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SUPDET 2016 ABSTRACT

Development of a 1.5GPM, sprinkler equivalent, residential watermist suppression system

The UK, and London predominantly, is a growing market for residential water-mist systems. Property prices, high terraced house density and limitations on redevelopment make the refurbishment of existing homes the most common consumer investment in property. Layout flexibility in these refurbishments tend to be limited by the prescriptive guidance of Approved Document B which calls for passive fire compartmentation. Partial sprinkler coverage is an acceptable "compensatory measure" (Alternative Means and Method) to protected escape routes but are cumbersome to retrofit, especially if only one floor needs coverage.

The need for retrofitable fire suppression which occupies very little space or draws very little flow is in strong demand as it allows for cost effective open plan refurbishments. The current product provided suppression but not at sprinkler (UL1626 level for example) so it was only accepted by the UK's Local Authority Building Control for a very specific application of 2 to 3 storeys loft conversion where an alternative escape route is expected (first floor windows).

Plumis wanted to develop a sprinkler equivalent system but with the same low flow as the existing system (1.5GPM). In the meantime, the UK was developing (and has published in November 2015) a standard for residential water-mist systems (BS 8458:2015) which is based on NFPA 750, UL 2167 and FM 5560 but adds some "curved balls" such as testing with a forced ventilation to simulate a wind draught and an "open room" arrangement by removing half of the walls to explore the fragilities of the small droplets of mist.

Plumis attempted a series of different approaches to improve the suppression effectiveness of its water-mist system to meet the performance criteria of this British Standard whilst keeping to its production water pump which outputs 1.5GPM at 100bar (1450psi) and allows for retrofit installations without the need for tanks or increased water supply. This project was supported by a grant from Innovate UK, a government organisation that incentivises and supports research and development by UK companies with a view to export innovations.

The key underlying principles were that:

1. The original concept of a mid-wall mounted spray head should be kept as it maximises the efficiency of water use by keeping the water droplets in the cooler level of the fire, where it is drawn to be base of the fire without being affected by the hot layer on the ceiling. Traditional watermist systems may use 25-40lpm (6.6-

10.5GPM) to meet the same fire performance for these residential applications and these flows already pose a problem for existing, limited supply, urban dwellings.

2. The system would not only have to meet the British Standard but would have to perform reliably and in every worst case scenario to be able to eventually be UL Listed with a view to be used in US residential applications and internationally. It should also be able to meet the 30-minute residential performance requirement instead of only the domestic 10-minute standard. This was to ensure robust performance and to prepare for a potential requirement of 30 minutes for unusual applications such as care or nursing homes.

3. An optimisation of the limited use of water would have to involve:

- An improved distribution of the mist horizontally while avoiding obstructions and the hot layer better than currently done.
- Improve detection response to tackle the fire on an early stage and therefore reduce heat release.
- Improve the effectiveness of the existing mist density by utilising additives to allow flow to be kept the same.

The proposed experiments to validate these techniques were:

- Computer Fluid Dynamics (CFD) by Greenwich University Fire Safety Group, led by Prof Ed Galea, to investigate variations in types of spray nozzles and positioning. a) A selection of nozzles was characterised for droplet size and velocity: flat and full cones. b) A control volume cube within the corner fire "entry point" was created and the variation of water mass capture within that volume was used as a proxy to determine the improvement in distribution, as suppression effect cannot be simulated. c) A variation in nozzles and its positioning in the room allowed for a wide range of comparisons of "effectiveness of droplet distribution".
  Because the mist head is located mid wall and the spray needs to reach an opposite wall, spray droplet conservation of kinetic energy is important to allow for the maximum horizontal range by minimising the parabolic trajectory.
  Performance limitations were found using the CFD. The biggest impact was the surprising effect a 180° spray pattern had on horizontal travel range. The large surface area for friction created by a flat 180° spray as well as the large volume displacement severely reduced travel. A trade-off was very clear between a wider, better distributed spray and a narrower, longer range spray. The narrower provided

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improved density when targeted to the fire due to its reduced friction but would fail once the fire load was placed in between the centreline of sprays nozzles.

- Fire tests with several detection methods: heat versus smoke versus combined PTIR detectors. These were run on the 3 main different scenarios: the corner fire, the centre fire and the centre fire with forced ventilation. Although there were clear reductions in activation times using the smoke and PTIR detection methods, the result in suppression effect was not obvious. This did not justify the significant on-cost of a PTIR detector neither the risk for false activations from a smoke detector. These experiments were still very useful: the main learning was the effect that the ventilated test had on activation times as opposed to the expected impact on suppression effectiveness. Consequently, a "draught environment" that was assumed would only impact watermist droplets in fact also impacts any thermosensitive trigger on the ceiling, and could be larger on the higher thermal inertia sprinkler bulb. Also surprising, was how repetitive the tests were by the consistency of the alarm activation times, so high that during the testing we were able to identify a problem with a fire load because its slower HRR resulted in a slower activation time, later confirmed on footage and thermocouple data.

- A series of tests were run with F-500, a commercially available surfactant for fire suppression. However, the biggest difficulty was to dose this additive with the least complexity (avoiding a dedicated pumping device) to keep reliability and robustness high. This should be ideally implemented on the low pressure inlet side of the pump to avoid dealing with high pressure dosing and sealing but that also meant a varying inlet mains water pressure of between 1 and 10bar. A closed system Venturi device was developed which allowed for very fine dosing of the additive with no moving parts and only the attachment of a "Venturi-bottle" between water inlet and pump. This worked very well with the consistent fixed flow of the positive displacement piston pump the system uses. Suppression performance was significantly improved with the use of the additive but it did not allow a consistent and clear pass in worst case scenarios. The designed Venturi device using 1litre of additive would have been satisfactory for the domestic requirements of British Standard (10 minute) but not to obtain UL Listing. However, concurrently, studies were made regarding the complexities during product lifetime: logistics of transporting and storing chemicals, the annual service full cycle commissioning, the disposal, the impact of smell in case of false activation. The biggest hurdle was annual commissioning in which a validation that the Venturi device was operating would necessarily involve the injection (and therefore loss) of additive, reducing the length of additive use once a

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full activation had happened. The complexities related to the manipulation of the additive by installers during the annual service would transform a very simple and quick process in a very technical one to ensure product reliability. The additive option was therefore abandoned.

The development was then left with the conclusion that only targeting mist to where the fire was would allow for a robust and consistent suppression performance. Focus was then turned onto how would it be possible to convert this full volume protection system into effectively a "selectable" local application system by only spraying in the area of the room where the fire was. To divert flow between a selection of, say, 4 different nozzles in a single spray head where all the flow would be direct to a single nozzle suggested a rotary barrel system so that a combination of expensive and complex on-off poppet solenoid valves could be avoided. This selection system would have to work only once in a fire and not a multitude of times.

The main challenge however, was to determine where the fire would be located in the room so that the correct selection could be made. The use of a number of ceiling mounted smoke or heat detectors was contemplated to create a "heat map" of the ceiling and determine approximate location. However, not only irregular (non-planar) ceilings would be a problem but the communication and reliable interpretation of data between these several detectors as well as aesthetics would be a problem. A proposal was then made of placing the sensor on the same rotary barrel as the nozzles so that a "room scan" would be possible. That resulted in a simplification of the design where a single nozzle would be placed in-line with the sensor and no selection process would be required, only the rotary movement. A series of sensors were used, visible light as a proof of concept and then infrared, using a variety of sensitivities and angular ranges.

Optimisations were also carried out to the angle and orientation of the single nozzle spray with a view to maximise range and suppression effectiveness, especially in the case of an obstruction placed close to the spray head. A narrow and vertical spray was chosen. The narrow spray, being less susceptible to friction allows the suppression to occur effectively even at 6m away, on a corner fire on the same wall as the spray head. A vertical spray allows the upper section of the high speed spray to tumble over obstructions creating a turbulent, watermist droplet rich environment where suppression is effective.

A number of computational simulations, prototype designs, live fire videos and graphical data will support the evaluation and conclusions of the proposed technique.