

LOW PRESSURE WATER MIST FIRE FIGHTING SYSTEMS THE ALTERNATIVE TO TRADITIONAL SYSTEMS

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ABSTRACT :

Etea Sicurezza S.r.l. has developed firefighting low pressure water mist systems. These systems base their effectiveness on fighting the fire by spraying droplets of reduced diameter with respect to the traditional fixed firefighting systems (sprinkler systems). The ETEA MIST LP systems combine the benefits of sprinkler systems to those of high pressure water mist systems. The ETEA MIST LP systems employ components normally used in common sprinkler systems and, at the same time, guarantee, against fires, performance and advantages of high-pressure water mist systems, such as a reduced consumption of water. The developed systems were tested according to the Technical Specification CEN/TS 14972 on full scale fire tests at a laboratory accredited by the Italian Ministry of Interior.

In case of high hazard storage, it may be that the little amount of water discharged is not sufficient to extinguish properly the fire, so an additive can be coupled with the water mist systems in order to enhance, or comply with, fire protection requirements. The ETEA MIST LP can be combined with an innovative extinguishing liquid, which attacks the four sides of the fire tetrahedron, obtaining a six time faster extinguishing effect compared with the use of plain water. Moreover, the extinguishing agent is eco-friendly, it is biodegradable, non toxic or dangerous so can be handled and stored without any hazard.

KEYWORDS:

Fixed Fire fighting system, Low Pressure Water Mist, extinguishing additive, saving water, innovation.

1. WATER MIST DEFINITION

According to CEN/TS 14972 the water mist is defined as a water spray for which the diameter $D_{v0,90}$ measured in a plane 1 m from the nozzle at its minimum operating pressure is less than 1 mm.

The system are defined by the following values according to the design pressure:

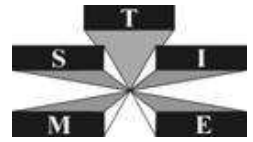
- for low pressure systems: up to 12.5 bar;
- for medium pressure systems: higher than 12.5 bar, but below 35 bar;
- for high pressure systems: 35 bar and higher.

The ETEA MIST LP systems are low pressure water mist systems: the best option as fixed fire-fighting systems.

1.1. Standard

The standards related to the water mist system are the CEN/TS 14972 – “Fixed firefighting systems – Water mist systems - Design and installation” and the NFPA 750 – “Standard on Water Mist Fire Protection Systems”. The technical specification specifies minimum requirements and gives information on design, installation and testing and gives criteria for the acceptance of fixed land based water mist systems for specific hazards and provides fire test protocols for a variety of hazard groups.

The document is not a universal design manual for water mist systems, as different systems have different characteristics and hence follow different design criteria to satisfy their duty requirements.



In the absence of a generalized design method, it is the intent of the standard that water mist systems are full-scale fire tested and its system component evaluations are conducted by qualified testing laboratories. The full system acceptance requires the relevant fire test report, the component test reports as well as manufacturer's design, installation, operation and maintenance manual for the application.

According to the European Technical Specification: "Water mist systems shall only be designed, installed and maintained by qualified companies and shall comply with the following requirements. The safe use of a water mist system is limited to applications it has been tested for. Parameters used during such tests define the limits of the its application, unless methods being acceptable to the authorities having jurisdiction to interpolate test results can be applied. Parameters include room geometry, ventilation conditions, fire load etc."

Therefore for each kind of application water mist systems shall be tested in a full scale fire test in accordance with the annexes of the TS and certified by a recognized authority.

Fire test protocols for a variety of hazard groups are described: flammable liquids (pool fire and small spray fire), cable tunnels fire, office and school occupancies of Ordinary Hazard group 1 and certain occupancies of Ordinary Hazard group 3, commercial deep fat cooking fryers, but there are no protocols for the High Hazard Storage (HHS) class.

The TS provides guidelines for defining representative fire test protocols, based on a proper fire protection engineering evaluation of the fire hazard, the compartment conditions, and the performance objectives for the system.

The full system evaluation includes also component testing. Tests should be conducted by qualified testing laboratories in order to evaluate, among others: operating temperature, water flow, water distribution, water droplets size, strength of nozzle body, strength of release element, leak resistance, heat exposure, thermal shock, stress corrosion, salt spray corrosion, moist air exposure, water hammer, resistance to heat, resistance to vibration.

2. ETEA MIST LP SYSTEM

Etea Sicurezza started developing the low pressure water mist systems in 2013, once it was clear how many benefits could come from such a technology, with respect to the traditional water based sprinkler systems.

The internal team of technicians and engineers, first, collected the data about the state-of-the-art related to low pressure water mist and, then, started the development of the nozzles.

Etea Sicurezza developed the nozzles internally, taking care of the design of the nozzles themselves with mechanical and fluid dynamic studies, and of all of their components such as escutcheons, filters and gaskets.

Etea Sicurezza developed both automatic systems, with the closed head nozzles called ET3 and ET3 IDF, and deluge systems, with the open head nozzles called ET1 and ET2.

Etea Sicurezza looked for the best suppliers for all the diverse components of each nozzles.

In particular, the ET3/ET3 IDF are closed head nozzles, therefore Etea Sicurezza looked for the best supplier of the heat sensitive bulbs in order to ensure to its customers the most reliable and efficient bulb. Etea Sicurezza chose a supplier with more than 50 years' experience in glass bulb technology.

The nozzles are manufactured and assembled at an Italian workshop.

The first prototypes of the ET1/ET2 nozzles were manufactured in August 2013, while for the ET3/ET3 IDF it occurred in December 2013.



Figure 1: Etea Sicurezza LPWM nozzles

Etea Sicurezza tested the nozzles on full scale fire tests, according to the CEN/TS 14972, at TE.S.I. S.r.l., a laboratory accredited by the Italian Ministry of Interior.

Four fire tests campaign were carried out by Etea Sicurezza in August, November, December 2013 and February 2014.

The ETEA MIST LP systems provide a wide range of applications depending on the different activities exposed to fire risk: hotels, schools and offices, public areas, museums, libraries, archives, technical spaces, garages, warehouses and industrial building.

The table below summarize the successful fire tests performed by Etea Sicurezza.

Table 1: Fire tests successfully performed by Etea sicurezza

Etea Sicurezza's LPWM nozzles	Nozzle Type	Hazard class**	Scenario	Results
ET1	Open head	OH3 ST1	Stacked wooden pallet	FIRE EXTINGUISHED
		HHS4 ST4	Racked cardboard boxes filled with EPS cups	FIRE EXTINGUISHED
		OH3 ST4	Racked empty cardboard boxes	FIRE EXTINGUISHED
ET2	Open head	HHS4 ST1	Stacked wooden pallets + bags filled with EPS pellets above	FIRE EXTINGUISHED
		HHS4 ST4	Racked cardboard boxes filled with EPS cups	FIRE EXTINGUISHED
ET3 IDF	Closed head	HHS4 ST4	Racked cardboard boxes filled with EPS cups	FIRE EXTINGUISHED
ET3	Closed head	HHS2 ST5	Paper archive	FIRE SUPPRESSED
ET4	Closed head	OH1	Office furniture	FIRE EXTINGUISHED

**According to UNI EN 12845:2009

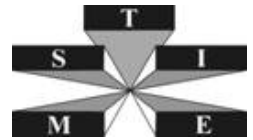


Figure 2: System performance test: an example

2.1. *Low pressure water mist automatic systems*

The automatic wet pipe low pressure water mist systems ETEA MIST LP ET3 are suitable for installation in any environment where there is not a risk of water freezing inside the piping and where the ambient temperature is not greater than 95 ° C.

The automatic wet pipe fixed ETEA MIST LP ET3 requires easy installation with simple components. The system provides a fixed fire protection using a network of pipes filled with pressurized water supplied all the time from a secure source, therefore the system must be kept under pressure and must be supplied by a source able to meet the need of the plant.

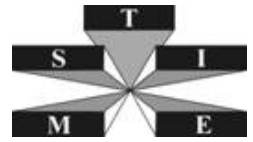
The nozzles of the automatic wet pipe ETEA MIST LP ET3 system are equipped with a heat-sensitive glass bulb and installed over the entire area to be protected; these determine the supply of water, following the breakdown of the heat-sensitive glass bulb. When the nozzle suffers a superheat above the temperature to which the heat-sensitive glass bulb is calibrated, this breaks enabling the passage of water through the orifices dispensing a mist on the area that it protects. The water, flowing in the pipes, actuates the alarms in order to signal that the plant is in operation. Only the nozzles installed in the area affected by the fire will activate.

2.2. *Low pressure water mist deluge systems*

A deluge System is a fixed fire protection system in which the pipe system is empty until the deluge valve operates to distribute pressurized water to the open nozzles ET1 or ET2. The number, the position and the size of these nozzles depend on the design parameters and the hazard class of the area. Deluge systems are more complex than automatic systems because they contain more components and equipment. The deluge valve is activated by operation of a fire detection system installed in the same area as the nozzles. When the detection device is activated, the deluge valve is opened and water flows into the piping system, discharging through all spray nozzles simultaneously.

3. HOW WATER MIST ACTS AGAINST FIRE

Combustion is the reaction between fuel and oxygen, in presence of an ignition source.



Water fights the fire because, by evaporating, it absorbs heat from the burning fuel, lowering its temperature under the flammable conditions.

The way the water is spread out over the fuel is a key point in its effectiveness in fighting fires.

Traditional sprinkler systems are based on nozzles that create droplets with average diameters larger than 1 mm. This means that the main principle through which sprinklers fight fires is flooding fuels and the areas protected by the systems.

The consequences are as follows:

- large reservoirs of water are needed to make sprinkler systems effective against fires;
- the objects (paper documents, furniture, goods, etc.) reached by water result irreversibly damaged.

Water mist systems are based on nozzles that create droplets with average diameter smaller than 1 mm (often they consist of some microns). This gives to water mist systems the capability to act against fire through three different principles:

- **Cooling:** heat absorption is a consequence of water evaporation. Evaporation rate is strictly related to surface – to – volume ratio of the droplets: the lower the droplet dimensions are, the higher the absorption rate is. The fine dispersion of droplets of water mist systems is able to evaporate and absorb heat much more fast and effective than traditional sprinkler systems.
- **Inertization:** when evaporating, water increases its volume up to 1640 times, which causes a rarefaction of the oxygen present in the air, at the source of fire.
The oxygen content is reduced near the origin of the flames, while the normal oxygen content in the environment around is maintained in all of the remaining room.
In this process, the extinguishing inertization means is not carried to the flame source from the outside, but it is produced only in direct proximity to the fire. Differently from all that occurs with extinguishing gases, the use of water mist systems does not require completely closed rooms.
- **Shielding effect:** the droplets of water present between the flames and the combustible surface strongly reduce the heat irradiation. The combustion rate decreases and the overheating of the surrounding possible flame sources is reduced. This prevents the possible spreading of the flames and can be exploited, for example, in order to create fire fighting barriers.

4. PROTECTION OF PEOPLE

The capability of water mist to reduce the temperature more quickly than traditional systems and to wash away the residual gases is of vital importance in the protection of the people.

In normal circumstances, also the reduction of the oxygen present in the air does not represent any danger because it occurs only in proximity to the fire. The fire is usually extinguished with an oxygen concentration of about 16-18% by volume (those oxygen concentration are not deemed harmful for the people).

Water mist systems can be activated with no notice, apart from particular situations.

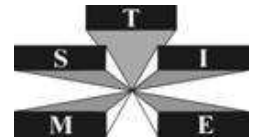
The radiant heat blocking also helps to protect against structural damage by protecting the building from the heat caused by the flames.

The entrance of the Fire Brigades in the areas where a water mist system has just fired, becomes then considerably safer.

5. ADVANTAGES OF ETEA MIST LP

The low pressure water mist systems offer many benefits with respect to the traditional water based sprinkler systems or to the high pressure water mist systems.

5.1. *Comparison between ETEA MIST LP systems and traditional sprinkler systems*



The low pressure water mist systems are more effective and efficient against fire than traditional sprinkler systems.

Thanks to the fine dispersion of droplets that the ETEA nozzles can create, the water is used more efficiently: compared to classic sprinkler systems, ETEA MIST LP consumes up to 70 % less water. This allows to allocate a smaller water reservoir; the reduced space requirements lead to construction cost savings.

The use of smaller pipe (diameters predominantly DN20 to DN50 instead of DN20 to DN150), makes it possible to save space for the piping paths, and to reduce the purchasing and installation costs.

The minimal water consumption, compared to usual sprinkler system, warrants in the case of a fire a minimal damage caused by the water.

For the end-user, as the electrical and water supply requirements are significantly reduced, this can result in significant savings both during install as well as during the life of the building.

As for the sprinkler systems in case of non sufficient reservoir, supplying water can be drawn from the municipal hydraulic piping.

The necessary maintenance is similar to that of a sprinkler system. A qualified installer can perform easily it, following the manual for installation, use and maintenance. The maintenance time is very low, this contributed to reduce the downtime of the company or of the activities performed in the ambient in which the ETEA MIST LP system is installed.

The table below shows the density discharge used in fire tests carried out by Etea Sicurezza with the LPWM nozzles, and the minimum density discharge that should be used with a traditional sprinkler system (SPR) in accordance with existing regulations.

The table shows also the minimum duration of the discharge for both systems.

Taking into account both parameters, the saving water is evaluated. The values are generally considerably high.

Table 2: Saving water

Etea Sicurezza's LPWM nozzles	Fire hazard class **	Discharge density [mm/min]		Minimum discharge duration [min]		SAVING WATER
		LPWM	SPR	LPWM	SPR	
ET1	OH3	3.9	5.0	30	60	61%
	HHS4 ST4	4.41	15	60	90	80.4%
	OH3	3.36	5	60	60	32.8%
ET2	HHS4 ST1	7.84	10	30	90	73.9%
ET3 IDF	HHS4 ST4	6	15	60	90	73.3%
ET3	HHS2 ST5	2.9	7.5	90	90	61.3%
ET4	OH1	2.3	5	60	60	54%

**According to UNI EN 12845:2009

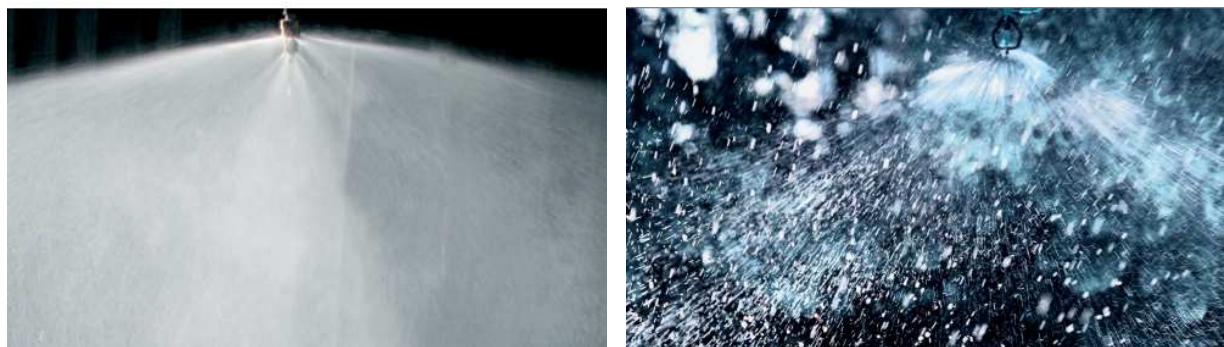
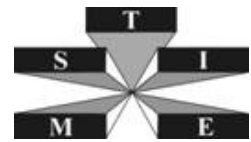


Figure 3: Comparison of the spray between an ETEA MIST LP nozzle (on the left) and a traditional sprinkler head (on the right)



5.2. *Comparison between ETEA MIST LP systems and high pressure water mist systems*

In the low pressure water mist nozzles, swirling and rotational motions are generated, increasing the water kinetic energy, and giving rise to very fine droplets, even at low pressure; the operating pressure of the ETEA's nozzles is generally 6 bar. Instead in a high pressure water mist nozzle the mist is generated thanks to the high value of the pressure, generally between 80 and 120 bar.

The ETEA MIST LP systems employ components normally used in common sprinkler systems.

It is possible to use polyethylene pipes, black iron (upstream of the filters provided), galvanized steel and 304 stainless steel, while in the high pressure water mist systems only 316 stainless steel pipes can be used. Therefore the low pressure water mist systems are significantly cheaper than high pressure water mist system.

The electrical pumps require significantly less power, which in turn reduces the connection and running costs.

The necessary maintenance is similar to that of a sprinkler system. A qualified installer can perform easily it, following the manual for installation, use and maintenance; while the high pressure water mist systems require a special and detailed maintenance, carried out by a qualified company.

ETEAs nozzles have larger outlet orifices, this in turn reduces the risks due to clogging of pipes or nozzles.

In case of non sufficient reservoir, supplying water can be drawn from the municipal hydraulic piping, while the high pressure system can not share the water reservoir of others.

6. ADDITIVE

In case of high hazard storage, it may be that the little amount of water discharged is not sufficient to extinguish properly the fire, so an additive can be coupled with the water mist systems in order to enhance, or comply with, fire protection requirements. The ETEA MIST LP can be combined with an innovative extinguishing liquid, which attacks the four sides of the fire tetrahedron, obtaining a six time faster extinguishing effect compared with the use of plain water.

The additive plays on the fire by inhibiting the fire chain reaction due to the free radicals and prevents the re-ignition of fuel. The objective of ETEA is to achieve the shortest possible extinguishing time by combining innovative nozzles and the special extinguishing agent which is totally non-toxic (i.e. breathable by humans) and 100% biodegradable (within 28 days), thus allowing easier environment remediation compared to traditional commercial additives.

The additive consists of six main components, each of those has his own effect against the fire, and they also interact among them to enhance the efficacy against the fire.

According to the scenario that needs to be protected, the recipes of the additive could be change in order to increase significantly the performance of the system.

The innovative extinguishing liquid only activates at temperatures above 85° C. The creation of free radicals breaks the combustion chain reaction. The additive has a strong cooling effect and it interacts with the smokes making them more transparent and therefore increasing the visibility. A thin layer is put over the fire source to prevent reignition.

Only 5% of the extinguishing liquid has to be mixed with water.

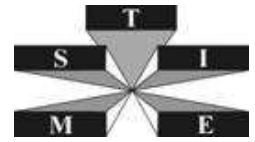
The extinguishing liquid, combined with the ETEA MIST LP system, allows to obtain a significant water saving and, thanks to the quick extinction, to limit the fire damage to structures and goods to be protected.

In addition this additive is suitable for extinguishment of forest fires; it can be coupled with salt or fresh water, it is biodegradable, and what is left works as a fertilizer.

7. FUTURE WORKS

Etea Sicurezza is further developing his nozzles and performing new fire tests, both with plain water and with the innovative extinguishing liquid. Etea Sicurezza will test his nozzles with new scenarios, at an accredited laboratory.

Etea Sicurezza began also the development of the fixed sidewall type nozzles. The sidewall type nozzles have a lateral jet and they are particularly suitable for those areas in which it is not easy or allowed to install the nozzle at the ceiling of the building. In these cases sidewall type nozzles can be installed along the wall of the room, at



a short distance from the ceiling. This is the best option for buildings with coffered ceiling or ceiling with frescos of great value.

Thanks to the experience gained with the pendent nozzles (ET1/ET2 and ET3/ET3 IDF), Etea Sicurezza realized quickly the mechanical and fluid dynamic studies needed to design properly the sidewall nozzles.

The skilled technicians designed the nozzle and had some prototypes manufactured. Some test have already been carried out.

Another goal of Etea Sicurezza is to develop an opening mechanism in order to create a new smaller and concealed sidewall type nozzle. This new nozzle will have a very low visual impact and will be suitable in historic or luxury buildings, in which it is needed not alter the aesthetic appearance.

The low pressure water mist system should be the best solution to protect the cultural and historic heritage since the minimum quantity of water discharged prevents damages to the precious properties, the limited water consumption of water allows to allocate a smaller water reservoir, which is a key features in existing buildings. All these advantages will be combined with a low visual impact, without compromising the efficacy and efficiency of the nozzle. Etea Sicurezza is working to add also this benefit to his nozzle.

8. CONCLUSIONS

The low pressure water mist systems have relevant benefit if compared with the other water based extinguishing system. Low pressure water mist systems create a fine dispersion of droplets that, thanks to their high surface-to-volume ratio, are able to quickly evaporate and absorb heat; the homogeneous mist generated by the systems, also, limits the radiant heat of the flames and helps to smother fire, due to a process of partial replacement of oxygen with the water in the area surrounding the fire.

Low pressure water mist systems ensure, against fires, the same performance as sprinkler systems, using 30 to 50% lower amount of water. This allows to allocate a smaller water reservoir and, in case of fire, limits the damage to objects and structures caused by the water flowed from the firefighting system.

All the Etea Sicurezza's nozzles have been testing on full scale fire tests at a laboratory accredited by the Italian Ministry of Interior.

In case of high hazard storage, it may be that the little amount of water discharged is not sufficient to extinguish properly the fire, so an additive can be coupled with the water mist systems in order to enhance, or comply with, fire protection requirements. The ETEA MIST LP can be combined with an innovative extinguishing liquid, which attacks the four sides of the fire tetrahedron, obtaining a six time faster extinguishing effect compared with the use of plain water. Moreover, the extinguishing agent is eco-friendly, it is biodegradable, non toxic or dangerous so can be handled and stored without any hazard.

In addition to the positive results already obtained, Etea Sicurezza is developing new nozzles and will carry on new fire test, both with water alone or with the additive.