Central Fire Brigades Advisory Council
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Sprinklers for Life Safety in Department Stores Summary Report

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The death of 10 people at the fire at Woolworth's in Manchester, Piccadilly in 1979 highlighted the inadequacy of fire precautions measures in force and raised the possibility that sprinklers might have prevented the fatalities. Subsequent research showed that conventional sprinklers would have responded too slowly to the fire to be of much assistance but suggested that the new generation of sprinkler systems incorporating more sensitive heads might have been effective.

After a series of preliminary studies, the Fire Research Station (FRS) were commissioned to undertake a programme of sprinklered fire tests between 1987 and 1990 in a full-scale department store test rig to study the ability of sprinklers to reduce the hazard to life sufficiently for the occupants to escape. This rig was constructed in the Fire Research Station's Cardington hangar in 1986/87. It was designed to represent an open sales area typical of those found in department stores such as the Manchester Woolworth's store, with dimensions 30m x 27m floor area and 3m high.

A sprinkler system was installed consisting of 4 sprinkler heads arranged in a 3.4m x 3.4m square (equivalent to an Ordinary Hazard class installation defined in BS 5306 part 2 and Loss Prevention Council (LPC) Rules) in the centre of the rig.

Both the traditional glass-bulb sprinkler head and the more recent solder-link fast-acting sprinkler were tested.

Instrumentation was installed throughout the compartment to monitor temperature and smoke density at a large number of points and additionally, the tests were recorded on video film.

A Life Hazard Criterion (LHC) was adopted that an optical density of 0.1 OD/m at a height of 2m above the floor, at 7.5m from the fire at the centre of the rig, should not be exceeded within 7 minutes from ignition. Only the first seven minutes from ignition were considered, since it was felt that the compartment containing the fire should have been evacuated within this period if escape had not been hazarded by smoke from the fire. This has proved to be a very severe hazard criterion.

THE TESTS

Tests began during 1987 with the fire at the centre of the grid and using fast-acting sprinklers. Without sprinklers the LHC was exceeded between 3 and 4 minutes from ignition of the fire. The test rig was usually filled completely with smoke of around 3 metres visibility within seven minutes from ignition.

Initial results were not encouraging, showing that fast response sprinklers might delay the onset of a hazard to life by only 15 seconds. However, these tests were done with a low initial ambient temperature and a damp test rig.

In 1988, with the same upholstered lounge furniture fire load (2 chairs and 2 settees), the results suggested

that fast-acting sprinklers could successfully prevent attainment of the LHC. Higher ambient temperatures seemed to constitute just one reason for this. Another was the extent to which the backs of the settees burnt through and thus allowed water more easily to reach the fire. The effect of the settee backs in shielding the fire from the sprinkler spray was determined to be a major factor affecting the effectiveness of the sprinklers.

That year saw the introduction of the "Furniture and Furnishings (Fire Safety) Regulations", so that new tests with complying products were required. In addition, visits to shops had shown that bedding and clothing materials were a probable hazard. So for 1989, pillows were chosen, since they contain materials common in bedding and clothing, were readily available and lent themselves to a multiplicity of arrangements.

First, a 'simple' fire consisting of a single layer of pillows stacked on edge showed that, provided water reached the burning material, it was rapidly extinguished and that increasing the water density above 5 mm/min would not affect control of the fire significantly. This is important in that most sprinklers currently installed are designed as 5 mm/min systems, and the provision of water supplies for higher densities would significantly increase the cost of installing new systems.

Fires designed to represent the situations observed on sales floors, consisting of stands with stacked pillows or pillows on shelving, were then tested. These tests showed that the effect of shielding by either unburnt pillows or by the display shelving used was a significant factor. The probability of not exceeding the LHC rose as the quantity of shielded pillows was reduced, and below certain limits sprinklers always controlled the fire sufficiently to prevent the hazard occurring.

A suspended ceiling conforming with the requirements of the LPC Rules or British Standard 5306: Part 2 (viz at least 70% clear area and apertures at least 25mm wide) delayed the operation of sprinklers by a small amount, but did not have any significant effect on their control of the fire.

Fires in the corner of the rig of a similar size to the central fires were controlled sufficiently by the one sprinkler that operated to keep below the LHC. This confirmed that the current requirements for sprinkler spacing adjacent to the walls of a compartment are adequate.

MATHEMATICAL MODELLING

Mathematical modelling by computer was then carried out to extrapolate the experimental results to compartments of other sizes. A 'zone' type model called "RADISM" was used, and modified to match the calculations with experimental data. A reasonable agreement was obtained between the model and experiment.

FRS RECOMMENDATIONS

For the final technical report the FRS scientists were asked to produce a set of recommendations for sprinklers in large sales areas using the knowledge gained from the tests, the computer model and their own expertise. The results are shown in the table below. However, its validity and how it might be enforced is still under discussion.

In particular there is concern that the success of the sprinkler system will also depend on the quantities of displayed goods, the amount of shielding provided by shelving and the space between adjacent units.

The recommended spacing and sprinkler type is shown in the following table:

Ceiling Height (m)	Floor Area (m)			
	400-500	500-800	800-1500	Over 1500
3-4	O	F+	F	F
4-5	O	F	F	C
5-6	O	F	C	C
6 & over (*)	F+	C	C	C

Notes:

O No sprinkler system can be recommended that would ensure safety.

C Conventional sprinkler system: ordinary response sprinkler head at 3.4 metre spacing

F Fast-response sprinkler head (see below) at 3.4 metre spacing.

F+ Fast-response sprinkler head (see below) at 3 metre spacing.

* For floor areas of 400 - 500 m^2 and ceiling heights of 7 - 8 metres, Fast Response sprinklers on a spacing of 3.4 metres could be used.

A fast-response sprinkler head should have a response time index of 50 $m^{1/2}$ $s^{1/2}$ or less, and operating temperature not greater than 74°C.

A 3.4 metre spacing is equivalent to an Ordinary Hazard, Class III system, typical of systems already installed in many premises.

Floor areas below 400m^2 were not considered. However, sprinklers may still have a role to play in these smaller shops or display areas.

CONCLUSIONS

The recommendations are that either fast-response or ordinary-response sprinklers should be installed depending on the compartment sizes and that these will delay the onset of hazardous conditions in the compartment sufficiently to allow escape of the occupants in most cases. For compartment sizes with floor area less than 500m^2 and ceiling height less than 6m, hazardous conditions may occur too soon for sprinklers to have an appreciable effect.

References

J S Webb, P G Smith, "Sprinklers for Life Safety in Departmental Stores -Experimental Work 1989/90", Fire Research Station report TCR 49/90, July 1990.

Cover photograph: sprinkler test in progress at the Fire Research Station, Cardington.

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