

Large-scale fire sprinkler tests with the AutoStore© compact storage system

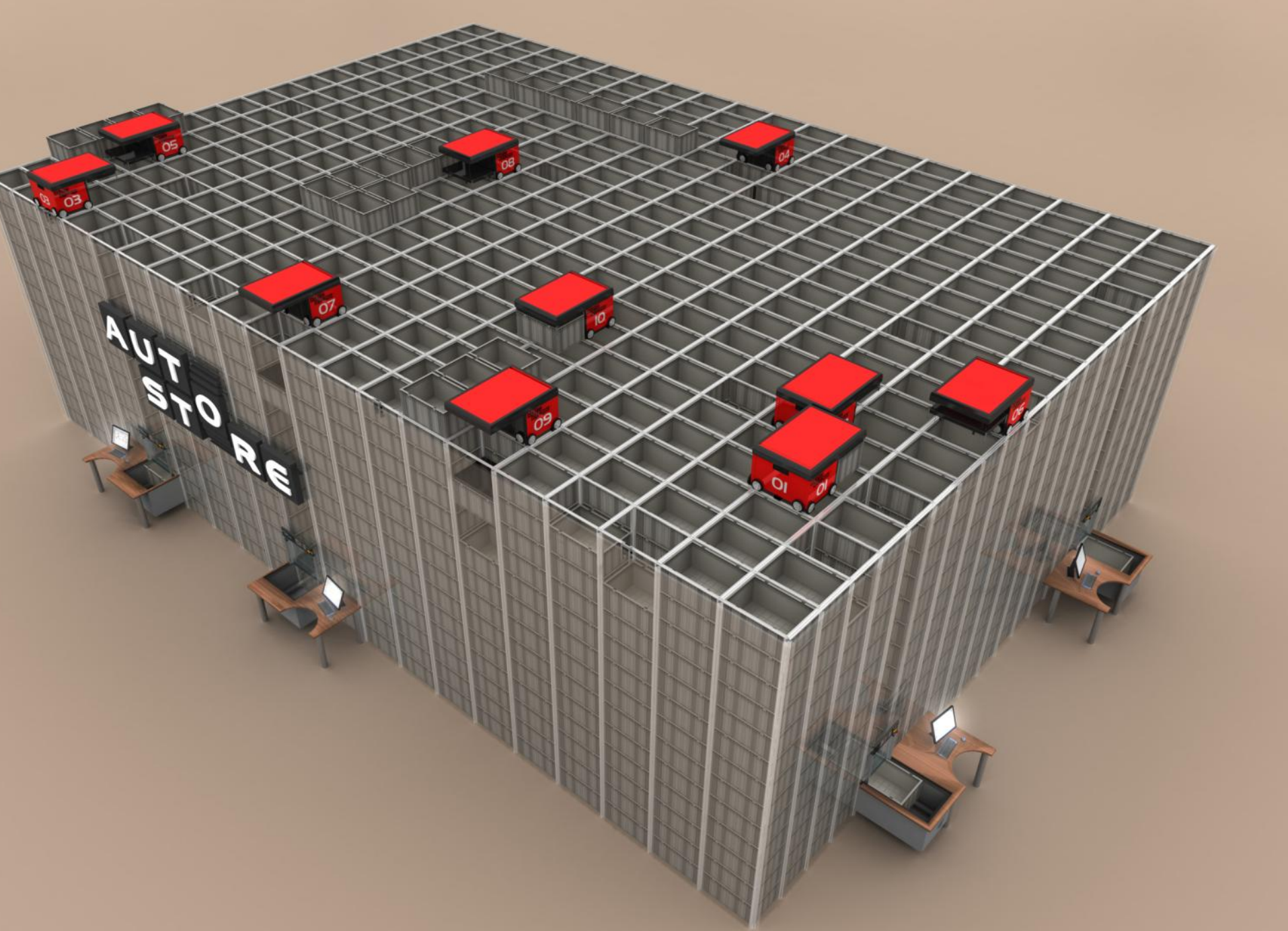
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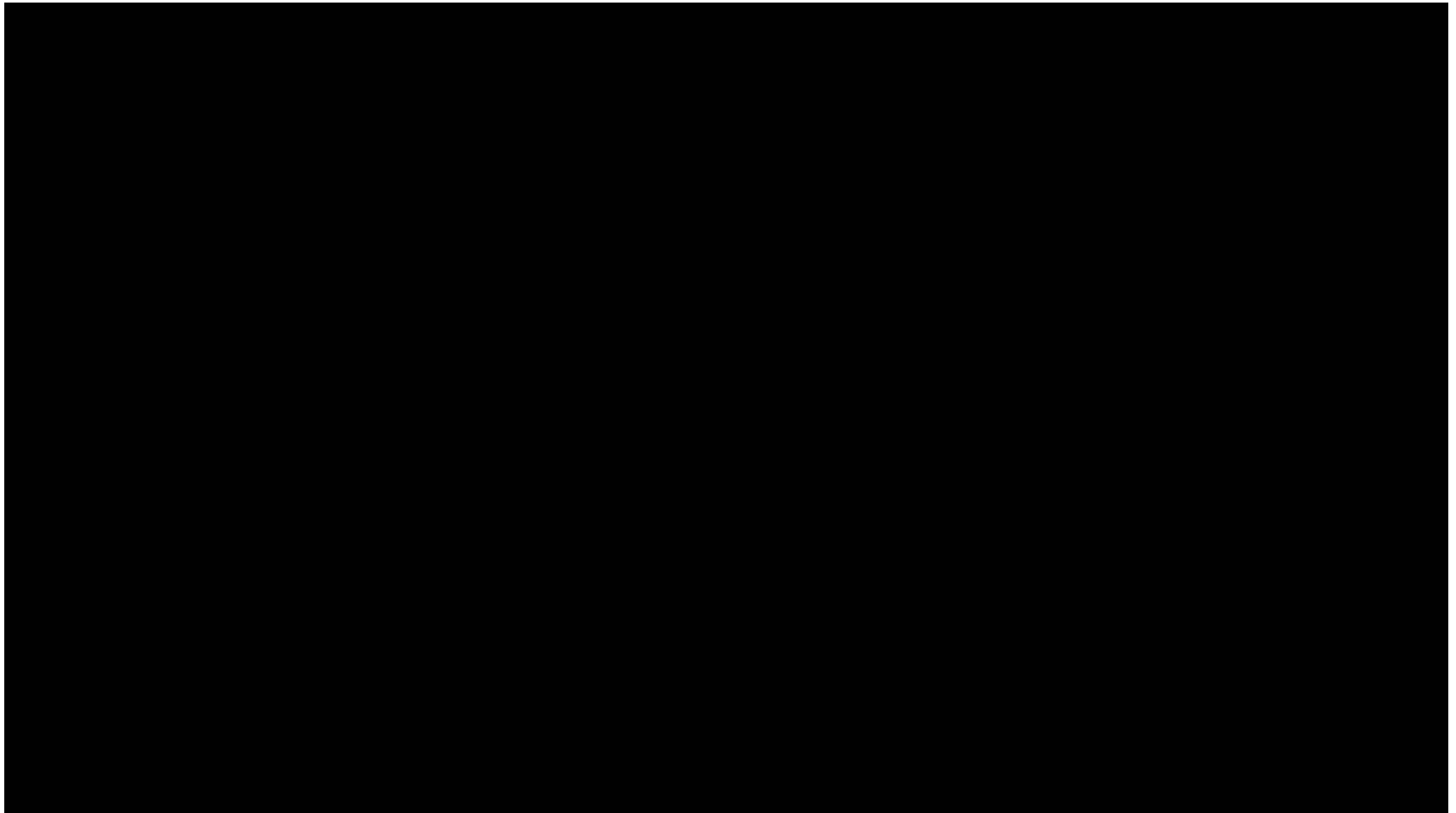
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Technical data and measures

- Size of bins: Internal size 601 mm by 401 mm by 310 mm.
- Size of bins: External size 649 mm by 449 mm by 330 mm.
- Maximum load capacity per bin: 30 kg.
- Two types of plastic raw material: HDPE or PP (contains carbon black to achieve anti-static properties).
- Storage height: Up to 16 bins = 5.3 m.
- Storage area: Large! Largest grid so far contains 70 000 bins.

Video



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The starting point regarding fire safety

- People have not normally access to the storage area of the AutoStore© system. The probability for unintentional or intentional ignition caused by humans is therefore low.
- The design of the robots fulfills the requirements of the electrical safety standard IEC 60950-1 and the probability for fire in a robot is expected to be low.
- Storage of flammable liquids is not allowed.
- Storage of commodity containing large amount of expanded plastic material is not likely.
- Fire tests have proven that a fire starting inside a bin will self-extinguish due to oxygen depletion.

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 a slow fire growth rate is anticipated.
- The flue spaces are always regular and open. No bins or commodity will block the flues.
- 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 limits the possibilities for horizontal fire spread.

...and disadvantages

- The bins have solid bottoms that are not permeable to water.
- No lids are used on the bins and 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 water from sprinklers going directly down the flue spaces.

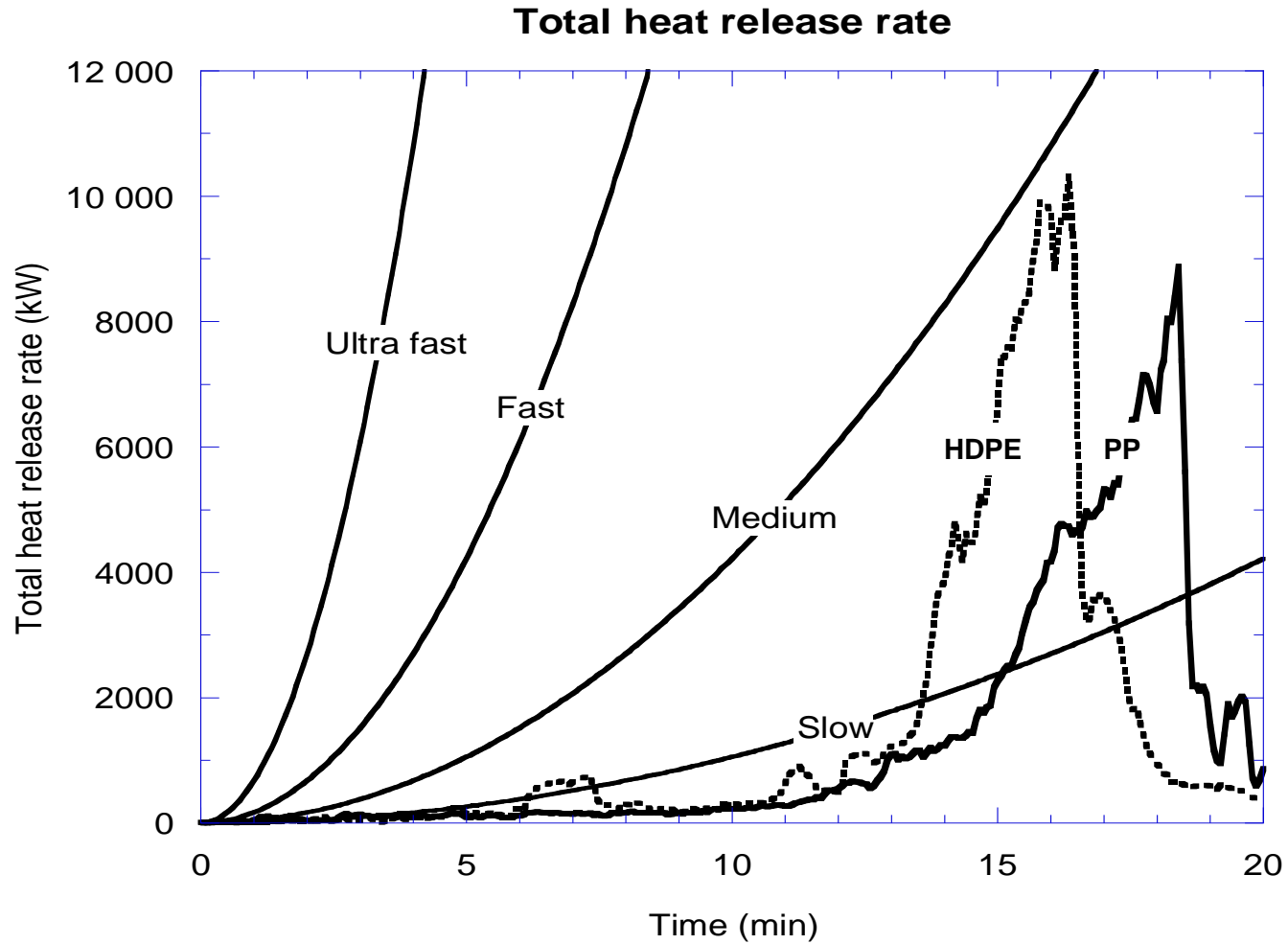
Previous work

- Small-scale fire test comparing the fire characteristics of the bins.
- Large-scale free-burn fire tests.
- The development of a high-expansion foam protection concept.

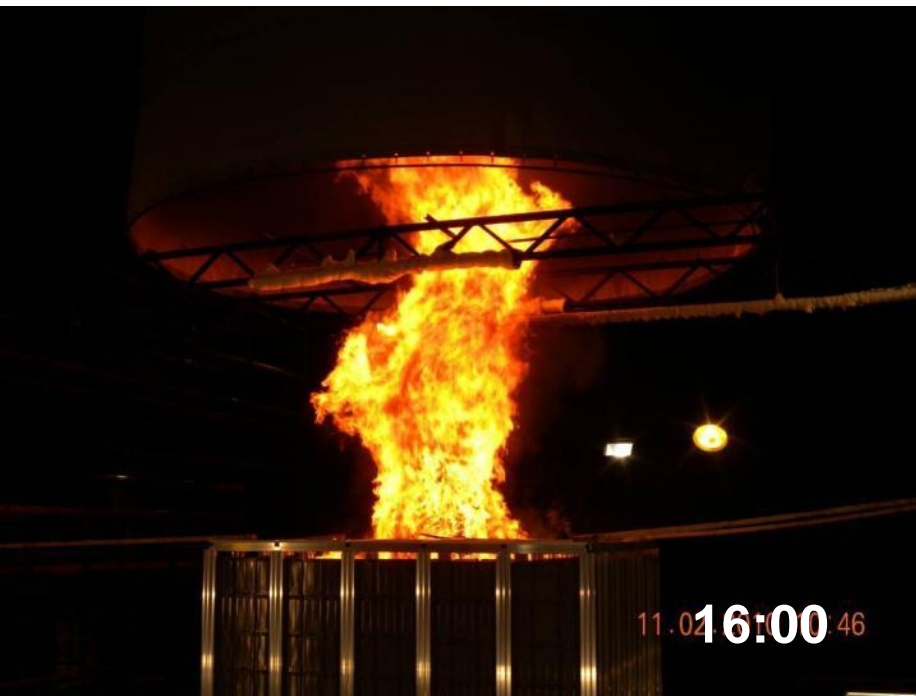
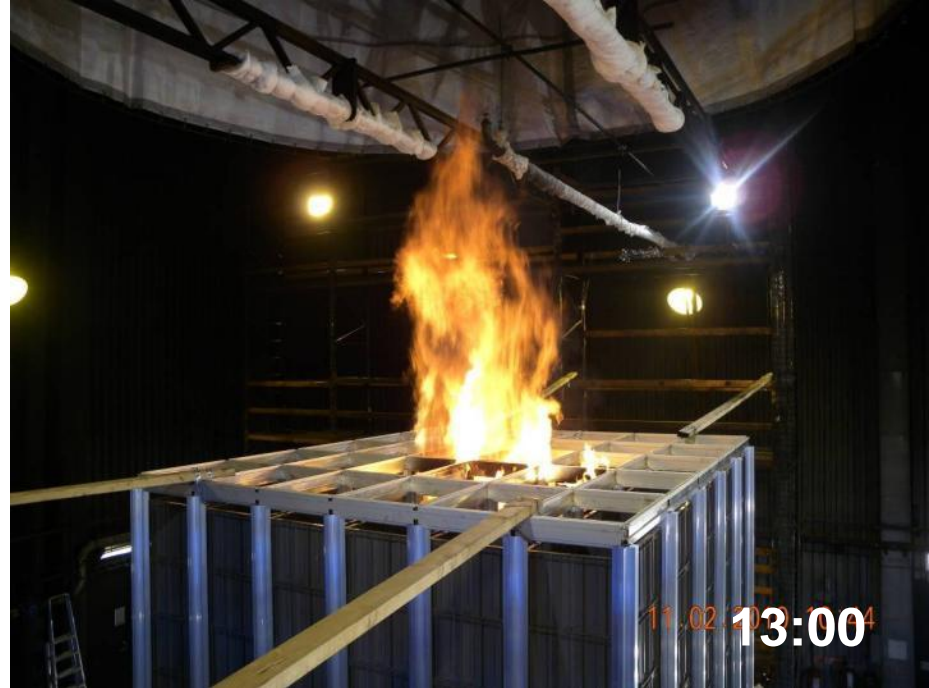


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Large-scale free-burn fire tests



Test 2



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,
 - limit fire spread, and,
 - limit the overall fire damage.
- To determine the most effective manual fire-fighting and mop-up strategy.



Large-scale fire tests at Underwriters Laboratories



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Footprint: 7 by 10 cells = 4.9 m x 4.8 m

Height: 5.3 m

01/05/2012 0



Point of fire ignition at the bottom of this flue space

01/05/2012 08

649 mm

449 mm

30/04/2012 10:01



A photograph showing the interior of a flue space. The walls are dark grey with vertical ridges. A brown rectangular object, wrapped in clear plastic and aluminum foil, is positioned at the bottom. In the foreground, there are several pieces of light-colored wood. The floor is covered with a light-colored, textured material.

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

01/05/2012 07

The ceiling sprinkler system

- Wet pipe system.
- 3.05 m by 3.05 m sprinkler spacing.
- Upright, K=160, quick-response sprinklers.
- Ceiling-to-sprinkler deflector distance: 165 mm.



Acceptance criteria

- 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 540°C (1000°F) for more than one minute.
- Ignition on the inner faces of the stacks of bins surrounding the center 5 by 6 cells not allowed.



Fire test program

Test	Fill rate of grid	Ignition location with respect to ceiling sprinklers	Discharge density [mm/min]	Ceiling height [m]	Clearance [m]
1	Completely full	Between four	24.5 mm/min	10.7 m	5.4 m
2	Completely full	Under one	24.5 mm/min	10.7 m	5.4 m
3	Two cells partly empty	Under one	30 mm/min	8.3 m	3.0 m
4	Completely full	Under one	30 mm/min	8.3 m	3.0 m



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 damages (robot removed)

01/05/2012 13:16

Test 1: Fire damages (robot removed)



01/05/2012 13:

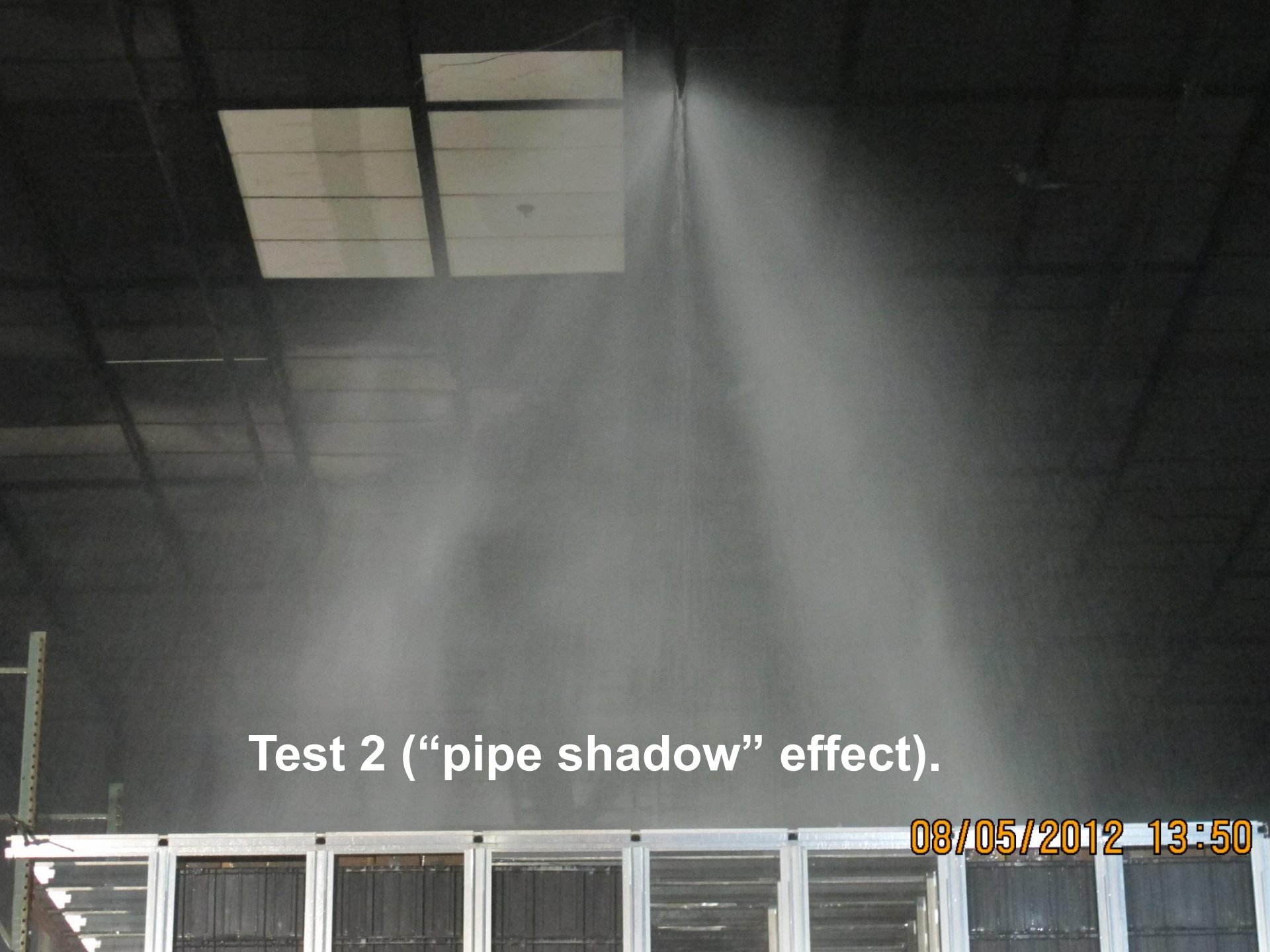
Summary of fire test results

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



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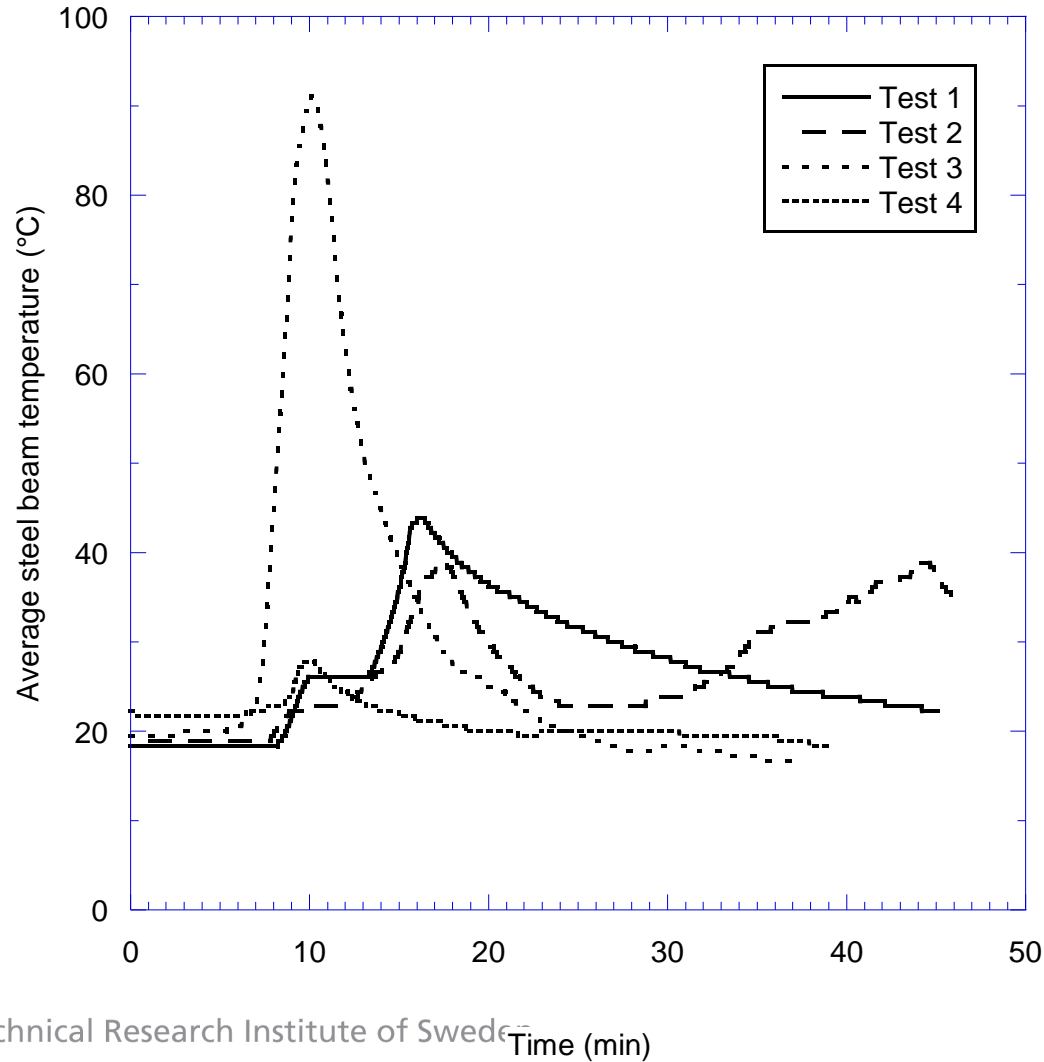
Fire damages after Test 2 ("pipe shadow" effect).



Test 2 (“pipe shadow” effect).

08/05/2012 13:50

Average steel beam temperatures



Conclusions

- Overall, test results were considered very successful.
- The slow fire growth rate noticed in previous free-burn fire tests was confirmed.
- The number of activated sprinklers and the average steel beam temperature at the ceiling were well below what was determined as the maximum allowed.
- Maximum extent of fire damages were, 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.
- No stability problems with the grid.
- Manual fire-fighting with low-expansion foam nozzles was effective.

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Thank you!



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