Water Mist for Healthcare

a report by

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Dr Jukka Vaari joined Fire Research and Testing, Technical Research Centre of Finland (VTT) in April 1998, since when he has been intensively involved in full-scale fire-suppression testing with water-mist systems. He has been participating in the preparation of a European performance-based design and installation standard for water-mist systems since 1999 and he has also been involved in the work of the Fire Protection Sub-Committee of the International Maritime Organization (IMO). In 2000 he was appointed as a member of the Scientific Council of the International Water Mist Association (IMWA). His main research interest is the modelling of total-flooding fire-suppression systems. Dr Vaari studied Technical Physics at the Helsinki University of Technology (TKK), with his graduate studies dealing with the application of experimental surface analytical techniques to the investigation of atom-scale problems in the field of heterogeneous catalysis. His dissertation was undertaken in 1995, after which he continued as a postdoctoral researcher and teacher at TKK.

Introduction

Water-mist fire protection technology, developed and commercialised to a large degree in the marine environment, has made an intense impact in recent years, with the range of land-based applications increasing rapidly. This development has its foundations in the experience gained in marine applications and is facilitated by approval procedures that make use of similarities between certain classes of marine and land-based applications. Thus, for example, water-mist systems that are approved for use in the accommodation areas of passenger ships are also expected to provide an adequate level of fire protection in applications such as hotels or hospitals. However, whereas the marine environment is subject to strict international regulations with respect to fire protection measures, the land-based applications come in a greater diversity of combustible materials, protected structures and fire protection objectives, and they are subject to locally varying regulations. This makes it necessary to consider possible extensions to the requirements for marine systems before they can be applied on land or, alternatively, to devise entirely new methods to ensure that the fire performance of the installed system provides the required level of fire safety. Water-mist technology is currently undergoing this stage.

Water Mist

Water mist is ordinary water atomised to very small droplets. The US National Fire Protection Association (NFPA) 750 Standard on Water Mist Fire Protection Systems (2000 edition)[1] defines water mist as a water spray in which 99% of the water is in droplets whose diameter is less than 1,000μm. However, many commercial water-mist fire-fighting systems are capable of producing mean droplet sizes down to the 100μm to 400μm range, and some even below that.

The word 'mist' relates to the fact that a water spray consisting of such small droplets has a 'misty' visual appearance. For reference, clouds – both in the upper atmosphere as well as close to ground (commonly termed fog or mist) – consist of droplets with a typical diameter of 1μm, while a typical raindrop has a diameter of 1,000μm to 2,000μm. These figures illustrate the effect of droplet size on the capability of a droplet to be suspended in gas. Thus, water-mist droplets, as defined for fire-fighting purposes, are not entirely aerosol-like particles, nor entirely raindrops, but something in between.

The principal reason for using water mist to fight fires is the high extinguishing effectiveness of small droplets. This effectiveness was first observed in practice by fire brigades in Europe and in the US by the 1930s, and fire-fighting tactics based on fine-water sprays were developed by the US Marine Corps in the 1940s, with further refinements reported in Sweden during 1980s. Fixed fire-fighting systems using fine-water sprays were studied in bench-scale during the 1950s, but commercialisation of full-scale systems was prevented mainly by the well-established sprinkler technology and the invention of halon fire-extinguishing agents. The ban on ozone-depleting substances and a mandatory requirement by the International Maritime Organization (IMO) to have sprinkler or equivalent systems installed on all ships were the two main impulses that led to the development of commercial water-mist systems at the beginning of 1990s.

Water Mist versus Other Systems

Since small water droplets are highly effective in fighting fires, it may be fair to think that water-mist systems generally exhibit superior fire performance in comparison with other fire-fighting systems, in particular, conventional sprinklers. Laboratory-scale studies have shown that, on a mass basis, the extinguishing efficacy of water equals that of a Halon 1301 fire-extinguishing system, provided that the droplet size is optimum (experiments suggest about 10μm). However, throughout the brief history of fixed water-mist systems, a keyword in the design of these systems has always been 'equivalency' with respect to fire performance. In the marine environment, water-mist systems were applied for the

1. *NFPA 750: Standard on Water Mist Fire Protection Systems, US National Fire Protection Agency (2000).*

protection of machinery spaces (volume protection, a gas-type application) as well as accommodation, public space and service areas (area protection, sprinkler-type applications). The idea was to enable the introduction of alternative technologies with a similar fire performance to a reference system, which was a conventional sprinkler system. Therefore, the choice of a particular system type for a vessel primarily depended on properties other than fire performance, such as price, weight, space requirements, reliability, ease of installation, maintenance, etc. A similar approach is adopted in the emerging land-based applications: water-mist systems on the market offer equivalent fire performance to other systems (especially sprinklers) and other properties dictate the choice of the technology.

Properties of Water-mist Systems

Perhaps the most significant and general property of water-mist systems is the low water consumption compared with that of conventional sprinkler systems. Full-scale testing has shown that, for a typical sprinkler-like application such as a hotel, water consumption by water-mist systems may be five to ten times lower than by conventional sprinklers designed for the same application. A low water consumption is possible by making use of the extinguishing effectiveness of small droplets and a similar fire performance to sprinklers is achieved by using water more efficiently.

Due to efficient use of fire-fighting water, there is less run-off of contaminated water to reduce environmental effects and less water damage to the protected property. Practical benefits of a low water consumption are that the water supply, the pump size and the diameter of the pipework can be substantially smaller for water-mist systems than for sprinkler systems. These are immediately reflected in the weight and space requirements of water-mist systems. In some applications, an adequate water supply may be small enough to enable a water-mist system to be a self-contained stand-alone unit that is not dependent on a connection to an external water supply, such as the municipal system.

An interesting and important property of water-mist systems is their ability to successfully fight fires whenever the fires are enclosed in a room. For room protection, gas systems would also be possible. However, with water-mist systems, the protected room does not need to be as tightly sealed as with gas systems. This is because the discharge of water mist is usually continuous and loss of extinguishing agent via leaks is not crucial to performance. Another advantage for water mist in rooms or enclosures is the superior ability of water mist to control the gas temperature. This is because the large number of small water droplets evaporates effectively, and because evaporation of water absorbs large amounts of energy. This is also the explanation for the somewhat paradoxical behaviour of water-mist systems for volume protection – the ability of water mist to extinguish fires increases with the fire size. Large fires release large amounts of heat, which is readily used by water-mist systems to convert water droplets to water vapour. Water vapour in turn displaces oxygen and acts like an inert extinguishing gas.

Small water droplets are effective in scattering heat radiation. Wide fog patterns are commonly used by fire-fighters as radiation shields when approaching an intense fire. The same principle applies to the water sprays delivered by water-mist systems. The mist sprays are capable of offering protection against heat radiation, thereby providing protection against heat exposure for both evacuating people and for advancing fire-fighters. The ability to scatter heat radiation is also considered as one of the extinguishing mechanisms of water mist. While protecting people from heat radiation, water mist also reduces the radiative heat flux to surfaces of combustible materials in the vicinity of the flame, which increases the ignition time of these materials and therefore slows down the spreading of the fire.

In many instances water-mist systems are marketed as particularly safe for people, with claims being made that water mist effectively scrubs smoke, i.e. it removes soot particles and even toxic gases from air to make air breathable. Such claims are often misleading. Water-mist systems exist that have demonstrated an effective smoke-scrubbing property. However, such systems operate by first removing soot and fire products from the protected volume or area, and then scrubbing this effluent in an environment that is particularly favourable for the scrubbing process. Plain water sprays, when discharged into the gas close to the fire, are not as efficient in scrubbing smoke and toxic gases, even though a moderate scrubbing effect can be observed. Therefore, efficient smoke scrubbing is not an inherent property of every water-mist system, but it can be a property of carefully engineered systems dedicated for smoke-scrubbing purposes.

Applications and Approvals

The possible range of applications for water-mist systems is often justified by listing their general properties. As an example, it is often stated that low water consumption leads to low corollary damages (less run-off water) and therefore water-mist systems are ideally suited for the protection of applications that are sensitive to water damage. Examples of such applications are museums, art galleries, archival institutions, libraries, data processing facilities and telecommunications facilities.

It is important to remember, however, that there are no generally accepted prescriptive design rules for water-mist systems. This is exemplified by the fact that different water-mist systems that have successfully passed exactly the same test protocol have quite varying system designs, such as nozzle types, pressures, flow rates and nozzle spacings. There are important corollaries to this. First, all current water-mist technologies must prove their fire performance in a performance test. Second, once the systems are tested to a test protocol, their installation must be restricted to applications that are related closely to the fire scenarios included in the test protocol. Third, a clear distinction should be made on the type of testing – whether it is an ad hoc test agreed, for example, between the system manufacturer and the end-user, or a consensus test protocol accepted by a wide variety of parties, including a number of manufacturers, end-users and others (such as approval organisations, test laboratories and authorities having jurisdiction). Thus, a necessary prerequisite for installing water-mist systems to museums, etc. is proof, preferably through a consensus test protocol, that the most important property of the system, the fire performance, is adequate. Potential benefits of water-mist systems alone are not sufficient to justify choosing water mist.

Consensus test protocols for land-based applications have been specially developed in the US by Factory Mutual Global (FM Global) and Underwriters Laboratories. These deal with occupancies belonging to Light Hazard (LH) and Ordinary Hazard (OH) Occupancies Group 1 and Group 2 according to US classification.[2] Also, more specific test protocols are available for the protection of enclosures that accommodate processes involving flammable liquids, computer rooms, wet benches and galley deep-fat fryers and ducts, industrial oil cookers and object protection systems.

In Europe and Asia, the situation is somewhat different, because fewer widely accepted test protocols are available, and system installations are more frequently based on ad hoc type testing. In Europe, however, the situation is to improve in the near future with the introduction of a European design, installation and maintenance standard for water-mist systems, currently prepared under The European Committee for Standardization Technical Committee (CEN/TC) 191 Fixed Firefighting Systems standard. Like the NFPA 750 standard, this standard will require performance testing of the systems. A distinction to NFPA 750 is provided by the fact that the European standard will include fire-test procedures.

With regard to the hazard classes, it is unfortunate that the classification is slightly different between the US and Europe. In Europe, the LH class is very limited (in practice it includes just prisons), and the OH class is sub-divided into four categories instead of two. For example, an office occupancy would be classified as LH in the US, but OH1 in Europe. A hospital is generally regarded as OH1 in Europe, but it should be noted that a building of one nominal classification may show widely different individual hazards. It may be noted that these test protocols cover a significant part of hazards found in a healthcare facility, such as patient sleeping and treatment rooms, cooking, seating and office areas, data processing centres, machinery rooms and, to some extent, storage spaces.

Despite the differences in the hazard classification system, it has proved possible to make use of the US test protocols in obtaining an approval in Europe. Recently, the Association of German Property Insurers (VdS) approved a water-mist system for the European OH1 class by considering the LH approval from FM Global in combination with an additional test series specifically designed for office occupancies. This example illustrates how one of the challenges for advancing water-mist technology in land-based applications is the development of new consensus test protocols.

Conclusion

Water-mist technology is an emerging fire protection technology. It has properties that make it an attractive choice for selected applications, in particular where low water consumption by the fire protection system is beneficial. A responsible way of implementing this new technology is to ensure that the technology is properly tested to meet the requirements set by the application. Currently, consensus test protocols and approval procedures exist to ensure that the fire performance of water-mist systems is adequate for the lowest hazard classes (especially LH1 and OH1). Also, a growing number of test protocols are under development to further expand the applicability of water-mist systems.

The true challenge with water-mist systems is to understand the limits of installation parameters within which a tested system can be safely applied to real-life situations. Water-mist technology is available for the protection of healthcare occupancies. Understanding this technology is the healthy way to care for fire safety.

2. A hazard class is assigned to an occupancy based on the combustibility of the contents, the quantity of combustibles, rate of heat release, storage height and quantity of flammable and/or combustible liquids. In practice, the assignment is not based on the engineering definitions of these characteristics, but to lists of typical examples.