

Protection of Exposed, Unexpanded Plastic Containers Incorporating Cartoned, Unexpanded Plastic Commodity in a Volume Optimized, Vertically Integrated Rack Storage Array



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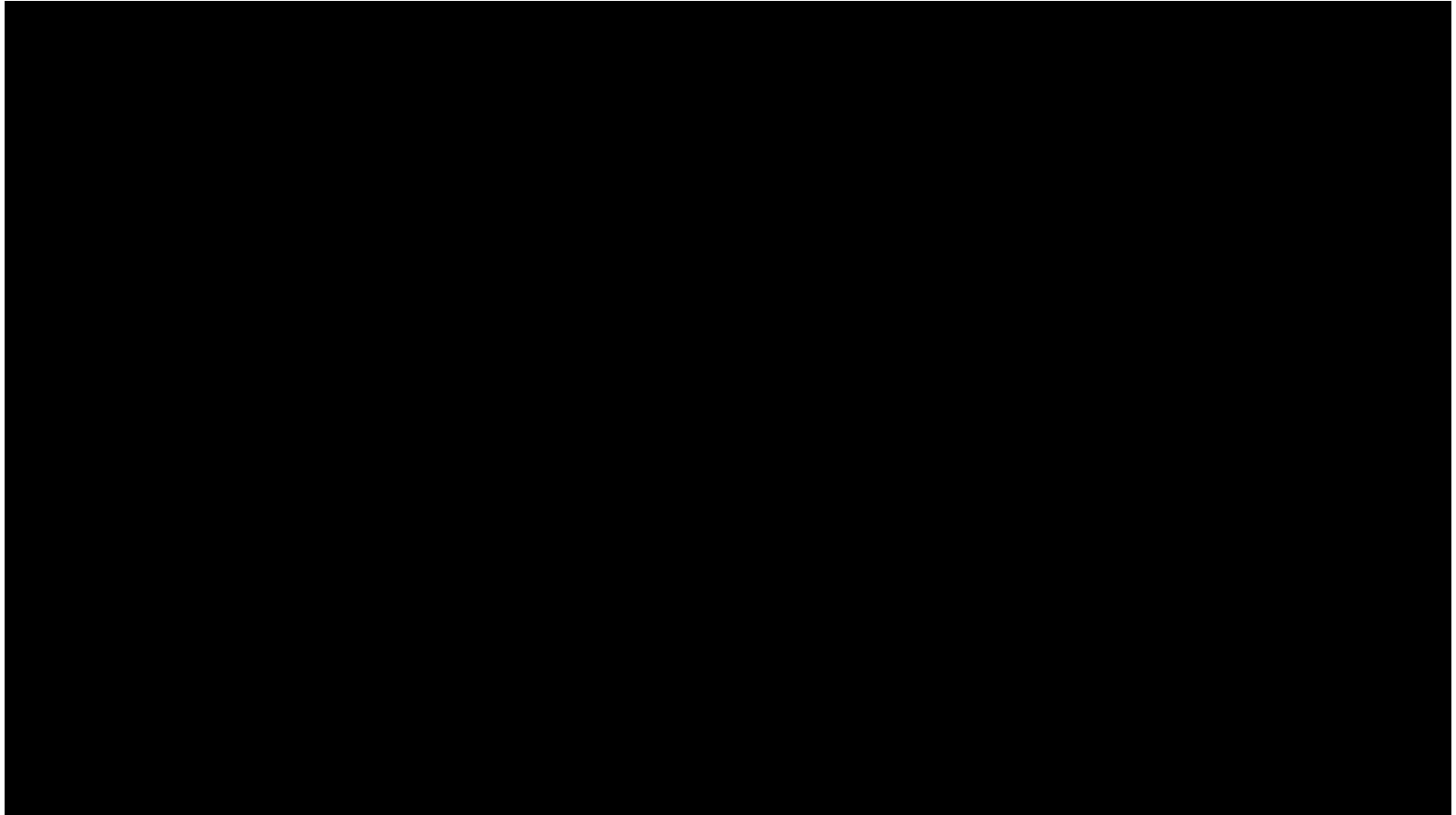
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Video





**AUTO
STORE**®

Technical data and measurements of bins and test array

- **Size of bins: External size 25-3/8 in. (645 mm) by 17-3/8 in. (441 mm) by 13 in. tall (330 mm).**
- **Maximum load capacity per bin: 66 pounds (30 kg).**
- **Two types of plastic raw material: HDPE or PP-ESD (contains carbon black to achieve anti-static properties).**
- **Storage height: Up to 16 bins = 17 ft. 4 in. (5.3 m).**
- **Storage area: Large! Largest grid so far contains 170,000 bins.**



Fire Safety discussion....

- People do not normally access the storage area of the AutoStore system. The probability for unintentional or intentional ignition caused by personnel is therefore low.
- The design of the robot systems fulfill the requirements of the electrical safety standard IEC 60950-1, therefore the probability for fire in a robot is expected to be low.
- Storage of flammable liquids is not allowed.
- Storage of commodity containing large amounts of expanded plastic material is not likely.



Design benefits from a sprinkler protection point of view....

- The storage is very compact with narrow flue spaces. Air movement through the array is therefore restricted and an overall slow fire growth rate has been verified.
- The flue spaces between bin stacks are well defined and open. No bins or commodity will block the flues due to the nature of the aluminum column style rack array.
- The storage array is very stable. Collapse or leaning of stacks across flue spaces is not likely to occur during initial fire development.
- The vertical aluminum supports limit the possibilities for horizontal fire spread.



...and disadvantages

- The bins have solid bottoms that are not permeable to water.
- No top covers are used on the bins, so water from sprinklers will initially be collected in the topmost bins.
- The flue spaces are narrow which will limit the amount of water from sprinklers reaching the seat of a fire.
- The grid track over the flue spaces will limit the ability for the water from sprinklers going directly down the flue spaces.



SP Fire Testing Laboratory in Sweden provided heat release rate measurements of a complete grid....

**Department of Fire Technology
SP Technical Research Institute of Sweden**

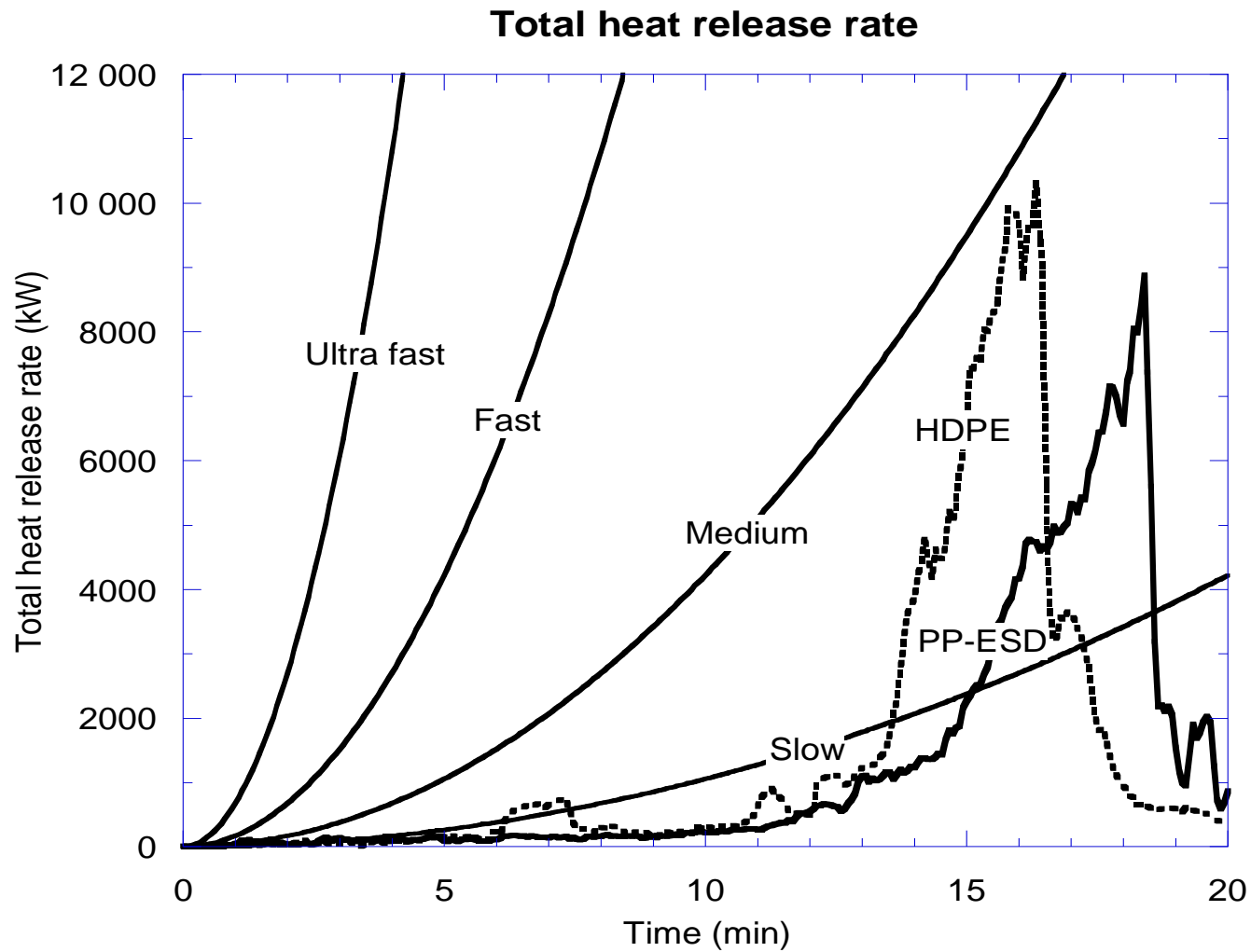
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Maria Hjohlman**

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Large-scale free-burn fire tests



The objective of the large-scale fire sprinkler tests

The development of an efficient sprinkler protection concept able to suppress a fire at an early stage, thereby:

- protecting the building,
- limiting fire spread,
- limiting the overall fire damage.

To determine the most effective manual fire-fighting and post fire mitigation strategy.



Large-scale fire tests at Underwriters Laboratories in Northbrook, IL





Footprint: 7 by 10 cells = 16 ft. (4.9 m) x 15 ft. 9 in. (4.8 m)
Height: 17 ft. 5 in. (5.3 m)

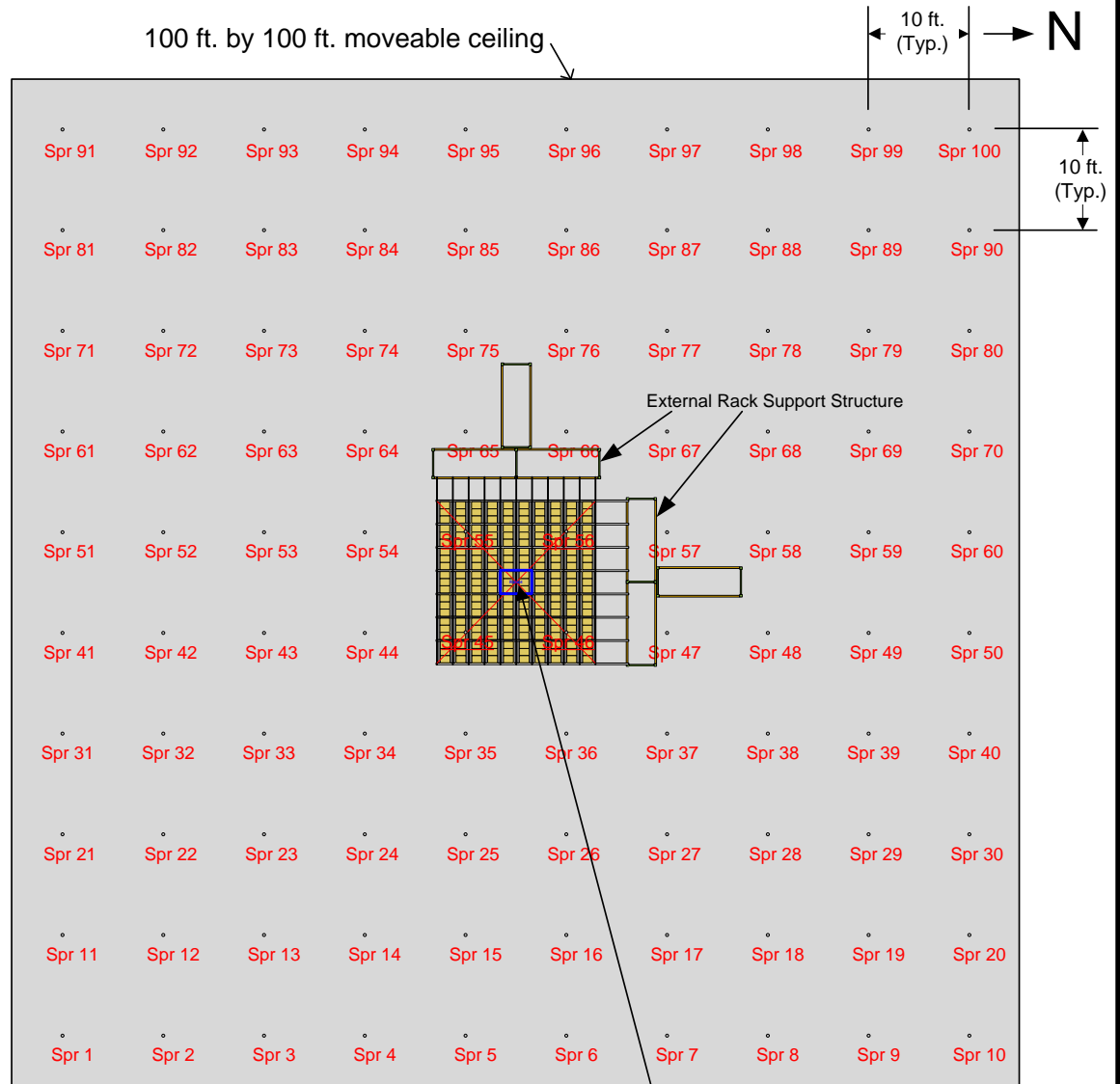
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Point of fire ignition at the bottom of this flue space

01/05/2012 08

Test 1: Ignition Between Four Sprinklers



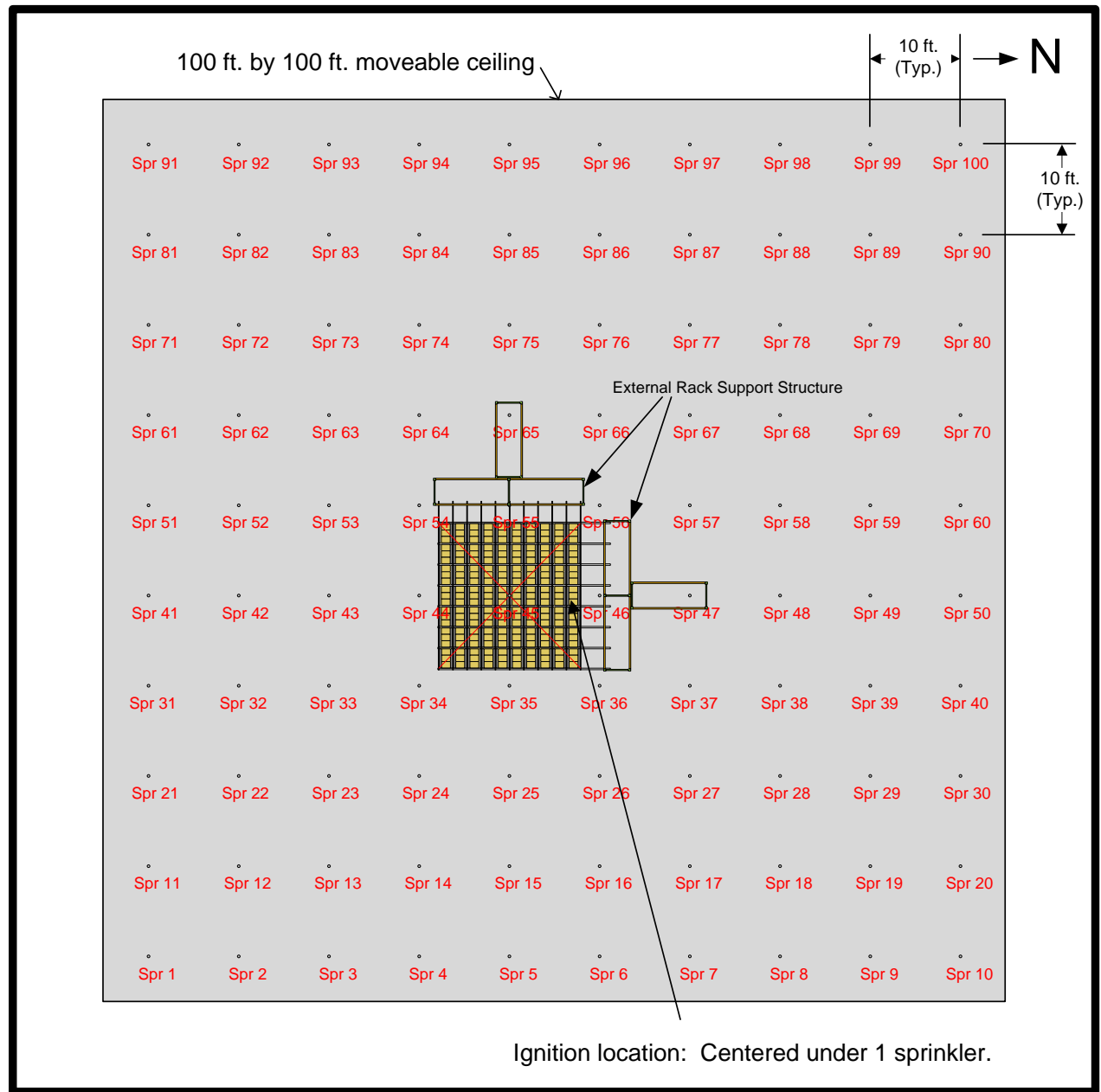
Ignition location: Centered between four sprinklers.

120 ft. by 120 ft. test area



Test 2- 4:

Ignition Under One Sprinkler




25.5 in. (649 mm)

17.6 in.
(449 mm)

30/04/2012 10:01





**Fire ignition source positioned
at the bottom of the flue space**

01/05/2012 07

Type of sprinkler

Upright

ELO, K=11.2 (K=160 metric)

Fast response

Nominal operating temperature of 155 °F (68 °C).



Acceptance criteria (as agreed with VdS)

- The number of operating sprinklers should not exceed 10.
- The temperatures of a steel beam positioned at the ceiling above the point of fire ignition should not exceed 1000 °F (540 °C) for more than one minute.
- Ignition on the inner faces of the stacks of bins surrounding the center 5 by 6 cells not allowed.
- The tests lasted 30 minutes after the activation of the first sprinkler and manual fire fighting was initiated thereafter.



Fire test program

Test	Fill rate of grid	Ignition location with respect to ceiling sprinklers	Discharge density gpm/ft ² [mm/min]	Ceiling height ft. [m]	Clearance ft. [m]
1	Completely full	Between four	0.60 (24.4)	35 (10.7)	18 (5.5)
2	Completely full	Under one	0.60 (24.4)	35 (10.7)	18 (5.5)
3	Two cells partly empty	Under one	0.74 (30.2)	27 (8.2)	10 (3.0)
4	Completely full	Under one	0.74 (30.2)	27 (8.2)	10 (3.0)





01/05/2012 09:48

Test 1: 15:23 [min:sec] – first sprinkler activates



01/05/2012 09:49

Test 1: 15:25 [min:sec] – second sprinkler activates



01/05/2012 09:49

Test 1: 15:27 [min:sec] – third sprinkler activates



01/05/2012 09:50

Test 1: 16:00 [min:sec] – visibility is obscured



Test 1: Fire damage (robot removed)

07/05/2012 13:16

Test 1: Fire damage (robot removed)

01/05/2012 13:



Video – Test 3




Summary of fire test results

Test	No. of activated sprinklers	Activation times min:sec	Maximum steel beam temperature °F [°C]	One minute average steel beam temperature °F [°C]	Primary extent of damage
1	3	15:23, 15:25, 15:27	111 (44)	110 (43)	3 by 4 cells
2	1	16:03	102 (39)	102 (39)	5 by 8 cells*
3	4	07:04, 07:23, 08:51, 09:01	196 (91)	194 (90)	3 by 4 cells
4	1	09:05	82 (28)	82 (28)	2 by 4 cells

* The fire damage criteria was exceeded in Test 2.





**Possible reason for the extended fire damage
in Test 2 (“pipe shadow” effect).**

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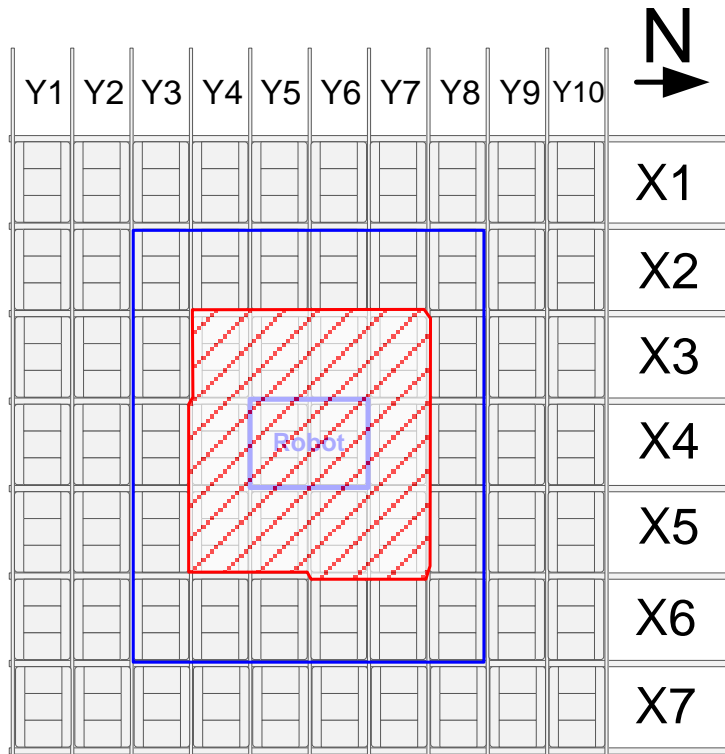
Fire damage after Test 2 (“pipe shadow” effect)





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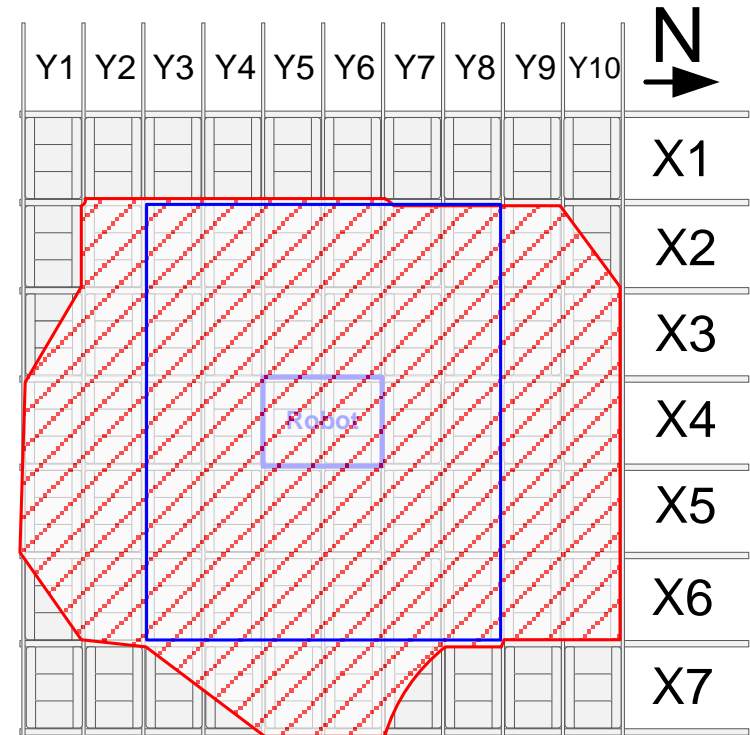
Nominal Clearance: 18 ft.



Fire damage after Test 1



-  Extent of Damage Throughout Entire Height of Array
-  Maximum Extent of Damage Allowed in Test Protocol

Fire damage after Test 2

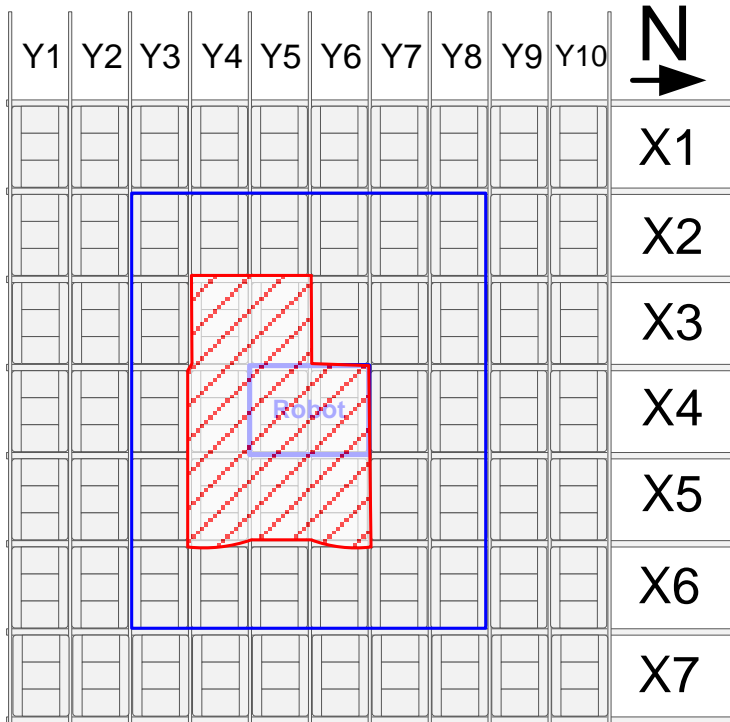




-  Extent of Damage Throughout Entire Height of Array
-  Maximum Extent of Damage Allowed in Test Protocol



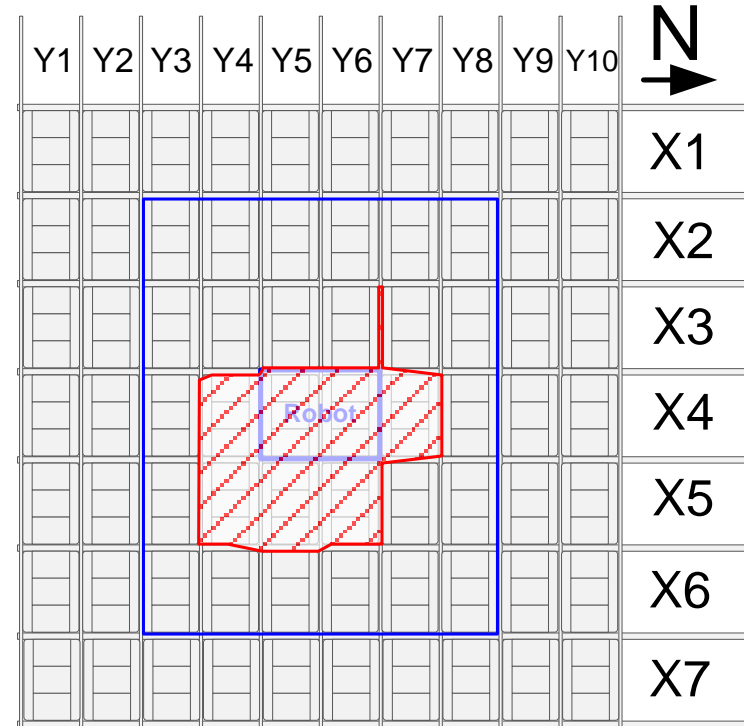
Nominal Clearance: 10 ft.



Fire damage after Test 3



-  Extent of Damage Throughout Entire Height of Array
-  Maximum Extent of Damage Allowed in Test Protocol

Fire damage after Test 4



-  Extent of Damage Throughout Entire Height of Array
-  Maximum Extent of Damage Allowed in Test Protocol



Conclusions

- Overall, test results were considered very successful.
- The slow fire growth rate noticed in the previous free-burn fire tests was confirmed.
- Increased fire growth rate with less loading of bins.
- Few sprinklers activated. Four sprinklers at most.
- The average steel beam temperature at the ceiling were well below what was determined as the maximum allowed.
- Maximum extent of fire damages was, except for Test 2, well below the maximum allowed. However, the fire was controlled in this particular test.
- No formation of pool fire of melted plastics was observed external to the test array.
- No stability problems with the grid.
- Manual fire-fighting with low-expansion foam nozzles was effective.



Questions?

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Large Scale Fire Testing

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