Significant Advancements in Water Based Fire Suppression for Storage Occupancies

By James Golinveaux
Senior Fellow
Higher – Faster - Further

How high can we go? – Ceiling Only?
Currently NFPA 13 and FM 8-9 limit Ceiling Only protection for some commodities to 45 ft (13.7m).

UL Specific Application Sprinklers (Reliable K22 and Tyco K25 ESFR) extend Ceiling Only protection for some commodities to 48 ft (14.6m).

K14 (200) ESFR have been limited to 35 ft (10.6m) ceilings from it’s original 40 ft (12m) application.

When installing in-rack sprinklers, most vertical spacing's are limited to 10 ft (3m) to 12 ft (3.7m) – requiring many levels of in-rack sprinklers.

At what height is Control Mode not enough for local fire department capability?

There are 17 different sprinklers in CMDA, CMSA and ESFR categories to select from for storage applications.
What is the Big Deal?

FM Global and NFPA have made Significant Changes for Storage in 2011 and 2012

- FM has eliminated all names of storage sprinklers such as ESFR, CMSA and CMDA, NFPA still uses the names to differentiate the rules
- FM has banned K5.6 (K80) and K8.0 (K115) from ceiling protection of storage, NFPA restricts the use but not a ban
- FM has banned 286 degree (high temperature) sprinklers from wet systems
- FM has eliminated density and area from design considerations, NFPA still highly dependent on density curves
- FM has eliminated storage height from design consideration of ceiling only protection, storage height and clearance a significant design consideration in NFPA
- FM and NFPA now recognize ceiling only designs with as few as 6 sprinklers in the hydraulic demand.
Getting the commodity class correct.
Recognizing storage arrangement and shelving definition limitations within design schemes.
Picking the best sprinkler orifice and temperature for the ceiling height.
Being able to sleep at night knowing that the facility operators know what a flue space is, a plywood shelf is not considered open and storage should be removed from the bottom of the pile to not exceed clearance limitations??
K5.6 Spray  7 psi (0.5 bar) to 100 psi (7 bar)
K25EC Droplet Size 7 psi (0.5 bar) to 100 psi (7 bar)
Droplets Ability to Penetrate the Fire Plume

22 MPH (45 KPH)
Small Drops are Carried Back to Ceiling - May Skip or Prevent Adjacent Sprinklers from Opening

Skipping

22 MPH (45 KPH)
### NFPA 13 K-factor Requirements for Storage Protection

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12.6.1: densities of 0.20 gpm/ft(^2) (8.2 mm/min) or less</td>
<td>5.6 (80) &amp; larger</td>
</tr>
<tr>
<td>12.6.2: densities of greater than 0.20 gpm/ft(^2) (8.2 mm/min) to 0.34 gpm/ft(^2) (13.9 mm/min)</td>
<td>8.0 (115) &amp; larger</td>
</tr>
<tr>
<td>12.6.3: densities greater than 0.34 gpm/ft(^2) (13.9 mm/min)</td>
<td>11.2 (160) &amp; larger</td>
</tr>
</tbody>
</table>

**FM 8-9**

2.3.3.2.1 Use only FM Approved sprinklers listed in the *Approval Guide under the heading of Storage Sprinklers* (Ceiling-Level) for any ceiling-level sprinkler options in this data sheet.

Currently, FM Approved ceiling-level Storage sprinklers have **K-factor values ranging from 11.2 (160) to 25.2 (360)**.
K8.0 (115) .33 gpm/ft² / 3000 sq ft (13.44 / 279)
CMDA - Pressure is not the Issue
Chapter 14 Example - 30 ft (9.1m) Class IV Palletized Storage under a 35 ft (10.6m) Ceiling – Wet System

CMDA

Figure 14.2.4.2 – 0.30 gpm/ft² (12.2 mm/min) X 190% (Figure 14.2.4.3) = .57 gpm/ft² (23.2 mm/min) over 2000 ft² (186 m²)

Table 14.1.3 - Hose allowance is 500 gpm (1900 L/min) for 150 minutes

K11.2 (160) @ 100 ft² = 26 psi (1.8 bar)
K16.8 (240) @ 100 ft² = 11.5 psi (0.8 bar)

CMSA

Table 14.3.1 – K19.6 (280) Pendent
15 sprinklers @ 25 psi (1.7 bar) = 15 x 98 gpm = 1470 (5564 L/min)

Table 14.3.1 - Hose allowance is 500 gpm (1900 L/min) for 90 minutes

ESFR

Table 14.4.1 – K25.2 (360) Pendent
12 sprinklers @ 20 psi (1.4 bar) = 12 x 113 gpm = 1356 (5112 L/min)

Table 14.4.1 - Hose allowance is 250 gpm (946 L/min) for 60 minutes
### Table 21.2 – K25.2 EC (360)

Upright 8 sprinklers @ 40 psi (2.6 bar) = 8 x 159 gpm = 1272 (4815 L/min)

### Table 21.2 - Hose allowance is 250 gpm (946 L/min) for 60 minutes

### K25.2 EC (280) @ 144 ft² (13.4 m²)

#### Table 21.3.1 Sprinkler Protection Criteria for Open-Frame Rack Storage of Class I Through Class IV and Cartoned Unexpanded Plastic Commodities

<table>
<thead>
<tr>
<th>Sprinkler Demand GPM (LPM)</th>
<th>Hose Demand GPM (LPM)</th>
<th>Total Flow GPM (LPM)</th>
<th>Duration Minutes</th>
<th>Total Gallons (Liters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,275 (4,819)</td>
<td>250 (946)</td>
<td>1,525 (5,769)</td>
<td>60</td>
<td>91,500 (346,140)</td>
</tr>
<tr>
<td>Sprinkler Type</td>
<td>Total Flow GPM (LPM)</td>
<td>Total Gallons (Liters)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
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<td>------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMDA K11.2 (160) or Greater</td>
<td>1,640 (6,215)</td>
<td>246,000 (932,250)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMSA - K19 (280) Pend</td>
<td>1,970 (7,376)</td>
<td>177,300 (663,840)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESFR - K25 (360) ESFR</td>
<td>1,606 (6,058)</td>
<td>96,360 (363,480)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special - K25 (360) EC</td>
<td>1,525 (5,769)</td>
<td>91,500 (346,140)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**FM 8-9 Example - 30 ft (9.1m) Class IV Palletized Storage under a 35 ft (10.6m) Ceiling – Wet System**

**FM Engineering Bulletin 06-11**

Table 3. Ceiling-Level Protection Guidelines for Class 4 and Cartoned Unexpanded Plastic Commodities in a Solid-Piled, Palletized, Shelf, or Bin-Box Storage Arrangement

<table>
<thead>
<tr>
<th>Ceiling Height, ft (m)*</th>
<th>Wet System, Pendant Sprinklers, 160°F (70°C)**</th>
<th>Wet System, Upright Sprinklers, 160°F (70°C)</th>
<th>Dry System, Upright Sprinklers, 260°F (140°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quick Response</td>
<td>Standard Response</td>
<td>Quick Response</td>
</tr>
<tr>
<td>K11.2 (K130)</td>
<td>K14.0 (K200)</td>
<td>K22.4 (K300)</td>
<td>K11.2 (K160)</td>
</tr>
<tr>
<td>15 (4.5)</td>
<td>20 @ 7 (0.5)</td>
<td>12 @ 35 (3.5)</td>
<td>20 @ 7 (0.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 @ 25 (1.7)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 @ 20 (1.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 @ 20 (1.4)</td>
<td></td>
</tr>
<tr>
<td>20 (6.1)</td>
<td>16 @ 20 (1.4)</td>
<td>12 @ 25 (1.7)</td>
<td>20 @ 7 (0.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 @ 20 (1.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 @ 10 (0.7)</td>
<td></td>
</tr>
<tr>
<td>30 (9.0)</td>
<td>20 @ 30 (3.3)</td>
<td>12 @ 20 (1.4)</td>
<td>25 @ 30 (2.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 @ 20 (1.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 @ 30 (2.1)</td>
<td></td>
</tr>
<tr>
<td>35 (10.5)</td>
<td>20 @ 30 (3.3)</td>
<td>12 @ 20 (1.4)</td>
<td>25 @ 30 (2.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 @ 20 (1.4)</td>
<td></td>
</tr>
<tr>
<td>40 (12.0)</td>
<td>20 @ 30 (3.3)</td>
<td>12 @ 20 (1.4)</td>
<td>25 @ 30 (2.1)</td>
</tr>
<tr>
<td>45 (13.5)</td>
<td>20 @ 30 (3.3)</td>
<td>12 @ 20 (1.4)</td>
<td>25 @ 30 (2.1)</td>
</tr>
</tbody>
</table>

* The protection options indicated in the protection table can be based on any ceiling height equal to or higher than the actual maximum ceiling height of the protected area.

** The protection options indicated in the protection table for upright sprinklers can also be used as an alternative option for pendant sprinklers having the same K-factor, RTI rating, nominal temperature rating and spacing requirements as the upright sprinkler.

*** The design of 8 @ 40 (2.8) has a hose stream allowance of 250 gpm (950L/min) and a duration of 60 minutes when the maximum linear spacing is up to 12 ft (3.6 m); for linear spacing over 12 ft (3.6 m) the hose stream allowance is 500 gpm (1,900 L/min) and the duration is 120 minutes.

90 Minutes – error in EB
### FM 8-9 Example - 30 ft (9.1m) Class IV Palletized Storage under a 35 ft (10.6m) Ceiling – Wet System – From Table 3

<table>
<thead>
<tr>
<th>35 ft (10.5m) Ceiling Height</th>
<th>K25.2EC (K360EC) Pendent and Upright 12ft x12ft (3.6m)</th>
<th>K25.2EC (K360EC) Upright 14ft x14ft (4.2m)</th>
<th>K16.8 QR (K240) Pendent 10ft x 10ft (3.0m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Table 3</strong></td>
<td>8 @ 40 psi (2.8 bar)</td>
<td>8 @ 40 psi (2.8 bar)</td>
<td>12 @ 50 psi (3.5 bar)</td>
</tr>
<tr>
<td>Sprinkler Demand GPM (LPM)</td>
<td>1,275 (4,819)</td>
<td>1,275 (4,819)</td>
<td>1426 (5,388)</td>
</tr>
<tr>
<td>Hose Demand GPM (LPM)</td>
<td>1,525 (5,769)</td>
<td>1,775 (6,719)</td>
<td>1676 (6,338)</td>
</tr>
<tr>
<td>Duration Minutes</td>
<td>60 min</td>
<td>90 min</td>
<td>60 min</td>
</tr>
<tr>
<td>Total Gallons (Liters)</td>
<td>91,500 (346,140)</td>
<td>159,750 (604,654)</td>
<td>100,560 (380,280)</td>
</tr>
</tbody>
</table>
## NFPA and FM 8-9 Example - 30 ft (9.1m) Class IV Palletized Storage under a 35 ft (10.6m) Ceiling – Wet System

<table>
<thead>
<tr>
<th>30 ft (9.1m) Class IV Palletized Storage under a 35 ft (10.6m) Ceiling – Wet System</th>
<th>NFPA 13</th>
<th>FM 8-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprinkler Demand GPM (LPM)</td>
<td>CMDA K11.2 (160) or Greater</td>
<td>CMSA - K19 (280) Pend</td>
</tr>
<tr>
<td>1,140 (4,315)</td>
<td>1,470 (5,476)</td>
<td>1,356 (5,112)</td>
</tr>
<tr>
<td>Hose Demand GPM (LPM)</td>
<td>500 (1,900)</td>
<td>500 (1,900)</td>
</tr>
<tr>
<td>Total Flow GPM (LPM)</td>
<td>1,640 (6,215)</td>
<td>1,970 (7,376)</td>
</tr>
<tr>
<td>Duration Minutes</td>
<td>150</td>
<td>90</td>
</tr>
<tr>
<td>Total Gallons (Liters)</td>
<td>246,000 (932,250)</td>
<td>177,300 (663,840)</td>
</tr>
</tbody>
</table>
45 ft (13.7 m) Ceiling Recommendation
Rack Storage With No In-Rack Sprinklers

Model ESFR-25
- K-Factor 25.2 (360)

NFPA/FM Global Exceptions
- No Solid Shelves
- Open-top containers
- Uncartoned Unexpanded Plastic
- Cartoned or Uncartoned Expanded Plastic
Expanded Exposed Plastic
Table 15.4.1 – The only ESFR recognized to protect Palletized or Solid Piled Exposed Expanded Plastic

Table 18.4(d) Rubber Tires – The only ESFR to protect laced tire storage up to 25 ft (7.6m) under a 40 ft (12.1m) ceiling

Table 18.4(d) Rubber Tires – The only ESFR to protect up to 30 ft (9.1m) storage under a 40 ft (12.1m) ceiling

Table 18.4(d) Rubber Tires – The only ESFR to protect up to 30 ft (9.1m) palletized portable rack storage under a 40 ft (12.1m) ceiling

Table 20.2 Automotive Components – The only ESFR to protect Automotive Components to 25 ft (7.6m) storage under a 35 ft (10.7m) ceiling

Section 20.3.7 Big Box Retail Plastics in Display Shelving – The only ESFR for Storage to 20 (6.1m) under a 30 ft (9.1m) ceiling. Only ESFR in the Retail section.

Section 20.7.3 – High Bay Record Storage – the only ESFR recognized for High Bay Record Storage up to 34 ft (10.4m) high.
Table 4 Protection of Cartoned Expanded Plastic Commodities in Solid-Piled, Palletized, Shelf, and Bin-Box Arrangements – The only ESFR (Pend QR) to protect 35 ft (10.7m) and 40 ft (12.1m) high ceilings

Table 6 Protection of Uncartonened Expanded Plastic Commodities in Solid-Piled, Palletized, Shelf, and Bin-Box Arrangements – The only ESFR (Pend QR) to protect 35 ft (10.7m) and 40 ft (12.1m) high ceilings

Table 9 Protection of Cartoned Expanded Plastic Commodities in Open-Frame Storage Racks – The only ESFR (Pend QR) to protect 35 ft (10.7m) and 40 ft (12.1m) high ceilings

Table 10 Protection of Uncartonened Unexpanded Plastic Commodities in Open-Frame Storage Racks – The only ESFR (Pend QR) to protect 35 ft (10.7m) and 40 ft (12.1m) high ceilings

Table 11 Protection of Uncartonened Expanded Plastic Commodities in Open-Frame Storage Racks - The only ESFR (Pend QR) to protect 35 ft (10.7m) and 40 ft (12.1m) high ceilings
Advantage Notes of the Tyco K25 (K360) ESFR (Pendent QR for FM) Expanded Applications

For ESFR Specific Application (UL) 48 ft (14.6m) ceilings, the Tyco K25 ESFR is 10 psi (.7bar) less pressure than the K22 ESFR and is the only ESFR that is also a Specific Application – the K22 ESFR has 2 models to cover both applications.

For greater than 40 feet (12.2 meters) ceiling height and up to and including 45 feet (13.7 meters) ceiling height the Model ESFR-25 will have more placement flexibility because the maximum deflector to ceiling distance is 18 inches (457 mm) 4 inches (100 mm) greater than competitions K25 ESFR.
Do not attempt to add additional insulation around the barrel in the heated area as a method to minimize condensation. This will reduce the calculated “Exposure Length”.

<table>
<thead>
<tr>
<th>Ambient Temperature of Discharge End of Sprinkler</th>
<th>Exposure Length of Sprinkler inches (mm) in Heated Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>40°F (4°C)</td>
<td>0</td>
</tr>
<tr>
<td>30°F (-1°C)</td>
<td>0</td>
</tr>
<tr>
<td>20°F (-7°C)</td>
<td>4 (100)</td>
</tr>
<tr>
<td>10°F (-12°C)</td>
<td>8 (200)</td>
</tr>
<tr>
<td>0°F (-18°C)</td>
<td>12 (305)</td>
</tr>
<tr>
<td>-10°F (-23°C)</td>
<td>14 (355)</td>
</tr>
<tr>
<td>-20°F (-29°C)</td>
<td>14 (255)</td>
</tr>
<tr>
<td>-30°F (-34°C)</td>
<td>16 (405)</td>
</tr>
<tr>
<td>-40°F (-40°C)</td>
<td>18 (455)</td>
</tr>
<tr>
<td>-50°F (-46°C)</td>
<td>20 (510)</td>
</tr>
<tr>
<td>-60°F (-51°C)</td>
<td>20 (510)</td>
</tr>
</tbody>
</table>
UL Specific Application Listing – K22 & K25 ESFR

Provide ceiling-only protection up to and including:

- 48 ft (14.6 m) Ceiling
- 43 ft (13.1 m) Storage

Eliminates need for in-rack sprinklers for storage arrangements beyond NFPA 13

Lower pressure provides flexibility when sizing system piping when compared to other listed sprinklers

10-Year Limited Warranty
Temperature rating: 212°F (100°C)

Deflector to top of storage: ≥ 36 in (914 mm)

Deflector to ceiling distance 6 – 14 in (152 – 356 mm)

Sprinkler system design: NFPA 13 for ESFR Sprinkler based on 45 PSI (3.1 bar)

Minimum aisle width: 8 ft (2.4 m)
### Where In-Racks Become Mandatory Based on Type of Sprinkler and Storage or Ceiling Height – NFPA 13

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Commodity</th>
<th>Storage Height</th>
<th>Building Height</th>
<th>CMDA</th>
<th>CMSA</th>
<th>ESFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Class IV</td>
<td>&gt;22 ft (6.7 m)</td>
<td>NA</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Class I - III</td>
<td>&gt;25 ft (7.6 m)</td>
<td>NA</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Class I - IV</td>
<td>&gt;35 ft (10.6)</td>
<td>&gt;40 ft (12.1 m)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Class I - IV</td>
<td>&gt;40 ft (12.1 m)</td>
<td>&gt;45 ft (13.7 m)</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>17</td>
<td>Group A plastic commodities in cartons, encapsulated or nonencapsulated</td>
<td>20 ft (6.1 m)</td>
<td>&gt;25 ft (7.6 m)</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group A plastic Cartoned Unexpanded</td>
<td>&gt;35 ft (10.6)</td>
<td>&gt;40 ft (12.1 m)</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group A plastic Cartoned Unexpanded</td>
<td>&gt;40 ft (12.1 m)</td>
<td>&gt;45 ft (13.7 m)</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Group A plastic Exposed Unexpanded</td>
<td>&gt;35 ft (10.6)</td>
<td>&gt;40 ft (12.1 m)</td>
<td></td>
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<td>x</td>
</tr>
<tr>
<td>Chapter</td>
<td>Commodity</td>
<td>Building Height</td>
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</tr>
<tr>
<td>Tables 7 - 11</td>
<td>Class I – IV and Cartoned</td>
<td>&gt;45 ft (13.7 m)</td>
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</tr>
</tbody>
</table>
ESFR Obstructed
We are approaching the maximum one shot protection scheme (ceiling only).

In-rack sprinklers may need to perform closer to suppression sprinklers when heights exceed local fire brigade operations.

The faster the sprinklers activate the better (now that the orifice sizes are regulated).

Allowing adjustments based on storage heights may cause future concerns.
QUESTIONS?
We have a passion to protect what matters most.

James Golinveaux
Senior Fellow

tyco
Fire Protection Products