NEW APPLICATIONS OF AQUEOUS AGENTS FOR FIRE SUPPRESSION

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1. INTRODUCTION

As a fire suppressant, water has a number of beneficial features, in particular its exceptionally high heat capacity. It is also extremely attractive in environmental terms. Some new applications into which water has been introduced were described in a previous paper (ref 1). These included suppression of fire in aircraft passenger cabins - a brief update on work in this area is given below. In addition, two new areas have been addressed more recently, and experimental findings are presented: these are protection of electrical and electronic equipment, and suppression of hydrocarbon fuel explosions.

2. AIRCRAFT CABIN WATER SPRAY

Recent work at the FAA Technical Center (ref 2) has led to significant enhancement of the performance of this system. The work relates not so much to the efficacy of the spray itself but to the detection and control system which is used to manage it.

Test work has continued on the FAA's 707 narrow body fuselage with a $7m^2$ external jet fuel pan fire adjacent to the door. As in previous tests, controlled inward air movement simulated the effects of wind, and the area inside the door was fully furnished with seats, carpets, stow bins and wall cladding.

The major innovation which has been introduced in the recent work is that the fuselage is divided into short zones some 2.5m in length, in each of which the spray is actuated only when the temperature in that zone exceeds 150°C. The spray is thus concentrated in the hazardous area. This results in a much reduced water requirement compared with the previous system which sprayed the whole interior; a requirement of 270L of water was reduced to 30L using the zoned system to achieve slightly better overall performance. The additional escape time resulting from the spray was 0.4 seconds per litre of water with the full spray system and an extremely impressive 5 seconds per litre with the zoned system. Additional benefits are improved visibility (there is no downward entrainment of the buoyant smoke layer outside the sprayed zone) and avoidance of unnecessary wetting of the passengers, thus removing a potential hazard when evacuation of the aircraft might be into cold external conditions.

The FAA and the European JAA are currently considering whether to introduce this system as a mandatory requirement, and these impressive results clearly are an important factor in their deliberations.

3. ELECTRICAL EQUIPMENT

Experiments have been conducted by FSI Research, Kidde Fenwal and GTE in the USA, and FSI Research, Kidde Graviner and Mercury Telecommunications in the UK on the use of water to protect electrical switchgear cabinets; and by FSI Research, Kidde Graviner and London Underground on high voltage power transformer protection. The aims of these experiments were to quantify not only the fire suppression performance but also any electrical hazard which resulted, and the subsequent recovery and return to service of equipment undamaged by fire.

The switchgear cabinets tested were typically 2.4m high by 0.6 X 0.5m and contained densely packed printed circuit boards **(PCBs)** separated by only 10mm. **AC** and **DC** power was supplied. In some tests, inner partitioning and cooling air flow were also present. In a separate series of tests, an 11kV power transformer measuring 2 X 1.4 X 1.4m was subjected to a water spray system; there was no fire in this test, the only objective being to assess the electrical hazard and the practicality of subsequent recovery of the equipment.

Ignition was achieved using a hot wire wrapped round a **PCB** at the base of the cabinet, and the suppression system was activated when flame was sustained on the next layer of **PCBs** above the ignition layer. Distilled or tap water, propelled by nitrogen at pressures which were varied over the range *2* to 100bar, was delivered through up to six nozzles at various locations within, and in some experiments outside, the cabinets. Nozzles types investigated included full cone, hollow cone, elliptical cone and air aspirated designs.

In the absence of a suppression system, very high levels of smoke obscuration were generated above the cabinets in a few seconds and flame was sustained on the next layer of **PCBs** in 1-3 minutes. Subsequently the fire spread very rapidly vertically through the cabinet, followed by slower lateral spread. At the height of the fire, temperatures exceeded **1000°C** and 2-4m flames were visible above the cabinet.

Suppression was extremely successful in the simple cabinets, with extinguishment within two seconds of activation using less than 1 litre of water. The most effective systems used high pressure, single fluid nozzles internally located at the top of the cabinet. The results were substantially unaffected by the presence or absence of the power supply or by the cooling air flow. However, internal partitioning significantly reduced the effectiveness of the sprays, necessitating additional or relocated nozzles.

In tests when power was applied, the electrical safety trips were activated immediately on impact of the water (and sometimes prior to this by the smoke). There was no electric shock hazard. Equipment undamaged by fire was returned to a fully serviceable condition in around one hour following the tests.

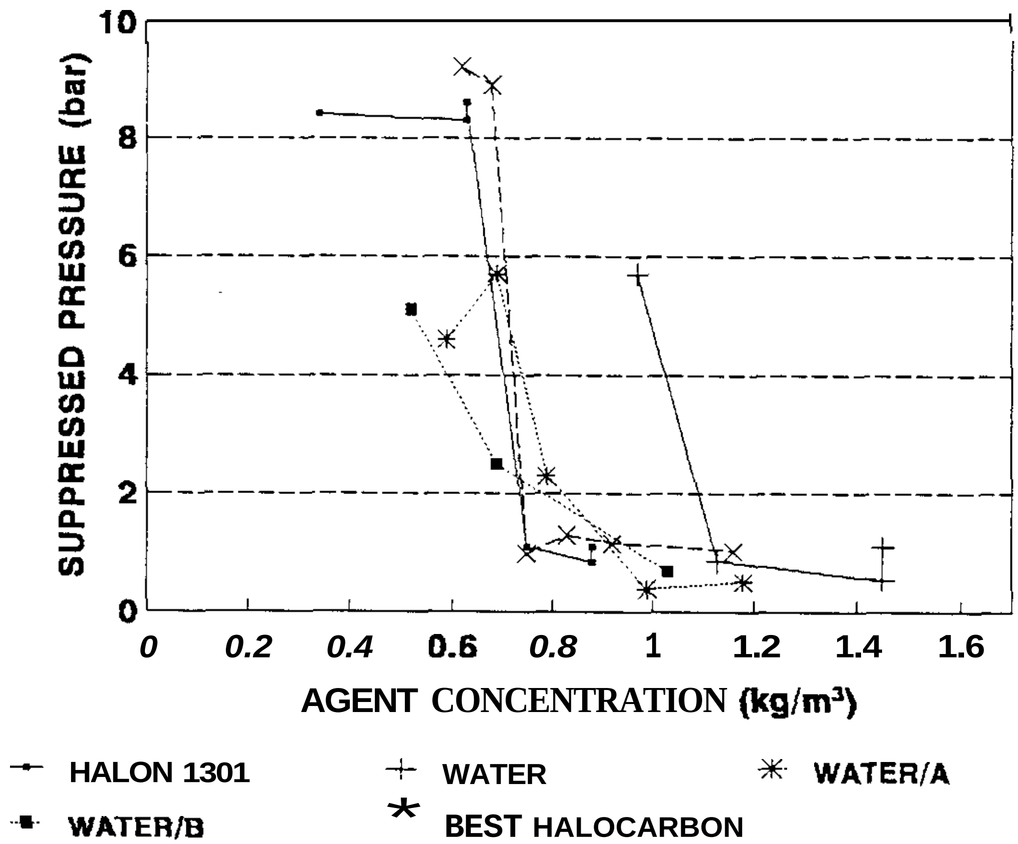
Water suppression of electrical equipment fires was thus shown to be effective, safe and non-destructive, but to be significantly affected by major internal obstacles. The critical parameters in such a system are droplet size, droplet velocity, and - as evidenced by the effect of obstacles - nozzle location and spray access.

4. FUEL EXPLOSION SUPPRESSION

Hydrocarbon fuel explosions are a major hazard in process industries where flammable solvents are handled, and in the crew compartments of armoured fighting vehicles where combat generated fires can occur.

Tests to simulate events of this type were performed in a fully sealed vessel of internal volume $6.2m^3$. Diesel oil was sprayed into the vessel at high pressure, generating a fine turbulent mist which was subsequently ignited by a pyrotechnic device. Control of the temperature of the oil, the pressure under which it was introduced and the time delay before ignition allowed the severity of the resultant explosion to be set to simulate the worst case explosion experienced in over one hundred live firing tests.

Suppression tests were undertaken with Halon 1301 as a baseline; with water, with and without additives; and with the new halocarbons, both singly and in mixtures. Achievement of the best performance with the aqueous agents and most of the halocarbons required the nozzle and delivery system to be modified compared to the standard Halon design. The results are presented graphically below,



While water alone performs relatively poorly, water with inorganic additives performs very similarly to Halon 1301 and the best of the new halocarbons. Water is believed to be a highly attractive solution in these areas, providing the problem of freezing can be overcome or tolerated.

5. SUMMARY

The results described above confirm that - provided the delivery system is carefully optimised - water and water based agents offer surprisingly good performance in applications where Halon 1301 would previously have been an automatic choice. However, limitations t .he applicability of water remain - it is (ref 1) no panacea

REFERENCES

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2. Hill R G, Marker T R and Sarkos C P: "Evaluation and Optimisation of an On-Board Water Spray Fire Suppression System in Aircraft" Water Mist Fire Suppression Workshop 1993