Managing Fire Hazard in Top-Loading Automatic Storage and Retrieval Systems

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What do sprinklers do?

**Control**: prevent fire spread beyond an acceptable area

**Suppress**: significantly reduce the fire size and prevent further spread
Top Loading Automatic Storage and Retrieval Systems (TL-ASRS)

- What makes them different
  - Containers stored in tall stacks
  - Robots move along the top track
  - No aisle spaces

- Efficient and scalable
  - Fully automated
  - Extremely dense storage
  - Minimal personnel required
Traditional Warehouse VS TL-ASRS Warehouse

Significant increase in storage density
No access for *manual* fire fighting efforts
1. Sprinkler system to suppress the fire
2. Fire Service to extinguish the fire
Redefining the Protection System Goal

1. Sprinkler system to suppress the fire
2. Fire Service to extinguish the fire

NEW Challenge: Extremely dense storage with minimal access areas

Final Extinguishment
**Traditional Strategies**

1. Increase sprinkler protection
2. Lower ceiling
3. Remove obstructions
4. Barriers
5. Aisles

**Final Extinguishment**

6. Monitor nozzles
7. Remove combustibles

**Pre-incident Planning**

8. Fire service access
9. Response strategy

Guidance available in FM Global Data Sheet 8-34
Solid-walled plastic containers

Final extinguishment achievable with combined automatic + manual intervention

- Ceiling sprinklers can extinguish fire for lower ceiling heights ($\leq 30$ ft [9.1 m])
- Manual intervention needed to extinguish fire for higher ceiling heights
Sprinklers
- K14 gpm/ft² (K200 lpm/bar₁/²)
- Quick-response
- Pendent

Installation
- 13 in. below ceiling (330 mm)
Vented plastic containers

Final extinguishment achievable with combined automatic + manual intervention

- Ceiling sprinklers can suppress initial fire
- Noncombustible breaks limit fire spread
- Manual intervention needed to extinguish fire
Configuration

- Vented containers
- 25 ft (7.6 m) storage
- 40 ft (12.2 m) ceiling
- 4 ft (1.2 m) aisles
- Ignition towards aisle edge of storage

Sprinkler protection

- K17 @ 1.2 gpm/ft²
  (K240 @ 49 mm/min)
- 10 x 10 ft (3 x 3 m)
- Centered above aisles
Final extinguishment.

- Noncombustible containers, not just metal
- Prevent fire spread away from origin
- Minimize need for manual intervention

- Any fire spread in TL-ASRS has a high loss potential
Carton Exposure – Baseline Results

Representative Scenario

Replace plastic container with steel container storing CUP product
Carton Exposure – Baseline Results

Instrumentation Layout

- Peak ~ 25 kW/m²
- Duration* ~9 minutes

*Representative duration at ½ peak heat flux
Sand Burner – Representative Hazards

<table>
<thead>
<tr>
<th>Propane (lpm)</th>
<th>Heat Flux (kW/m²)</th>
<th>HRR* (kW)</th>
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<td>52.2</td>
<td>24.4</td>
<td>80</td>
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<td>98.4</td>
<td>49.3</td>
<td>145</td>
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<tr>
<td>180.4</td>
<td>74.4</td>
<td>260</td>
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</table>

*predicted from propane flow

Test Average (3 minute)
Key Factors Evaluated to Date

- **Combustible Containers**
  - Solid side-walls
  - Vented side-walls

- **Storage Design**
  - Up to 25 ft (7.6 m) tall
  - Containers storing CUP

- **Ceiling Height**
  - 25 to 45 ft (7.6 or 13.7 m)

- **Sprinkler Protection**
  - K14.0 (K160) to K33.6 (K480)
  - 1.0 to 2.0 gpm/ft²
    (49 to 120 mm/min)

- **Supplemental Protection**
  - Monitor nozzles
  - Vertical barriers
  - Noncombustible breaks (aisles)

* To support final extinguishment
Take-Aways

- **New protection strategies available for final extinguishment**
  - Sprinkler only protection for ceilings up to 30 ft (9.1 m)
  - Supports installation of drop ceilings
  - Requires prolonged water supply durations

- **Fire incident response is critical**
  - Successful test results do not guarantee extinguishment
  - Sprinklers should remain active until confirmation

- **Noncombustible container evaluation ready to go**
  - Waiting on commercial containers
Thank You!

Questions?

Protection Recommendations can be found in FM Global Property Loss Prevention Data Sheet 8-34, Protection for Automatic Storage and Retrieval Systems (2020)