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CONCERNS ON INSTALLING LONG-THROW SPRINKLERS IN TALL HALLS

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ABSTRACT

There are concerns over long-throw sprinkler installation in halls with high ceilings which are likely to store large amount of combustible materials. These concerns will be addressed in this paper. At the moment, it is unknown whether such sprinkler installation can protect high-ceiling halls which store large amount of combustibles. The concept should be further explored with in-depth research through full-scale burning experiments with big fires.

1. INTRODUCTION

Long-throw sprinklers are installed at height over 14 m [1] to protect high-ceiling halls which are unlikely to store high amount of combustibles. However, festive decorations, like huge combustible Christmas trees which are several-story high, are put in those shopping malls such as in Fig. 1. Igniting such a big combustible item would give very different fire phenomena as reported [2]. Burning a family Christmas tree might give a 7 MW fire; and burning an exhibition stall might only give 10 MW. But burning a tall Christmas tree as in Fig. 1 would give a much higher heat release rate. It has not been demonstrated that a long-throw sprinkler system can suppress such a big fire. Water coverage tests indicated that sufficient amount of water can be delivered to the protected area. Indoor aerodynamics would be different under big fires, hence affecting the performance of the smoke exhaust system [3]. The situation is even worse for a static smoke exhaust system. Smoke might be cooled down to lose buoyancy, and thus unable to be exhausted out through the natural vents [4].

It should be noted that the hot smoke test [3] carried out to evaluate the performance of the smoke exhaust system was set on a 2 MW fire, with alcohol being used as fuel. A smoke generator added smoke for easy visual examination of the rising hot air plume. The long-throw sprinklers were tested separately without actual spray on the alcohol bed and smoke generator bed, and the intention was to measure the water density of the sprinkler spray, possibly without recording the entrained air velocity of the sprinkler. There are deep concerns [5] over the performance of long-throw sprinkler in high-ceiling halls storing high amount of combustibles.

Fig. 1: High combustible content in a tall hall

2. TWO POINTS OF CONCERN

Two points were raised [5,6] recently on installing long-throw sprinklers at height in halls storing high amount of combustibles:

- Air entrained and water droplets of the sidewall water spray would cool the hot smoke and push it as colder slumps to people at the lower levels.
- Blocking the views of people and firefighters.

The strong side push of the air entrainment of the long-throw sprinklers will generate large volumes of diluted smoke. The smoke will disperse to low areas of the hall, unless some physical barrier stops such dispersal.

Therefore, the following tests are suggested to be further explored:

- Set up the designed long-throw sprinklers, and operate them to obtain data and map out 3-dimensional envelopes. It helps to calculate and estimate air and water mist entrainment, and volume extent without burning objects.

- Set a big fire to test the estimations and investigate the likely outcome.

This sprinkler system is actuated by a sequence of electronic fire detection, comparison and analysis of received signals, set-up of electro-mechanical valves and pumps. Based on statistics [7], integrated system analysis will show that the overall system reliability will not be higher than 80%. A detailed quantitative analysis should be carried out to compile a report in order to give a more reliable number which is supported by experimental evidence. If the sprinkler system fails in case of a fire of the captioned case, it may damage the ceiling. Such a huge damaging surface area at height is very difficult to clean. Deformation of certain metal members would lead to collapse of the buildings.

3. SUGGESTION

Past preliminary tests on long-throw sprinkler with a wood crib fire less than 0.5 MW [1] indicated that heat released can be controlled only if the burning object is very small. However, mixing of smoke with air and steam should be cautioned [8] for any bigger fires over 0.5 MW, even when the ceiling is low.

That is because buoyancy of hot gases from big fires would induce stronger, more turbulent airflow. Air entrainment towards the fire plume and water spray of sprinklers would be entirely different from the flow pattern of a small fire. In a hall with high ceiling, the long distance travelled by water droplets of water spray can intensify the situation, contributing to a much higher air entrainment rate. On the other hand, direct action of water spray on smoke will cool it down. Loss of buoyancy will give an unstable smoke layer at the ceiling.

Therefore, shopping malls, which have large atriums and are likely to store large quantity of high combustibles, should address to the two concerns discussed above. It is strongly recommended for shopping malls with a tall Christmas tree as in Fig. 1. to pay extra attention to such issues. The concern was also raised recently [9].

4. CONCLUSIONS

Sprinkler protection for halls with large atrium storing high amount of combustibles is a concern raised years ago [10]. Any design concept must be evaluated with full-scale burning tests of big fires, not just by one or two small-scale field tests. Small-scale field tests in a hall with a ceiling lower than 5 m would not indicate anything abnormal. The results will be very different when burning combustibles in a high-ceiling hall.

In-depth investigation is needed to address the proposed concerns [5,6] due to the large air entertainment rate of water droplets travelling long distances, and buoyancy-induced air flow due to a big fire. Current design concept is only applicable in places which are unlikely to store high content of combustibles, as the heat release rates will be lower than 0.5 MW.

The situation is very complicated for large high-ceiling halls with long-throw sprinklers and a static smoke exhaust system. To demonstrate whether integrating the fire suppression system with the natural vents is workable [11-15], full-scale burning tests on long-throw sprinklers at height must be carried out in places storing high amount of combustibles. There is no experimental evidence that the system will suppress big fires like the one shown in Fig. 1 at the moment. Inadequate fire safety design will be very dangerous to firemen when they combat big fires and rescue people trapped inside.

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