at which it fails structurally. Excessive steel deflection can break sprinkler piping and deprive the building contents of fire protection at a time of maximum need. Wind and total absence of sprinkler protection make yard fires especially difficult to control.

Fire spreading up the side of a paper column quickly burns through the outer ply. Unless there is some arrangement to prevent it, paper then unwinds or peels from the rolls. Peeled material rapidly increases burning surfaces and spreads fire by contact with adjacent piles. Rolls continually shed outer layers wet by sprinkler discharge, exposing dry paper.

C.2 Paper Grades

Fire tests and loss experiences have shown that the weight or grade of paper can affect fire severity. Fires involving light-weight papers operate more sprinklers, create higher temperatures, and cause significantly more damage than do fires involving heavy-weight paper.

Medium-weight papers can exhibit more rapid flame spread than heavy-weight paper, but the fire hazard is not quite as severe as with light-weight paper.

Paper is sometimes measured in pounds per 1000 ft², 2600 ft², and 3000 ft² or per total area of a ream of paper (usually 500 sheets) or in g/m². It should be verified which method is used when classifying the paper at any location. For the purposes of this data sheet, all basis weights are given in lb/1000 ft² (g/m²).

Table 4 shows the base areas in ft² for the various kinds of paper that could be used in the paper industry. For example, given the weights shown on labels of roll paper stock in a printing plant, this is the weight of 500 sheets with dimensions of 17 × 22 in. (430 × 560 mm), which is a total area of 1298.6 ft² (120.7 m²). To convert this to a 1000 ft² (92.9 m²) basis:

X = the basis weight in lb shown on the label.

Y = 1298.6 ft², which is the area for the basis weight shown on the label used by that particular industry from Table 4 basis weight (lb/1000 ft²) = (X/Y) × 1000.

If X = 21 lb on the label, then:

basis weight (lb/1000 ft²) = (21/1298.6) × (1000) = 16 lb/1000 ft² (78 g/m²).

C.3 On-End Storage

On-end storage is more varied and more widely used than on-side storage. Roll paper is usually handled by using clamp or vacuum-clamp lift trucks or overhead cranes. Use of this equipment usually causes variation in vertical flue spaces.

Where clamp-jaw equipment is used, jaw clearance space of at least 4 in. (100 mm) is usual, resulting in an open or standard array storage arrangement. Rolls varying in diameter provide spaces between stacks that may reach several feet. Fire can grow rapidly in such storage; not only can paper peel freely, but air supply is favorable for burning in flue-like spaces. In addition, heat radiated and re-radiated from one stack to another promotes intense fires.

Individual stacks consisting of rolls with assorted diameters, such as butt rolls, are considered an open array.

When all rolls in a sector of storage are of the same diameter, adjacent stacks can be placed in or nearly in contact in both directions. Close stacking or butting requires extra care and effort by equipment operators and their supervisors, particularly where clamp-jaw equipment is used. Less effort is needed where vacuum clamp equipment is used, but some papers cannot be handled by suction. In addition to space economy, this closed array storage arrangement has important fire protection advantages. Unwinding or peeling is

limited and air supply is restricted. If there is less than a 1 in. (25 mm) separation between stacks, fire growth is slow and intensity is relatively low. Standard array storage also can reduce fire intensity in heavy-weight paper, but not as effectively as closed array.

Metal bands and wire reduce unwinding or peeling when heavy-weight and medium-weight paper is stored in an open array. Some roll paper is banded with plastic bands that are black and shiny, hence, easily confused with steel bands. The practice of using metal bands and wire has decreased due to issues such as production costs.

Light-weight and medium-weight roll paper may be wrapped with heavy-weight Kraft paper for protection during shipment and storage. The wrapper tends to reduce the fire hazard of the lighter grade paper.

Rolls are sometimes stored vertically on pallets; the fire hazards are the same as storage without pallets in an open array.

C.4 On-Side Storage

On-side storage arrangements prevent unwinding or peeling. Rolls stored on-side may be nested between rolls of a lower tier or separated by dunnage placed between tiers. Where dunnage is used, there is opportunity for fire to burrow into a pile and make extinguishment more difficult than for nested rolls. Such fire is well shielded from fire fighting efforts, can involve a large portion of the storage, and can become quite severe in vertical flues between roll ends.

C.5 Storage on Axial Rods

Paper is sometimes supported horizontally on racks by rods that run axially through the rolls. Such arrangements, because of separation between rolls that allow the paper to peel or unwind, have the same general fire characteristics as separated vertical stacks.

Table 4. Trade or Basis Paper Size

<i>Kind of paper</i>	<i>Trade or basis size (in. x in.) and Number of Sheets</i>	<i>Trade size area, ft²</i>
Writing and Printing	17 × 22, 500	1298.6
Blotting	19 × 24, 500	1583.3
Cover	20 × 26, 500	1805.6
Carbon paper	20 × 30, 500	2083.3
Cardboard	22 × 28, 500	2138.9
Bristol and tag	22-1/2 × 28-1/2, 500	2226.6
Binder's board	25-1/4 × 30-1/4, 500	2652.1
Index	25-1/2 × 30-1/2, 500	2700.5
News, wrapping, tissue, paperboard, bag paper	24 × 36, 500	3000.0
Tissue	24 × 36, 480	2880.0
Book	25 × 38, 500	3298.6
News board	26 × 38, 500	3430.6
Former TAPPI standard size	25 × 40, 500	3472.2

C.6 Example Using Writing and Printing Paper

Basis size is 17 in. x 22 in. A ream of this paper is made up of 500 sheets.

Trade size is $((17 \text{ in.} \times 22 \text{ in.}) / (144 \text{ in.}^2 / \text{ft}^2)) \times 500 = 1298 \text{ ft}^2$.

The basis weight on the shipping label is 20 lbs. Note: This is the weight, in pounds, of the trade size.

Convert to basis weight measured in lbs/1000 ft²: $(20 \text{ lbs} / 1298 \text{ ft}^2) \times 1000 \text{ ft}^2 = 15.4 \text{ lbs} / 1000 \text{ ft}^2$

Convert from a basis weight in lbs/1000 ft² to a basis weight in g/m²: $15.4 \text{ lbs} / 1000 \text{ ft}^2 \times 4.88 \text{ (g/m}^2) / (\text{lbs} / 1000 \text{ ft}^2) = 75.2 \text{ g/m}^2$.