

CAROUSEL STORAGE AND RETRIEVAL SYSTEMS

Table of Contents

	Page
1.0 SCOPE	3
1.1 Changes	3
2.0 LOSS PREVENTION RECOMMENDATIONS	3
2.1 Introduction	3
2.1.1 Ignition Source Control	3
2.2 Construction and Location	3
2.2.1 Steel Protection	3
2.2.2 Heat and Smoke Venting	3
2.2.3 Mezzanines	3
2.3 Occupancy	6
2.3.1 Commodity Classification	6
2.3.2 Separation and Compartmentation	6
2.3.3 Covered Carousels	6
2.3.4 Container Type	6
2.3.5 Storage Clearance	6
2.4 Protection	7
2.4.1 Ceiling Sprinkler Protection	7
2.4.2 In-Rack Sprinkler Protection	8
2.4.3 Mechanical Damage Protection	10
2.4.4 Smoke Detection	10
2.4.5 Hoses	10
2.4.6 Computers	10
2.4.7 Protection of High Value Storage	10
2.4.8 Horizontal Carousels	11
2.4.9 Vertical Carousels	12
2.4.10 "Up and Over" Carousels	12
3.0 SUPPORT FOR RECOMMENDATIONS	12
3.1 General	12
3.1.1 Horizontal Carousels	13
3.1.2 Vertical Carousels	14
3.1.3 "Up and Over" Carousels	15
3.1.4 Carousel Rack Arrangement and Location	15
3.1.5 High Value Storage	16
4.0 REFERENCES	17
4.1 FM	17
APPENDIX A GLOSSARY OF TERMS	17
APPENDIX B DOCUMENT REVISION HISTORY	18

List of Figures

Fig. 1. Sprinkler location below mezzanine.	4
Fig. 1a. Sprinkler location below mezzanine.	5
Fig. 2. In-rack sprinkler arrangements.	8
Fig. 3. Typical horizontal carousel.	13
Fig. 4. Carousels with shelves adjusted for various storage heights.	14
Fig. 5. Carousels (storage approximates solid shelves).	15
Fig. 6. Typical vertical carousel.	16



Fig. 7. "Up and over" carousel. 17

List of Tables

Table 1. Decision Table for Determining Sprinkler Protection for Carousel Rack Storage Occupancies 7
Table 2. Ceiling Sprinkler Protection for Carousel Rack Storage (NOTE 1) 7
Table 3. In-Rack Sprinkler Protection for Carousel Rack Storage (NOTE 1). 9
Table 4. Smoke Detection Decision Table 10
Table 5. Ceiling Sprinkler Protection for 8 ft High Horizontal Carousel Storage 11

1.0 SCOPE

This data sheet provides guidelines for the fire protection of carousel storage and retrieval systems containing Class 1, 2, 3, 4 and plastic commodities. Carousel storage of hanging garments is covered in Data Sheet 8-18, *Storage of Hanging Garments*.

1.1 Changes

September 2004. References to FM Global earthquake zones have been modified for consistency with Data Sheet 1-2, *Earthquakes*.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

The following recommendations pertain to all three types of carousels: horizontal (see Section 3.1.1 and Figure 5), vertical (see Section 3.1.2 and Figure 6) and “up and over” (see Section 3.1.3 and Figure 7). Provide appropriate safeguards as outlined in Data Sheet 8-0, *General Storage Safeguards*, and Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*.

The use of suppression mode and large-drop ceiling sprinklers, rather than standard or extra-large orifice (ELO) ceiling sprinklers, should always be considered first.

2.1.1 Ignition Source Control

2.1.1.1 Maintain strict control of potential ignition sources. Some common ignition sources include hot work, electric equipment, smoking and unit heaters.

2.2 Construction and Location

2.2.1 Steel Protection

Protection of overhead roof steel or steel columns is not needed when protection is in accordance with this data sheet.

2.2.2 Heat and Smoke Venting

The protection recommended in this data sheet is based on construction without roof vents and draft curtains.

2.2.2.1 Automatic Vents

2.2.2.1.1 Fire tests have shown that automatic vents are not cost-effective and that the vents may even increase sprinkler water demand. Hence, permanent heat and smoke vents, if any, should be arranged for manual operation only. Alternatively where local codes require automatic vents, use 360°F (182°C) fusible links to operate vents. Drop-out (melt-out) type vents should not be used, since there is no way to delay their operation.

2.2.2.2 Smoke Removal

2.2.2.2.1 Smoke removal during mop-up operations frequently can be achieved through eave-line windows, doors, monitors and non-automatic exhaust systems (gravity or mechanical), or through manually-operated heat and smoke vents. Fire departments can cut holes in steel or wood roofs, and also use their smoke exhausters.

2.2.3 Mezzanines

2.2.3.1 Solid Mezzanines

Where mezzanines are used, it is recommended that they be solid instead of grated.

Protect solid mezzanines as follows:

2.2.3.1.1 Solid mezzanines should extend at least 2 ft (0.6 m) beyond any storage. In addition, a combustible-free, clear space should be maintained around each opening in the mezzanine floor. A clear space of 2-3 ft (0.6-0.9 m) is acceptable.

2.2.3.1.2 Install sprinklers (ceiling and in-racks) below the mezzanine based on below-mezzanine storage conditions. Ceiling sprinklers should be installed directly below the mezzanine in accordance with Table 2 (see Section 2.4.1) with a minimum clearance of 3 ft (0.9 m) between the sprinkler deflectors and top of storage below the mezzanine.

See 2.2.3.1.5 (below), for installations where minimum clearance of 3 ft (0.9 m) between sprinkler deflectors and top of storage below the mezzanine cannot be provided.

2.2.3.1.3 Install sprinklers (ceiling and in-racks) above the mezzanine based on the occupancy above the mezzanine.

2.2.3.1.4 Water demands above and below the *solid* mezzanine may be determined independently.

2.2.3.1.5 If there is less than 3 ft (0.9 m) clearance between the storage on the lower level carousels and the mezzanine:

- a) Install sprinklers in every flue (inner flue and outer flue between carousels) and aisle, and between the last carousel and the perimeter of the mezzanine, as shown in Figure 1. Horizontal spacing between sprinklers should be 8 to 10 ft (2.4 to 3 m).

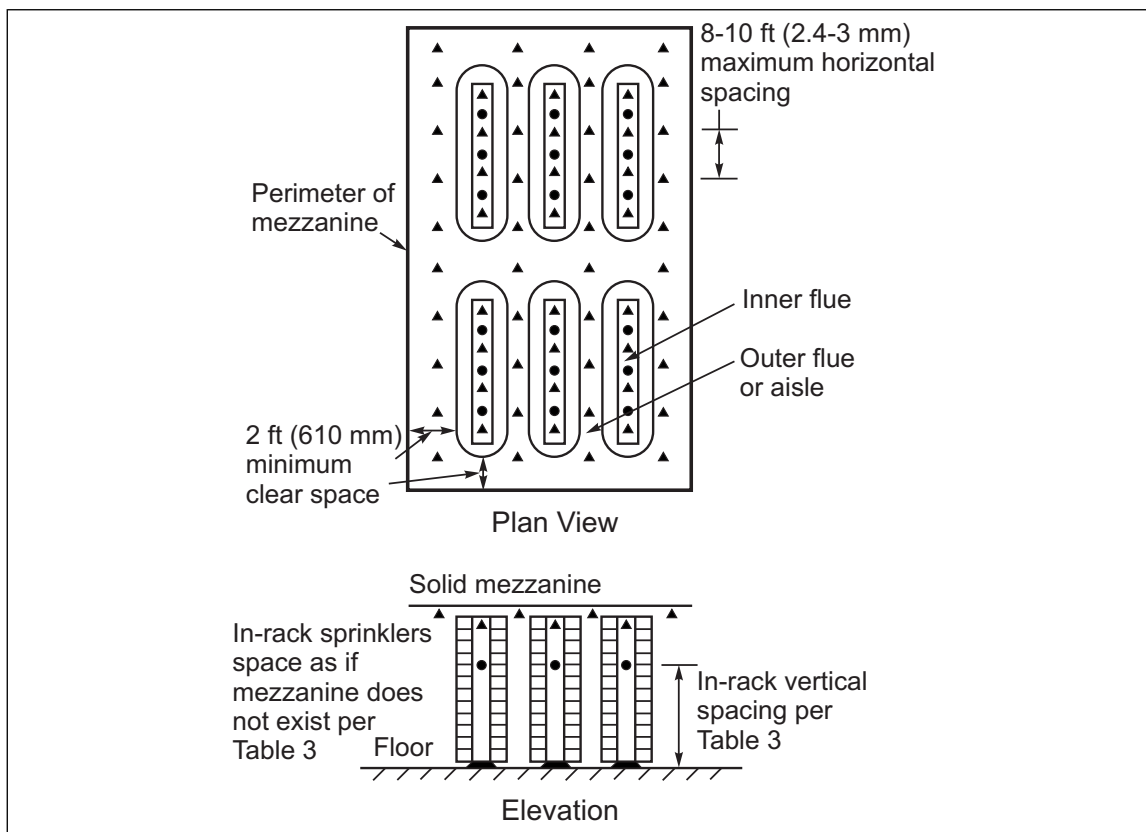


Fig. 1. Sprinkler location below mezzanine.

- b) Water demand for sprinklers under the mezzanine should be based on a minimum of:
 - i) For *Class 1–3* commodities, 22 gpm (84 l/min) per sprinkler from the most remote 10 sprinklers (5 sprinklers per line on most remote two lines);
 - ii) For *Class 4* commodities, 22 gpm (84 l/min) per sprinkler from the most remote 14 sprinklers (7 sprinkler per line on most remote two lines);

iii) For *Plastic* commodities (expanded and unexpanded), 30 gpm (114 l/min) per sprinkler from the most remote 14 sprinklers (7 sprinklers per line on most remote two lines).

c) Where sprinklers under the mezzanine are in accordance with all vertical and horizontal spacing guidelines in Table 3, they can be considered as a level of in-rack sprinklers.

2.2.3.1.6 Evaluate the need for smoke detectors in accordance with Table 4, Section 2.4.4, Smoke Detection.

If smoke detectors are recommended for occupancy above or below mezzanine, install them above *and* below the mezzanine arranged to simultaneously stop carousels above and below the mezzanine.

2.2.3.2 Grated Mezzanines

Where grated mezzanines are unavoidable, protect as follows:

2.2.3.2.1 Install ceiling sprinklers above the mezzanine in accordance with Table 2, Ceiling Sprinkler Protection for Carousel Rack Storage (see Fig. 1a and Section 2.4.1).

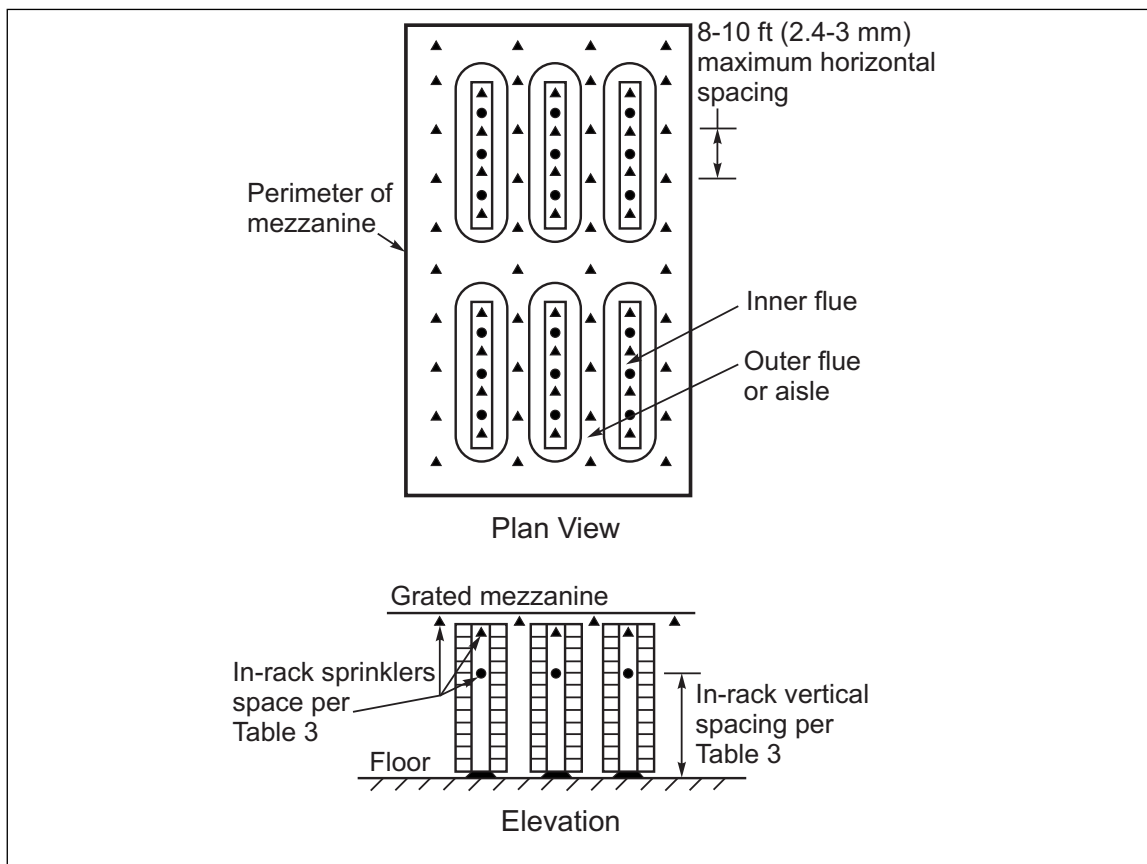


Fig. 1a. Sprinkler location below mezzanine.

2.2.3.2.2 Install sprinklers directly below the grating. Locate them in the area (either flue or aisle) not already occupied by the in-rack sprinklers. Determine their horizontal spacing as if they were in-rack sprinklers, and their demand based on one in-rack level.

2.2.3.2.3 Install the in-rack protection based on the total storage height as if the mezzanine were not in place. However, make certain that the choice of sprinkler levels includes the level *immediately* below the mezzanine.

2.2.3.2.4 The sprinkler demands specified above should be available simultaneously, and should be hydraulically balanced at the point of connection.

2.2.3.2.5 Use FM Approved (See Appendix A for definitions) rack storage type sprinklers (except for those installed at roof level).

2.2.3.2.6 Evaluate the need for smoke detectors in accordance with Table 4, Section 2.4.4, Smoke Detection.

If smoke detectors are recommended, install them at the roof arranged to simultaneously stop carousels above and below the mezzanine.

2.2.3.2.7 If the grated mezzanine is converted to a solid one by a permanent retrofit, protection for solid mezzanines may be used.

2.3 Occupancy

2.3.1 Commodity Classification

Use Data Sheet 8-1, *Commodity Classification*, in determining commodity classification. Base classification on product, packaging and container materials. For example, where products including their packing are handled in plastic containers, classification should be at least unexpanded plastic.

2.3.2 Separation and Compartmentation

If valuable storage is so concentrated that recommended protection would not limit fire damage to a reasonable level, limit the fire damage to a single carousel by one of the following methods:

1. Provide a separation of at least 3-½ ft (1.1 m) between each carousel face; or
2. Separate each carousel with a partition such as light gauge sheet or corrugated metal or ½-in. (13 mm) thick plywood. The ends of the carousels need not be partitioned unless they face other combustibles located within 3-½ ft (1.1 m). In such cases, provide a shutter or door for the picking of parts or product that will close automatically when actuated by the smoke detection system.

2.3.3 Covered Carousels

Where carousels have covers that would obstruct sprinkler discharge, the covers should be removed or a row of sprinklers should be placed below them. Base the design of this row of sprinklers upon that for a single level of in-rack sprinklers in accordance with Table 3, Section 2.4.1. If the vertical spacing of this row of sprinklers exceeds the maximum vertical spacings in Table 3, additional levels of in-rack sprinklers are needed below.

For example, an 8 ft (2.4 m) high horizontal covered carousel would require two levels of in-rack sprinklers: one level at the 5 ft (1.5 m) elevation and the second level at the 8 ft (2.4 m) elevation. Ceiling sprinkler demands should be in accordance with Table 2, Section 2.4.1. In-rack demands should be in accordance with Table 3, Section 2.4.1. Ceiling and in-rack demands should be available simultaneously and balanced at the point of connection.

2.3.4 Container Type

Use noncombustible containers whenever possible. This significantly reduces the sprinkler protection required and potential damage. In-rack sprinklers are not required for noncombustible containers provided either of the following:

1. Noncombustible containers have hinged (attached) covers.
2. The space between the top of one container and the bottom of the above container is nominally 1 in. (25 mm) or less.

The use of covers and/or minimal space (1 in. [25 mm] or less) vertically between containers will allow water penetration to lower levels and prevent water collection in the containers, which will reduce the potential for structural failure due to added weight of water.

Ceiling sprinkler protection able to provide a 0.25 gpm/ft² (10 mm/min) density over the most remote 2,000 ft² (186 m²) is adequate for either 1. or 2. above.

Where combustible containers are used, follow guidelines in Section 2.4, Table 1, to determine the ceiling and in-rack sprinkler protection to be provided.

2.3.5 Storage Clearance

Maintain storage a minimum of 36 in. (915 mm) below sprinkler deflectors.

2.4 Protection

Use Table 1 as a guide in determining appropriate sprinkler protection.

2.4.1 Ceiling Sprinkler Protection

2.4.1.1 Install ceiling sprinkler protection in accordance with Table 2 guidelines. Table 2 guidelines anticipate in-rack sprinkler protection installed in accordance with Table 3.

Exception: For Horizontal Carousel Storage up to 8 ft (2.4 m) high with a maximum building height of 25 ft (7.6 m), ceiling sprinkler protection can be installed in accordance with Table 5 *without the installation of in-rack sprinklers* (see Section 2.4.8, Horizontal Carousel Storage).

Table 1. Decision Table for Determining Sprinkler Protection for Carousel Rack Storage Occupancies

IF	THEN
1. Carousels use Open Top Combustible Containers Or Carousels use Close Top Combustible Containers in wire mesh shelves Or Storage approximates solid shelves with exposed Combustible Bottoms Or Height of storage and the classification of commodity would justify in-rack protection per Data Sheet 8-9.	Install In-rack sprinklers for carousels higher than 6 ft (1.8 m) in accordance with Section 2.4.2, In-Rack Sprinkler Protection. And Install Ceiling Sprinkler Protection in accordance with Section 2.4.1, Ceiling Sprinkler Protection.
Carousel rack arrangements that are not included in those outlined in 1. above.	Protect in accordance with Data Sheet 8-9.
Carousels use Noncombustible Containers	Protect in accordance with Data Sheet 8-34

Note: In-rack sprinklers may be omitted as noted in Table 5.

Table 2. Ceiling Sprinkler Protection for Carousel Rack Storage (NOTE 1)

Storage Height ft (m)	Container Type	Commodity Classification	Ceiling Sprinkler Water Demands gpm/ft ² (mm/min per m ²)		Sprinkler Temperature Rating °F (°C)	Orifice Size in. (mm)
			Grouped as:			
			Single or Double Row Racks [NOTE 2]	Multiple Row Racks [NOTE 2]		
Any	Open or Closed Top Combustible Containers	Class 1–2	0.15/2000 (6/186)		286°F (141°C)	½ (15)
		Class 3	0.20/2000 (8/186)			
		Class 4	0.25/2000 (10/186)			
		Unexpanded and Expanded Plastics	0.30/2000 (12/186)	0.30/3000 (12/279)		

NOTE 1: Table 2 guidelines are based on a maximum storage height of 5 ft (1.5 m) above the uppermost level of in-rack sprinklers. Where storage height above the uppermost level of in-racks exceeds 5 ft (1.5 m), install an additional level of in-rack sprinklers.

NOTE 2: Carousels can be evaluated as either single, double or multiple row racks depending on the overall depth defined by 3-½ ft (1.1 m) aisles between individual carousels. See Appendix A, Glossary of Terms.

2.4.1.2 Provide a minimum clearance of 3 ft (0.9 m) between ceiling sprinkler deflectors and top of carousel rack storage.

2.4.1.3 Where sprinkler clearance above the carousels exceeds 20 ft (6.1 m), place a noncombustible horizontal suspended ceiling 3 to 10 ft (0.9 to 3 m) above and continuously across the carousels, with sprinklers located below.

1. Ceiling sprinkler protection below the suspended ceiling should be in accordance with Table 2. Extend the horizontal suspended ceiling at least 2 ft (0.6 m) beyond the last row of sprinklers in all directions.

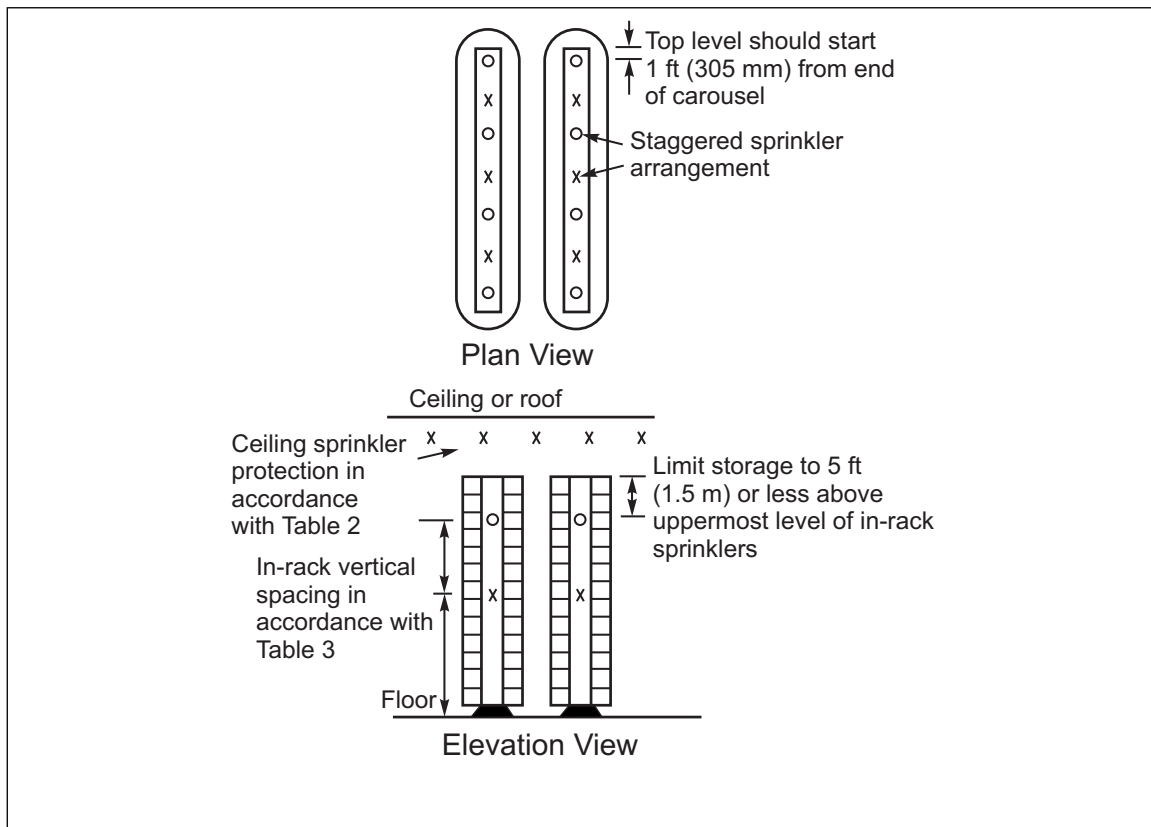


Fig. 2. In-rack sprinkler arrangements.

2. Roof level sprinklers above the suspended ceiling should provide a density of at least 0.15 gal/min/ft² (6 mm/min) over 2,000 ft² (186 m²) for Class 1 Commodities, and 0.2 gal/min/ft² (8 mm/min) over the most remote 2,000 ft² (186 m²) demand area for Class 2, 3, 4 and plastic commodities, or as dictated by the surrounding occupancy. The demand for the roof level sprinklers need not be added to that for sprinklers below the suspended ceiling.

2.4.2 In-Rack Sprinkler Protection

2.4.2.1 Install in-rack sprinkler protection in accordance with Table 3. Locate in-rack sprinklers in the longitudinal flue (inner flue) space in the center of the carousel (see Fig. 2). Where the inner flue is sheathed, see recommendations under Section 2.4.8.3, Sheathed Flue Spaces.

1. Where in-rack sprinklers are on 7 to 8 ft (2.1 to 2.4 m) maximum horizontal spacings, and multiple levels of in-racks are installed, sprinkler spacing should be on an approximate 4 ft (1.2 m) staggered arrangement between levels (see Fig. 2).
2. Limit storage height above the uppermost level of in-racks to a maximum of 5 ft (1.5 m) (see Fig. 2). Where storage height above uppermost level of in-racks exceeds 5 ft (1.5 m), install an additional level of in-rack sprinklers.
3. Balance ceiling and in-rack sprinkler demands at the point of connection.
4. Refer to Data Sheet 8-9, for general in-rack installation recommendations not outlined in Table 3 (e.g., valving, alarms, etc.).
5. Use Approved Rack Storage sprinklers.

Table 3. In-Rack Sprinkler Protection for Carousel Rack Storage (NOTE 1).

Container Type	Commodity	In-Rack Sprinkler Demand No. of Sprinklers, Minimum Flow per Sprinkler		In-Rack Sprinkler Spacing, ft (m)	Stagger	In-Rack Sprinkler Orifice Size and Temperature Rating
		Grouped As:				
		Single Row Racks [NOTE 2]	Double Row or Multiple Row Racks [NOTE 2]			
Open Top Combustible Containers	Class 1-3	One Level Installed: 6 sprinklers, each flowing 22 gpm (84 l/min) minimum.	10 sprinklers, each flowing 22 gpm (84 l/min) minimum. • 5 per line on remote two lines for one or more levels installed	Maximum Vertical Spacing: 5-6 ft (1.5-1.8 m) Maximum Horizontal Spacing: 7-8 ft (2.1-2.4 m)	Yes— See Figure 2	1/2 or 17/32 in. (15 or 20 mm) 165°F (74°C)
		More than One Level Installed: 10 sprinklers, each flowing 22 gpm (84 l/min) minimum • 5 sprinklers per line on remote two lines.				
	Class 4	One Level Installed: 8 sprinklers, each flowing 22 gpm (84 l/min) minimum.	14 sprinklers, each flowing 22 gpm (84 l/min) minimum. • 7 per line on remote two lines for one or more levels installed			
		More than One Level Installed: 14 sprinklers, each flowing 22 gpm (84 l/min) minimum. • 7 per line on remote two lines.				
	Unexpanded and Expanded Plastics	One Level Installed: 8 sprinklers, each flowing 30 gpm (114 l/min) minimum.	14 sprinklers, each flowing 30 gpm (114 l/min) minimum. • 7 per line on remote two lines for one or more levels installed			
		More Than One Level Installed: 14 sprinklers, each flowing 30 gpm (114 l/min) minimum. • 7 per line on remote two lines.				
Closed Top Combustible Containers	Class 1-4, Unexpanded Plastics	In-Rack Demand the same as for Open Top Plastic Containers		In-rack Spacing the same as for Open Top Containers. Or Maximum Vertical Spacing: 10 ft (3 m) with Maximum Horizontal Spacing: 4 ft (1.2 m)	None	1/2 or 17/32 in. (15 or 20 mm) 165°F (74°C)

NOTE 1: Limit storage height above the uppermost level of in-racks to a maximum of 5 ft (1.5 m) — see Figure 2. Where storage height above uppermost level of in-racks exceeds 5 ft (1.5 m), install an additional level of in-rack sprinklers.

NOTE 2: Carousels can be evaluated as either single, double or multiple row racks depending on the overall depth defined by 3-1/2 ft (1.1 m) aisles between individual carousels. See Appendix A, Glossary of Terms.

2.4.3 Mechanical Damage Protection

2.4.3.1 Where in-rack piping is supported by the racks, install flexible grooved couplings at the connection between the branch lines and the cross mains. The flexible grooved couplings will help reduce adverse effects on the in-rack piping system caused by the vibrations of the carousel rack structure.

1. In **FM 50-year through 500-year earthquake zones as shown in Data Sheet 1-2, Earthquakes**, or lower, provide swing joints arranged with flexible fittings/couplings at the top of drops to in-rack sprinklers or drops to cross-mains supplying branch lines to in-rack sprinklers.
2. Where in-rack sprinklers are exposed to mechanical damage, install a bump-rail or other protection mechanism to help prevent mechanical damage.

2.4.4 Smoke Detection

2.4.4.1 Use Table 4 as a guide in determining whether or not smoke detection should be installed over carousel storage areas.

Table 4. Smoke Detection Decision Table

IF	AND	THEN
Arrangement allows for quick visual detection of smoke Carousel Storage is not highly susceptible to smoke or water damage	Deadman control of Carousel movement is provided	Smoke detection over Carousel Storage is not needed
Carousel Storage is highly susceptible to smoke or water damage	—————>	Smoke detection is recommended.

Where smoke detectors are recommended:

1. Use Approved smoke detectors installed in accordance with Data Sheet 5-48, *Automatic Fire Detectors*.
2. Limit horizontal spacing between detectors to a maximum of 15 ft (4.6 m).
3. Arrange smoke detectors to shut down carousel rack movement and sound an alarm at a point where prompt response is ensured. Initiate shutdown of carousel movement and alarm upon activation of a single detector.

2.4.5 Hoses

2.4.5.1 Provide sufficient 1-1/2 in. (38 mm) hoses to reach all parts of the carousel. Allow a minimum of 100 gal/min (380 l/min) for inside hose streams and 500 gal/min (1,900 l/min) for total combined inside and outside hose streams.

Exception: Where only a single small carousel is in any given fire area, a 250 gal/min (850 l/min) combined hose stream demand is acceptable. A small carousel is one that covers 200 ft² (19 m) or less floor area and is not more than 8 ft (2.4 m) high.

2.4.5.2 Install hose connections in accordance with Data Sheet 8-9.

2.4.6 Computers

2.4.6.1 Provide protection for the computer in accordance with Data Sheet 5-32, *Electronic Data Processing Systems*.

Where carousel inventory is tracked and/or maintained via computer, general operations may be totally dependent upon uninterrupted availability of this data. Duplicate records should be maintained and stored in a separate fire area. The duplicate records should be updated as frequently as necessary to ensure their effectiveness following loss of the originals.

2.4.7 Protection of High Value Storage

Sprinkler protection guidelines provided in this data sheet should limit the fire to an area of about 200 to 250 ft² (19 to 23 m²). However, some storage conditions are of such high value that a 200 ft² (19 m²) fire area would still produce an unacceptably high monetary loss.

In such situations, install smoke detection to ensure that early detection will occur, and follow recommendations in Section 2.3.2, Separation and Compartmentation, to limit fire area to about 100 ft² (9.5 m²).

If smoke detection and the guidelines in Section 2.3.2 do not provide for an acceptable level of damage, then contact the nearest FM office.

2.4.8 Horizontal Carousels

2.4.8.1 Ceiling Sprinkler Protection for 8 ft (2.4 m) High Horizontal Carousel Storage

Where horizontal carousel rack storage is to a maximum of 8 ft high (2.4 m) with a maximum building height of 25 ft (7.6 m), an acceptable alternative to installing sprinklers at the ceiling and in-rack is to install sprinklers *at the ceiling only* in accordance with Table 5.

Where large-drop sprinklers are used, install them in accordance with Data Sheet 2-7, *Installation Rules for Sprinkler Systems Using Large-Drop Sprinklers*.

Where horizontal carousel rack storage is higher than 8 ft (2.4 m) or building height is greater than 25 ft (7.6 m), installation of ceiling and in-rack sprinklers is recommended in accordance with Table 2 and Table 3, respectively.

2.4.8.2 In-Rack Sprinklers

When providing in-rack sprinklers in the longitudinal flue space, place one sprinkler within 1 ft (305 mm) of each end of the enclosed flue. The remaining sprinklers should be spaced in accordance with Table 3.

Table 5. Ceiling Sprinkler Protection for 8 ft High Horizontal Carousel Storage

Maximum Building Height ft (m)	Maximum Storage Height ft (m)	Container Type	Commodity	Ceiling Water Demand	
				Standard 1 ⁷ / ₃₂ -in. (20 mm) Orifice Sprinklers gpm/ft ² per ft ² (mm/min per m ²)	Large Drop Sprinklers No. of Sprinklers @ Minimum Operating Pressure psi (bar)
15 (1.5)	8 (2.4)	Any Combustible Containers	Class 1–4 and Unexpanded Plastic	0.60/3500 (24/325)	15 @ 50 psi (3.4 bar)
20 (6.1)				DNA	20 @ 50 psi (3.4 bar)
25 (7.6)				DNA	25 @ 50 psi (3.4 bar)

Where there is more than one level of in-rack sprinklers, the highest level should be within 1 ft (305 mm) of each end of the carousel. Where sprinklers are staggered, the next lower level of sprinklers should be within 4 ft (1.2 m) of each end of the carousel.

2.4.8.3 Sheathed Flue Spaces

If the inner surface of the carousel is sheathed, or if the backs of the baskets are solid, thereby creating a sheathed effect, sprinklers located within the inner flue will be ineffective.

In such cases, locate the in-rack sprinklers within 6 in. (150 mm) of the outer surface of the carousel or in the flue space between adjacent carousels. For the top level, place a sprinkler within 1 ft (0.3 m) of each end of the carousel, and in the space remaining provide sprinklers in accordance with Table 3. Where sprinklers are staggered, the next lower level of sprinklers should be within 4 ft (1.2 m) of each end of the carousel.

Where sprinklers will be exposed to mechanical damage, provide a bump-rail or an equivalent protective mechanism to prevent mechanical damage.

2.4.9 Vertical Carousels

2.4.9.1 Special Sprinkler Location

Because storage at the top of the carousel obstructs ceiling sprinkler discharge from entering the flue space, provide an additional row of sprinklers below the carousel apogee in order to achieve coverage within the space (see Fig. 6, Section 3.1.2).

Base the water demand on that which would be provided for in-rack sprinklers. This row of sprinklers can be considered a level of in-rack sprinklers if it is installed in accordance with Table 3.

2.4.10 “Up and Over” Carousels

“Up and over” carousels are special built-in-place units. A particular design may require special treatment. However, in addition to recommendations outlined under Section 2.1, Introduction, the recommendations in the following sections would apply.

2.4.10.1 Special Sprinkler Location

At least one level of sprinklers should be located in the vertical section at the highest point possible while remaining below the travel plane of the upper horizontal section (see Fig. 7, Section 3.1.3).

2.4.10.2 In-Rack Sprinklers (Vertical Portion)

The need for additional levels of protection in the vertical portion should be treated as described in Section 2.3.1, Special Sprinkler Location for Vertical Carousels.

2.4.10.3 In-Rack Sprinklers (Horizontal Portion)

The horizontal portion of the carousel should be treated as a multiple row rack configuration, and protected in accordance with Data Sheet 8-9.

2.4.10.4 Protection from and for Other Combustibles

The underside of the horizontal section should be sheathed with a noncombustible material, supported in such a manner that it will remain in place if wet. Install sprinklers below the sheathing using a design and water demand based upon the occupancy below.

2.4.10.5 Smoke Detectors

Where recommended, locate smoke detectors so that at least one line is located at the top of the vertical section.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General

Carousel storage and retrieval systems are factory-built, motorized storage systems that revolve around a fixed base. In most cases the path of revolution has two long, parallel sides connected by round, short radius ends. They use fixed tracks with the motor mounted either on the top or the bottom (see Fig. 3). Although most carousels revolve in a horizontal plane, they also may be vertical, or a combination of both.

Products stored in the carousel are brought to a stationary picking station using manual or computer control. Computers are commonly used to simultaneously maintain inventory records and conduct ordering. Typically, the commodities are small parts/products used in assembly and picking operations.

Electronic equipment in various stages of assembly is often handled in carousel racks. In these cases, the storage is an assembly line, with the carousel racks moving the equipment from one work station to the next. Also, electric power may be provided to individual carousel shelves to allow in-place testing or aging of electric products.

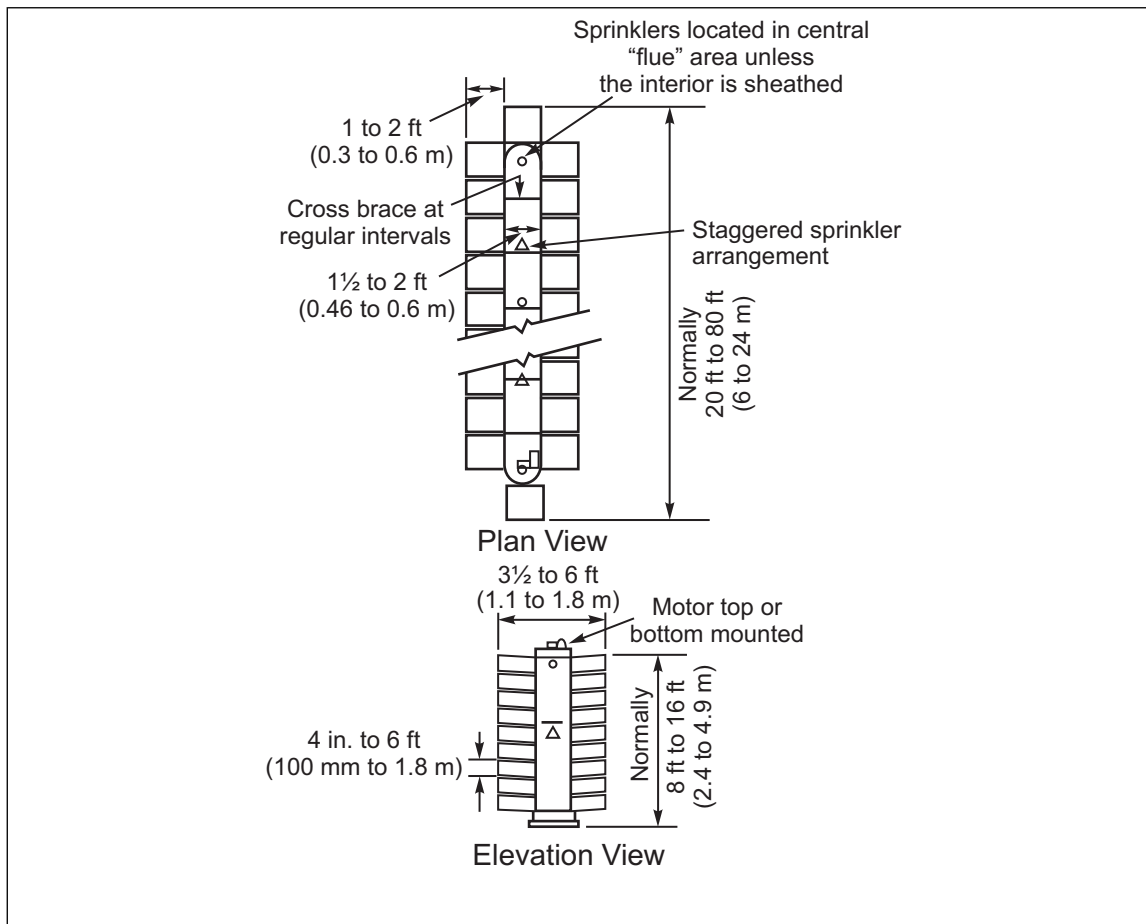


Fig. 3. Typical horizontal carousel.

3.1.1 Horizontal Carousels

The most common form of carousel is the horizontal type, in which all movement is along a floor-mounted rail.

Most are between 8 and 16 ft (2.4 and 4.9 m) high with integral shelves or containers comprising the entire height. The shelves or containers are usually less than 2 ft (0.6 m) deep and are adjustable to allow for a close vertical fit between the product and the upper shelf. An 8 ft (2.4 m) high section that contains a dozen or more levels of storage is fairly common (see Fig. 4).

Generally, the width of the various containers is uniform. The widths are selected in order to minimize wasted space. Hence, only a minimal transverse flue space (1-½ in. [38 mm]) usually exists. However, the area between the two long, parallel portions provides a substantial longitudinal flue space (1-½ to 2 ft [460 to 610 mm]). If the longitudinal flue space is unshathed, it can provide good access for provision of fixed fire protection, when needed.

The containers usually are of cardboard or plastic, and the shelves and backs are either of heavy gauge wire or solid metal. The choice of materials depends upon the size of the individual products stored. Occasionally, solid noncombustible containers are used. Because the storage is of an assembly line nature, closed containers are rare (although small sealed boxes may be present within a container).

Storage generally is so tight that it approximates solid shelves, even when stored on open wire shelves or in basket-like containers (See Fig. 5).

With sprinkler protection installed as recommended in this data sheet, the fire area normally will be confined to about 200 to 250 ft² (19 to 23 m²) of storage. Depending on the location of in-rack sprinklers, this would involve both "legs" of a single carousel or one leg each of two adjacent carousels.



Fig. 4. Carousels with shelves adjusted for various storage heights.

If the storage has such high unit value that the recommended protection still allows more damage than is acceptable, other actions can be taken to further reduce the fire area (see Section 2.4.7, Protection of High Value Storage).

3.1.2 Vertical Carousels

Vertical carousels are increasing in use. These transport the storage in a tight vertical ferris wheel fashion (see Fig. 6). Each carousel is fairly small, generally having a floor area of less than 50 ft² (4.6 m²) and a height of less than 20 ft (6 m). The carousels are used primarily for storing small valuable parts that have a rapid turnover. Optical parts, jewelry and electronic components are stored in this manner. Often, the individual shelves contain open boxes of uniform size. The boxes fit very snugly within the shelves allowing only minimal air space near each surface.

Depending upon their end use, vertical carousels may be located individually throughout the assembly area, or may be grouped in clusters or back-to-back rows in a single location.

If the units are separated by less than 3-1/2 ft (1.1 m) and they are not enclosed by solid sheathing, it is likely that a fire in one carousel will involve adjacent carousels. An actual fire area of 200 to 250 ft² (19 to 23 m²) would be expected with sprinkler protection as recommended in this data sheet.

When the value of storage within this fire area is above acceptable limits, other actions can be taken to limit the fire to a single carousel or even to a small portion of a carousel.

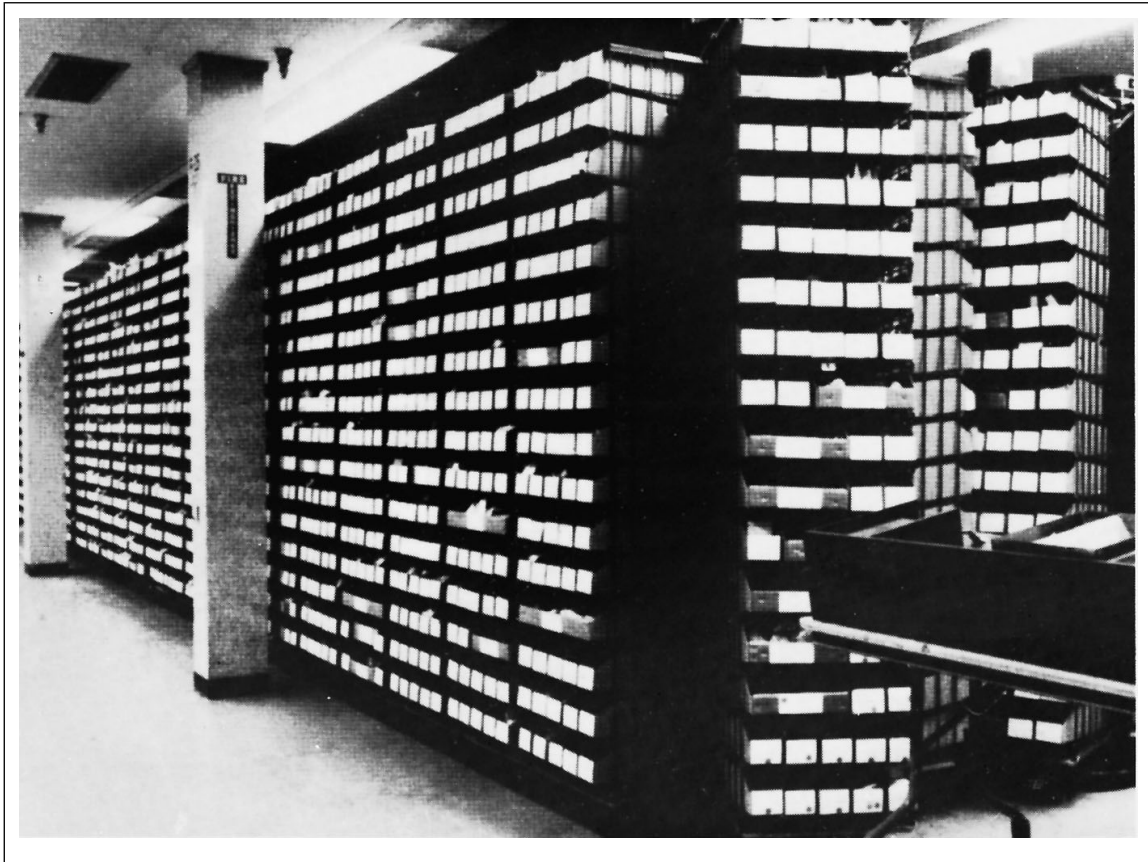


Fig. 5. Carousels (storage approximates solid shelves).

3.1.3 “Up and Over” Carousels

A third type of carousel is a hybrid of the others. Called the “up and over,” it transports storage vertically from the picking station to the building roof, horizontally out across the underside of the roof, then back under the first horizontal pass and down to the picking station (see Fig. 7).

“Up and over” carousels have been constructed with shelves able to accommodate up to six pallet loads side by side. Such carousels are capable of carrying more than 100 pallet loads in a two-high arrangement (one level on each of the two horizontal conveyor portions) at the ceiling level.

“Up and over” and vertical carousels usually have a level of storage directly above the longitudinal flue space. This obstructs discharge from ceiling sprinklers, thereby necessitating the use of other arrangements to ensure adequate sprinkler coverage.

The fire challenge and the recommended protection for these carousels are similar to conventional multiple-row, solid shelf racks. The area of expected fire damage with adequate sprinkler protection would be 200 to 250 ft² (19 to 23 m²).

3.1.4 Carousel Rack Arrangement and Location

Vertical and/or horizontal carousels may be “stacked.” This is done by providing a mezzanine, which is supported either independently or by the carousels. This provides a secondary picking level, with conveyors usually used to transport material to and from the main floor. (See Data Sheet 7-11, *Conveyors*, for conveyor protection.) In nearly all cases, little or no clearance exists between the top of the carousel and the underside of the mezzanine. Unless properly constructed and protected, the use of a mezzanine can result in a single fire affecting both areas (see Section 2.2.3, Mezzanines).

Carousels usually are arranged in a manner that is contrary to a fundamental rule of fire protection: the separation of manufacturing and storage. Since their “reason for being” is to increase assembly or

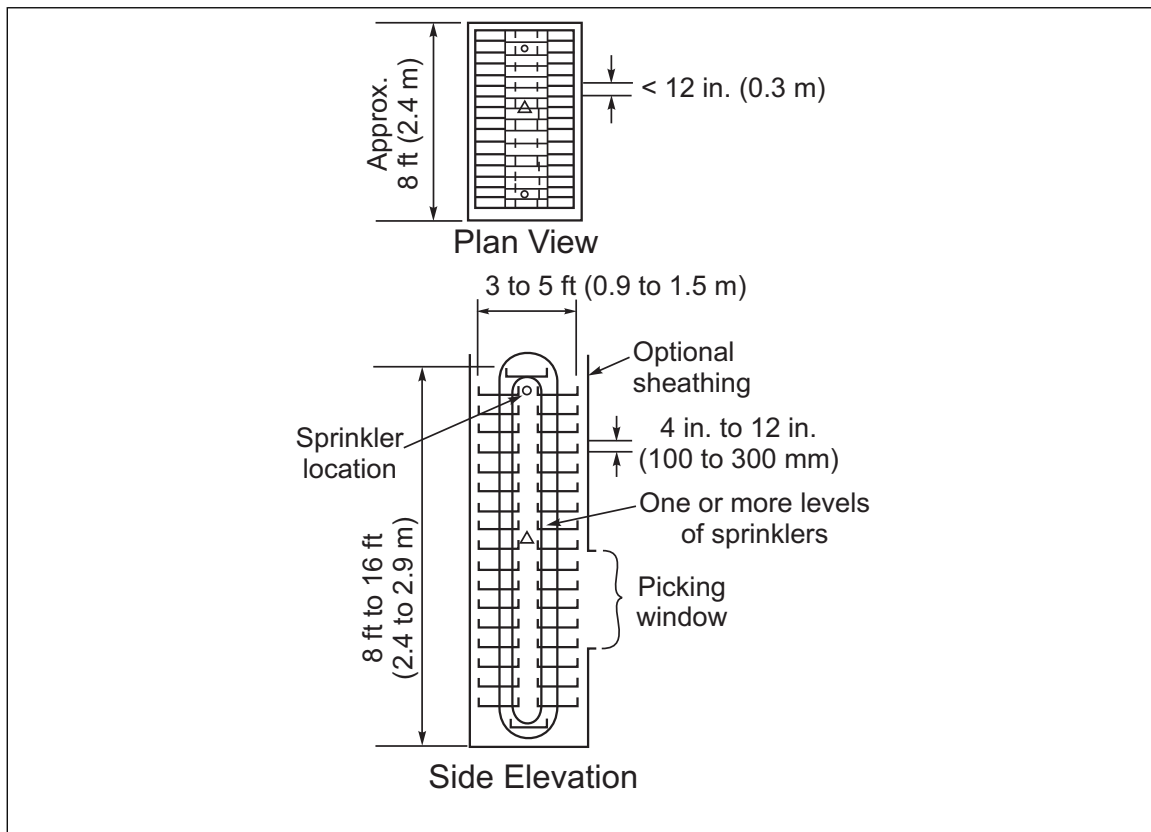


Fig. 6. Typical vertical carousel.

manufacturing efficiency, carousels are an integral part of assembly and manufacturing areas. Although this condition often cannot be changed, it can be treated as an unfavorable condition warranting close adherence to such storage area practices as strict smoking control and supervision of any ignition source.

Because the carousels are a vital or even indispensable part of the assembly process, loss of a carousel may represent a much higher business interruption potential than would loss of a conventional storage rack. Providing "make-up" material from another location generally would have a minor benefit at best, since it is the automated accessibility that is vital. Therefore, protecting the controls and the computer are as necessary as protecting the carousel.

3.1.5 High Value Storage

When using carousels, valuable storage can be concentrated into such compact areas that normal sprinkler control will not prevent a large monetary loss.

In most cases, fire damage will involve both sides of one carousel (if in-rack sprinklers are in the aisle space), or one side of two adjacent carousels (if in-rack sprinklers are in the inner flues). Fire damage may be limited to a single side by installing sprinklers in the inner flue, and separating adjacent carousels with a partition or clear space (see Section 2.3.2, Separation and Compartmentation).

However, in some cases, value is such that even separation and compartmentation will not provide an acceptable level of protection. In these cases contact the nearest FM office.

4.0 REFERENCES

4.1 FM

Data Sheet 1-2, *Earthquakes*.

Data Sheet 2-7, *Installation Rules for Sprinkler Systems Using Large Drop Sprinklers*.

Data Sheet 2-8N, *Installation of Sprinkler Systems*.

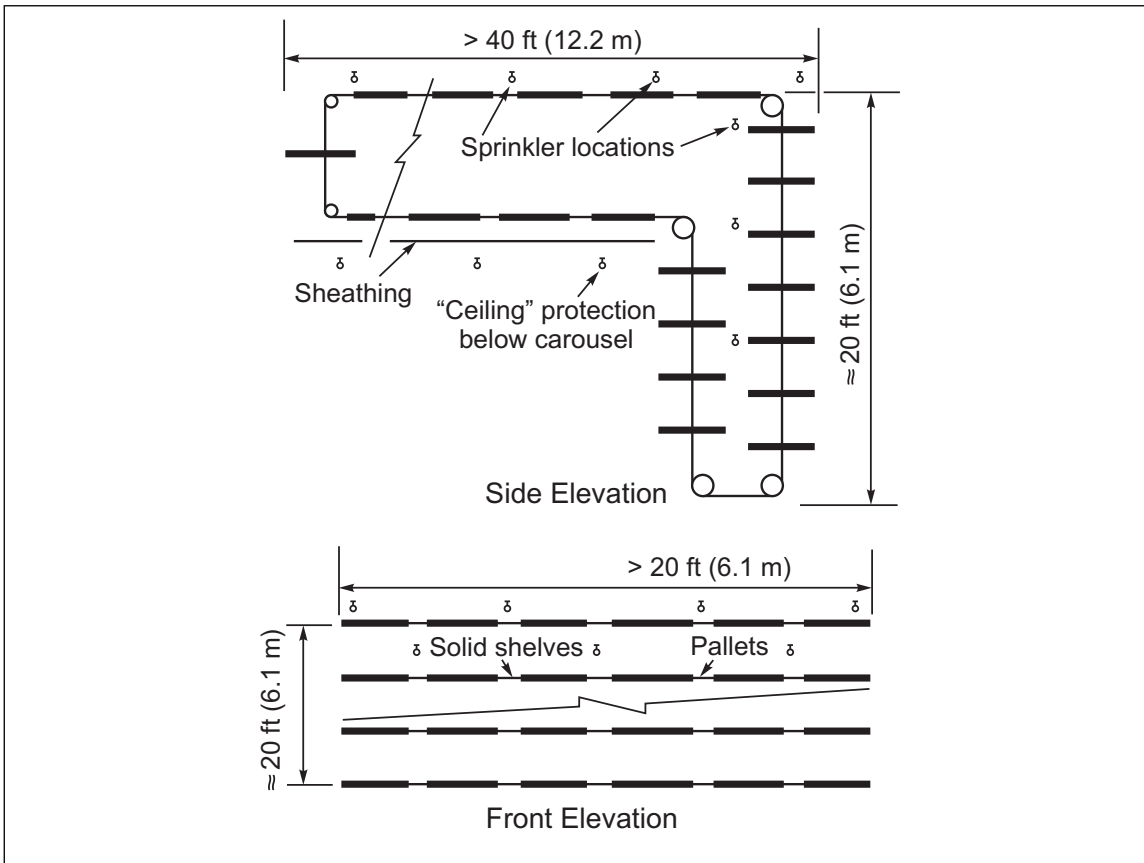


Fig. 7. "Up and over" carousel.

- Data Sheet 5-32, *Electronic Data Processing Systems.*
- Data Sheet 5-48, *Automatic Fire Detectors.*
- Data Sheet 7-11, *Conveyors.*
- Data Sheet 8-1, *Commodity Classification.*
- Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities.*
- Data Sheet 8-18, *Storage of Hanging Garments.*
- Data Sheet 8-34, *Protection for Automated Storage and Retrieval Systems.*

APPENDIX A GLOSSARY OF TERMS

Approved: references to "Approved" in this data sheet means the product and services have satisfied the criteria for FM Approval. Refer to the *Approval Guide* for a complete listing of products and services that are FM Approved.

Single Row Racks: racks that have an overall depth of 6 ft (1.8 m) or less. Depth of rack is defined by at least 3-1/2 ft (1.1 m) loading aisles at rack faces.

Double Row Racks: racks that have an overall depth of 12 ft (3.6 m) or less. Depth of rack is defined by at least 3-½ ft (1.1 m) loading aisles at rack faces.

Multiple Row Racks: racks that have an overall depth greater than 12 ft (3.6 m). Depth of rack is defined by at least 3-½ ft (1.1 m) loading aisles at rack faces.

APPENDIX B DOCUMENT REVISION HISTORY

January 2003. Clarification regarding the storage clearance was added.

September 2000. This revision of the document has been reorganized to provide a consistent format.