Fire Protection Technology

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FM Global

- Mutual Property Insurance Company – 1835
- 250 Standards
- Technically-Based:
  - Research
  - Engineering Standards
  - FM Approvals

FM Global Property Loss Prevention Data Sheets
July 2019

*FM Global Property Loss Prevention Data Sheets are engineering guidelines written to help reduce the chance of property loss due to fire, weather conditions, or failure of electrical or mechanical equipment, and incorporate loss experience, research results, input from consensus standards committees, equipment manufacturers and others.*
Agenda

- Fire Protection Technology
  - Consumer Fireworks
  - Energy Storage Systems
Consumer Fireworks
Types of Fireworks

Consumer Fireworks

Display Fireworks
Types of Consumer Fireworks

Novelties

Ground based

Aerials
Types of Retail Displays
Industry Need

In 2015, the National Association of State Fire Marshals (NASFM) approached FM Global to undertake research to provide a validated fire protection design for retail sales of consumer fireworks.
Test Array Layout

- Aisles: 4 ft (1.2 m)
- Shelf depth 1.5 ft (0.5 m)
- Shelf length 24 ft (7.3 m)
- Interior shelf height 6 ft (1.8 m)
- Perimeter shelf height 12 ft (3.7 m)
- Ceiling:
  - Test 1: 16 ft (4.9 m)
  - Test 2: 30 ft (9.1 m)
Test Array Layout

- **Aisles:** 4 ft (1.2 m)
- **Shelf depth:** 1.5 ft (0.5 m)
- **Shelf length:** 24 ft (7.3 m)
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- **Ceiling:**
  - Test 1: 16 ft (4.9 m)
  - Test 2: 30 ft (9.1 m)
Test Array Layout

- Combustible flame breaks
  - Longitudinally
  - Laterally every 16 ft (4.9 m)
Devices

- 500 g fountains
- Four types (A, B, C, and D)
- Duration of ~3 min

~16 ft
~(4.9 m)
Test Array Layout

- 88% of shelf volume full
- Average energy density of 3.2 lb/ft$^3$ (50.9 kg/m$^3$)
Damage: 16ft Ceiling, 0.2gpm/ft$^2$
Damage: 16ft Ceiling, 0.2gpm/ft²
Ceiling Level Steel Temperatures

16 ft (4.9 m) Ceiling
0.2 gpm/ft² (8.1 mm/min)

30 ft (9.1 m) Ceiling
0.3 gpm/ft² (12.2 mm/min)
# Performance Evaluation

## Fire Test Results

<table>
<thead>
<tr>
<th>Test Description</th>
<th>16ft Ceiling</th>
<th>30ft Ceiling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sprinklers Opened</td>
<td>35&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>36&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>First Sprinkler Operation Times (min:s)</td>
<td>00:57</td>
<td>01:28</td>
</tr>
<tr>
<td>Last Sprinkler Operation Times (min:s)</td>
<td>02:53</td>
<td>02:20</td>
</tr>
<tr>
<td>Peak Ceiling-level Steel Temperature/Time</td>
<td>842°F (450°C) @ 03:55 min</td>
<td>610°F (326°C) @ 03:48 min</td>
</tr>
<tr>
<td>Ignition of Side C?</td>
<td>Yes @ 01:47</td>
<td>Yes @ 01:08</td>
</tr>
</tbody>
</table>

1. The capacity of the water delivery system was exceeded, and water pressure dropped below the target value until supplemental water was provided.
2. 35 of 36 installed sprinklers operated, 21 of which were perimeter operations.
3. Every installed sprinkler operated, 22 of which were perimeter operations.
Summary

• Flame Spread
  • Flames DID NOT breach the back side of Targets C, D or E
  • Combustible flame breaks (as tested) can limit flame spread
  • Flame spread controlled and building structural integrity preserved

• Ceiling Level Steel Temperatures
  • Temperature DID NOT exceed 1000 °F (538 °C)

• Number of Sprinkler Operations
  • Expect activation of all sprinklers in a small retail store
  • Large demand area

Research Technical Report
https://www.fmglobal.com/research-and-resources/research-and-testing/research-technical-reports
Energy Storage Systems
FM Global

Single Module

Multi-Module

Full Rack
Free burn

Multi-Rack
Sprinklered
- Overheat bottom half of module
  - Three heaters, 1 inch x 12 inch
  - 41°F/min

Ignition
7:30 min after ignition
Ignition
9:30min after ignition
Near Peak HRR

Heat Flux Threshold

- **Combustibles**
  - $\leq 12.5 \text{ kW/m}^2$
  - ~ critical value for ignition of cellulosic and plastic materials

- **Non-combustibles**
  - $\leq 27 \text{ kW/m}^2$
  - ~ damage to steel / glass
2nd Peak HRR
Sprinkler Protection

- K-factor: K5.6
- Density: 0.3 gpm/ft²
- Rating: 155°F
- Ceiling-to-link: 1 ft
- Spacing: 10 × 10 ft
- Quick-response, Pendent
# The Role of Sprinkler Protection

## What can sprinklers do?
- Reduce the fire severity
- Delay or prevent fire spread
- Protect the surroundings

## What can’t sprinklers do?
- Extinguish the fire
- Avoid collateral (thermal / non-thermal) damage
Installation Guidance

Separation Distance

- **Sprinklered**
  - **Non-combustibles**
    - LFP: 3 ft
    - NMC: 6 ft
  - **Combustibles**
    - LFP: 5 ft
    - NMC: 9 ft
Complications to Protection Guidance

- **Unknown Impacts**
  - Battery chemistry
  - Total electrical capacity
  - Rack design

- **Building Construction**
  - Wall / ceiling fire rating

- **Long Duration Fire Events**
  - Water demand + drainage

- **Other Hazards**
  - Cable trays
  - Stranded Energy
  - Explosion vs. fire

- **Fire Test Requirements**
  - Many installation options
  - Difficulty targeting hazard
Summary

➢ Conducted small- through large-scale free burn and sprinklered fire tests on two ESS chemistries

➢ ESS can be adequately protected, but may require:
  ▪ Sprinkler protection and installation considerations

➢ Guidance to be added to FM Global Property Loss Prevention Data Sheet 5-33: Electrical Energy Storage Systems
More Data at….

www.fmglobal.com/researchreports
www.nfpa.org/foundation
www.youtube.com