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Water Mist System for Fire Suppression:
Intent, Approach and Design

- by Pradip Sheth & Megha Bhatt

1. Introduction:

1.1 Fire has been a part and parcel of human development since ages.It has a positive and negative impact in various ways. Human civilization would have not progressed in absence of fire.

1.2 This write up relates to hazard of fire and its impact on various activities being conducted by human beings along with measures to mitigate the fire impact. To mitigate fire, human beings have tried various measures since dawn of civilization. As development is becoming more and more complex, various measures are discovered and implemented to mitigate the fire. In modern times planning envisages the fire system as one of the important components in the integrated development by way of a part of building code relating to fire and life safety.

2. Fire system in general:

2.1 Building code as regards to fire and life safety prescribes various measures and system to be adopted as an integrated part of overall planning concept of any development. For this code classifies various types of building development with reference to hazards - Low, Medium, High. Consultants are required to follow this code while designing fire system.

3. Norms :

NFPA and NBC prescribes various norms as regard to fire system for planning and configuration of any building along with various measures to be provided to prevent and mitigate fire events. These are broadly enumerated as under:

3.1 Development Control room and general building requirement.

- Land use Classification and Uses Permitted
- Means of Access
- Community open spaces and amenities
- Requirements of plot
- Classification of buildings
- Open spaces (Within a plot)
- Area and height limitation
- Off-street parking spaces
- Greenbelts, landscaping and water conservation
- Requirements of parts or building
- Design and construction
- Lighting and ventilation
- Electrical and allied installations
- Air Conditioning, heating and mechanical ventilation
- Acoustics, sound insulation and noise control
- Heat insulation
- Installation of lifts and escalators
- Plumbing services and solid waste management

3.2 Fire and safety requirement:

On the basis of classification of building based on occupancy, various prescriptions and provisions are laid down for fire related issues. They are listed as under:

- Fire Extinguishers with hoses
- Dry and wet risers
- Down comers
- Yard Hydrants
- Automatic Sprinkler System

- Fire Alarm System – Manual and Automatic
- Storages – underground and terrace level
- Pumping Machinery of different types

3.3 Sprinkler System is provided in almost all types of buildings. Water Mist is a part of sprinkler system having specialized function and use. This is normally provided in sensitive areas where utmost safety against fire is prescribed and sprinkler system is not recommended due to nature of the development having special consideration. Such places can be as under:

- Industrial Installation
- Basement
- Aircraft Hangers
- Electrical Installation
- Aircraft cabin
- Shipboard machinery and accommodation space
- Engine room spaces
- Pools
- SShops prone to fire in airport

4. Water Mist:

4.1 This is one of the measures adopted for Fire suppression. It uses varying fine water spray by way of mist. The smaller water droplets allow the water mist to control, suppress or extinguish fire by different effects as under:

- Cooling Effect – quick cooling by evaporation and latent heat
- Oxygen Replacement – Replacement of air with water vapor generated in large quantity and absorption of the radiation heat.
- Shut off Effect – floating foam forming walls of water.
- Smoke eliminating effect – floating smoke particles being absorbed and settled by the fog.

4.2 The effectiveness of water mist in fire suppression depends upon its spray characteristics, which include the droplet size distribution, flux density and spray dynamics with respect to fire scenario, such as the shielding of fuel, fire size and ventilation condition.

5. Classification of mist system:

5.1 Classification based on the working pressure:

5.1.1 Low pressure water mist system

A system which is subject to pressure of 1.2 Mpa or less.

5.1.2 Intermediate pressure water mist system

A system where the distribution piping is subject to pressure greater than1.2 Mpa and less than 3.5 Mpa.

5.1.3 High pressure water mist system

A system where the distribution piping is subject to pressure of 3.5 Mpa or greater.

5.2 Classification based on type of fire:

Overall fire hazard directly relates to type and quantity of the fuel. The ease of ignition and reignition of the fuel, the growth rate, and the difficulty of achieving control, suppression, extinguishment, or any combination thereof, are to be considered when selecting or designing water mist system.

5.2.1 Class A Fires

Fuel loading and configuration is to be considered when

Skyscraper structures have unique challenges related to fire protection such as longer egress times and distance, evacuation strategies, fire department accessibility, smoke movement and fire control

selecting/designing a system to protect a space or area containing class A materials. If fire extinguishment is desired, consideration is to be given to the potential for deep-seated as well as to the potential for smoldering fires.

5.2.2 Class B Fires

The hazard associated with Class B fires is related primarily to the fuel loading, fuel configuration, and flash point and burning rate of the fuel. Class B fires are pool grouped into two categories – Two dimensional pool fires and three dimensional spray and running fuel fires.

5.2.3 Class C Fires

Electrically conductivity of water and water mist is to be addressed when considering applications where the primary fire is a Class C fire.

5.2.4 Combination Fires

Combinations in fuel and hazards shall be addressed.

5.3 Classification based on type of fuel

5.3.1 Single fluid system – It is water based system.

5.3.2 Twin fluid system – A water mist system in which water and atomization media (air/ nitrogen) are separately supplied and mixed at water mist nozzle.

5.4 Classification based on particle size distribution

The size distribution varies from coarser to finer spray across the 1000μm spectrum of this standard definition of water mist. It is sub divided into Class 1, 2 or 3 water mist, according to the droplet size.

5.4.1 Class 1 water mist

It represents finest water mist and diameter of droplet is 100μm and 200 μm.

5.4.2 Class 2 water mist

A porting of the cumulative percent volume distribution curve lies beyond the limits of a class 1 spray. The diameter varies between 200 μm and 400 μm.

5.4.3 Class 3 water mist

It is greater than 400 μm or whichever portion of the curve extends to the right 2 cut-off line.

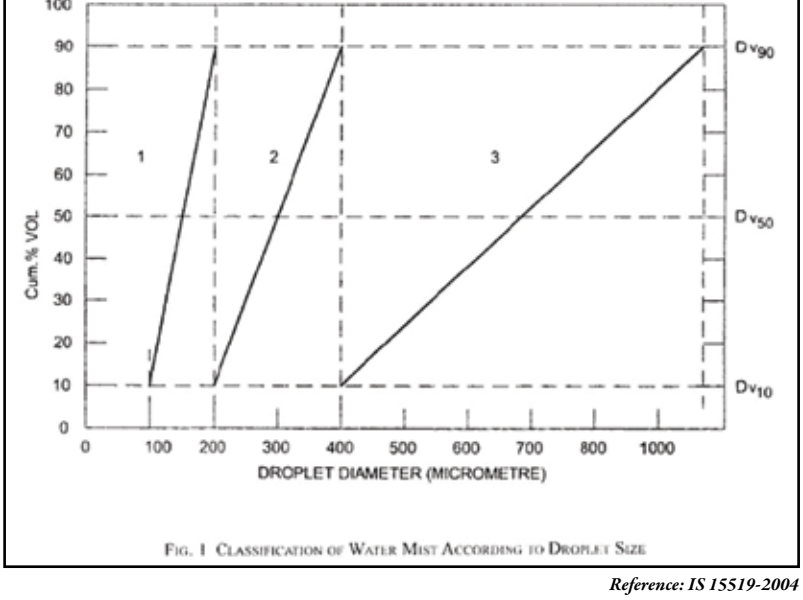


Fig. 1 Classification of Water Mist According to Droplet Size

Reference: IS 15519-2004

6. System types:

Following are the major systems:

6.1 Pre-engineered Systems:

This has pre-determined flow rates, nozal pressures, volumes and pre density.

6.2 Engineering System:
Here system is on individual design and calculation.

6.3 Deluge System:

Here all the nozzles operate simultaneously by way of controls.

6.4 Dry System:

Here pipe will be dry containing air, nitrogen or inert gas. In case of fire, valve is operated allowing flow of water through pipes and nozzles.

6.5 Pre-action System:

Here nozzles are sealed and pipe contains air. When the fire is detected valve is automatically actuated allowing water to flow in the system.

6.6 Wet System:

Sealed nozzles attached to the piping system is connected to water supply system and discharges to system when heat generated to the fire operates.

6.7 Total Flooding System:
This is provided mainly in which it takes care of all types of hazards.

6.8 Local Application System:

Mist is applied directly to the affected objects.

7. System Uses:

7.1 Rooms, vaults, enclosed machines, containers, storage tanks and bins.

7.2 Flammable liquid storage and processing areas.

7.3 Engines using flammable fuels.

7.4 Computers, data processing equipment and control rooms.

7.5 Electrical hazards, such as transformers, switches, circuit breakers, and rotating equipment.

7.6 Electronic equipment, including telecommunication equipments.

7.7 Cooking equipment using cooking oil and fats.

7.8 Ship engine bay.

7.9 Aircraft cargo bay, crew and cabin compartment.

8. System Advantages:

The use of water mist fire suppression when compared to the use of gaseous agent and traditional sprinkler system has revealed the following advantages:

8.1 Immediate activation.

8.2 High efficiency in the suppression of a wide variety of fires.

8.3 Minimized water damage.

8.4 Environmentally sound characteristics.

8.5 No toxic problem.

8.6 Better penetration into the seat of the fire.

8.7 Superior coverage of the protected volume.

10.0 Comparison between conventional Fire Sprinkler vs. Mist System

	Description of items								
System type	**Design Objective**	**Smoke control**	**Operating Temperature of Auto Nozzles**	**Visibility During Operation**	**Droplet size Microns**	**Droplet Velocity average**	**Water usage LPM**	**Run time Water storage**	**Head spacing**	**Use on Various types of Fire**
Conventional Fire sprinkler system	Fire Control	Poor	57-68°C	Good	1000	Gravity	80-120 LPM	As per type of Fire Hazards & Minimum 20 Minutes	3-5 meter	No
Low pressure Water Mist system	Fire suppression & Extinguishment	Good	57-68°C	Good	70-120	10 m/s	8-22 LPM	Minimum 10 minutes	3 meter	Yes
High Pressure Fog system	Fire suppression & Extinguishment	Very good	57-68°C	Poor	20	>20 m/s	8LPM	30 Minutes	2-3 meter	Yes

Reference: AMF system – Fire suppression specialist

8.8 An improved cooling effect from better mixing of gases and high evaporation rate.

8.9 Lower overall system weight.

8.10 Less water consumption.

9. System Limitation:

9.1 The systems shall not be used for direct application to materials that react with water to produce significant amounts of heat or hazardous products. These materials include the following:

9.1.1 Reactive metals, such as lithium, sodium, potassium, magnesium, titanium,

zirconium, uranium and plutonium, etc.

9.1.2 Metal alkoxides, such as sodium methoxide.

9.1.3 Metal amides, such as sodium amide.

9.1.4 Carbides, such as calcium carbide.

9.1.5 Halides, such as benzoyl chloride and aluminium chloride.

9.1.6 Hydrides, such as lithium aluminium hydride.

9.1.7 Oxyhalides, such as phosphorus exybromide.

9.1.8 Silanes, such as trichloromethysilance.

9.1.9 Sulfides, such as phosphorus pentasulfide and

9.1.10 Cyanates, such as methyl isocyanate.

10. Design Steps:

Step-1: Determine the hazard of the volume.
Step-2: Determine the nozzle grid.
Step-3: Determine the nozzle spacing.
Step-4: Determine the size of mist system.
Step-5: Determine the piping layout.
Step-6: Determine the pipe size.
Step-7: Develop part list.

11. Hydraulic calculation:

11.1 Darcy–Weisbach Calculation Method for Intermediate and High Pressure, Single Fluid, Single Liquid Phase Systems

$$h_f = f \frac{L}{D} \frac{V^2}{2g} \quad \text{and} \quad V = \frac{Q}{A}$$

If non - circular duct, D computed from $D = \frac{4A}{P}$

11.2 Pipe friction losses shall be determined by one of the following methods:

11.2.1 Hydraulic calculations shall be permitted to be performed using the Hazen–Williams calculation method for intermediate and high pressure systems having a minimum 20mm (¾ in.) pipe size, provided that the maximum flow velocity through the system piping does not exceed 7.6 m/s (25 ft. /sec).

11.2.2 When used to calculate the head loss with the International System of Units, the equation becomes

$$S = \frac{h_f}{L} = \frac{10.67\, Q^{1.85}}{C^{1.85}\, d^{4.87}}$$

Where:

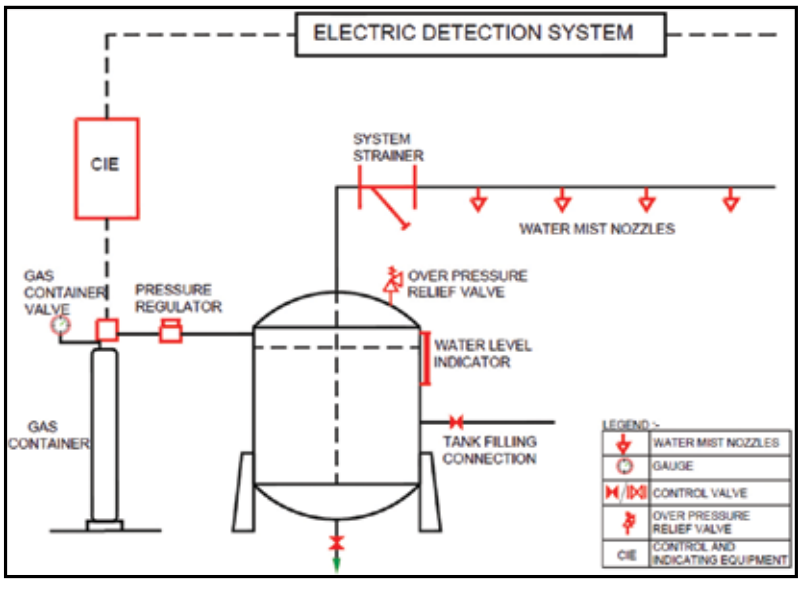
- S = Hydraulic slope.
- hf = head loss in meters (water) over the length of pipe.
- L = length of pipe in meters.
- Q = volumetric flow rate, m3/s (cubic meters per second)
- C = pipe roughness coefficient
- d = inside pipe diameter, m (meters)

Note: Pressure drop can be computed from head loss as hf × the unit weight of water (e.g., 9810 N/m3 at 4 deg C).

12.0 Conclusion

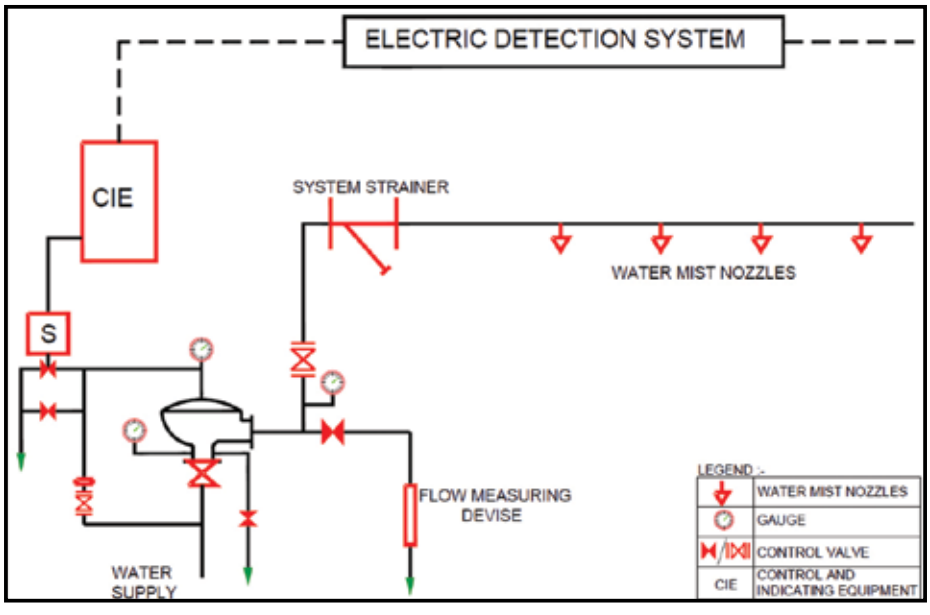
Although conventional sprinkler system use tremendously more water compared to mist, they are however, much more adaptable to a range of different design criteria. The mist system is more specific but it is hard to install a complete system using individual components from different manufacturers increasing in the cost considerably.

Fig 2 – Typical arrangement of gas & water containers for pre-engineered system



Reference: IS 15519-2004

Fig 3 – Typical control assembly for water mist deluge system



Reference: IS 15519-2004

13.0 Reference

NFPA-750 STANDARD ON WATER MIST FIRE PROTECTION SYSTEMS -2006 EDITION

IS – 15519 (2004): WATER MIST FIRE PROTECTION SYSTEMS-SYSTEMS DESIGN, INSTALLTION AND COMMISSIONING –CODE OF PRACTICE (CED 22: FIRE FIGHTING)

NATIONAL BUILDING CODE OF INDIA 2005

Water mist systems have been proven effective in controlling, suppressing, or extinguishing many types of fire

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