New In-rack Design Criteria in NFPA 13 and FM Data Sheet 8-9

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Outline

Background
- Testing of EC In-rack Sprinkler System

FM Data Sheet 8-9: July 2018 Interim Revision

Summary
Background
☑ 2013 Edition
NFPA 13
2013 NFPA 13
No design criteria for
Expanded Group A Plastics
Stored in Racks

Design criteria for Exposed Expanded Group A plastics stored in racks
- Max. Ceiling Height: 12m
- Max. Storage Height: 11m
- Min. Aisle Width: 2.4m
- Vertical barriers at max. 5.0m and 11.5m² intervals
- Sprinkler: K25.2 (K360) ESFR Intermediate Temperature
- Design Criteria: 12 sprinklers at 4.1 bar
- Basic water demand: 8 750 lpm
Table 11

Uncartononed Expanded Plastics

- Max. Ceiling Height: 12m
- Sprinkler: K25.2 (K360) QR Storage
- Design Criteria: 20 sprinklers at 5.2 bar
- Basic water demand: 16 420 lpm
Background
Reliable Research on
Extended Coverage
In-rack Sprinkler System
Why In-rack Sprinklers?

Tall Buildings
High Hazards
Water Savings
Concepts

1. Virtual Floor
2. Extended Coverage In-rack Sprinkler System
   ◦ N-RACK-EC®
Virtual Floor
Extended Coverage
IRAS
N-RACK-EC®
In-rack Sprinklers

STANDARD IN-RACK SPRINKLERS

EXTENDED COVERAGE IN-RACK SPRINKLERS
K25.2 (K360) PENDENT
Extended Coverage IRAS
Tested Double-row Rack Layout
Extended Coverage IRAS Test
Exposed Expanded Group A Plastics

12m ceiling
11m storage

Ceiling level sprinkler system
◦ K16.8 (K240) ESFR @ at 3.5 bar

In-rack sprinkler system
◦ K25.2 (K360) EC Pendent
  ◦ 520 lpm per sprinkler
  ◦ Intermediate temperature
◦ 1 level at 9.1m
Extended Coverage IRAS Test
Multiple-row Racks up to 4.7m Deep
Extended Coverage IRAS Test
Multiple-row Racks up to 4.7m Deep
Extended Coverage IRAS
Tested Multiple-row Rack Layout
Extended Coverage IRAS Test
Cartoned Unexpanded Group A Plastics

14.6m ceiling
13.1m storage

Ceiling
  ◦ K25.2 (K360) EC Pendent @ 2.1bar

In-rack
  ◦ K25.2 (K360) EC Pendent
    ◦ 520 lpm per sprinkler
    ◦ Intermediate temperature
  ◦ 1 level at 30 ft
Cartoned Unexpanded Group A Plastic Commodity

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2019 NFPA 13

First Draft
February 2017

Second Draft
January 2018

Motions Report
April 2018

Publication Expected
September 2018
Reorganized Storage Chapters

Ch. 20
  ◦ General Requirements for Storage

Ch. 21
  ◦ Protection of High Piled Storage Using CMDA Sprinklers

Ch. 22
  ◦ CMSA Requirements for Storage Applications

Ch. 23
  ◦ ESFR Requirements for Storage Applications

Ch. 24
  ◦ Alternative Sprinkler System Designs

Ch. 25
  ◦ Protection of Rack Storage Using In-Rack Sprinklers
2019 NFPA 13
New Storage Protection Criteria

1. In-rack Sprinklers

ESFR
2. In-rack Sprinklers

K25.2EC (K36) Pendent
1. ESFR In-rack Sprinklers
ESFR In-Rack
Max. Vertical Spacing of In-rack Levels

12m
- Class I – IV Commodity
- Cartoned Unexpanded Plastic Commodity

9.1m
- Cartoned Expanded Plastic Commodity
- Uncartonened Plastic Commodity
# ESFR In-rack Hydraulic Design

<table>
<thead>
<tr>
<th>Max. Vertical Spacing of In-rack Levels</th>
<th>Commodity</th>
<th>Min. K-factor</th>
<th>Min. Flow per In-rack Sprinkler</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td></td>
<td>gpm/psi&lt;sup&gt;1/2&lt;/sup&gt; (lpm/bar&lt;sup&gt;1/2&lt;/sup&gt;)</td>
<td>lpm</td>
</tr>
<tr>
<td>9.1</td>
<td>Class I-IV Cartoned Unexpanded Plastics</td>
<td>14.0 (200)</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Cartoned Expanded Plastics</td>
<td>14.0 (200)</td>
<td>380</td>
</tr>
<tr>
<td></td>
<td>Uncartoned Plastics</td>
<td>22.4 (320)</td>
<td>455</td>
</tr>
<tr>
<td>12</td>
<td>Class I-IV Cartoned Unexpanded Plastics</td>
<td>22.4 (320)</td>
<td>455</td>
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</tbody>
</table>
ESFR In-rack Hydraulic Design

<table>
<thead>
<tr>
<th>Rack Configuration</th>
<th>Number of Sprinklers in In-rack Hydraulic Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class I-IV Commodity and Cartoned Plastics</td>
</tr>
<tr>
<td></td>
<td>Uncartoned Plastics</td>
</tr>
<tr>
<td>Single-row racks up to 0.9m deep</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Single-row racks up to 1.8m deep</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Double- and Multiple-row racks</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>6 &amp; 6</td>
</tr>
</tbody>
</table>

Not balanced with ceiling sprinkler system. Treat highest in-rack sprinkler system as a “virtual floor” when selecting ceiling sprinkler system.
ESFR In-rack: Single-row Racks

Max. 4.5 ft (1.4 m)

Max. 8.5 ft (2.6 m)

Max. 8.5 ft (2.6 m)

6 ft (1.8 m) max.

3 ft (0.9 m) max.

1 ft (0.3 m) max.
ESFR In-rack: Double-row Racks
ESFR In-rack: Multiple-row Racks
2. K25.2EC (K360) Pendent In-rack Sprinklers
EC In-rack
Vertical Spacing of In-rack Levels

9.1m
• Class I – IV Commodity
• Cartoned Plastic Commodity

6.1m
• Uncartoned Plastic Commodity
EC In-rack Horizontal Barriers

Located at each in-rack level

Min. 10mm plywood or 0.7mm metal

Cover flue spaces
- 75mm max. gap permitted at uprights
- 75mm max. gap permitted at rack members, pipe drops, etc.
EC In-rack
Single-row Rack Layout

PLAN VIEW (OPTION 1)

PLAN VIEW (OPTION 2)
EC In-rack
Double-row Rack Layout
EC In-rack
Multiple-row Rack Layout
EC In-rack
Hydraulic Design

520 lpm per sprinkler

Single- and double-row racks
  ◦ 4 sprinklers

Multiple-row racks (up to 4.7m deep)
  ◦ 8 sprinklers (3 at each face and 2 in-between)

Not balanced with or added to ceiling sprinkler system demand
Installation Example 1

Scenario: Change of commodity in existing warehouse with 12m ceiling height
- Ceiling height: 12m
- Storage height: 10.7m
- Ceiling sprinkler system: K16.8 (K240) ESFR sprinklers
- Storage racks: Double-row 2.4m deep
- Old commodity: Cartoned Unexpanded Group A plastics
- New commodity: Exposed Expanded Group A plastics
### Example 1: Existing 12m Building with Commodity Change

<table>
<thead>
<tr>
<th></th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
<th>Ceiling Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling sprinklers</td>
<td>Existing* K16.8 (K240) ESFR</td>
<td>Existing* K16.8 (K240) ESFR</td>
<td>Existing* K16.8 (K240) ESFR</td>
<td>New K25.2 (K360) ESFR</td>
</tr>
<tr>
<td>Ceiling sprinkler</td>
<td>Existing* Ceiling Only</td>
<td>Existing* Ceiling Only</td>
<td>Existing* Ceiling Only</td>
<td></td>
</tr>
<tr>
<td>design criteria</td>
<td>12 at 3.5bar</td>
<td>12 at 3.5bar</td>
<td>12 at 3.5bar</td>
<td>12 at 4.1bar</td>
</tr>
<tr>
<td>In-rack sprinklers</td>
<td>K8.0+ (K115+) QR</td>
<td>K22.4+ (K320+) ESFR</td>
<td>K25.2EC (K360EC) Pendent</td>
<td>None</td>
</tr>
<tr>
<td>In-rack sprinkler</td>
<td>8 at 230 lpm</td>
<td>10 at 450 lpm</td>
<td>4 at 520 lpm</td>
<td>None</td>
</tr>
<tr>
<td>design criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. In-rack Sprinklers</td>
<td>10 (5 on 2 levels)</td>
<td>5</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>per Rack Bay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic sprinkler demand</td>
<td>5 400 lpm (existing)</td>
<td>5 400 lpm (existing)</td>
<td>5 400 lpm (existing)</td>
<td>8 750 lpm</td>
</tr>
<tr>
<td>Barriers</td>
<td>Horizontal</td>
<td>None</td>
<td>Horizontal</td>
<td>Vertical</td>
</tr>
</tbody>
</table>

*Based on design criteria from FM Global Data Sheet 8-9*
Installation Example 2

Scenario: New Tall Storage Building

- Ceiling height: 32m
- Storage height: 29m
- Storage racks: Double-row 2.4m deep
- Commodity: Cartoned Unexpanded Group A plastics (CUP)
Example 2: New 32m Building with CUP Commodity

<table>
<thead>
<tr>
<th></th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3a</th>
<th>Option 3b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling sprinklers</td>
<td>K25.2EC (K360EC)</td>
<td>K25.2EC (K360EC)</td>
<td>K25.2EC (K360EC)</td>
<td>K22.4 (K320) ESFR</td>
</tr>
<tr>
<td>Ceiling sprinkler design criteria</td>
<td>6 at 2.1bar</td>
<td>6 at 2.1bar</td>
<td>6 at 2.1bar</td>
<td>12 at 2.7bar</td>
</tr>
<tr>
<td>In-rack sprinklers</td>
<td>K8.0+ QR</td>
<td>K22.4+ (K320+) ESFR</td>
<td>K25.2EC (K360EC) Pendent</td>
<td>K25.2EC (K320EC) Pendent</td>
</tr>
<tr>
<td>In-rack sprinkler design criteria</td>
<td>8 at 230 lpm</td>
<td>6 at 450 lpm</td>
<td>4 at 520 lpm</td>
<td>4 at 520 lpm</td>
</tr>
<tr>
<td>No. In-rack Sprinklers per Rack Bay</td>
<td>35 (5 on 7 levels)</td>
<td>10 (5 on 2 levels)</td>
<td>3 (1 on 3 levels)</td>
<td>2 (1 on 2 levels)</td>
</tr>
<tr>
<td>Basic sprinkler demand</td>
<td>3 100 lp</td>
<td>3 100 lpm</td>
<td>3 100 lpm</td>
<td>6 400 lpm</td>
</tr>
<tr>
<td>Barriers</td>
<td>Horizontal</td>
<td>None</td>
<td>Horizontal</td>
<td>Horizontal</td>
</tr>
</tbody>
</table>

Barriers: Horizontal

Notes:
- K25.2EC (K360EC) represents the K25.2 EC sprinklers with a K360 EC label.
- K22.4 (K320) ESFR indicates a K22.4 sprinkler with a K320 ESFR label.
- Pendent sprinklers are used for ceiling applications.
- Horizontal barriers are used to divide the building.
- In-rack sprinklers are specifically designed for rack environments.

Design criteria values are provided for each option, ensuring adequate water flow and coverage for fire protection.
1.1 Changes

**July 2018.** Interim revision. A new Section 2.3.6.8 has been created to address the installation and design guidelines for protection scheme using quick-response K25.2EC (K360EC) pendent sprinklers as in-rack sprinklers in combination with horizontal barriers to protect open-frame rack storage of commodity hazards up to and including cartoned unexpanded plastics when the in-rack sprinkler protection was installed 30 ft (9.0 m) above floor level.

“... using quick-response K25.2EC (K360EC) pendent sprinklers as in-rack sprinklers ...”
EC In-rack in FM Data Sheet 8-9
Commodities

Class I – IV
Cartoned nonexpanded group A plastic
Containers must be closed top
EC In-rack in FM Data Sheet 8-9

Racks

Open frame racks

Single-, double- or multiple-row

Horizontal barriers at each in-rack level

- Extend across longitudinal flue
- Not required at transverse flues with uprights
EC In-rack in FM Data Sheet 8-9

Horizontal Sprinkler Spacing

Linear: 2.1m to 2.5m
Area: 4.6m² to 6.3m²

Linear spacing may be 1.3m or less when area spacing is 1.6m² or less

Must be spaced at least 0.9m from rack uprights within single-row racks and double-row racks up to 2.4m wide

Exception: Where the max. linear spacing is 1.3m and max. area spacing is 1.6m²
## EC In-rack in FM Data Sheet 8-9

### Rows of Sprinklers per Level

<table>
<thead>
<tr>
<th>Rack Type</th>
<th>No. Rows of Sprinklers per In-rack Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-row</td>
<td>1</td>
</tr>
<tr>
<td>Double-row up to 2.7m deep</td>
<td>1</td>
</tr>
<tr>
<td>Double-row more than 2.7m deep</td>
<td>2</td>
</tr>
<tr>
<td>Multiple-row</td>
<td>Use horizontal spacing rules and provide sprinklers within 450mm of each rack face</td>
</tr>
</tbody>
</table>
EC In-rack in FM Data Sheet 8-9

Vertical Spacing

Max. Vertical Distance between in-rack sprinklers: 9.0m

Max. distance from deflector to horizontal barrier: 175mm

Min. clearance from storage to deflector: 225mm
**Design Criteria: 605 lpm per sprinkler**

<table>
<thead>
<tr>
<th>Rack type</th>
<th>Rack depth</th>
<th>Aisle width</th>
<th>No. of IRAS in Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-row</td>
<td>Up to 1.8m</td>
<td>Up to 1.2m</td>
<td>6 total; 3 in most remote rack and 3 in nearest adjacent rack</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Over 1.2m</td>
<td>3 in most remote rack</td>
</tr>
<tr>
<td>Double-row</td>
<td>Up to 9.7m</td>
<td>Up to 1.2m</td>
<td>8 total; 4 in most remote rack and 4 in nearest adjacent rack</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Over 1.2m</td>
<td>4 in most remote rack</td>
</tr>
<tr>
<td></td>
<td>Over 9.7m</td>
<td>Any</td>
<td>8 total; 4 on each rack face in most remote rack</td>
</tr>
<tr>
<td>Multiple-row</td>
<td>Any</td>
<td>Any</td>
<td>8 total; 4 along the rack face and the nearest 4 sprinklers in the most remote rack</td>
</tr>
</tbody>
</table>
Ceiling Sprinkler Design Criteria
The “Virtual Floor”

Consider the top level of in-rack sprinklers as a floor when selecting the ceiling sprinkler system design criteria.
EC In-rack in FM Data Sheet 8-9

Water Demand

Hose stream allowance: 950 lpm
Water supply duration: 60 minutes

In-rack sprinkler system not balanced with or added to ceiling level sprinkler demand when overhang of commodity beyond horizontal barrier is max. 75mm.
Summary
2019 NFPA 13

Anticipated publication September 2018

New in-rack design criteria using ESFR sprinklers or K25.2EC (K360EC) Pendent sprinklers
New in-rack design criteria for K25.2EC (K360EC) QR Pendent Sprinklers
Designing “Independent” In-rack Sprinkler Systems

USE THE “VIRTUAL FLOOR” FOR EXTENDED COVERAGE AT THE CEILING
Thanks for your attention!!!!