Trends in Warehouse Automated Storage and Associated Fire Challenges

SFPE – SoCal

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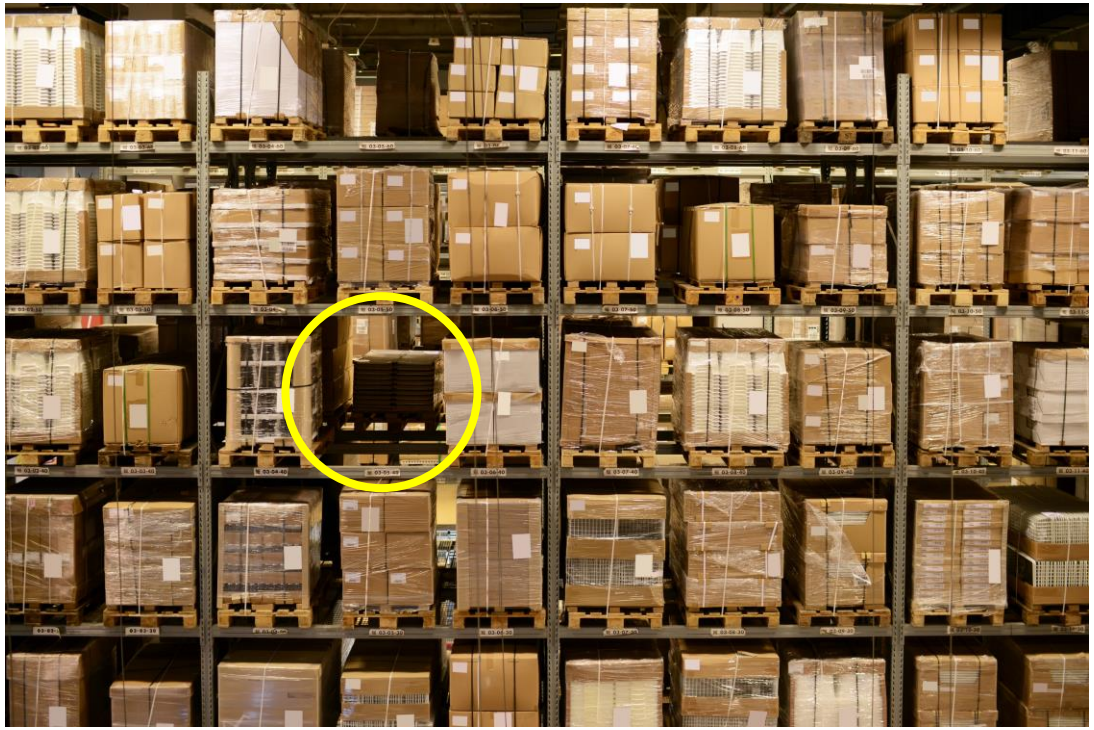
FM Global

RESILIENCE IS A CHOICE.

What is an Automatic Storage and Retrieval System (ASRS)?

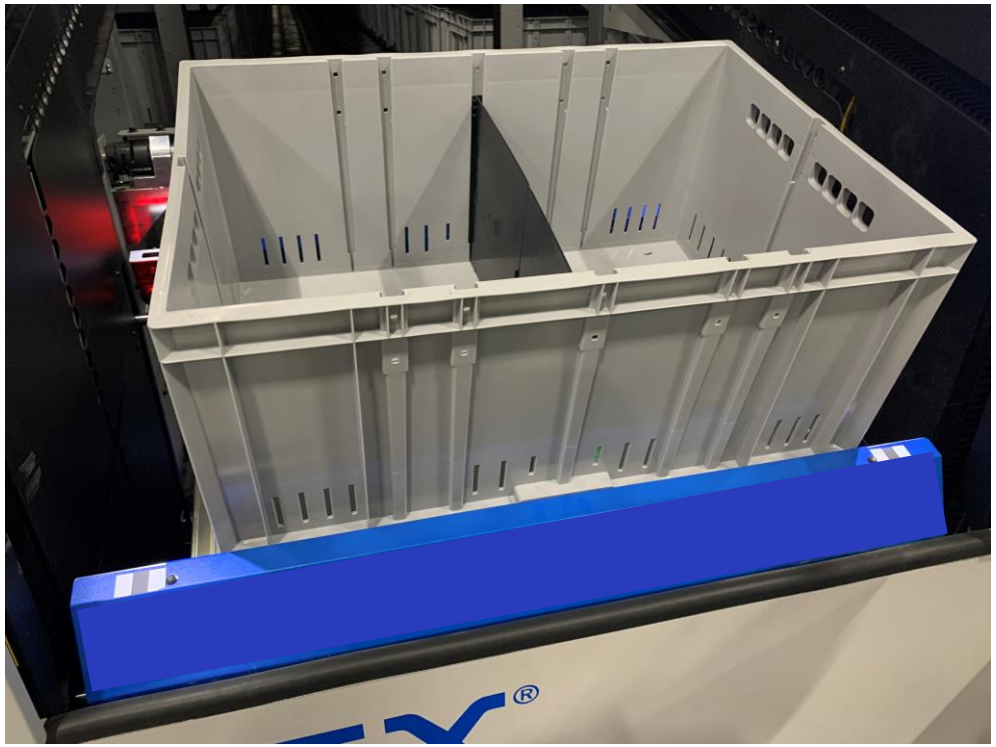
Trends in Today's Warehousing



RESILIENCE IS A CHOICE.

Trends in Today's Warehousing

Trends in Today's Warehousing



Trends in Today's Warehousing

Efficient storage for individual items

Dense storage w/ minimal aisles

Types of ASRS Arrangements?

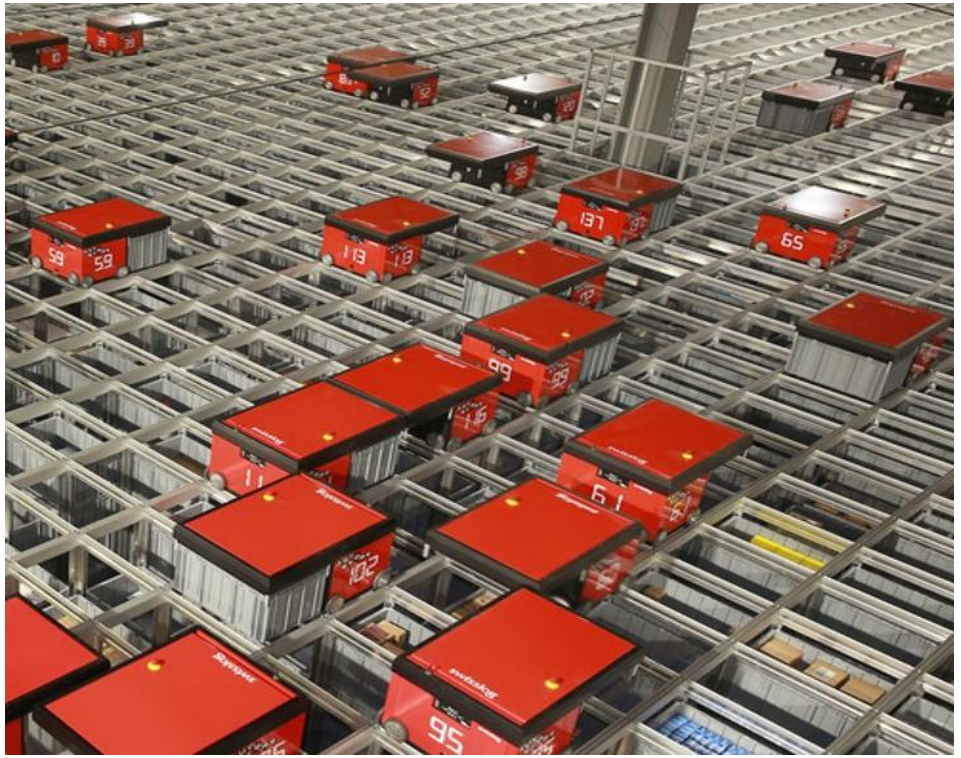
Trends in Today's Warehousing

Types of ASRS arrangements?

2 Basics Types:

1. Vertical aka Top-Loading TL-ASRS

(Solid-Piled Storage)



Trends in Today's Warehousing

Types of ASRS arrangements?

2 Basics Types:

2. Horizontal-Loading

(Rack Storage)

Trends in Today's Warehousing

Types of Horizontal- Loading ASRS

Storage on Angle Irons (Mini-Load)

Trends in Today's Warehousing

Types of Horizontal- Loading ASRS

Storage on Metal Slats or Wire Mesh Shelving (Shuttle Type)

Fire Challenges of ASRS Arrangements?

Containers

ASRS Fire Challenges- Containers

Plastic

- Heat of Combustion

Plastics >> Ordinary Combustibles

More water needed to protect plastics than ordinary combustibles

ASRS Fire Challenges- Containers

Plastic

- Water Absorption

Can’t pre-wet plastics containers

Makes horizontal fire control more challenging

ASRS Fire Challenges- Containers

Open-Top

- Collect Water

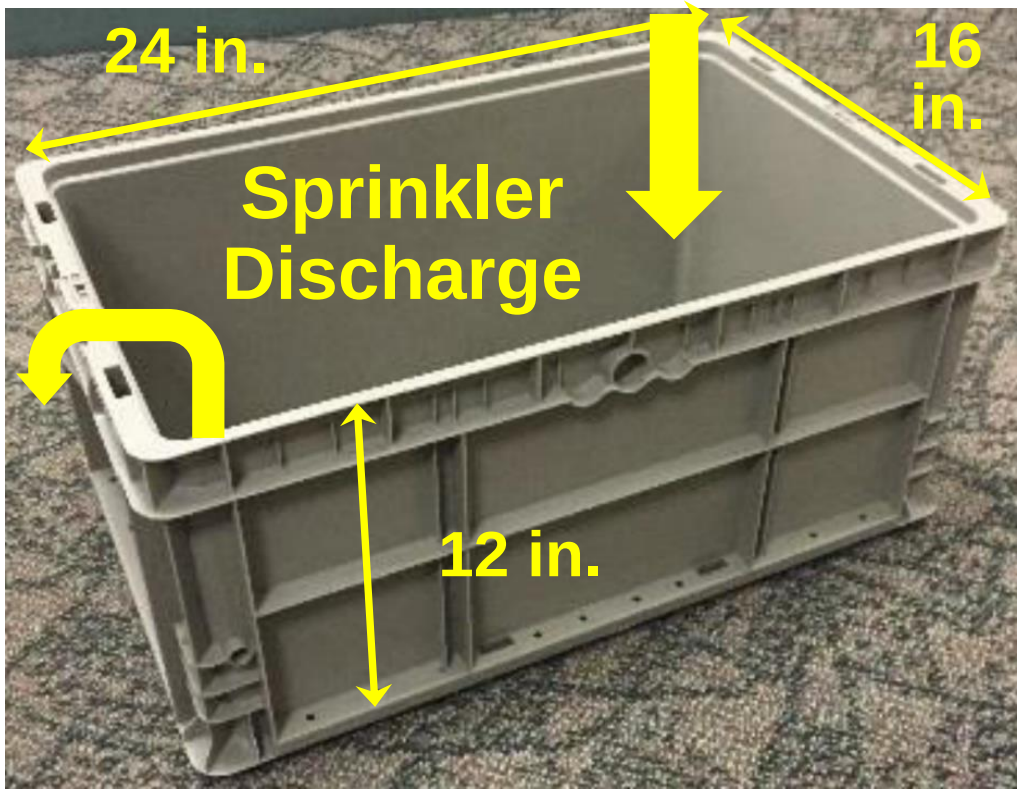
Time to fill a typical KLT sized container with ceiling density at 1.0 gpm/ft²?

a. 45 seconds

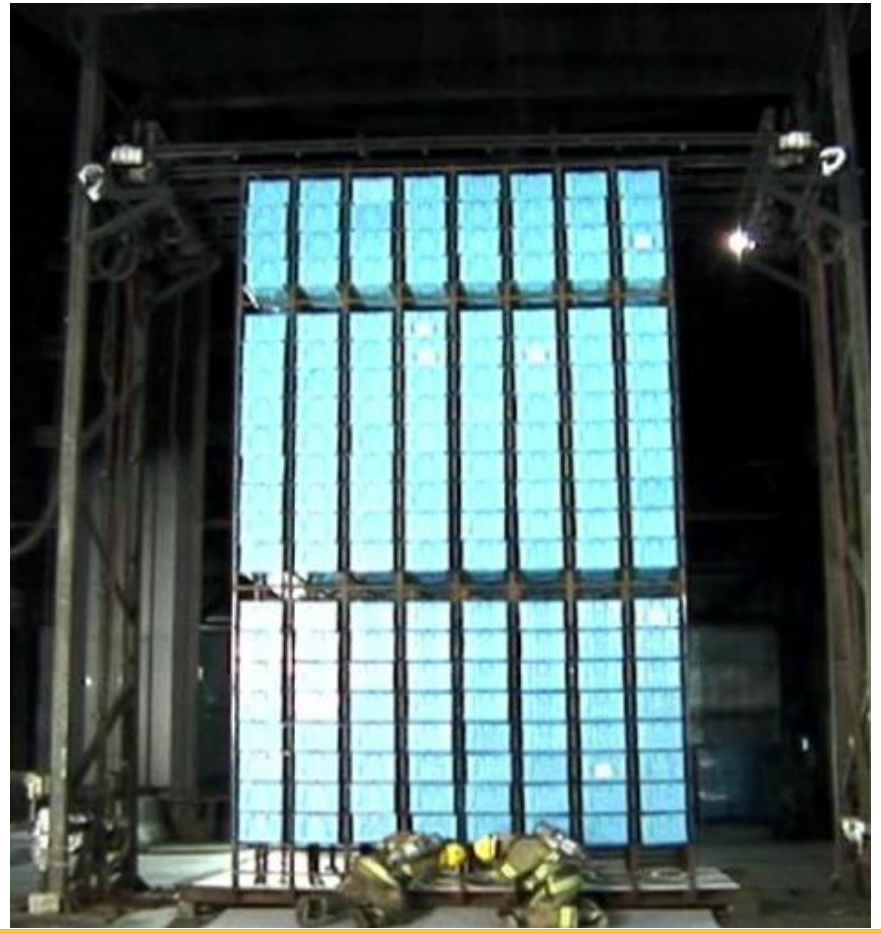
b. 2 minutes 15 seconds

c. 4 minutes 30 seconds

d. 7 minutes 30 seconds



ASRS Fire Challenges- Containers



ASRS Fire Challenges- Containers

Open-Top

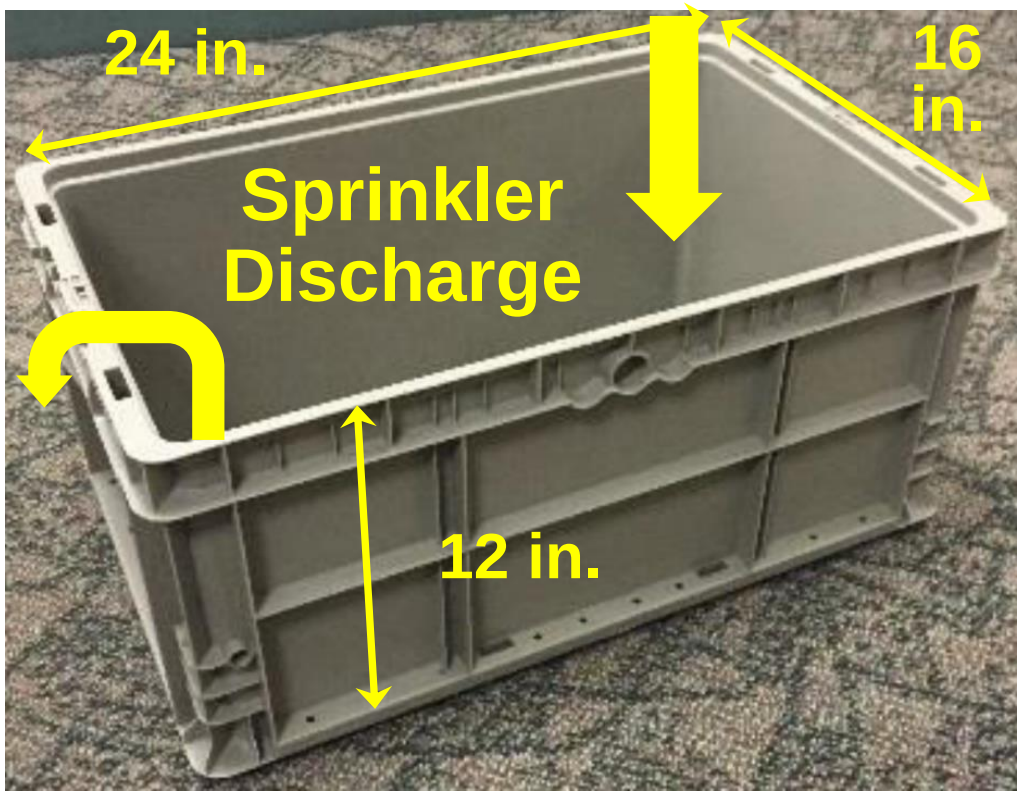
- Collect Water

Time to fill a typical KLT sized container with ceiling density at 1.0 gpm/ft²?

7 minutes 30 seconds!

Just need to fill one container

Right?



ASRS Fire Challenges- Containers

Open-Top

- Collects Water

Top-Loading ASRS w/
solid-walled containers

Just need to fill one container

Right?

ASRS Fire Challenges- Containers

Open-Top

- Collects Water

Horizontal-Loading

Just need to fill one container

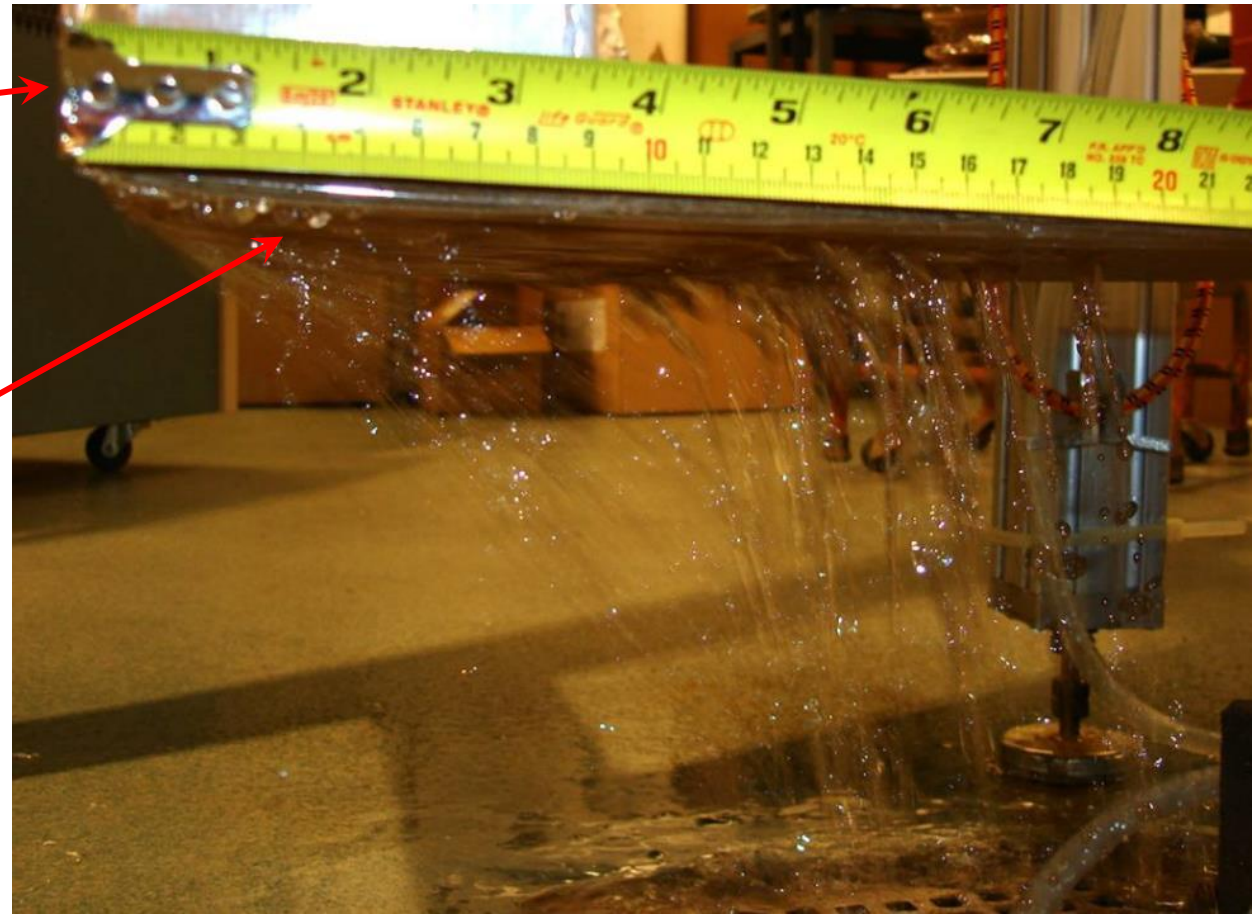
Right?

ASRS Fire Challenges- Containers

Front Side of Simulated Load

Simulated Pallet Load w/out Pallet

Underside of Simulated Load

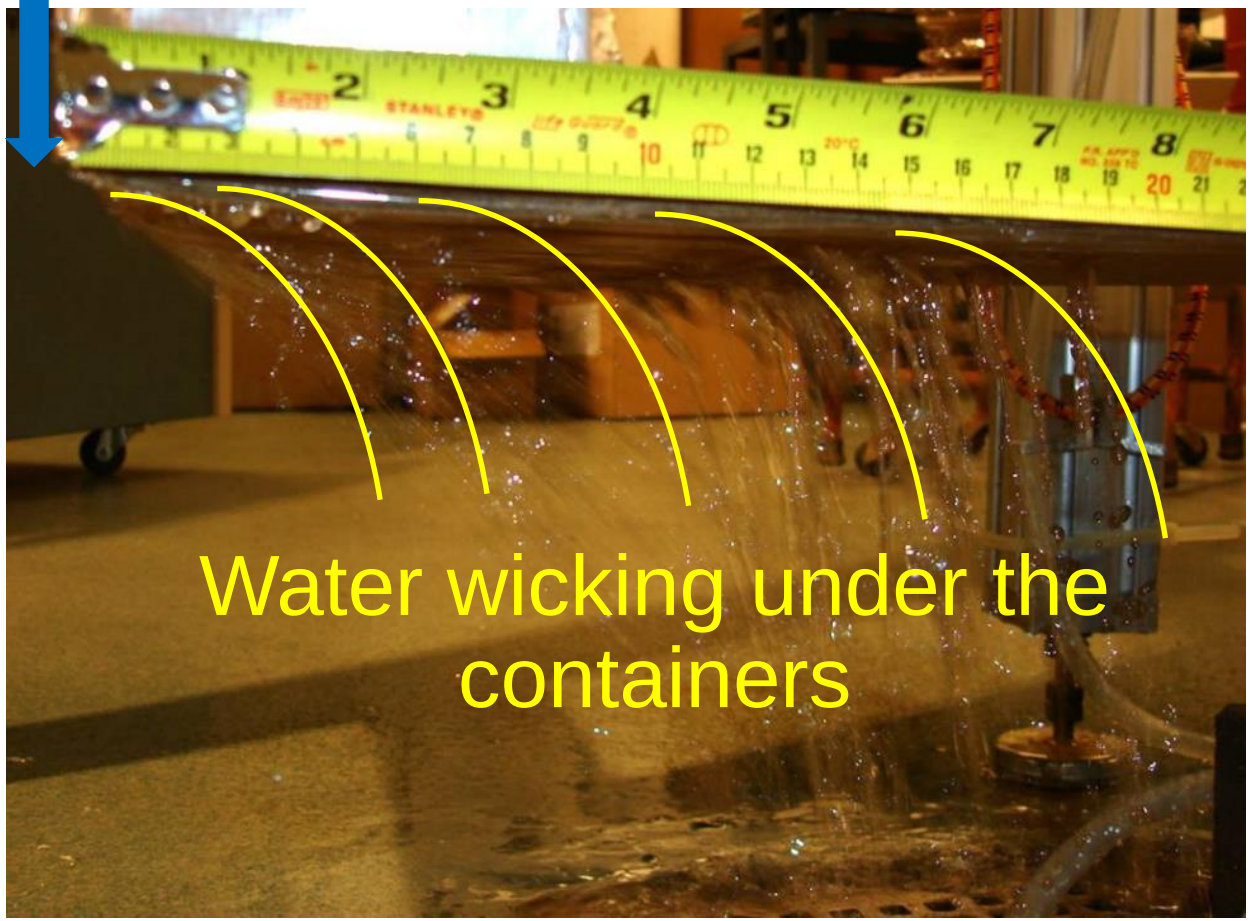


ASRS Fire Challenges- Containers

Water
Runoff

Simulated Pallet Load
w/out Pallet

Water would end up discharging into every container stored vertically



ASRS Fire Challenges- Containers

Solid Walled

- Transfer of Flame

Solid side walls help reduce speed of horizontal flame spread

ASRS Fire Challenges- Containers

Non-Solid Walled

- Transfer of Flame

Non-solid side walls allow greater speed of horizontal flame spread

Fire Challenges of ASRS Arrangements?

Storage Arrangements

ASRS Fire Challenges- Arrangements

Top-Loading (Solid-Piled)

- Fire Hazard

On-Floor < Racks

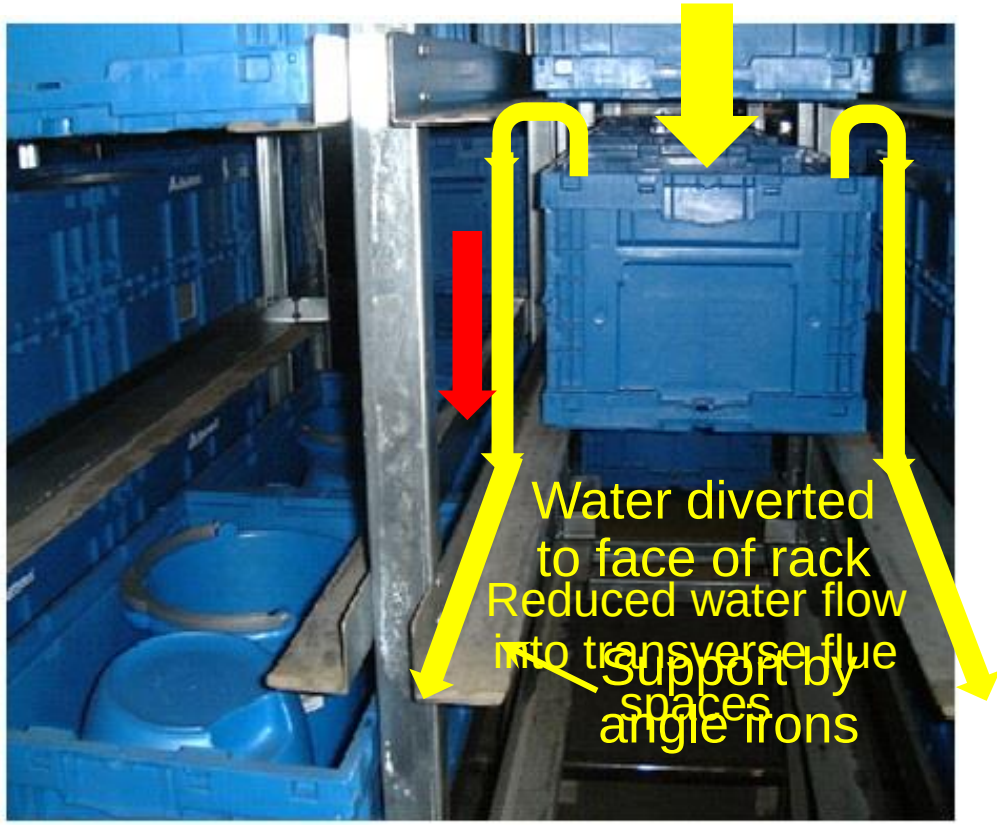
Top-Loading ASRS typically does not have aisles

Fire service access to fire area challenging

ASRS Fire Challenges- Arrangements

Horizontal-Loading (Rack Storage)

- Water Collection
- Water Diversion



ASRS Fire Challenges- Arrangements

Horizontal-Loading (Rack Storage)

- Water Collection
- Water Diversion

Majority of water diverted into the aisles instead of within the rack

ASRS Fire Challenges- Arrangements

Horizontal-Loading (Rack Storage)

- Flue Spaces

  Very limited in width

ASRS Fire Challenges- Arrangements

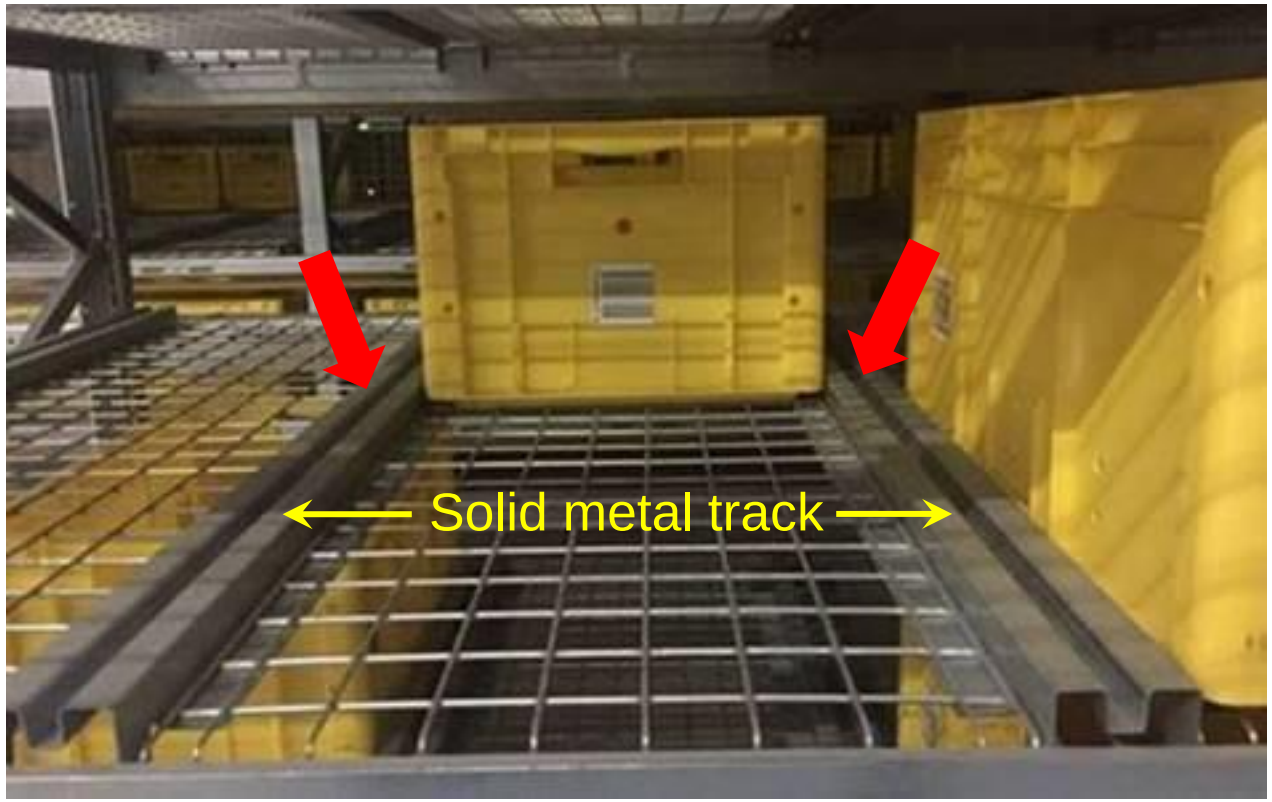
Horizontal-Loading (Rack Storage)

- Flue Spaces

Very limited in width

If any at all!

Allows for potential horizontal flame spread down length of rack



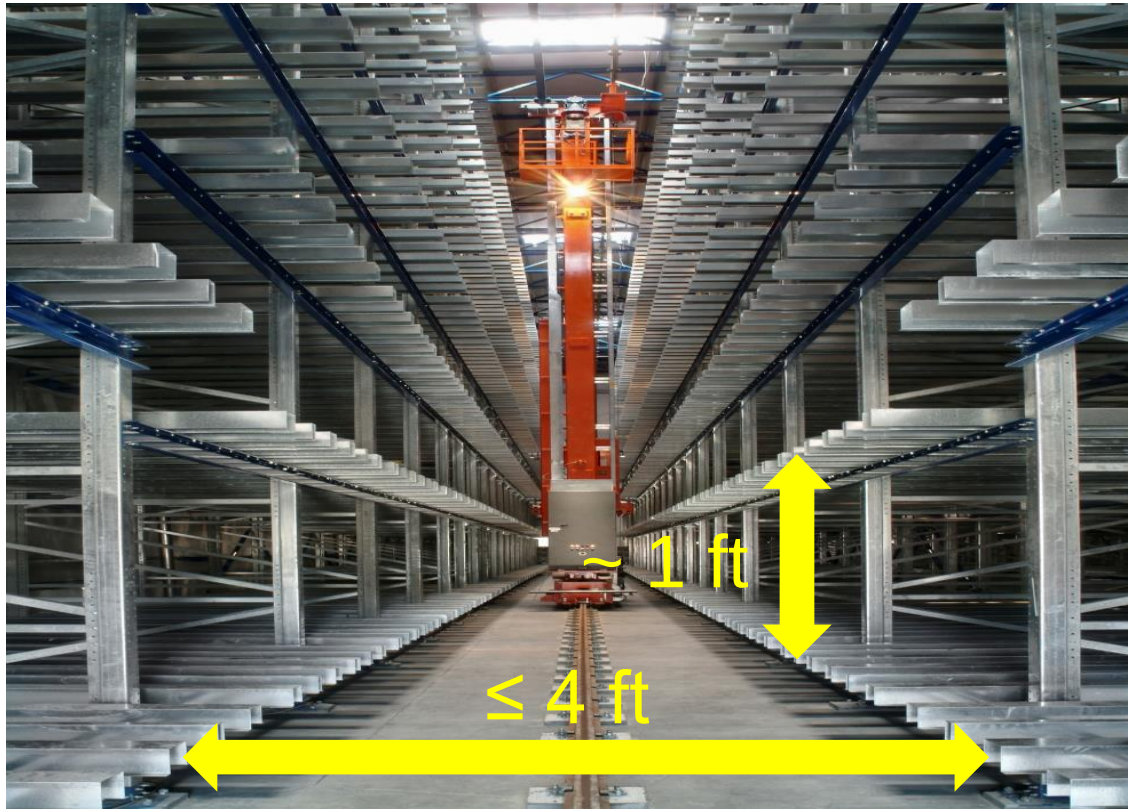
ASRS Fire Challenges- Arrangements

Horizontal-Loading (Rack Storage)

- Tier Height
- Aisle Width

Allows for potential horizontal flame spread across aisle

Access to fire area very challenging to local fire services

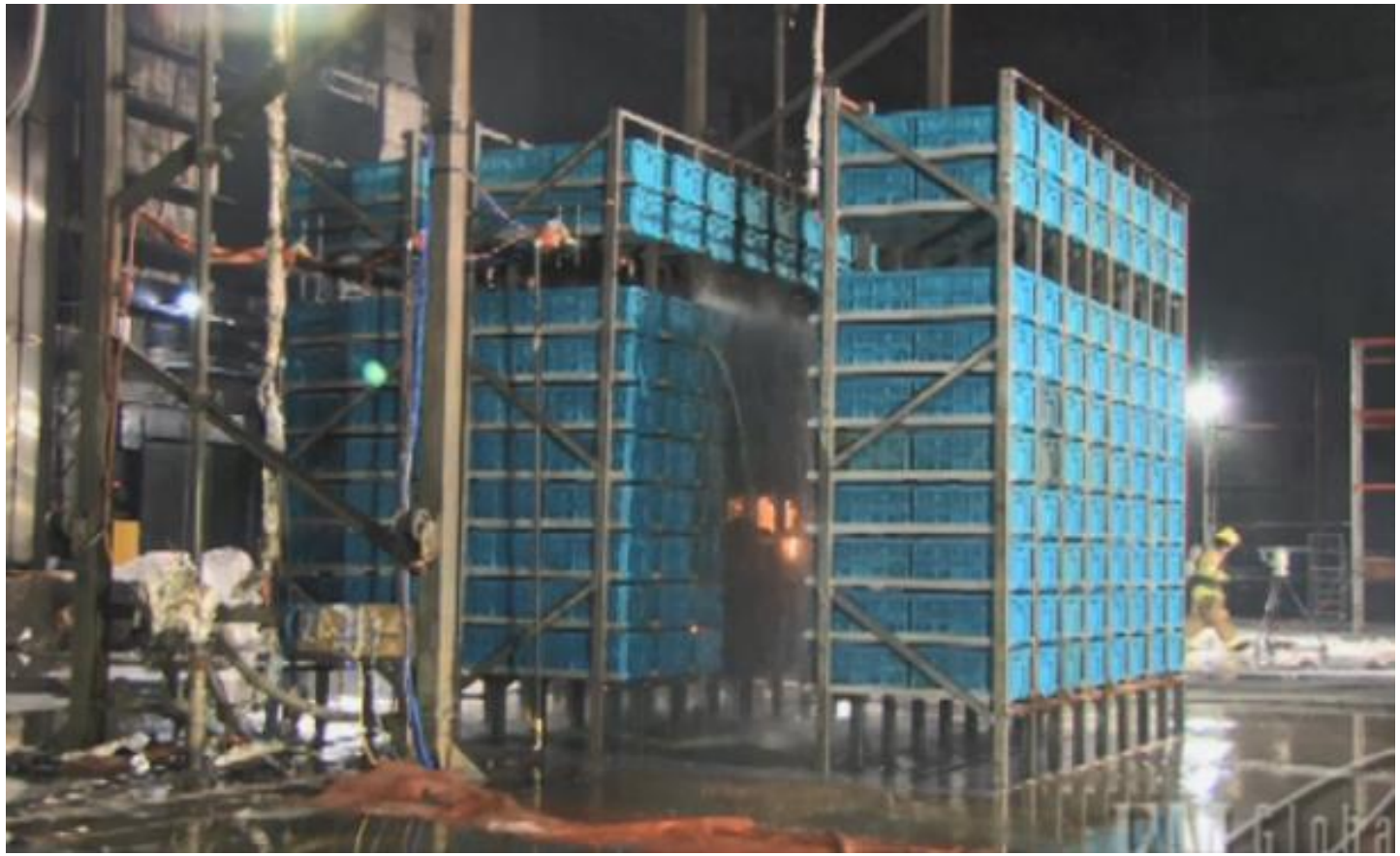


Research Conducted on ASRS Arrangements

Horizontal-Loading

Horizontal-Loading ASRS Research

How to protect Horizontal-Loading ASRS structures using in-rack sprinklers



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Horizontal-Loading ASRS Research

Main Research Testing Goal:

Achieve “Modular” IRAS System Concept

- In-rack sprinklers operate and **suppress** the fire
- Fire **doesn’t** grow vertically past nearest in-rack sprinkler level
- Ceiling and in-rack sprinkler systems **do not** need to be hydraulically balanced

Horizontal-Loading ASRS Research

Containers Tested:

Open-top <u>vented</u> plastic (water relieving) container with solid bottom
(may not be actual container tested)

Open-top <u>solid-walled</u> plastic (water trapping) container with solid bottom
(may not be actual container tested)

Horizontal-Loading ASRS Research

Full-Scale Fire Testing:

- Face ignition, mid-bay
- IRAS @ 10 ft tier level
- Open-top plastic vented (water relieving) container
- K11.2 @ 60 gpm

Horizontal-Loading ASRS Research

Full-Scale Fire Testing:

- Face ignition, mid-bay
- IRAS @ 10 ft tier level
- Open-top plastic non-vented (water trapping) container
- K14.0 @ 100 gpm

Horizontal-Loading ASRS Research

Full-Scale Fire Testing:

- Face ignition, mid-bay
- IRAS @ 15 ft tier level
- Open-top plastic vented (water relieving) container
- K14.0 @ 100 gpm

Horizontal-Loading ASRS Research

Full-Scale Fire Testing:

- Face ignition, mid-bay
- IRAS @ 15 ft tier level
- Open-top plastic non-vented (water trapping) container
- K25.2 @ 140 gpm

Horizontal-Loading ASRS Research

What about storage above the top in-rack sprinkler level?

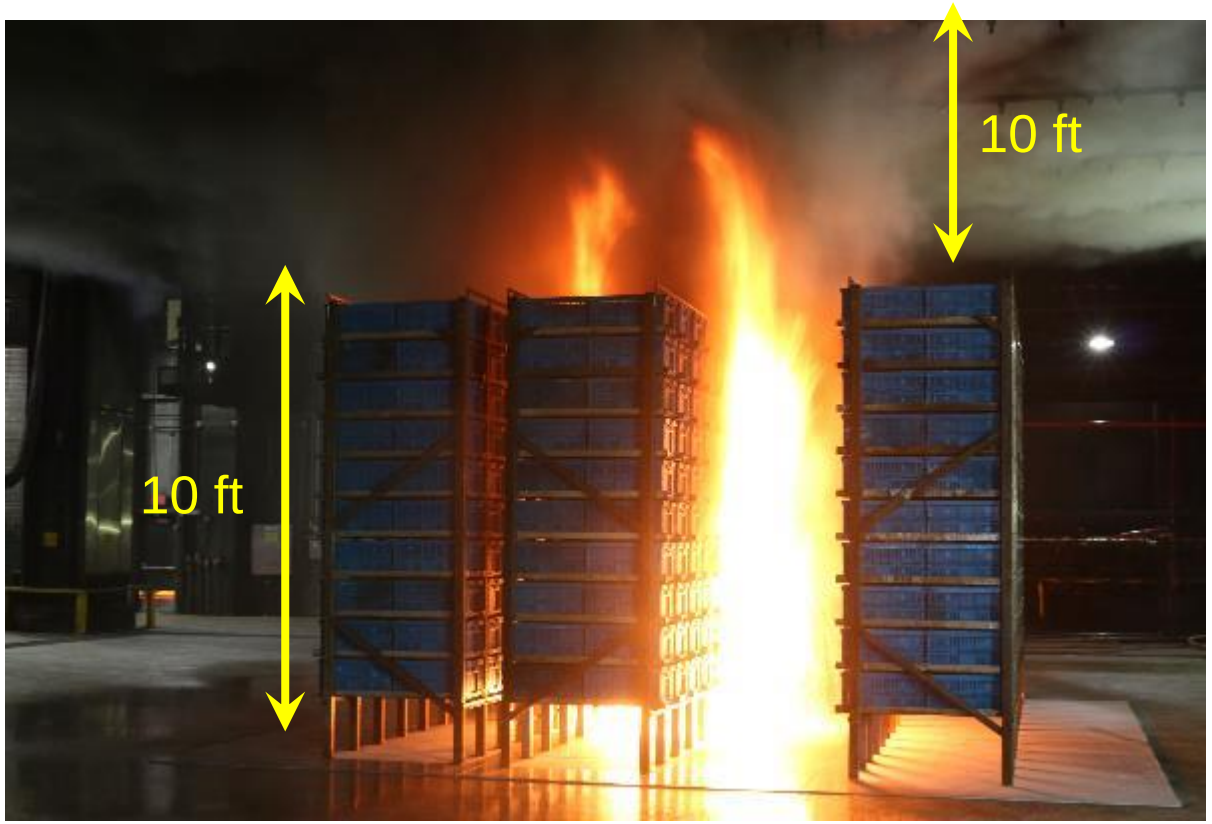
Horizontal-Loading ASRS Research

How much storage could be protected by ceiling sprinkler system?

QR K14.0 Pendent @ 75 psi

Limited to:

- 10 ft storage, and
- 10 ft clearance



Research Conducted on ASRS Arrangements

Top-Loading

Top-Loading ASRS Research

Goals of Testing:

- *Is fire **control** possible by ceiling sprinkler system?*

The following is an example of one of the full-scale fire tests with solid-walled containers

Note: Example of solid-walled container; may not be actual container tested

Test Setup

Configuration

- Area: 200 ft^2
- Height: 18 ft
- Ceiling : 40 ft

Ignition

- Base of storage
- Beneath robot
- Under-1 sprinkler

Sprinkler Protection

- K14.0, QR Pendent
- 75 psi = 1.2 gpm/ft^2
- Applied for at least 30 minutes

Top-Loading ASRS Research

Goals of Testing:

- *Is fire control possible by ceiling sprinkler system?*

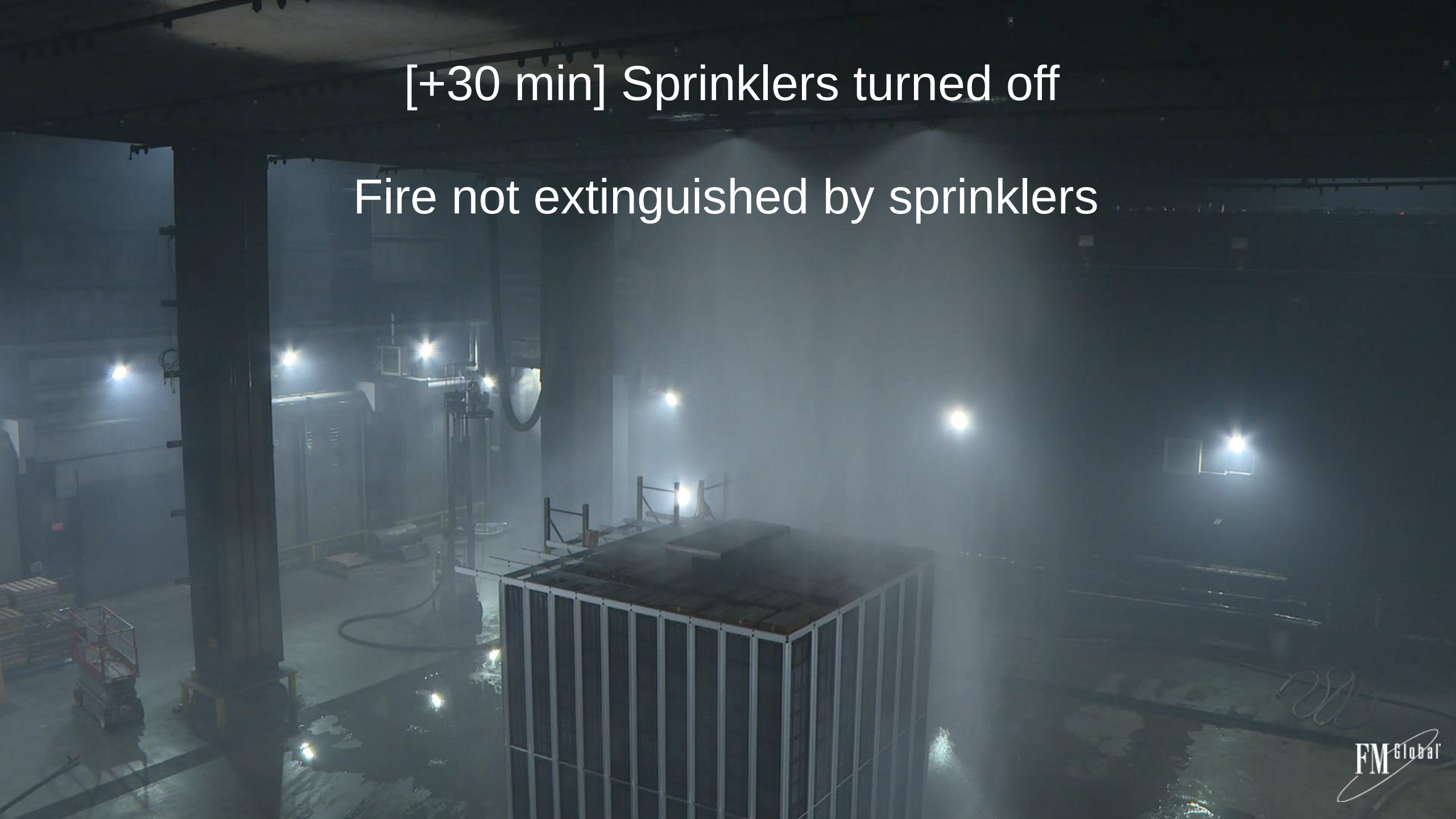
Fire was suppressed by ceiling sprinkler system!

Top-Loading ASRS Research

Goals of Testing:

- *Is fire **extinguishment** possible by ceiling sprinkler system?*

To find out, let test run for 30 minutes then turned off sprinklers


[+30 min] Sprinklers turned off
Fire not extinguished by sprinklers
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Top-Loading ASRS Research

Goals of Testing:

- Can fire **extinguishment** be achieved using a lower ceiling height?

Top-Loading ASRS Research

Goals of Testing:

Fire Extinguishment <u>Accomplished</u>:

- 25 ft Ceiling: QR K14.0 pendent sprinkler @ **100** gpm; thermal element 13 in. below ceiling
- 30 ft Ceiling: QR K33.6 pendent sprinkler @ **270** gpm; thermal element 13 in. below ceiling

2.7x the demand for 5 more feet!

ASRS Recommendations

Top-Loading

Top-Loading ASRS Recommendations

FM Global
Property Loss Prevention Data Sheets **8-34**

July 2017
Interim Revision July 2023
Page 1 of 119

PROTECTION FOR AUTOMATIC STORAGE AND RETRIEVAL SYSTEMS

Data Sheets available at www.FMGlobal.com

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Top-Loading ASRS Recommendations

Ceiling AS control + FD final extinguishment

- Ceiling Protection (ceilings up to 45 ft.) per FM DS 8-34
  - Storage up to 20 ft., Table 45
  - Storage over 20 ft., Table 46
- Pre-Incident Plan with FD
- Perimeter Mezzanines
- Small Hose Connection Stations
- Limited Footprint Size of ASRS
- Vertical Barriers
- Monitor Nozzles & Infrared Cameras

Ceiling AS Extinguishment

- Ceiling Protection per FM DS 8-34, Table 44
  - Ceilings up to **30 ft**., storage to 20 ft.
- Max vertical distance of sprinkler thermal element is **13 in.** below ceiling

ASRS Recommendations

Horizontal-Loading

Horizontal-Loading ASRS Recommendations

- Is a ceiling-only sprinkler protection option a possibility?
  - Adequate transverse flue spaces?
  - Storage height?
  - Mini-load or shuttle ASRS?
  - Open-top or closed-top containers?

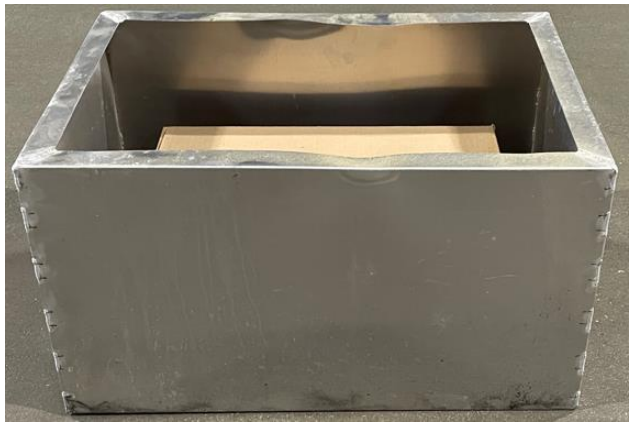
Horizontal-Loading ASRS Recommendations

- When in-rack sprinklers are needed:
  - Determine horizontal in-rack sprinkler arrangement
  - Determine vertical intervals of the in-rack sprinklers
  - Determine in-rack sprinkler design
  - Based on height of storage above top in-rack sprinkler level, determine ceiling sprinkler system design
  - Determine hose demand and system duration

What’s Next in ASRS?

FM Global & ASRS- Looking Forward

- How can we store ignitable liquids, aerosols, and lithium ion batteries in ASRS?
- Can oxygen reduction systems be used in TL-ASRS?
- How can we reduce water demand for TL-ASRS?
  - Non-flame-propagating containers
  - Noncombustible liners



Training Resources

FM Global On-Line Training Resources

www.KeepTheSprinklersOn.com

FM Global's Fire Service Learning Network

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Thank You!

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