Case Study on the separation of electronic and ESFR sprinklers in a warehouse facility

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Agenda

- Electronically activated sprinklers (EAS) and the early grouped activation concept
- Problem overview
- Draft curtain design criteria
- Simulation framework
- Results and conclusions
[Automatic Sprinklers]

- Cannot control where and when sprinklers will operate during a fire
- Typically operate once fire is well established
- Design for “extra” sprinklers due to uncertainty

[Electronic Sprinklers (EAS)]

- Intelligent, simultaneous operation of an array of sprinklers around point of origin
- Operate earlier in fire development
- Design for only required sprinklers to address the fire threat
Ceiling only protection of up to exposed, expanded group A plastics stored up to 30 ft. (9,1 m) under a 35 ft. (10,7 m) ceiling.

<table>
<thead>
<tr>
<th>System Type</th>
<th>ESFR (NFPA 13)</th>
<th>EAS (PBD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-Factor (gpm/psi^0.5)</td>
<td>25.2</td>
<td>16.8</td>
</tr>
<tr>
<td>Pressure – PSI (BAR)</td>
<td>60 (4.1)</td>
<td>52 (3.6)</td>
</tr>
<tr>
<td>Flow per sprinkler – GPM (LPM)</td>
<td>195 (738)</td>
<td>121 (458)</td>
</tr>
<tr>
<td>Design qty. sprinklers</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Ceiling demand – GPM (LPM)</td>
<td>2342 (8865)</td>
<td>1090 (4126)</td>
</tr>
<tr>
<td>Total water required – Gal (m^3)</td>
<td>155k (587)</td>
<td>81k (307)</td>
</tr>
<tr>
<td>Max ceiling - ft (m)</td>
<td>40 (12,2)</td>
<td>35 (10,7)</td>
</tr>
<tr>
<td>NOTES:</td>
<td>Vertical barriers</td>
<td>Barriers not required</td>
</tr>
</tbody>
</table>
Electronically Activated Sprinkler (EAS) system

**Control Panel:**
- Addressable releasing panel

**Software:**
- Fire detection algorithm(s)
- Sprinkler selection algorithm(s)
- Sprinkler release criteria

**Sprinkler:**
- Existing ESFR
- Electronic Actuation

**Fire Detection:**
- Addressable heat detector
- Actuation relay
- Supervised output

**Existing panel with custom software**
**Existing sprinkler with electronic actuation**
**Existing addressable heat sensor tech.**

**A sensor for every sprinkler**

**Digital SLC (Style 6)**
Detect
11°C/min (20°F/min) \( \Delta T \)

Select (6-9 heads)

1st traditional ESFR
101°C (214°F link)
Design challenge

ESFR

EAS
Design challenge
Design goal
Acceptable if ESFR operates first
EAS activation criteria

1. 11°C/min (20°F/min) $\Delta T$ ROR

2. 68°C (155°F) or 88°C (190°F) FT

3. Min # sensor activations

Require one 100°C (212°F) ESFR sprinkler operation at or before first 11°C/min (20°F/min) EAS ROR sensor
ESFR RTI ~25 \( (\text{m}\cdot\text{s})^{0.5} \)

EAS sensor RTI ~7 \( (\text{m}\cdot\text{s})^{0.5} \)*

* Measured using plunge tunnel test per FM 2000 section 4.28 at 68°C (155°F)
100°C (212°F) ESFR

EAS (algorithm based)
Existing draft curtain design criteria

**NFPA 13: 2019**

14.2.5.1 Where ESFR sprinkler systems are installed adjacent to sprinkler systems with standard-response sprinklers, a draft curtain of noncombustible construction and at least **2 ft (600 mm) in depth** shall be required to separate the two areas.

14.2.5.2 A **clear aisle** of **4 ft (1.2 m) centered below** the draft curtain shall be maintained for separation.

**FM 1-10: Jan 2011**

2.3.2 ... If the curtain is centered within the aisle, use a minimum aisle width equal to **1.5 times the spacing between ceiling sprinklers** in the direction perpendicular to the curtain.

2.3.3 Use **2 ft (0.6 m) deep**, noncombustible draft curtains installed per DS 2-0 to separate quick-response and special-response sprinklers from areas protected by standard-response sprinklers...

2.3.4 ... Where draft curtains are recommended by FM Global data sheets, ensure the minimum depth of the draft curtain \(d_{\text{min}}\) measured down from \(H_{\text{max}}\) is the **greater** of:

- a. \(d_{\text{min}} = H_{\text{max}}/8\), or
- b. \(d_{\text{min}} = 4 \text{ ft (1.2 m)} \) ...
Simulation framework

UL/NFPRF Sprinkler, Vent, and Draft Curtain Study
FDS validation case
Simulation variables

1. Draft curtain depth
2. Curtain distance from rack face
3. Storage height
4. Sprinkler Spacing
5. Ignition location
Case 1&2

NFPA 13 based

Case 4  

Case 3&5

FM 1-10 based

3 m (10 ft)

2.4 m (8 ft)
CASE 1
NFPA 13
0.6 m (2 ft) curtain

CASE 2
NFPA 13 modified
1.2 m (4 ft) curtain
CASE 1
NFPA 13
0.6 m (2 ft) curtain

ESFR 68°C (155°F)  80 s
ESFR 100°C (212°F) 103 s
EAS 30°C (86°F)     73 s

CASE 2
NFPA 13 modified
1.2 m (4 ft) curtain

ESFR 68°C (155°F)  83 s
ESFR 100°C (212°F) 104 s
EAS 30°C (86°F)     112 s
CASE 2
NFPA 13 modified
0.6 m (2 ft) from curtain (B2)

CASE 3
FM 1-10
2.0 m (6.5 ft) from curtain (A4)

CASE 4
FM 1-10
3.2 m (10.5 ft) from curtain (B2)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Time (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESFR 68°C (155°F)</td>
<td>83 s</td>
</tr>
<tr>
<td>ESFR 100°C (212°F)</td>
<td>104 s</td>
</tr>
<tr>
<td>EAS 30°C (86°F)</td>
<td>112 s</td>
</tr>
<tr>
<td></td>
<td>101 s</td>
</tr>
<tr>
<td></td>
<td>114 s</td>
</tr>
<tr>
<td></td>
<td>107 s</td>
</tr>
<tr>
<td></td>
<td>114 s</td>
</tr>
<tr>
<td></td>
<td>77 s</td>
</tr>
<tr>
<td></td>
<td>102 s</td>
</tr>
<tr>
<td></td>
<td>109 s</td>
</tr>
</tbody>
</table>
CASE 3
FM 1-10
4 tiers

CASE 5
FM 1-10
3 tiers

ESFR 68°C (155°F)  101 s
ESFR 100°C (212°F)  114 s
EAS 30°C (86°F)  114 s

ESFR 68°C (155°F)  111 s
ESFR 100°C (212°F)  120 s
EAS 30°C (86°F)  119 s
# Results

## VARIABLES

<table>
<thead>
<tr>
<th></th>
<th>CASE 1</th>
<th>CASE 2</th>
<th>CASE 3</th>
<th>CASE 4</th>
<th>CASE 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft curtain depth</td>
<td>0.6 m (2 ft)</td>
<td>1.2 m (4 ft)</td>
<td>1.33 m (4.4 ft)</td>
<td>1.33 m (4.4 ft)</td>
<td>1.33 m (4.4 ft)</td>
</tr>
<tr>
<td>Curtain distance from rack face</td>
<td>0.6 m (2 ft)</td>
<td>0.6 m (2 ft)</td>
<td>2.0 m (6.5 ft)</td>
<td>3.2 m (10.5 ft)</td>
<td>2.0 m (6.5 ft)</td>
</tr>
<tr>
<td>Storage height</td>
<td>6.1 m (20 ft)</td>
<td>6.1 m (20 ft)</td>
<td>6.1 m (20 ft)</td>
<td>6.1 m (20 ft)</td>
<td>4.6 m (15 ft)</td>
</tr>
<tr>
<td>Sprinkler spacing</td>
<td>3.0 m x 3.0 m (10 ft x 10 ft)</td>
<td>3.0 m x 3.0 m (10 ft x 10 ft)</td>
<td>2.4 m x 3.0 m (8 ft x 10 ft)</td>
<td>2.4 m x 3.0 m (8 ft x 10 ft)</td>
<td>2.4 m x 3.0 m (8 ft x 10 ft)</td>
</tr>
<tr>
<td>Ignition location</td>
<td>between 2</td>
<td>between 2</td>
<td>among 4</td>
<td>between 2</td>
<td>among 4</td>
</tr>
<tr>
<td>Basis of design</td>
<td>NFPA 13</td>
<td>NFPA 13 with deeper curtain</td>
<td>FM 10-1</td>
<td>FM 10-1 B2 ignition</td>
<td>FM 10-1</td>
</tr>
</tbody>
</table>

## RESULTS

<table>
<thead>
<tr>
<th></th>
<th>CASE 1</th>
<th>CASE 2</th>
<th>CASE 3</th>
<th>CASE 4</th>
<th>CASE 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 68°C (155°F) ESFR</td>
<td>80 s</td>
<td>83 s</td>
<td>101 s</td>
<td>77 s</td>
<td>111 s</td>
</tr>
<tr>
<td>First 100°C (212°F) ESFR</td>
<td>103 s</td>
<td>104 s</td>
<td>114 s</td>
<td>102 s</td>
<td>120 s</td>
</tr>
<tr>
<td>First EAS detection</td>
<td>73 s</td>
<td>112 s</td>
<td>114 s</td>
<td>109 s</td>
<td>119 s</td>
</tr>
<tr>
<td>Max EAS sensor temp at ESFR operation</td>
<td>41°C (106°F)</td>
<td>29°C (84°F)</td>
<td>31°C (88°F)</td>
<td>31°C (88°F)</td>
<td>34°C (93°F)</td>
</tr>
<tr>
<td>EAS system activation before ESFR operation</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
Design approach:

1. Follow FM 1-10 guidelines
2. Use simulation framework to evaluate alternative designs
Thank You!