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Position Paper

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Fixed Extinguishing Installations

Position Paper on water mist for fire control/extinguishing applications

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1 Scope

The purpose of this document is to provide basic information to non-specialists that need to evaluate the applicability of water mist in fire protection systems. It sets out both the principle benefits of water mist and the known limitations or disadvantages, when compared to alternative protection methodologies. The guidance provided is generic and may not be applicable to a particular system or to future product developments.

Eurofeu has representation from suppliers of water mist systems, CO_2 systems, chemical agent systems, inert gas systems, sprinkler systems, water spray systems, foam systems and dry powder systems. This position paper seeks to provide balanced advice which needs to be considered together with the commercial implications in the selection of efficacious fire protection options.

Prescriptive valid design criteria for water mist fire-extinguishing systems do not exist, in contrast to other extinguishing systems (e.g. sprinkler systems). Therefore these systems are manufacturer-specifically designed to suit specific risks, and components are not interchangeable. As a result the design parameters of one particular system cannot be applied to systems of other manufacturers.

2 Introduction

Water mist – a review

On 2 March 1989 the EU decided to ban harmful greenhouse gases (CFC chlorofluorocarbon) by the end of the 20th century. Subsequently, on 1 August 1991 the Federal Republic of Germany adopted the Regulation on the Prohibition of CFCs-Halons and by the end of 1994 had completed the withdrawal from the use of fully halogenated chlorofluorocarbons.

The search for a replacement for the halon gas fire extinguishers began. With the water extinguishing systems this led to further development of the water atomization technologies which went back to the early 30s of the last century. These days there are a great number of different systems on the market which produce water mist with various methods.

Water mist fire fighting systems provide fire protection for life and property without any adverse impact on the environment from the suppressant itself. It is important to recognise in categorising the scope of protection of any water mist system that a distinction should be made between:

- Fire Control: where the design purpose of the system is to restrict and reduce fire propagation until other mitigating measures or interventions can be taken, and
- Fire Extinguishing: where the design purpose is to ensure the suppression and complete extinction of all combustion.

System design requirements (e.g. water supply) will vary depending on the type of fire protection (Fire Control/Fire Extinguishing) provided by the system. In general ordinary combustible materials (class A fires) can be controlled while flammable liquids (class B fires) can be extinguished.

Equivalence of Effectiveness

The water mist extinguishing systems produced by various manufacturers are to be considered as equivalent in their effectiveness if they have been accredited by an independent approved certification body for the relevant application (see info box). This applies independently of the operating pressure of the system (see operating pressures). In order to acquire accreditation for a system, the owner of the system needs to comply with the following conditions (see also info box)

- **Proof of the suitability of the system for the defined fire risk (application) by fire trials at full scale. The mock-up used during the fire trials shall have a fire load, a fire growth and obstructions that represents the risk to be protected. Additionally, the test scenarios during the fire trials shall cover the fire scenarios expected (e.g. pool fire, spray fire)**
- **Use of approved components**
- **Presentation of approved planning and installation documents**

The effectiveness of water mist systems is dependent on both the characteristics of the delivered mist and its deployment relative to the type and location of the fire. The rate of water delivery, the number, and the location of the selected water mist nozzles is thus a critical design consideration.

Water is effective as an extinguishant because it removes heat from the system, and in doing so generates steam which beneficially depletes the oxygen in the combustion zone – thus enhancing the extinguishing effect. Small water droplets (water mist) provide a larger heat absorbing surface, and thus a more rapid quenching of the combustion temperature and also a more rapid generation of oxygen depleting steam in the combustion zone. Thus, with water mist the extinguishing efficiency of water is significantly enhanced, and in consequence fire control or suppression is achieved with a corresponding reduction in the quantity of deployed water.

There are many other effective fire fighting systems which use water, gaseous and other media.

Gaseous extinguishing agents are discussed in a separate paper entitled "Eurofeu position paper on gaseous alternatives to Halons in fire fighting".

Water mist systems have been used since the mid 19th century, and may also be known as "water fog systems", "fine water spray systems", and other synonyms.

3. Types of Water Mist Systems

As previously stated the scope of protection can be fire control or fire extinguishing. For fire control heat actuated closed nozzles are usually selected – these are deployed in a 'wet system', or alternatively in a 'dry system' where the distribution pipework is pressurized with air or dry nitrogen, and the loss of pressure from heat sensitive nozzles opening causes the system to deploy water into the piping for discharge from these and other nozzles that have opened by the heat of the fire. For fire extinguishing, all of the nozzles are open nozzles fitted within a 'dry system' which is actuated by a traditional fire detection means – achieving a full deluge through the nozzle array.

Pre-action variants – where pressured water is deployed into the dry pipework upon receipt of a confirmed fire detection signal from a separate alarm system are also a user selectable option.

Water mist systems are usually classified based on three nozzle pressure ratings: low, medium and high. Each pressure rating has its technical characteristics and benefits, but the effects of water in mist form on the fire and on materials are essentially the same. As a generalization, the finer the droplets delivered the more effective the extinguishing effect, but of course finer droplets have lower mass and thus require higher delivery velocities to secure an effective throw. For those applications where pre-wetting the adjacent combustible material limits the fire growth, coarser droplet size spray patterns can provide more effective protection. In some hardware designs twin fluid nozzles (nitrogen and water) are used to secure mist deployment from the nozzle.

The attributes and differences between water mist systems of each class are of a more commercial nature and are not discussed in this paper.

Water mist systems are defined as water based systems in which at least 90% by volume of the water is distributed in droplets of less than 1000 microns. Extinguishing performance is critically dependent on the droplet size distribution, and on the temporal and spatial deployment of the water mist from each of the nozzles.

Components of Water mist Systems	
A water supply	Typically either a pumped system with strainers to prevent clogging of nozzles or a stored pressure system using compressed gas to expel the water charge.
An alarm System	Provides the local and any remote alarms in the event of an activation.
A distribution system	A distribution pipework array with either heat activated closed nozzles at each nozzle node, or open nozzles. 'Dry systems' include a detection means that releases the water into the distribution system.

There are different techniques to produce water mist:
- The single fluid system using water with or without additives
- The twin fluid systems, water as the extinguishing medium is turned to mist with the aid of compressed air/gas at the nozzle.

Note:
We are not looking at a water mist system if the chief extinguishing effect is achieved with quenching gases and the water is only added for its cooling effect (Hybrid systems).
Operating pressures of water mist extinguishing systems.
The classification of the extinguishing systems is decided by the plant operating pressure.

CEN/TS 14972:2008
• Low pressure <12.5 bar
• Medium pressure > 12.5 but < 35 bar
• High pressure > 35 bar
By VdS classification
• Low pressure up to 16 bar
• High pressure above 16 bar

Types of nozzles and triggering mechanisms of different systems

When designing plants we differentiate – in the same way as with water spraying systems and sprinkler systems – between open and closed water mist extinguishing systems.

Nozzle types:
- prinkler/nozzle with thermal trigger element (glass bulb or soldered struts)
- Open nozzles

Furthermore, in the case of open systems we differentiate between the following trigger mechanisms:
- electronic triggering
  - automatically by detection elements via fire alarm systems/extinguishing control panels
  - by manual release switch via fire alarm systems/extinguishing control panels
- pneumatic/hydraulic triggering
  - automatically through tripping systems with thermal detection elements

Watermist systems can be deployed to protect objects, where agent deployment is directed to protect the fire zone associated with the object (Local applications), to protect volumes (Total flooding) or to protect multiple hazards in a predetermined portion of an area (zones application systems).

Typical applications where watermist has been use for fire control are:
- Hotel rooms
- Domestic dwellings
- Office spaces
  - car garages
- Ships accommodation areas
- Tunnels

Typical applications where watermist has been use for fire extinguishing are:
- Industrial fryers
- Gas turbines
  - Machinery spaces
- Engine test cells

4 Compliances

There are an increasing number of standards and guidance documents applicable to water mist systems for use on land based applications, and for marine applications the use of watermist is now regulated under the IMO codes. Work is in progress towards an endorsed European Standard. There is a published EN14972-1 Water mist systems — Design, installation, inspection and maintenance together with a series EN14972-XX providing fire test protocols for multiple applications. Most of these fire test protocols are already being published while others are close to be published. Some accredited certification bodies have established and published their own detailed codes (BRE xxxx, VdS xxxx etc), and will certify hardware and system performance compliance against said codes. International codes include Factory Mutual (FM5560: 2009 and) and an NFPA code (NFPA 750: 2019) which is currently under revision.

Eurofeu FEI strongly advise that all traded watermist system should be third party validated against one of these available codes, and that where applicable component parts of the systems are tested and certified for compliance to prevailing national or voluntary codes.

The effectiveness of water mist systems is specific to the application and fuel type. It is important to recognize the scope and limitations of performance validation tests, and to ensure that no unjustified extrapolations are made.

Current areas of application of VdS-approved water mist extinguishing systems.
The areas of application of water mist systems are defined by the following parameters:
- The kind of risk
- Application limits within the risk (e.g. materials, geometry of the room, storage height etc.)

The parameters named above are found in the approvals of the individual systems.
At present there are VdS approvals for the following areas of application:
- OH 1 – risks
- OH2 – risks (garages)
- OH3 – risks in OH 1 risks
- Production and storage sites for combustible liquids
- Machine protection e.g. hydraulic rooms /aggregates
- Transformers
- Cable ducts
- Guards
- Engine test beds
- Paint spraying facilities
- Escalators
- Gas and steam turbines
- Tunnels

Developments are constantly advancing so that at any time new applications can be added.

Water mist system technology has become established with tested and approved systems. Obviously not all possibilities for water mist systems have been explored yet and there is plenty of room for development of further areas of application.

bvfa quality criteria for safe water mist extinguishing plants

1. VdS approved products have to be used
2. The company installing the system has to have a VdS approval for water mist extinguishing systems
3. For the respective field of application there has to be:
   - Low pressure up to 16 bar
   - High pressure above 16 bar

In both cases a planning and installation handbook has to specify the application and area of protection.
Functionality records for the use of the equipment have to be kept. (1:1 fire test)

5 Further Considerations

5.1 General conditions of use

Water mist systems can be applied to protect specific equipment (local application) or selected areas within enclosures, or alternatively the whole enclosure

5.2 Enclosure Pressurisation considerations

The predominant suppression mechanism of water mist is flame cooling. The initial steam produced upon contact with the heat of fire will result in a pressure increase, followed by a subsequent pressure decrease, which can result in a transient negative pressure within the closure. For weak structures, consideration must be given to the need for enclosure strengthening and/or properly engineered pressure relief.

5.3 Ventilation considerations

Water mist is usually only applicable for areas with low air flow to ensure reliable control, suppression or extinguishment is attained. For volume protection applications, enclosure openings may also be critical to achieving a sustained extinguishment although in many fire test protocols water mist systems are tested with openings. Additional fire protection provisions need to be taken where ventilation or openings are an issue.

5.4 Flammability considerations

Most fires involve the reaction of oxygen with a hydrocarbon or other combustible material. The reaction generally takes place when the combustible material is in the vapour phase, i.e. not in the liquid or solid phase. The amount of fuel vapour released from light liquid hydrocarbons will be more than that from distillates or heavier fuels under the same thermal and pressure conditions. In fact if spilled gasoline is not vented immediately or ignited very soon after the spill, an explosive mixture is liable to form. This is not the case with heavier fuels (such as diesel, lube oils, transformer oils, etc.). Extrapolation from test results with one type of fuel may not necessarily be valid for other fuels.

5.5 Types of Fires

For Class A fires (solid organic materials) control or extinguishment can be achieved for as long as the controlling or extinguishing flux of water mist is sustained. Re-strike (Burn back) or re-ignition is, like with most fire protection measures, is a possibility after the agent deployment is stopped.

For Class B fires (Flammable liquids) liquid fuel fires involving heavier fuels are either 2-dimensional pool fires, 3-dimensional jet or spray fires or a combination. Larger fires will generate a substantive quantity of steam. For more volatile flammable liquids, the risk of flash fires or explosions is more prevalent. Such risks cannot be fully mitigated without recourse to explosion suppression measures.

Fires which are small relative to the enclosure size do not generate enough steam to dilute the oxygen to an adequate level for extinguishment – they rely only on heat abstraction. To accomplish extinguishment water needs to be discharged directly into the combustion zone.

Similarly deep-seated or smouldering fires represent a challenge for water mist systems and may not be fully mitigated.

Watermist is not applicable for fires involving metals, live electrical equipment, pyrophoric, pyrotechnic or explosive materials.

5.6 Water Quality Considerations

The water normally used in a water mist installation must be very clean water completely free of solids in order to prevent the nozzles from blocking during discharge. This is especially true for high pressure nozzles with very small orifices. If seawater is used, additional means of cleaning, filtering and flushing after use may be needed.

Potable, distilled, de-mineralised and de-ionised water is recommended, with consideration given to the possible corrosive or environmental effects of any additives (biocides or surfactants).

5.7 Water mist with foam additives

The fire control properties of foam, including the ability to spread readily over pool fires, may contribute to the effectiveness of a water mist system. The use of water-foam mixtures may improve the effectiveness of the system and minimise re-ignition potential.
Foam may be considered in applications where:

- there are obstructions between the mist source and the fire (e.g. pool fires under open floors) and / or
- the risk of a re-ignition needs to be minimised.

Foam should only be added when the equipment protected is not likely to be affected by the corrosive, or degreasing properties of foam, and appropriate cleaning is scheduled after a discharge. The system must have been fully fire tested in combination with this foam additive.

5.8 Detection and Control System:

The detection and control system is of paramount importance for correct and efficient system functioning of watermist deluge systems. It should always be designed and carried out by specialists in accordance with the relevant standards.

5.9 System Reliability

The reliability of a water mist system and its components should be demonstrated by accredited third party testing.

5.10 Water supply

Consideration should be given to the duration and availability of the water supply, especially where rapid suppression cannot be guaranteed or reignition is likely to occur.

6 Safety & Environmental Issues

6.1 General

Human safety relating to the deployment of water mist in manned areas has been addressed by the US Environmental Protection Agency (E.P.A). A Medical Health Panel evaluated the water mist under the Significant New Alternatives Policy (SNAP) and the results were published in August 1995.The overall conclusion was that water mist using potable water is benign to nature and does not present a toxicological or physiological hazard to human beings and is thus safe for use in occupied areas.

The use of additives or blends in the systems should be assessed on a case by case basis.

6.2 Security of fire control

Water mist is transient in nature. It does not produce a lasting inert atmosphere, nor does it maintain a total flooding concentration in an enclosed space once the discharge has finished. Consequently, permanent extinguishment may not be attained if re-ignition sources, such as open flame or electric arcing are present. Fuel sources should be fitted with automatic shut off devices. Watermist systems should not be used outdoors unless fully fire tested in representative environmental conditions.

6.3 Personnell exposure

Hypoxic atmospheres can be produced when an inert gas is used as a propellant for the water and in extreme cases when steam generation in fire extinguishment is significant. Areas protected by a water mist system should be evacuated in the event of a fire alarm, not because of the application of mist itself but in order to prevent harm to personnel due to exposure to the fire and its combustion products.

6.4 Visibility during and after discharge

Water mist can significantly reduce visibility in the protected areas during discharge. It dissipates fairly rapidly afterwards, depending on factors such as air temperature and humidity.

6.5 Environmental impact

Water mist using potable water is benign to nature and does not present an environmental hazard unless the water absorbs dangerous substances from the fuel or fire. In such cases careful consideration should be given to preventing water entering the drainage system or running onto the land.

Caution – water mist helps strip smoke and particulate from the air and can absorb soluble gases – The absorption of acid gases may lead to increased risk of acidity, contamination and corrosion from the water effluent.

7 Conclusions

Water mist provides industry with a valuable fire protection option. This paper has set out generic guidance on its applicability and limitations of use. Specialist advice should always be sought to attest to the appropriateness of a water mist application for a specific purpose, and provide comparison with other fire protection options.