

FSICA Technical Seminar
August 30, 2006

2006年8月30日星期三

Technical Seminar
A Special Presentation for: FSICA

Topics of Discussion

-
- Sprinkler Protection for Atriums and other High Clearance Occupancies
 - Dry Pipe Alternatives for Eliminating in-rack sprinklers
 - Design and Installation Guidelines of Window Sprinklers for Glazing Protection
 - Brief Introduction and Significant Changes to the 2007 NFPA 13

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FSICA Technical Seminar
August 30, 2006

An Investigation of Automatic Sprinkler Protection of Buildings with Non-Storage Occupancies and High Clearances

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自动喷水灭火系统
非储水性建筑
高净空
研究

Background

- Sprinkler performance and effectiveness in buildings with high roofs and non-storage occupancies such as: atria, convention centers, auditoriums, theaters, exposition halls and others, is not well understood.
- Need to investigate the adequacy of the two different approaches for protection in FM Global Data Sheet 3-26.

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自动喷水灭火系统
非储水性建筑
高净空
研究

Questions Related to Sprinkler Performance Include:

- Will automatic sprinklers ever operate?
- What would be the fire size at sprinkler operation?
- What type of sprinkler and design criteria to use, and will sprinklers be effective in controlling the fire?

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幻灯片制作软件

FM Global Automatic Sprinkler Design Criteria

Occupancy	General Occupancy		Exception to the General Occupancy		
	Water Demand	ORAS*	Description	Water Demand	ORAS*
J. Mercantile areas Retail stores and similar ordinary hazard buildings open to the public except as noted. Examples: Grocery, department, clothing, hardware, drug and similar retail stores; bowling alleys, theaters, auditoriums and display areas.	Table 6	Yes*	1. "Warehouse stores" or wholesale mercantile buildings where merchandise is displayed on racks or shelves typical of those found in warehouses. Stock rooms and warehouse areas in retail stores. 2. Exhibit halls with unusually high ceilings, high concentration or shielding of combustibles.	Applicable storage data sheets Table 8	No

Table 2 D.S. 3-26

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幻灯片制作软件

FM Global Automatic Sprinkler Design Criteria

Table 6 D.S. 3-26

Type of Sprinkler System	Sprinkler Temperature Rating	Density ¹ , gpm/sq ft (mm/min)	Area ¹ of Demand, sq ft (sq m)
Wet	High,	0.15 (6)	2500 (230)
Dry	intermediate or ordinary		3500 (330)

Hose stream demand: 250 gpm (950 l/min). Duration: 60 min.

Table 8 D.S. 3-26

Type of Sprinkler System	Sprinkler Temperature Rating	Density ¹ , gpm/sq ft (mm/min)	Area ¹ of Demand, sq ft (sq m)
Wet	High	0.30 (12)	5000 (460)
Dry			8000 (740)

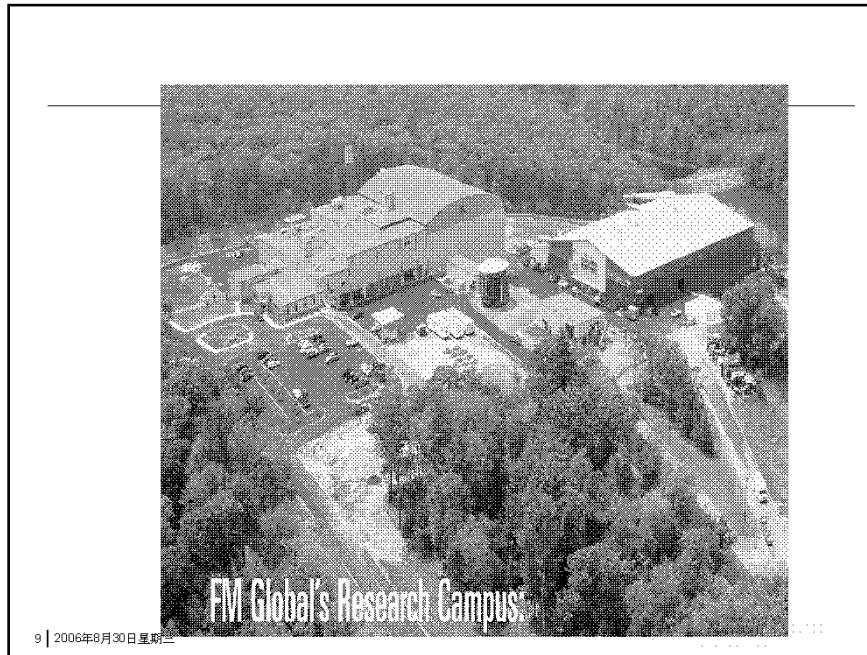
Hose stream demand: 500 gpm (1900 l/min). Duration: 120 min.

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Goals of Test Program

- To investigate sprinkler performance in non-storage buildings with high clearances, starting with 15.3 m (50 ft) clearance between top of fuel and ceiling.
- To determine automatic sprinkler design criteria for buildings with high roofs and non-storage occupancies, typically Ordinary Hazard occupancies containing potential fuel stacks lower than 3 m (10 ft) high.

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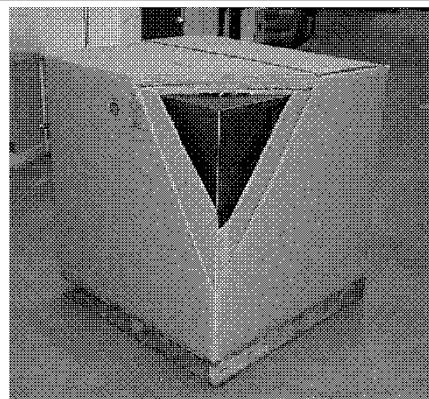
Summary of Full Scale Fire Test 1

- Fuel Arrangement: Class 2 commodity
- Fuel Height: 2.26 m
- Clearance to ceiling: 15.4 m
- Clearance to deflector: 15.2 m
- Arrangement: 8 by 8, solid pile, 2 tiers
- Density: 12 mm/min
- Sprinklers: K115, RTI 140 (m-s)1/2
- Spacing: 3.0 m x 3.0 m

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http://www.fireprotectionsystems.com

CLASS II Commodity

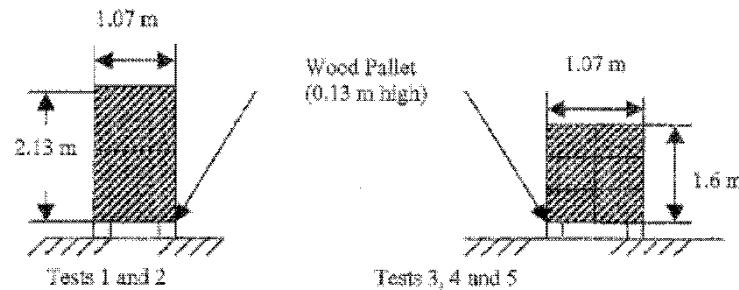


Metal-lined double tri-wall corrugated carton on a
wood pallet

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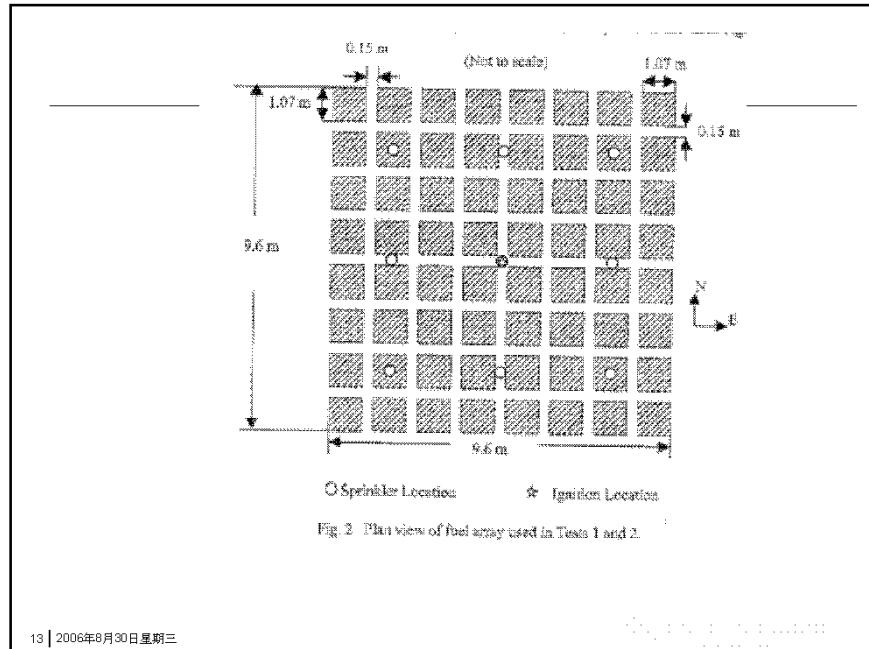
幻灯片制作软件

Side View of Fuel Array

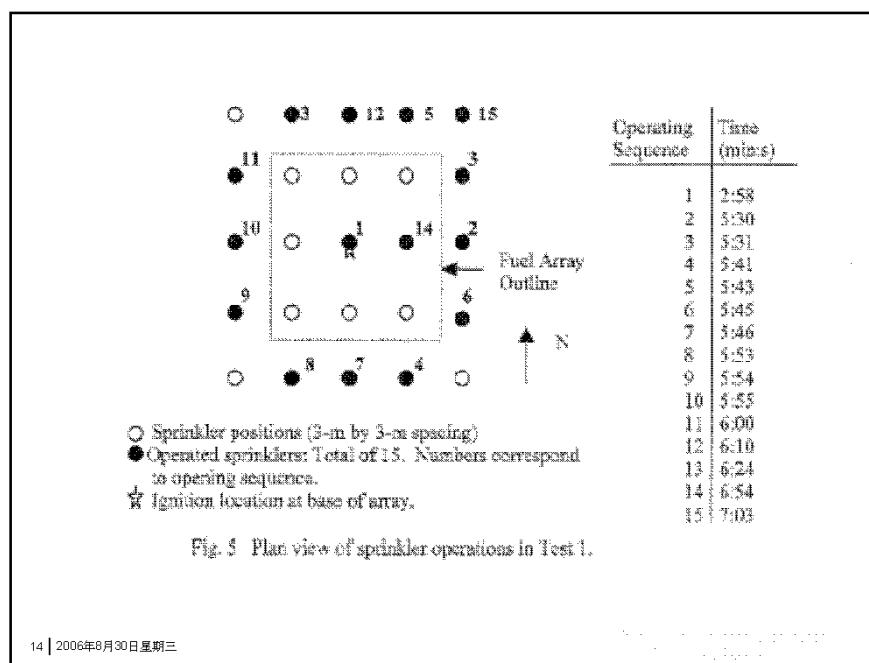


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幻灯片制作软件

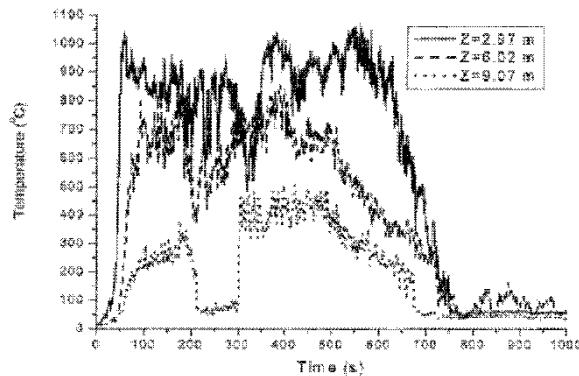


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Temperature Measurements in Test 1



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Results Test 1

- Number of Sprinklers Operated: 15
- Ceiling and steel temperatures: Acceptable
- Fire Damage: Acceptable
- Skipping of sprinklers observed.

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Summary of Full Scale Fire Test 2

- Fuel Arrangement: Class 2 commodity
- Fuel Height: 2.26 m
- Clearance to ceiling: 15.4 m
- Clearance to deflector: 15.2 m
- Arrangement: 8 by 8, solid pile, 2 tiers
- Density: 6 mm/min
- Sprinklers: K= 80, RTI 140 (m-s)^{1/2}
- Spacing: 3.0 m x 3.0 m

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幻灯片制作软件

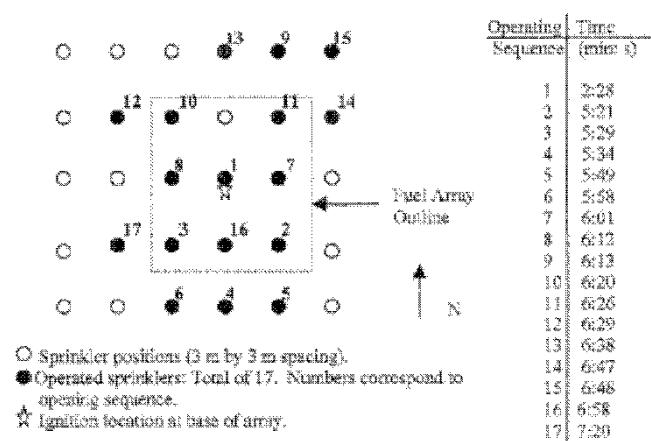


Fig. 7 Plan view of sprinkler operations in Test 2.

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幻灯片制作软件

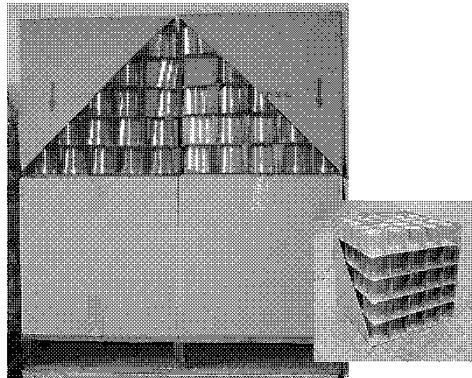
Results Test 2

- Number of Sprinklers Operated: 17
- Ceiling and steel temperatures: Acceptable
- Fire Damage: Acceptable
- Skipping of sprinklers observed.

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Office of the Fire Marshal

Unexpanded Group A Plastics

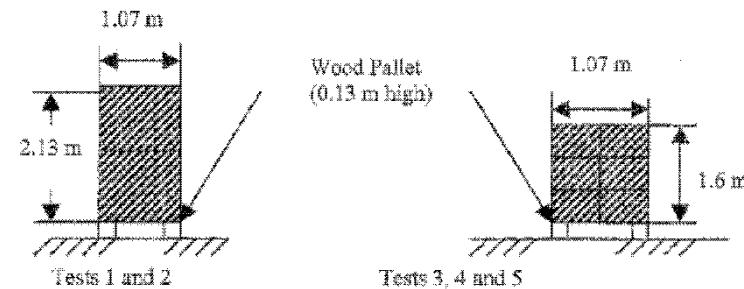


16-oz Polystyrene Plastic Jars in
compartmented cardboard cartons

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Office of the Fire Marshal

Side View of Fuel Array



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第十一章 水喷雾灭火系统设计

(Not to scale)

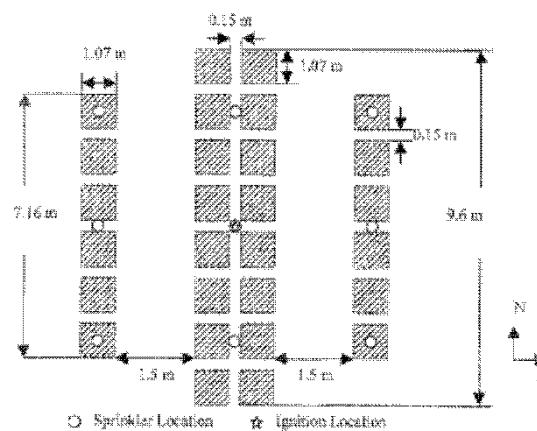


Fig.3 Plan view of fuel array used in Tests 3 and 4

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第十一章 水喷雾灭火系统设计

Summary of Full Scale Fire Test 3

- Fuel Arrangement: Group A Plastics
- Fuel Height: 1.73 m
- Clearance to ceiling: 15.9 m
- Clearance to deflector: 15.7 m
- Arrangement: 2 by 8, solid pile, 1 tier
- Density: 12 mm/min
- Sprinklers: K115, RTI 140 (m-s)^{1/2}
- Spacing: 3.0 m x 3.0 m

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[REDACTED]

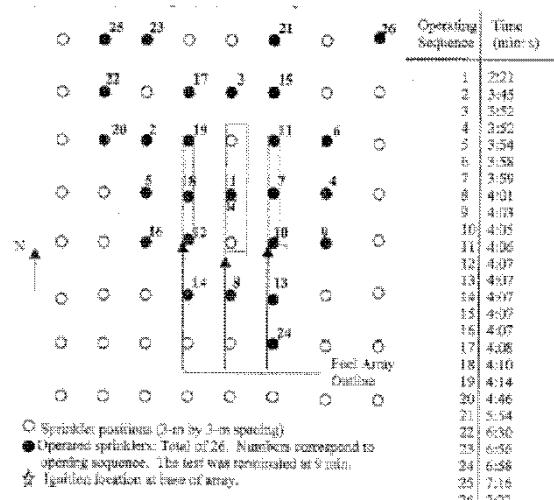


Fig. 8 Plan view of sprinkler operations in Test 3.

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[REDACTED]

Results Test 3

- Number of Sprinklers Operated: 26
- Skipping of Sprinklers observed
- Test terminated at 9 minutes

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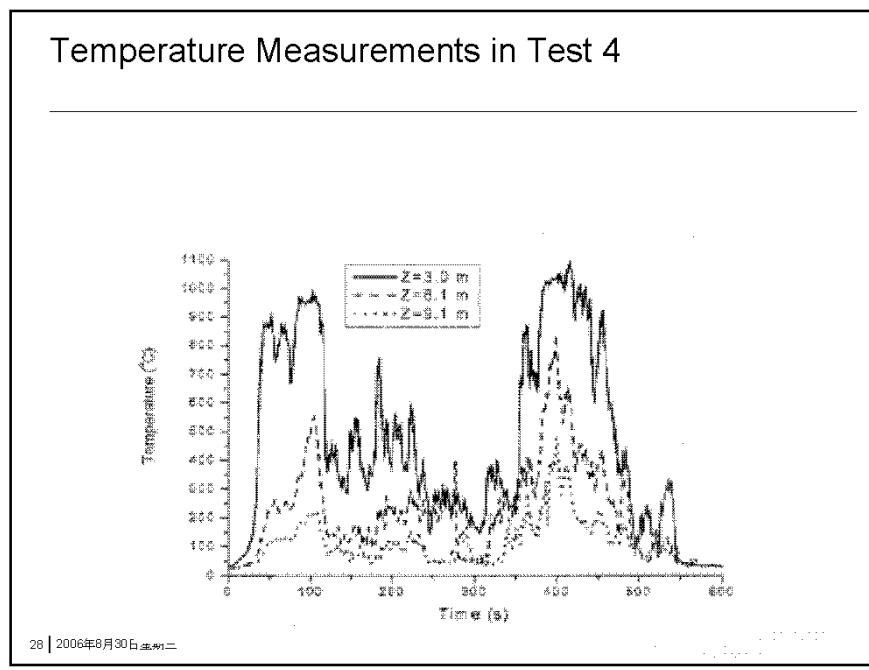
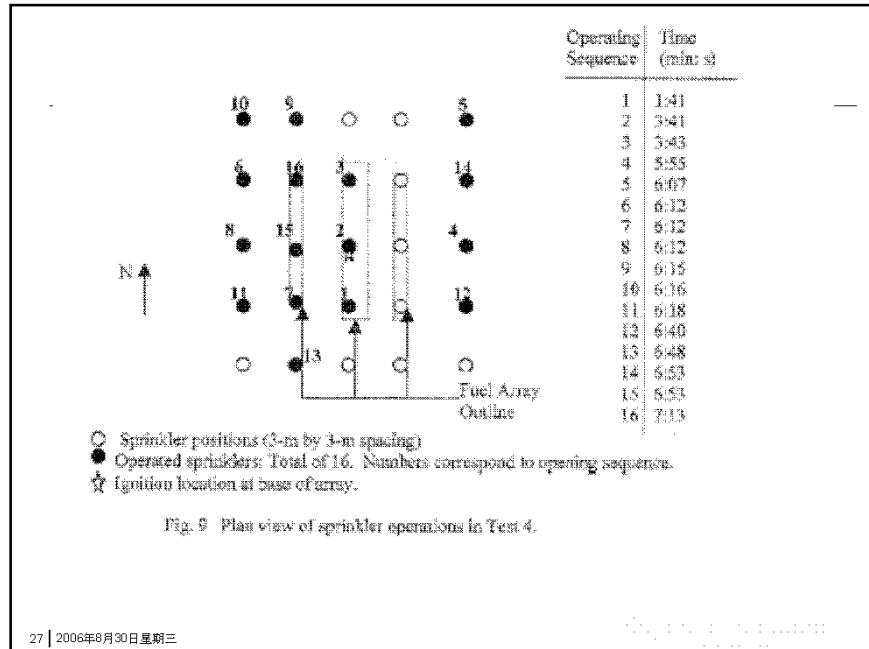
http://www.1233456.com

Summary of Full Scale Fire Test 4

- Fuel Arrangement: Group A Plastics
- Fuel Height: 1.73 m
- Clearance to ceiling: 16.6 m
- Clearance to deflector: 16.4 m
- Arrangement: 2 by 8, solid pile, 1 tier
- Density: 18 mm/min
- Sprinklers: K= 160, RTI 50 ($m \cdot s$)^{1/2}
- Spacing: 6.1 m x 6.1 m

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http://www.1233456.com



Results Test 4

- Number of Sprinklers Operated: 16
- Ceiling and steel temperatures: Acceptable
- Fire Damage: Acceptable
- Skipping of Sprinklers observed

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http://www.1233456.com

Summary of Full Scale Fire Test 5

- Fuel Arrangement: Group A Plastics
- Fuel Height: 1.73 m
- Clearance to ceiling: 16.6 m
- Clearance to deflector: 16.4 m
- Arrangement: 2 by 8, solid pile, 1 tier
- Density: 18 mm/min
- Sprinklers: $K=360$ (EC-25), $RTI\ 50\ (m \cdot s)^{1/2}$
- Spacing: 6.1 m x 6.1 m

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http://www.1233456.com

EC-25 (Extended Coverage Extra Hazard Sprinkler)

- Maximum Working Pressure 12,1 bar
- Pipe Thread Connection 1 inch
NPT or ISO 7-R1
- K-factor – 360 LPM/bar^{1/2}
- Temperature Ratings 74°C or 101°C
- Finish - Natural Brass



Navigation icons: back, forward, search, etc.

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Results Test 5

- Number of Sprinklers Operated: 1
- Ceiling and steel temperatures: Acceptable
- Fire Damage: Acceptable
- No Skipping of sprinklers since only 1 operated.

Navigation icons: back, forward, search, etc.

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Conclusions

- For the test conditions, automatic sprinkler design criteria of 12 mm/min over 460 m² was validated while the 6 mm/min over 230 m² criteria appears marginally adequate.
- High clearances may induce temporary or permanent skipping of automatic sprinklers and more work is needed to evaluate its effect on fire control.
- The K360 (EC-25) sprinkler provided superior fire control and the effects of skipping should not be a factor. Design for 18mm/min. over 460 m².

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Protecting Dry Pipe & Refrigerated Warehouses with Control-Mode Specific Application (CMSA) Sprinklers

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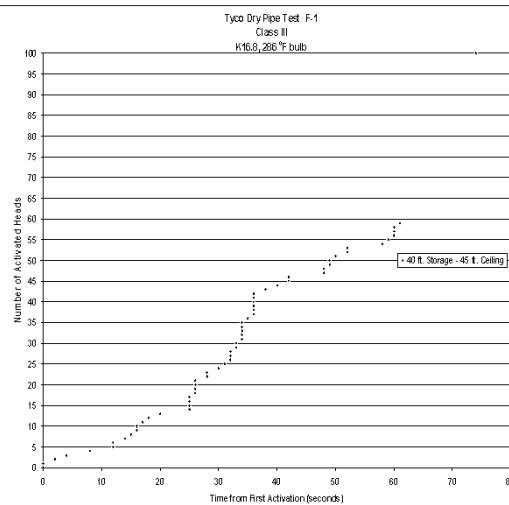
Dry System Testing



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Class III Free Burn Sprinkler Activation Time



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Refrigerated Warehouses Uses

- General Storage
 - a wide variety of food products, wrapped or unwrapped, which pass through the warehouse, depending on the season of the year.
 - The commodity classification of the material in the occupancy may dramatically vary from season to season.
- Processing Plants
 - stable inventory of particular items.
 - The commodity classification of the material in the occupancy will be consistent all year long.



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http://www.123rf.com

Classification of Refrigerated Storage

- Coolers ~ 0°C to 18°C (32°F to 65°F)
 - Storage of foods such as apples, eggs or nuts
- Chill Rooms ~ -9°C to 2°C (16°F to 35°F)
 - Curing Meat
- Freezers ~ -23°C to -15°C (-10°F to 5°F)
 - Storage of frozen foods such as meats, poultry, fish or vegetables
- Sharp Freezers ~ -37°C to -17°C (-35°F to 0°F)
 - Initial Freezing & Normal Storage of Frozen Foods

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http://www.123rf.com

Common Combustible Material in Cold-Storage Warehouses

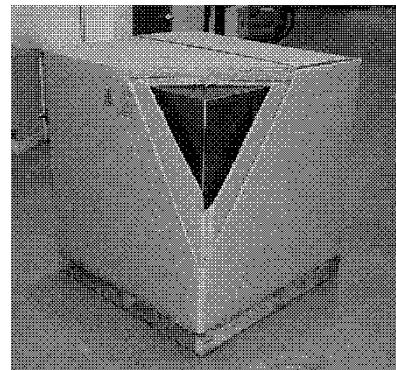
- Different Types of Food, Wood/Plastic Pallets, Wood Boxes Containing Food, Fiberboard Food Containers, Wooden Baskets, Polystyrene Egg Cartons, Waxed Paper, Heavy Paper Wrapping, Cloth Wrapping, Grease or Grease-Impregnated Materials, or Pharmaceuticals.
- Commonly Class II or Class III

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FSICA Fire Protection Systems

Commodities Tested - CLASS II

- Noncombustible product that is in slatted wooden crates, solid wood boxes, multiple-layered corrugated cartons, or equivalent combustible packaging material, with or without pallets.



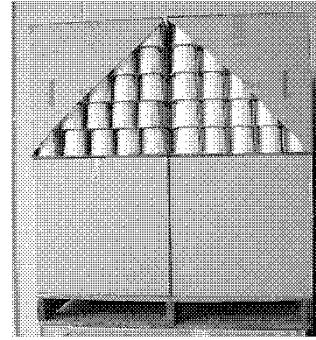
Metal-lined double tri-wall corrugated carton on a wood pallet

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FSICA Fire Protection Systems

Commodities Tested - CLASS III

- A product fashioned from wood, paper, natural fibers, or Group C plastics with or without cartons, boxes, or crates and with or without pallets.
- Class II Commodities on Plastic Non-reinforced Pallets



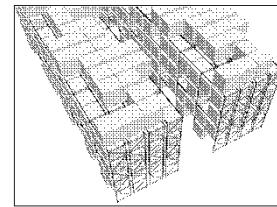
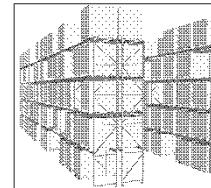
Paper cups in compartmented
cardboard cartons on wood
pallets

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Typical Storage Arrangements

- Rack Storage (No Solid Shelves)
 - Single Row
 - Double Row
 - Multiple Row



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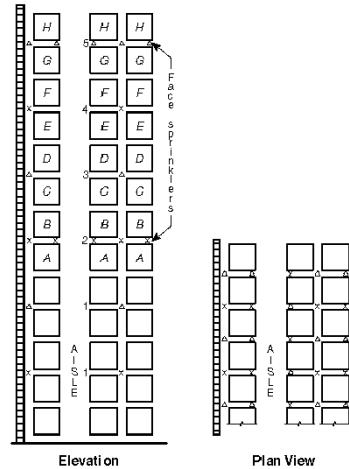
Current NFPA 13 (2002) Criteria for Rack Storage of Class I - IV Commodities Over 7.6 m (25 ft)

Commodity Class	In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing ^{a,b}		Figure	Maximum Storage Height	Staggered	Ceiling Sprinkler Operating Area		Ceiling Sprinkler Density Clearance up to 10 ft (3.1 m) ^{c,d}						
						ft^2	m^2	Ordinary Temperature		High Temperature				
	Longitudinal Line ^e	Face ^{f,g}						gpm/ ft^2	min/min	gpm/ m^2	min/min			
I, II, III	Vertical 5 ft (1.5 m) (min) 10 ft (3.0 m) and 25 ft (7.6 m)	Horizontal 5 ft (1.5 m)	12.3.4.4.1.1(c)	Up to (3.1 m)	Yes	2000	186	0.3	12.2	0.4	16.3			
	Vertical 10 ft (3.1 m) Horizontal 10 ft (3.1 m)	Vertical 30 ft (9.1 m) Horizontal 10 ft (3.1 m)	12.3.4.4.3.1(d)	Higher than 25 ft. (7.6 m)	Yes			0.3	12.2	0.4	16.3			
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.1 m)	Vertical 30 ft (9.1 m) Horizontal 5 ft (1.5 m)	12.3.4.4.3.1(e)		Yes			0.3	12.2	0.4	16.3			
	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	12.3.4.4.3.1(f)		No			0.3	12.2	0.4	16.3			
	Horizontal barriers at 20 ft (6.1 m) Vertical intervals -- no rows of sprinklers under barriers -- maximum horizontal spacing 10 ft (3.0 m), staggered		12.3.4.4.3.1(g)		Yes			0.3	12.2	0.4	16.3			

Double-Row Rack Storage

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12.3.4.4.1.1 (c)



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Current NFPA 13 (2002) Criteria for Rack Storage of Class I - IV Commodities Over 7.6 m (25 ft)

Commodity Class	Encapsulated	In-Rack Sprinklers ^{1,2,3}						Height Limit (ft)	Stagger	Figure	Maximum Spacing Between Storage to Highest In-Rack Sprinklers	Ceiling Sprinklers Density							
		Approximate Vertical Spacing		Maximum Horizontal Spacing in A Plane		Maximum Horizontal Spacing across Racks						Ceiling Sprinkler Operating Area		165° Rating					
		ft	m	ft	m	ft	m					ft ²	m ²	gpm/ft ²	l/min/m ²				
I	No	29	8.3	12	3.7	10	3.1	Note Between adjacent floors	Figure 12.3.4.4.1.3(a)	10	3.1	2090	186	0.25	31.2	0.35	14.5		
	Yes											0.31		0.44					
I, II, and III	No	15	4.6	10	3.1	10	3.1	Figure 12.3.4.4.1.3(b)	10	3.1	2090	186	0.30	32.2	0.40	10.3			
	Yes											0.37		0.50	20.4				
I, II, III, and IV	No	19	5.8	10	3.1	10	3.1	Figure 12.3.4.4.1.3(c)	5	1.5	2090	186	0.35	14.3	0.45	18.3			
	Yes											0.48		0.56					

Notes for Table 12.3.4.4.1.3(a) through (c):

¹All four rack levels shall be protected by sprinklers located within 18 in. (0.46 m) of the faces, as indicated in Figure 12.3.4.4.1.3(a) through Figure 12.3.4.4.1.3(c). Racks shall not be required for each sprinkler level to protect all faces.²All in-rack sprinkler spacing dimensions sum from the floor.³In Figure 12.3.4.4.1.3(a) through Figure 12.3.4.4.1.3(c), each square represents a storage cube measuring 1 ft to 6 ft (3.2 m to 1.8 m) wide. Actual load heights can vary from approximately 3 ft to 16 ft (0.96 m to 3.1 m). Therefore, there could be as few as one load or as many as six even loads between in-rack sprinklers that are spaced 10 ft (3.1 m) apart vertically.

Multiple-Row Rack Storage

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Current NFPA 13 (2002) Criteria for Rack Storage of Class I - IV Commodities Over 7.6 m (25 ft)

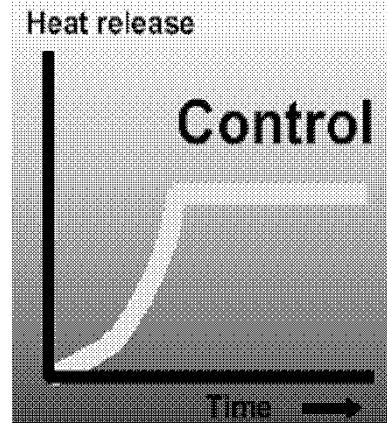
Commodity Class	Nominal R-Factor	Maximum Storage Height		Type of System	Number of Design Sprinklers/Minimum Area	Hose Stream Demand		Water Supply Duration (hours)	
		ft	m			#/psi	#/bar		
I, II	11.2	30	9.1	Wet	20/25+1 level of in-rack	20/1.7+1 level of in-rack	500	1900	1½
						30/25+1 level of in-rack	30/1.7+1 level of in-rack	500	1900
III, IV	Design criteria not applicable to Class III or Class IV commodities stored in excess of 10 ft (3.1 m) in height								

Large Drop

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What is our goal for protection with Control Mode Sprinklers?

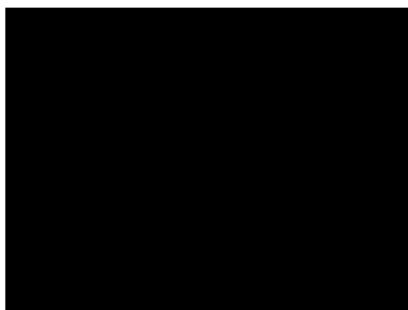
- Limit the size of a fire by distribution of water so as to control the heat release rate and pre-wet adjacent combustibles, while controlling ceiling gas temperatures to avoid structural damage.



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Navigation icons: back, forward, search, etc.

FM Testing of Dry Systems Using Large Drop Sprinklers in the 1990's



60 sec. Delay



30 sec. Delay

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Navigation icons: back, forward, search, etc.

60 Second Delay										Operating Sequence	Time (mins)
○	○	○	○	○	○	○	○	○	○	1	211
○	○	○	○	○	○	○	○	○	○	2	216
○	○	○	○	○	○	○	○	○	○	3	220
○	○	○	○	○	○	○	○	○	○	4	221
○	○	○	○	○	○	○	○	○	○	5	227
○	○	○	○	○	○	○	○	○	○	6	228
●	●	●	●	○	○	○	●	●	●	7	228
●	●	●	●	●	●	●	●	●	●	8	231
●	●	●	●	●	●	●	●	●	●	9	231
●	●	●	●	●	●	●	●	●	●	10	233
●	●	●	●	●	●	●	●	●	●	11	234
●	●	●	●	●	●	●	●	●	●	12	235
●	●	●	●	●	●	●	●	●	●	13*	240
●	●	●	●	●	●	●	●	●	●	14	243
●	●	●	●	●	●	●	●	●	●	15	244
●	●	●	●	●	●	●	●	●	●	16	244
●	●	●	●	●	●	●	●	●	●	17	245
●	●	●	●	●	●	●	●	●	●	18	246
●	●	●	●	●	●	●	●	●	●	19*	246
●	●	●	●	●	●	●	●	●	●	20	250
●	●	●	●	●	●	●	●	●	●	21	251
●	●	●	●	●	●	●	●	●	●	22	252
●	●	●	●	●	●	●	●	●	●	23	252
●	●	●	●	●	●	●	●	●	●	24	253
●	●	●	●	●	●	●	●	●	●	25	253
●	●	●	●	●	●	●	●	●	●	26	254
●	●	●	●	●	●	●	●	●	●	27	254
●	●	●	●	●	●	●	●	●	●	28	255
●	●	●	●	●	●	●	●	●	●	29	256
●	●	●	●	●	●	●	●	●	●	30	257
●	●	●	●	●	●	●	●	●	●	31	257
●	●	●	●	●	●	●	●	●	●	32	257
●	●	●	●	●	●	●	●	●	●	33*	258

30 Second Delay										Operating Sequence	Time (mins)
○	○	○	○	○	○	○	○	○	○	1	213
○	○	○	●	●	○	○	○	○	○	2	217
○	○	○	●	●	○	○	○	○	○	3	223
○	○	○	●	●	○	○	○	○	○	4	230
○	○	○	●	●	○	○	○	○	○	5	230
○	○	○	●	●	○	○	○	○	○	6	231
●	●	●	●	●	●	●	●	●	●	7	232
●	●	●	●	●	●	●	●	●	●	8	232
●	●	●	●	●	●	●	●	●	●	9	234
●	●	●	●	●	●	●	●	●	●	10	234
●	●	●	●	●	●	●	●	●	●	11	235
●	●	●	●	●	●	●	●	●	●	12	243
●	●	●	●	●	●	●	●	●	●	13	244
●	●	●	●	●	●	●	●	●	●	14	246
●	●	●	●	●	●	●	●	●	●	15	248
●	●	●	●	●	●	●	●	●	●	16	248
●	●	●	●	●	●	●	●	●	●	17	251
●	●	●	●	●	●	●	●	●	●	18*	251
●	●	●	●	●	●	●	●	●	●	19	255
●	●	●	●	●	●	●	●	●	●	20	257
●	●	●	●	●	●	●	●	●	●	21	1000
●	●	●	●	●	●	●	●	●	●	22	1728
●	●	●	●	●	●	●	●	●	●	23	1828
●	●	●	●	●	●	●	●	●	●	24	1831

FM 8-9

Table 2.3.7.4(e) Control Mode Specific Application Sprinklers for Rack Storage of Class 1 and 2 Commodities with Open Shelves

Maximum Storage Height, ft (m)	Maximum Building Height, ft (m)	Class 1, Class 2 Commodities, with Non-Openless Than 20.5° (2.0 m²) Branches			
		Wet Pipe, No. A.S. Pressure, psi (bar)		Dry Pipe, No. A.S. Pressure, psi (bar)	
		K-factor 16.8 (235, 160°F (70°C))	K-factor 11.2 (150, 280°F (140°C) or 160°F (70°C))	K-factor 16.8 (235, 150°F (70°C))	K-factor 11.2 (150, 280°F (140°C))
20 (6.0)	30 (9.0)	35 @ 10 (0.7)	15 @ 25 (1.7)	DNA	25 @ 25 (1.7)
	40 (12.2)	DNA	15 @ 25 (1.7)	DNA	25 @ 25 (1.7)
	46 (13.5)	DNA	20 @ 25 (1.7)	DNA	30 @ 25 (1.7)
25 (7.5)	30 (9.0)	35 @ 10 (0.7)	20 @ 25 (1.7)	DNA	30 @ 25 (1.7)
	40 (12.2)	DNA	20 @ 25 (1.7)	DNA	30 @ 25 (1.7)
	46 (13.5)	DNA	20 @ 25 (1.7)	DNA	30 @ 25 (1.7)
30 (9.0)	35 (10.5)	DNA	20 @ 25 (1.7) & 1 Level RAS	DNA	30 @ 25 (1.7) & 1 Level RAS
	40 (12.2)	DNA	35 @ 55 (3.8) Note 6	DNA	35 @ 55 (3.8) Note 7
	46 (13.5)	DNA	35 @ 55 (3.8) Note 6	DNA	35 @ 55 (3.8) Note 7
35 (10.5)	40 (12.2)	DNA	35 @ 55 (3.8) Note 6	DNA	35 @ 55 (3.8) Note 7

Note 6: This design is based on a inner remote 6 sprinklers on the most remote 6 branchlines.

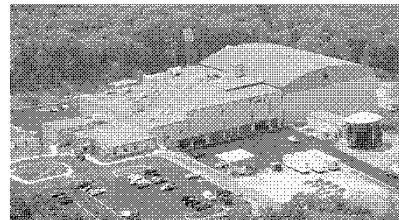
Note 7: This design is based on full-scale fire testing, conducted by FM Global. Specifics of the testing and the type of sprinkler system tested are confidential and can only be discussed with FM Global clients. Any sprinkler system using this design must be reviewed by FM Global (this service only available to FM Global clients) and found to be in full compliance with all applicable FM Global guidelines in order to be considered acceptable for insurance purposes.

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FM 8-9

The Problem

- December 21, 2004
 - FM Approvals suspended Approval of all large drop automatic fire sprinklers
- Benchmark Testing



K11.2 Large Drop Sprinklers 30' Building - 20' Storage 50 psi - 79 gpm	
Number of operated sprinklers	
New Facility	Lagacy Facility
31	20

Tyco Large Drop Sprinklers successfully passed full-scale fire testing at UL and remain UL listed

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FM 8-9

Class II Testing – FM (Double Row)

Commodity or Type of Fuel	Standard Class II
Arrangement or Storage Medium	Double Row Rack
Array Size (ft x ft x ft)	33 ft x 21 ft x 34 ft
Stack Height (ft-in)	35-11
Number of Rows	2
Ceiling to Ceiling (ft-in)	6-10
Distance to Sprinklers (ft-in)	6-2
Aisle Width (ft)	10
Iginition Covered Below (Number of Sprinklers)	4 corners
Sprinkler Nominal Orifice Size (in.)	16.8
Sprinkler Temperature Rating (°F)	286
Sprinkler Spacing (ft x ft)	10 x 10
Constant Water Pressure (psi)	22
Minimum Discharge Density (gal/min/ft ²)	0.79
Sprinkler Delay Time (s)	50
Sprinkler Identification	Tyco TY7153 CMSA
First Sprinkler Operation (min:sec)	2:35
Last Sprinkler Operation (min:sec)	5:09
Total Number of Sprinklers Operated	7
Peak/Maximum One Minute Average Gas Temperature (°F)	1568/1268
Peak/Maximum One Minute Average Steel Temperature (°F)	340/62
Peak/Maximum One Minute Average Flame Velocity (ft/sec)	31.3/1.25
Peak/Maximum One Minute Average Heat Flux (Btu/ft ²)	2.18/1.75
Time of Aisle Jump (min:sec)	No Jump
Equivalent Number of Pallet Loads Consumed	7
Test Duration (min)	15

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FM Approved for the Protection of Class II Commodities up to 10.5 m (35 ft) high

- Commodity Hazard: Class 1 and 2 in closed-top non-plastic or non-combustible containers
- Maximum Storage Height: **35 ft (10.5 m)**
- Maximum Building Height: **40 ft (12.2 m)**
- Storage Arrangement: Solid-Piled, Palletized, Shelf, Bin-Box, as well as Open-Framed Single-Row, Double-Row and Multiple-Row Racks
- Sprinkler System Type: Dry
- Maximum Water Delivery Time: 30 seconds upon operation of first sprinkler
- System Design: **25 AS @ 22 psi (1.5 bar)** plus 500 gpm (1,900 l/min) hose allowance
- Approval Guide: If confirmed by a listed software program, the sprinkler operation sequence should be based on the simultaneous opening of the most remote 4 sprinklers (2 sprinklers on 2 lines)

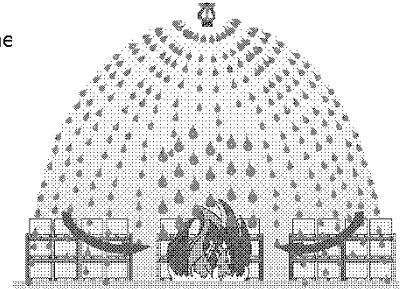
FM 7-2006

Engineering Results in Brief	
Reference with Data Sheets 1-7 and 8	
TO:	General
FROM:	Werner C. Baier
SUBJECT:	20 ft x 20 ft x 35 ft Double-Row Solid-Piled Storage Area Sprinkler System Approval
DATE:	September 19, 2006
SUMMARY In addition to normal FM Approved Class II (K25) Commodity Specific Application guidelines (NSN 17-7215), the following specific data is furnished: Commodity Hazard: Class 1 and 2 in closed-top non-plastic or non-combustible containers Maximum Storage Height: 35 ft Maximum Building Height: 40 ft Storage Arrangement: Solid-Piled, Palletized, Shelf, Bin-Box, as well as Open-Framed Single-Row, Double-Row and Multiple-Row Racks Sprinkler System Type: Dry Maximum Water Delivery Time: 30 seconds upon operation of first sprinkler System Design: 25 AS @ 22 psi (1.5 bar) plus 500 gpm (1,900 l/min) hose allowance Hose Allowance: 500 gpm (1,900 l/min) Hose Length: 100 ft Hose Diameter: 1-1/2 in. Hose Material: PVC Hose Coupling: Threaded Hose Fitting: Threaded Hose Support: Gravity Hose Weight: 10 lb/ft Hose Capacity: 500 gpm (1,900 l/min) Hose Pressure: 22 psi (1.5 bar) Hose Temperature: 140°F (60°C) Hose Life: 10 years Hose Strength: 100 psi (7 bar) Hose Weight: 10 lb/ft Hose Capacity: 500 gpm (1,900 l/min) Hose Pressure: 22 psi (1.5 bar) Hose Temperature: 140°F (60°C) Hose Life: 10 years Hose Strength: 100 psi (7 bar)	
RECOMMENDATION Engineering Report (ER) #4945, Tyco Model K25 & K25-C Commodity Specific Application guidelines (NSN 17-7215) can be used to govern the following: Commodity Hazard: Class 1 and 2 in closed-top non-plastic or non-combustible containers Maximum Storage Height: 35 ft Maximum Building Height: 40 ft Storage Arrangement: Solid-Piled, Palletized, Shelf, Bin-Box, as well as Open-Framed Single-Row, Double-Row and Multiple-Row Racks Sprinkler System Type: Dry Maximum Water Delivery Time: 30 seconds upon operation of first sprinkler System Design: 25 AS @ 22 psi (1.5 bar) plus 500 gpm (1,900 l/min) hose allowance Hose Allowance: 500 gpm (1,900 l/min) Hose Length: 100 ft Hose Diameter: 1-1/2 in. Hose Material: PVC Hose Coupling: Threaded Hose Fitting: Threaded Hose Support: Gravity Hose Weight: 10 lb/ft Hose Capacity: 500 gpm (1,900 l/min) Hose Pressure: 22 psi (1.5 bar) Hose Temperature: 140°F (60°C) Hose Life: 10 years Hose Strength: 100 psi (7 bar)	
Note: due to 30 second delivery time limit, valve confirmed to open quickly. In Engineering Report #4945, valve confirmation is based on the specification of 25 AS @ 22 psi (1.5 bar). Valve confirmation for this application should be based on the information contained in the data sheet 4 (sprinkler system design).	
Follow Data Sheet 6-7 specifying all other mandatory products for this commodity.	

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Fire Plume Penetration

- A high challenge fire can have an upward draft equivalent to 30 – 35 mph (50 – 56 kph)
- The Larger K-factor Ultra K17 produces larger water droplets than the LD resulting in better fire protection.



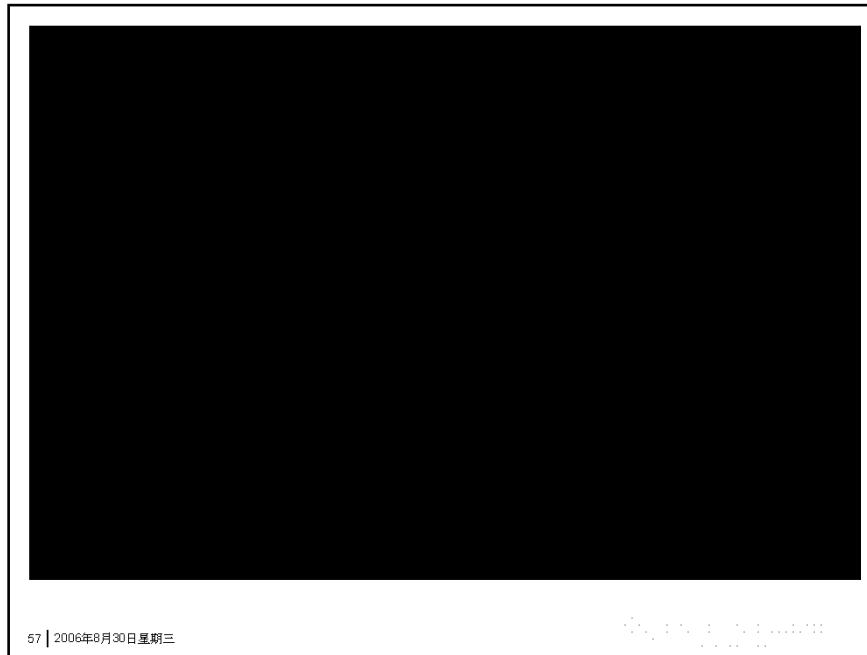
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Class III Testing

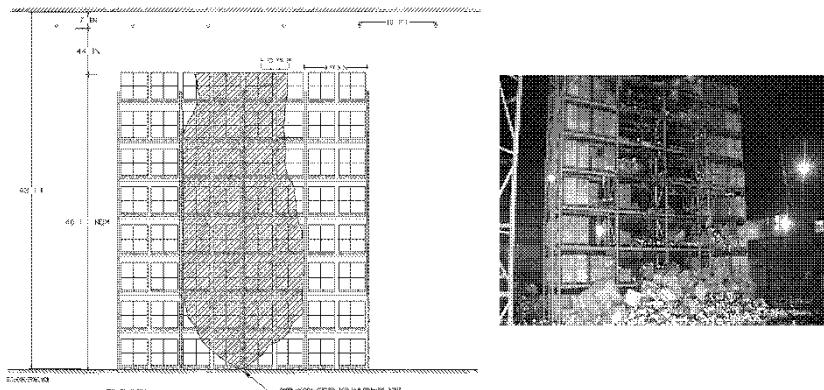
Storage Type	Double Row Rate
Cannistered Type	Class III
Nominal Storage Height (ft)	40
Nominal Ceiling Height (ft)	43
Nominal Clearance (ft)	3
Sprinkler Location	Ceiling 4' Offset
Temperature Rating °F	258
Nominal Glass Ball - Response Time Index (S-sec) ^{1/2}	100
Deflector to Ceiling (in)	7
Nominal Sprinkler Discharge Coefficient K (gpm/psi ^{1/2})	16.8
Nominal Discharge Pressure (psi)	30
Nominal Discharge Density (gpm·ft ²)	0.92
Aisle Width (ft)	8
Sprinkler Spacing (ft x ft)	10 x 10
Water Decay (%)	21
RANGE	
Length of Test (min:s)	30:50
First Ceiling Sprinkler Operation (min:s)	1:54
Water to Sprinklers (min:s)	2:15
Sprinkler Pressure at 50 psi	2.33
Number of Operated Ceiling Sprinklers	20
Peak Gas Temperature at Ceiling Above Ignition °F	1472
Minimum 1 Minute Average Gas Temperature at Ceiling Above Ignition °F	1394
Peak Steel Temperature at Ceiling Above Ignition °F	986
Maximum 1 Minute Average Steel Temperature Above Ignition °F	888
Fire Spread Across Aisle	No
Fire Spread Beyond Extrusions	No

1. EXTRUSION SPANNING LENGTH = 10 FT.
2. CEILING SPRINKLER K = 16.8 LPS/PSI STANDARD RESPONSE SPRINKLER COILS
3. CEILING SPRINKLER COVERAGE = 10 FT X 10 FT
4. EXTRUSION SPANNING LENGTH = 10 FT

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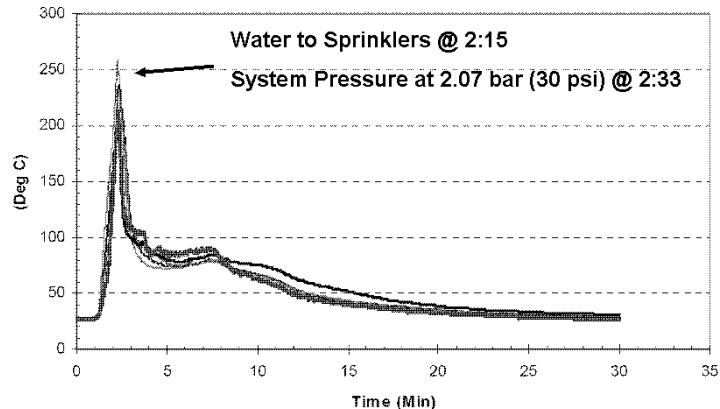
Main Array Damage From North



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http://www.1233456.com

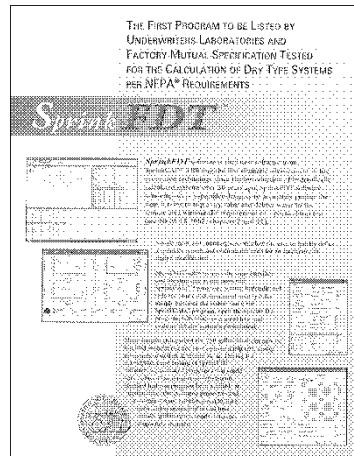
Steel Temperatures At Ceiling Above Ignition



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Navigation icons

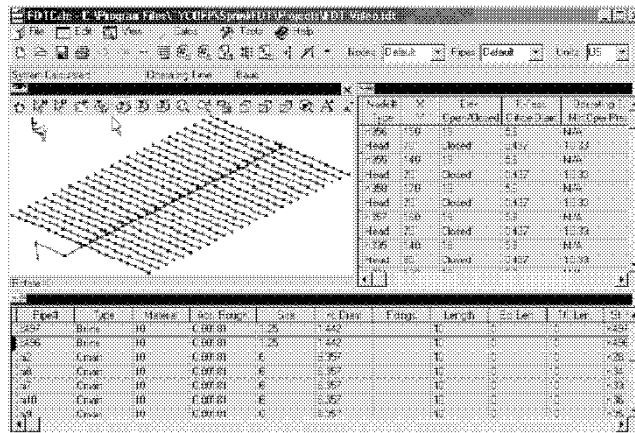
The key is predicting water transit time



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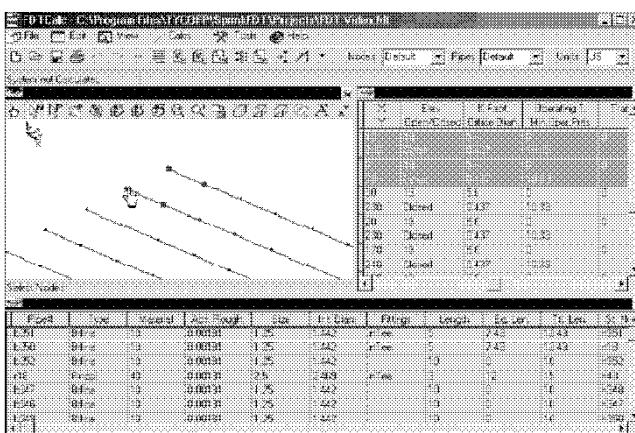
Navigation icons

Insert your system



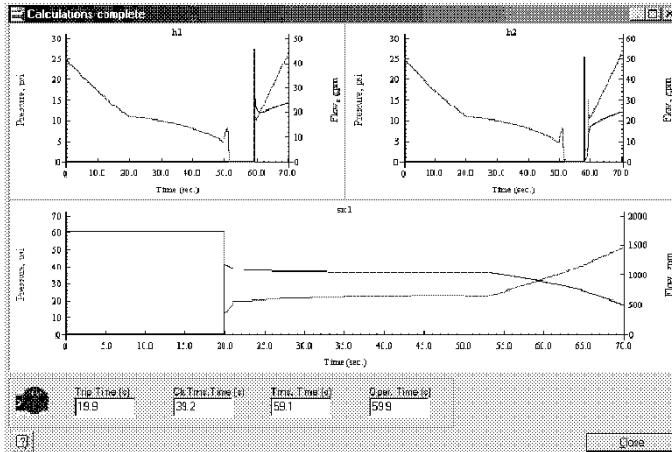
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Select the sprinklers that are open



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Perform Calculation



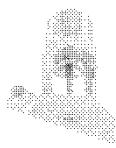
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Dry Systems Summary

- Knowing the predicted fire size/growth – Class II and III
 - Using a sprinkler capable of fire control with a delayed operation – Ultra K17
 - Calculating the water delivery time of the dry pipe systems – Fluid Delivery Time Software
- =
- **Custom Designed Dry Systems that Perform as Well or Better than Wet Systems**

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Design and Installation Guidelines of Window Sprinklers for Glazing Protection



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http://www.1233d.com

Specific Application

NFPA 13 states:

“... Nothing in this standard is intended to restrict new technologies or alternate arrangements, provided the level of safety prescribed by this standard is not lowered...”

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http://www.1233d.com

What is meant by “Specific Application”

- A method of developing specific design and protection criteria for fire hazards not covered by current Standards.

OR

- A method of developing “improved” specific design and protection criteria for hazards currently covered by Standards, but may be found to be insufficient by today's needs.

How does a “Specific Application” come about?

- A need is identified by:
 - Manufacturer
 - Consortium (e.g. Retail Groups; Building Manufacturers; Tire Manufacturers; etc)
 - Insurance Underwriters
 - Private Sector

How Does a Specific Application Come About?

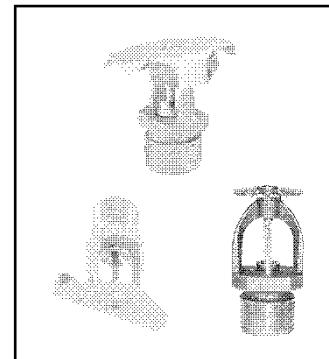
- Full Scale fire testing is performed by a Nationally Recognized Laboratory
 - At which;
- A "Specific Application" Listing is published in an appropriate Listing Guide
 - and/or
- A Technical Report is written outlining the full scale fire testing and associated data

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火 灾 防 护 系 统

Special Sprinklers

- **Special sprinklers** – A type of sprinkler that is intended for the protection of specific hazards or construction features and that has been evaluated and listed for performance under the following conditions:
 - Fire tests related to the intended hazard
 - Distribution of the spray pattern with respect to wetting of floors and walls
 - Distribution of the spray pattern with respect to obstructions
 - Evaluation of the thermal sensitivity of the sprinkler
 - Performance under horizontal or sloped ceilings
 - Area of design

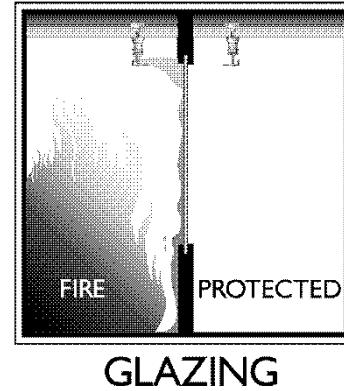


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火 灾 防 护 系 统

The TFBP Model WS Specific Application Window Sprinkler

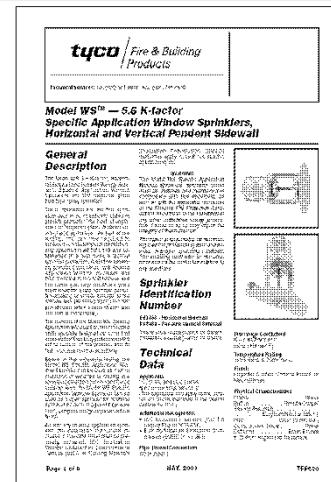
- These sprinklers are the first sprinklers ever to be specifically Listed to provide protection for heat strengthened or tempered glass windows using automatic sprinklers.
 - These sprinklers are also recognized by ICC-ES, & ULC as providing a two-hour equivalency for a fire separation assembly.



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Installation Requirements

- Specific Application Sprinkler
 - Use the Literature for Guidelines
 - Very Specific Rules for Installation
 - Reviewed by all Approval Agencies



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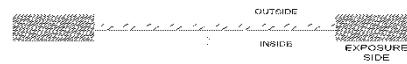
Area of Use

Interior Fire Separation



- When acceptable to the Authority Having Jurisdiction the Model WS Specific Application Window Sprinklers may be used in either a sprinklered or un-sprinklered building to protect non-operable window openings that are part of a fire separation.

Exterior Spatial Separation (Sprinklers Inside)



Exterior Spatial Separation (Sprinklers Outside)

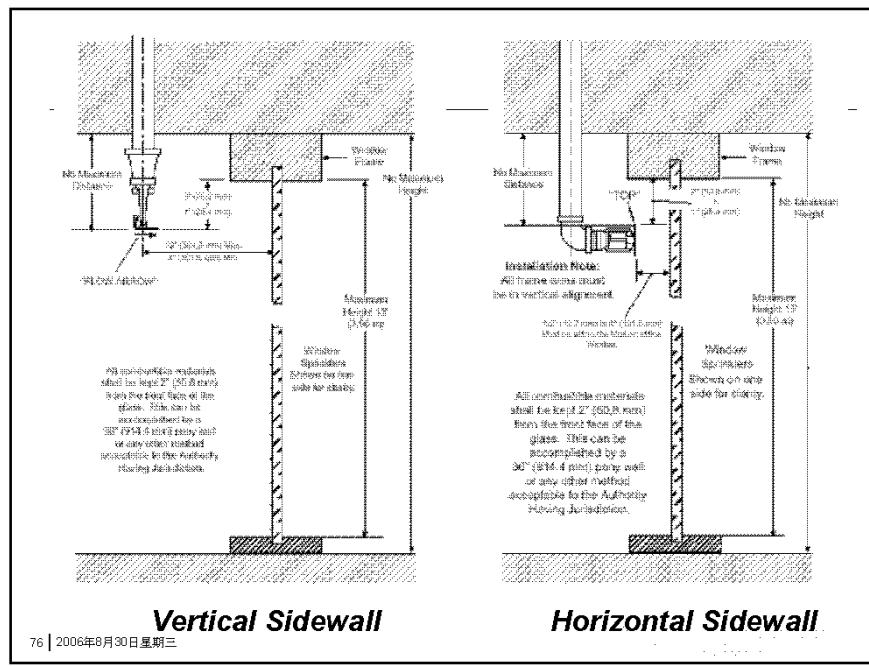
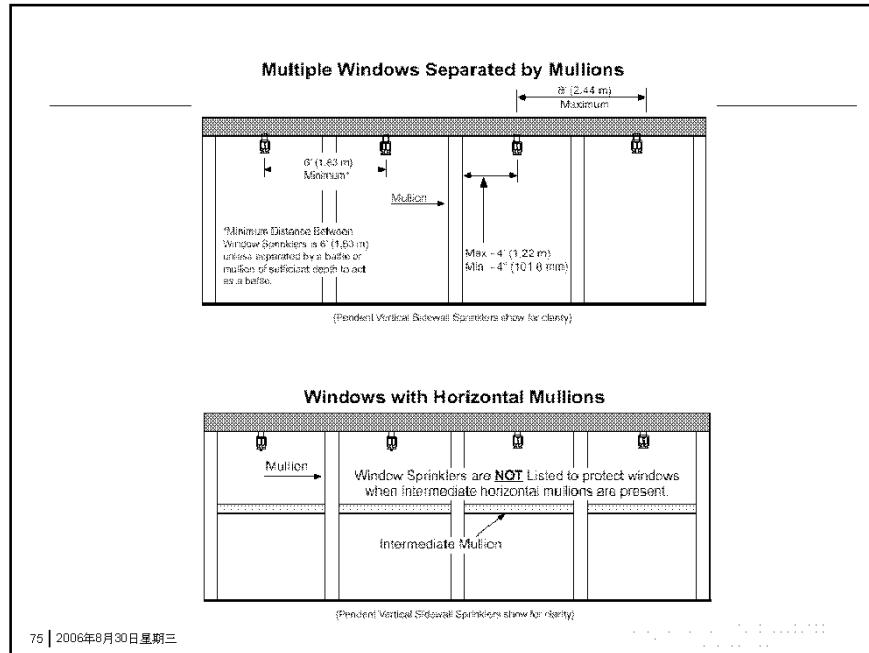


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Glass Type

- Single-glazed (Single Pane), Double-glazed (Double Pane) or Insulated, Non-operable Heat-strengthened, Tempered, or stronger glass window assemblies where each individual pane is a minimum 1/4" (6 mm) thick.

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Listings & Approvals

- UL & C-UL Listed
 - ULC – Underwriters Laboratories Of Canada
 - BMEC - Building Material Evaluation Commission
 - ICC Evaluation Service – ICC-ES Legacy Report NER-516
 - New York City Approval
 - Witnessed by Factory Mutual-Report Available

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NER-516

Re-issued January 1, 2003

ICC Evaluation Service, Inc.
www.icc-es.org

Business Regional Office • 6591 Glenhaven Hill Road • Whittier, California 90601 • (213) 670-0448
Regional Office • 913 Montclair Road, Suite A • Birmingham, Alabama 35213 • (205) 904-6621
Regional Office • 4015 Valley Flats Road • Canyon Club, Idaho 83478 • (208) 736-2381

Legacy Report on 2000 International Building Code with the 2002 Accumulative Supplement to the International Codes, the 2000 International Residential Code for One- and Two-Family Dwellings with the 2002 Accumulative Supplement to the International Codes, the BOCA National Building Code/1999, the 1999 Standard Building Code, the 1997 Uniform Building Code and the 1998 One- and Two-Family Dwelling Code

DIVISION 13 – SPECIAL CONSTRUCTION

Section 13930 – Wet-Pipe Fire Suppression Sprinklers

REPORT HOLDER

**TYCO Fire Products Research and
Development**
1467 Elmwood Avenue
Cranston, Rhode Island 02910
www.tycoflow.com

TYCO Fire Products Research and Development
1467 Elmwood Avenue
Cranston, Rhode Island 02910
www.tycofire.com

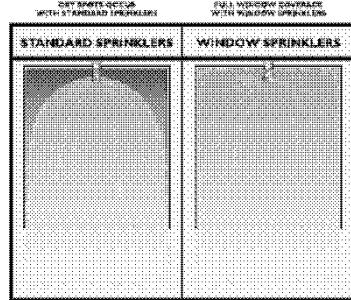
TYCO FIRE PRODUCTS (TYP)/CENTRAL SPRINKLER COMPANY (CSC) WINDOW SPRINKLER™ MODEL WST™, 12 INCH ORIFICE QUICK RESPONSE VERTICAL AND HORIZONTAL SIDEWALL SPRINKLERS SIN TY338Z, TY348Z, CSC338Z AND CSC48Z

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EVALUATION SUBJECT:

Why a Window Sprinkler?

- Distribution from Standard Spray Sprinklers does not efficiently cover a glazing assembly
- Original Testing conducted in Canada by Gem & RJA. Not Specifically Listed. Used By Variance. Both the AHJ & specifying engineer assumed liability/responsibility for its use

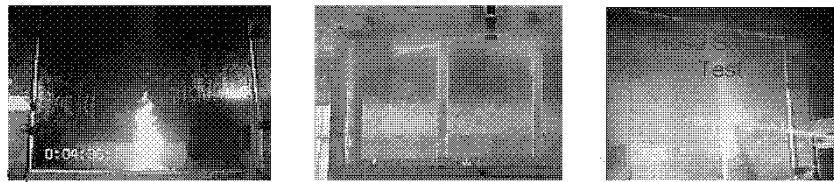


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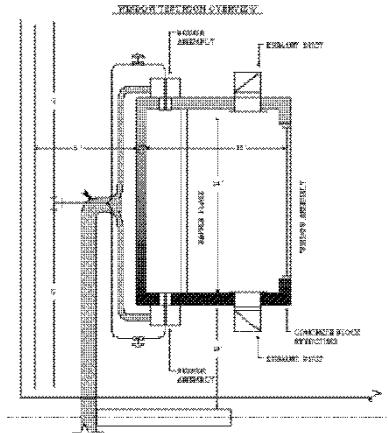
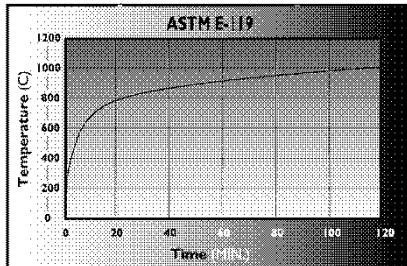
http://www.fsppt.com

Testing

- Same temperatures as ASTM/UL E-119 and CAN/ULC-S101-M89 (for 2 hours)
- In accordance with CCMC's Technical Guide for Sprinkler Protected Glazing Systems
- Tested with Butt Joints and Mullions
- Passed the Hose Stream Test ANSI/UL 10B
- No cracking or physical damage to window



Test Furnace Set Up



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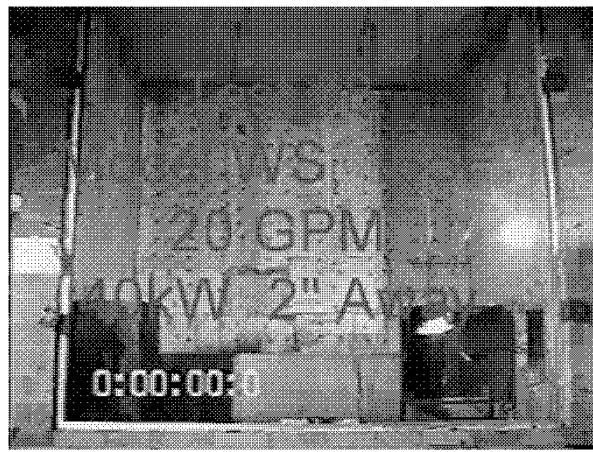
Testing Overview

- Calibration Test
 - Same temperatures as ASTM/UL E-119 and CAN/ULC-S101-M89
- Five Tests with Window Sprinklers
 - Various Assembly Types
 - Various Sprinkler Locations
- Fire Test then Hose Stream Test
- Small Fire Scenario - 40 kW

Hose Stream Test Video



Fire Test #8 Video



Brief Introduction and Significant Changes to the 2007 Edition NFPA 13

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火灾自动报警系统

Overview Committee Reports

- NFPA 13 – 2007
- NFPA 13D – 2007
- NFPA 13R – 2007
- 1200+ proposals and comments acted on for the 2007 Edition

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火灾自动报警系统

Chronology of Sprinkler Standards 2006 Annual Revision Cycle

- Reports on Proposals (ROP): 6-24-05
- Reports on Comments (ROC): 2-24-06
- Presentation at Technical Committee Reports Session – NFPA World Safety Conference – June 2006
- Standards Council Meeting – July 2006

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Chapter 3 Definitions

- New Definitions for:
 - Institutional Sprinkler
 - Pilot Line Detector
- Available Height for Storage
 - Clearance Requirements
- Aisle Width
 - Measured Between Loads, Not Racks

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Chapter 3 Definitions

New Definitions of "wood" and "plastic" Pallets

New requirements for idle plastic pallets stored on rack

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Chapter 3 Definitions

- New Definitions of "wood" and "plastic" Pallets
 - New requirements for idle plastic pallets stored on rack
- Types of rack storage
 - Solid
 - Slatted
 - Open
- Revised "open rack" to clarify 50% calculation rule
- "Rack shelf area" defined by minimum 3 in. flue spaces on all four sides

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Chapter 5 Occupancy/Commodity Classification

- Plastic Pallets
 - Plastic Pallets are to be considered reinforced unless otherwise permanently marked or certified.

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http://www.firerescue1.com

Chapter 6 Components and Hardware

- 6.2.9 – List of Installed Sprinklers required in spare sprinkler cabinet
 - SIN
 - Description
 - Temperature Rating
 - Quantity of Spare Sprinklers
- 6.3.8 Marking of pipe. Removed “continuously”. Must be visible on all lengths 3.6 m.

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http://www.firerescue1.com

Chapter 7 System Requirements

- New air venting requirements
 - Means to exhaust air while filling
 - Suitably located inspectors test or aux. drain OK
 - Intended to reduce oxygen and corrosion
- High water level protection
 - Externally resetting dry valves
 - Low differential dry pipe valves
 - Use either a high water level device or automatic drain

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第7章 系统要求

Chapter 7 Dry System Water Delivery

- Size of dry systems limited by water delivery time
 - 60 second rule
 - Table 7.2.3.4.1 Time and outlet requirements based on the hazard
- Time determined by
 - Listed water delivery program
 - Water delivery to test header
- No exception for systems under 500 gallon or with QOD

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第7章 干式系统供水

What are NFPA's requirements for a Dry Pipe System?

System Size Gal. (Liters)	Quick Opening Device	Required Water Delivery Time to Inspectors Test Connection
0 - 500 Gal. (0 - 1893 L)	N	None
500 - 750 Gal. (1893 - 2839 L)	N Y	60 Sec. None
Over 750 Gal. (2839 L)	N Y	60 Sec. 60 Sec.

What's so magical about 60 seconds?



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Chapter 7 Dry System Water Delivery

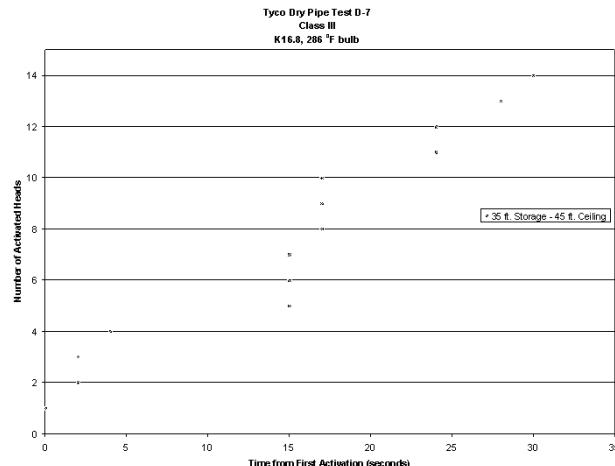
Table 7.2.3.4.1 Dry System Water Delivery

Hazard	Number of Most Remote Sprinklers Initially Open	Maximum Time of Water Delivery
Residential	1	15 seconds
Light	1	60 seconds
Ordinary I	2	50 seconds
Ordinary II	2	50 seconds
Extra I	4	45 seconds
Extra II	4	45 seconds
High piled	4	40 seconds

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Activation Sequence 10.7 m Class III / 13.7 m Ceiling



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Chapter 7 Preaction Systems

- Single and non-interlocked system size remains at 1000 sprinklers
- Double interlocked preaction systems
 - Water delivery in 60 seconds
 - Water delivery based on time and hazard – similar to dry pipe systems
- Single and double interlocked preaction systems protecting storage shall not be gridded (excluding miscellaneous storage)

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Chapter 7 Antifreeze Systems

- Antifreeze and ESFR sprinklers must be Listed for use together
- Riser placard required for remote antifreeze systems
- Placard on Anti-freeze control valve listing anti-freeze type, brand, concentration and system volume
- Test/drain connection required for systems over 40 gallons
- Use minimum concentration required for temperature

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Chapter 7 Refrigerated Spaces

- ROP proposed elimination of dry systems
 - ROC went back to 2002 wording
 - DPV's have a place in refrigerated rooms and small freezers – not specifically prohibited in large systems, however, that was the original intent
- New detection requirements for preaction systems
 - Detectors should operate before sprinklers
 - Electric/Pneumatic fixed temperature – no rate of rise
 - Detector placement rules – ceiling and racks

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Chapter 8 Installation Requirements

- Furniture (wardrobes, cabinets, trophy cases) do not require sprinklers inside, even if attached to the building.
- Multiple buildings – One sprinkler system?
 - Multiple attached building may be protected by a single sprinkler system
 - Detached buildings require separate sprinkler system
 - Authority Having Jurisdiction can allow – Appendix guidance provided

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Chapter 8 Installation Requirements

- Sprinkler protection caps and straps
 - New UL Listing requirements for protective caps and straps on glass bulb sprinklers
 - Recommend removal after other construction activities completed
 - When sprinklers are more than 3.1m (10ft) above the floor, may be removed immediately after installation
 - Must be removed before sprinkler system placed in service
 - Remove per manufacturer's instructions

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Chapter 8 Dry Sprinklers

- New Section 8.4.10
- Consider length of pipe to avoid freezing due to conduction
- Seal space around sprinkler barrel to avoid air leakage

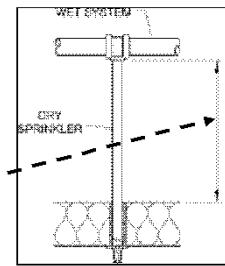
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Calculating Dry Type Sprinkler Length

Concern: The travel of cold conduction from the freeze area to the water seal. Formula creates length within the warm area in order to disperse freezing temperatures. Applying insulation to the sprinkler barrel will compound the issue.

Length determined from the face of the fitting to the top of insulation
"OUTSIDE OF THE PROTECTED AREA"



>12 inches when the temperature within the protected area is -20°F/-29°C.
>18 inches when the temperature within the protected area is -40°F/-40°C
>24 inches when the temperature within the protected area is -60°F/-51°C

For protected area temperatures between those given above, the minimum recommended length from the face of the fitting to the outside of the protected area may be determined by interpolating between the indicated values.

Formula

$$A=B+0.3(20-C)$$

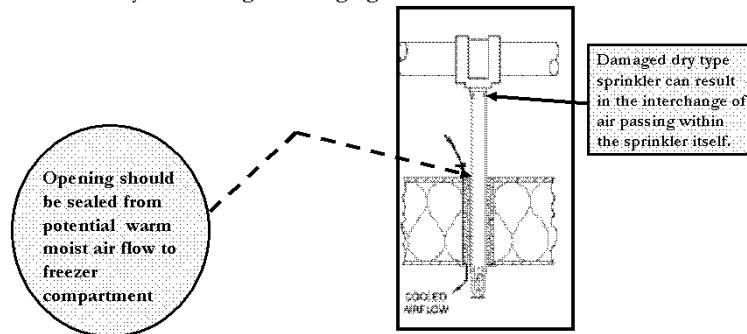
B= Depth from the top of the insulation to the finished ceiling of the freezer

C=Temperature of the freezer in degrees F

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Ice buildup inside dry type sprinklers due to air interchange

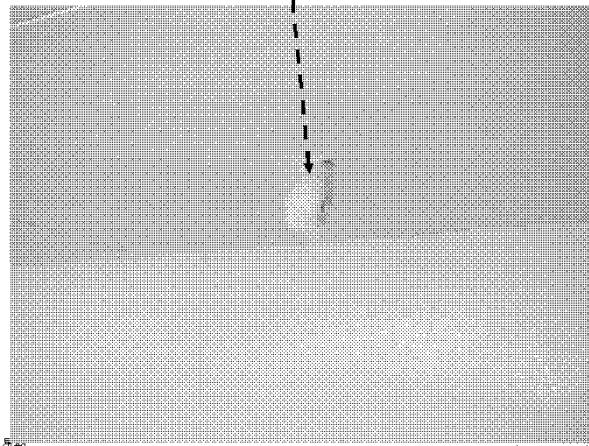
Concern: Air interchange resulting in warm moist air from outside the freezer coming in contact with dryer cold air in freezer. Condensation can form on sprinkler thereby obstructing or damaging the device.



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Example of Humid Moist Air Infiltration and Resultant Freezing Around Dry Pendant



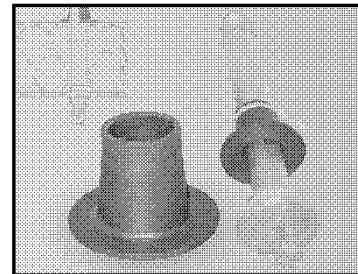
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The Solution to Air Interchange for Dry Pendent Installations in Freezers

Tyco DSB-1 Dry Sprinkler Boot

One size fits various Tyco dry pends
Saf-T-Lok industrial grade sealant application only
No screws or additional freezer box penetrations
Complete installation with 2 nylon zip ties as clamp
Provides equivalent thermal insulating properties as spray foam insulation.
Boot material and geometry allows radial and axial movement.

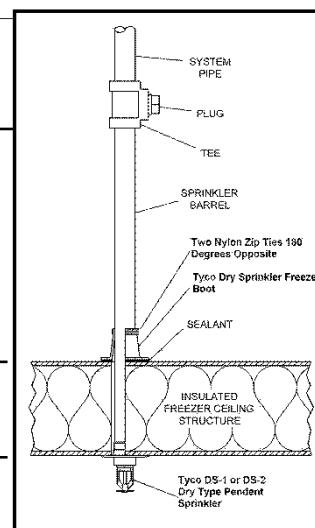
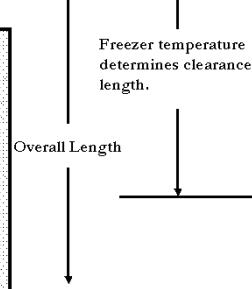


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Installation of Dry Type Sprinklers in Freezers

(Example) Overall length of dry pendent 21 inches due to expected freezer temperatures of -30F and 6 inches of insulation.
Additionally, installation may utilize run of Tee with outlet side plugged.
(Couplings not to be utilized)



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Chapter 8 EC/Residential Sprinklers

- Soffits and cabinets in residential areas
 - Sprinklers may be installed on face of soffits < 300 mm wide installed above cabinets without installing sprinklers below the cabinets
 - If soffit is more than 0.9 m above cabinet, install sprinkler below soffit when cabinets are 300 mm deep
 - Based on distribution testing with kitchen cabinets

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Chapter 8 Residential Sprinklers

- Minimum of 2.4 m horizontally between sprinklers on sloped ceilings
- Listed sprinklers shall be used when available

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Chapter 8 Pilot Line Detectors (Sprinklers)

- New Section 8.14
- Covers spacing
 - Under ceilings
 - Open sided buildings
 - Outdoor installation
 - Between vertical levels outdoors
 - Rules for protection from damage
- Piping/support requirements
- Covers waterspray systems and cooling towers

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Chapter 8 Combustible Concealed Spaces

- Many proposals on amount/type of combustibles rejected – revised annex

A.8.15.1.2.1 Minor quantities of combustible materials such as but not limited to: cabling, nonmetallic plumbing piping, non-structural wood, etc... can be present in concealed spaces constructed of limited or noncombustible materials but should not typically be viewed as requiring sprinklers (see [A.7.5.1.1](#)). For example, it is not the intent of this section to require sprinklers, which would not otherwise be required, in the interstitial space of a typical office building solely due to the presence of the usual amount of cabling within the space. The threshold value at which sprinklers become necessary in the concealed space is not defined.

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Chapter 11 Design Approaches

- Retained Area/density curves
- Clarified general criteria section to apply to all hydraulically calculated systems, including storage
- Clarified that water supply and hose stream durations are the same

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Chapter 11 Design Approaches

- New Section dedicated to “special design approaches”
 - Residential sprinklers
 - Exposure protection
 - Water curtains

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Chapter 11

Design Approaches

- New criteria for protection of concealed/combustible roof spaces:
 - Wood members spaced no more than 0.9 m on center, and
 - Slopes at or greater than 1 in 3

The minimum operating pressure is dependent on sprinkler spacing (parallel to the slope)

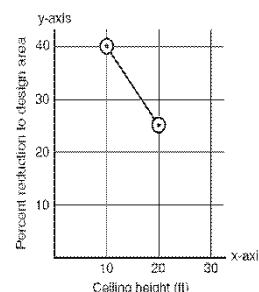
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Navigation icons

Chapter 11

Design Approaches

- Continue to allow the area reduction for ordinary hazard protection with QR sprinklers
- Where listed quick-response sprinklers are used the system area of operation can be reduced without revising the density
 - Wet pipe system
 - Light hazard or ordinary hazard occupancy
 - 6.1-m (20-ft) max. ceiling height
 - There are no unprotected ceiling pockets as allowed exceeding 3.0 m² 32 ft²
- The number of sprinklers in the design area shall never be less than five.



Note: $y = \frac{-3x}{2} + 55$
 For ceiling height ≥ 10 ft and ≤ 20 ft, $y = \frac{-3x}{2} + 5$
 For ceiling height < 10 ft, $y = 40$
 For ceiling height > 20 , $y = 0$
 For SI units, 1 ft ≈ 0.31 m.

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Chapter 12 (through Chapter 20) Storage

- Retained Area/density curves
- Reorganized (9 chapters)
 - General
 - Miscellaneous storage
 - Class I-IV
 - Plastics and rubber commodities
 - Rubber tire storage
 - Rolled paper/baled cotton
 - Special designs

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Chapter 12 (through chapter 20) Storage

- Rack storage protection
 - Revised criteria incorporating new definitions/limitations on:
 - Rack shelving
 - Slatted rack shelving
 - Open rack shelving
 - Rack shelf area

Conditions which must be met to not be considered solid shelf storage

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Chapter 12 (through 20) Storage

- Storage for ceilings > 9.1 m and clearances > 6.1 m
 - Protection to be provided that would result in a 6.1 m distance between top of storage and ceiling
 - Added new annex note with technical references

(Reflects concerns with absence of full scale test data to justify use of k 5.6 and k 8.0 for protection of storage where high ceilings and significant clearances from top of storage to ceiling exist).

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Chapter 12 (through chapter 20) Storage

- New cold storage protection:
 - Control Mode Specific Application (CMSA)
 - Up to 10.7 m of Class II commodity
 - Up to 12.2 m ceiling height
 - No in-rack sprinklers

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Chapter 12 (through chapter 20) Storage

- New Compact Shelf Storage requirements removed during members voting at annual conference