Hot Issues in Fire Engineering

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A Note on Cabin Fire Design for Protecting Large Halls

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Many big public transport terminals in the Far East including the airport and many subway stations [1] in Hong Kong are not fully covered by fire suppression and smoke exhaust systems. Only the cabin concept [2-4] was used in many big halls, but mostly protecting some areas for retail and catering. Apart from the hard efforts of the author and his students [5-19], very few systematic experimental studies were reported to demonstrate that the design [20-23] can control the heat release rate to a certain value, nor smoke would not spread to the entire big hall. Heat removed by operating the sprinklers in a cabin was not measured, but only presumed to be controlled within a small value such as 2 MW. Almost no full-scale burning tests appeared in the literature to demonstrate that the cabin concept would work as expected [24], particularly in the Far East, where social responsibility and education of citizens are very different from those in advanced countries. Taking the Hong Kong airport terminal as an example, it was observed that combustibles (apart from luggage) are always placed outside the cabin! Research results compiled in advanced countries might not be applicable to such developing areas [7]. Strong justification with full-scale burning tests is needed on watching flashover in a cabin fire as proposed [25,26].

A ‘full’ cabin is required [1-3] to have a sprinkler system to control the fire, and a smoke exhaust system to remove smoke. Preliminary studies showed that burning a typical newsstand [8,18] would give heat release rates up to 8 MW. Values higher than 8 MW are expected if large amounts of combustibles including wine are stored. Therefore, it is difficult to convince the public that the heat release rate in a retail shop fire in a cabin can be controlled at low values such as 2 MW even with sprinklers [24].

A long-term research programme with very limited resources [1,27,28] on cabin fires was worked out by the author for over ten years, in collaboration with several research groups in China. The project started with theoretical analysis on the fire environment inside a ‘bare cabin’, possibility of onsetting flashover, and shop spill plume. Experiments on such bare cabin fires and smoke spilling out to the hall were then carried out to understand the possible hazards. The performance of sprinklers and smoke exhaust systems in a cabin of length 3.5 m,

width 4 m and height 3 m was studied. The study was only on a 0.6 m by 0.6 m wood crib fire of height 0.4 m ignited over a pool of size 0.25 m by 0.25 m with mass of fuel 0.2 kg. The steady heat release rate of the wood crib was measured experimentally in an oxygen consumption room calorimeter to be 650 kW over 300 s. The heat release rate of two wood cribs placed within 0.3 m was up to 1.3 MW.

The following were observed in those preliminary tests:

- Air temperature inside a bare cabin fire would increase quickly upon burning the crib. The ceiling temperature could be up to 600^{o}C when two such wood cribs were burnt.

- Mechanical smoke exhaust system would control smoke in the cabin. However, smoke cannot be controlled, after operating the sprinkler, because of disturbing the stability. Large quantity of hot smoke was then observed to be spilling out to the hall outside. Therefore, a smoke exhaust system should be provided in the entire hall to keep smoke at high level.

- For cabins not completely closed, known as ‘open cabin’ in Hong Kong, air supply might lead to flashover in the cabin. The cabin itself would then become a big burning object. Therefore, the outside hall should have a fire suppression system.

- It was observed that sprinklers operating under normal design conditions [29] could not extinguish such a small wood crib fire with low heat release rates of 1.3 MW. All combustibles inside the cabin were burnt out even with the sprinklers operating. Those preliminary tests suggested that sprinklers might not be able to control a cabin fire if the combustible content inside the cabin is not controlled. Those retail shops storing many combustibles should be watched carefully.

- In particular, open cabins with only sprinklers inside but no fire suppression system in the outside hall should be reviewed carefully. This is because flashover inside a small cabin can be onsetted easily to give a big fire!

- A normal sprinkler system using design parameters specified in the local fire code [29] might not be adequate. It cannot control fires with two wood cribs of 1.3 MW. Note that experimental data by the Swedish suggested that burning potato crisps bags [30] would give a heat release rate curve following a fast t^2-fire up to 6 MW quickly. Such a big starting fire would ignite adjacent combustible items (observed many times, apart from luggage) to give a much bigger fire. An alternative suppression system, such as a water mist system, should be provided inside the cabin if the fire load inside is not limited to

very low values. Full-scale burning tests with such a water suppression system should be carried out to justify whether such big fires can be suppressed. Otherwise, appropriate fire suppression systems should be installed in the entire hall.

- As demonstrated in the preliminary tests on small wood crib fires and typical newsstand fires, water mist discharged from a high speed water fog nozzle might be able to control the fire if designed properly.

Anyway, the above are just preliminary results at two remote sites in China with limited funding. It is difficult to say that the cabin concept is safe as assumed in advanced countries [2-4,24] in protecting against the big hall, far too many problems were identified while using the cabin concept in the developing countries. Further systematic research should be carried out to demonstrate that the cabin concept would work for big public transport terminals in the Far East. In particular, full-scale fire tests under realistic big fires should be carried out in big terminals. The heat release rates of burning bigger retail cabins should be measured [12].

If the cabin design is demonstrated to have difficulties in functioning as expected in limiting the fire to 2 MW and unable to avoid spreading smoke out to the halls, workable fire suppression and smoke exhaust systems must be installed as soon as possible to protect the entire hall. Most of the public transport terminals in airports and subway stations in the Far East are very busy. Any disturbance to normal operation of the terminals will lead to disasters. Difficulty in locating the fire source encountered in the Chek Lap Kok airport fire was a good lesson to learn [31]. More importantly, improper fire safety design would also affect the firefighting and rescue strategies, and bring ill effects to the safety and health of firemen. They took several hours to locate the burning source as experienced at the Hong Kong airport fire in April 1998!

With the possibility of developing new phases of the airport, it is the right time to review the fire safety strategy proposed over 20 years ago [2-4]. Further systematic experimental studies [1,5-19,27,28] must be carried out, not just relying on doing one or two demonstration tests with small fires in a few days.

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