The Science Behind Water Mist Protection of Typical Building Hazards

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tyco Fire Protection Products
What is water mist?

How does it work?

How is it tested to protect typical building occupancies?

- Light Hazard
- Ordinary Hazard
- Residential
What is water mist?

**NFPA 750 (2010) Definition**

3.3.19 **Water Mist.** A water spray for which the Dv99 for the flow-weighted cumulative volumetric distribution of water droplets, is less than 1000 microns at the minimum design operating pressure of the water mist nozzle.

e.g. Dv99 ≈ 400 µm
What is water mist?

NFPA 750 (2010) Definition

3.3.19 Water Mist. A water spray for which the Dv99 for the flow-weighted cumulative volumetric distribution of water droplets, is less than 1000 microns at the minimum design operating pressure of the water mist nozzle.
What is water mist?

NFPA 750 (2010) Definition

3.3.19 Water Mist. A water spray for which the Dv99 for the flow-weighted cumulative volumetric distribution of water droplets, is less than 1000 microns at the minimum design operating pressure of the water mist nozzle.

3.3.22 Water Mist System. A distribution system connected to a water supply or water and atomizing media supplies that is equipped with one or more nozzles capable of delivering water mist intended to control, suppress, or extinguish fires and that has been demonstrated to meet the performance requirements of its listing and this standard.

There are many different types of water mist, and many different types of water mist systems.
NFPA 750 (2010) Scope

1.1 Scope. This standard contains the minimum requirements for the design, installation, maintenance, and testing of water mist fire protection systems. This standard does not provide definitive fire performance criteria, nor does it offer specific guidance on how to design a system to control, suppress, or extinguish a fire. Reliance is placed on the procurement and installation of listed water mist equipment or systems that have demonstrated performance in fire tests as part of a listing process.

There are many different types of water mist, and many different types of water mist systems.
How does it work?

Why water?
- Water is basically inert
- Extremely high latent heat of vaporization
- Evaporates at a relatively low temperature
- Expands nearly 1700 times in volume when it vaporizes

Why small water droplets?
- Low droplet mass promotes rapid heating
- Large surface area for heat penetration (~ 1/r)

Thermal Properties of H₂O
- 87% Heat from 20 °C to 100 °C
- 13% Completely vaporize at 100 °C
How does it work?

Primary mechanisms:
- Gas phase cooling
- Oxygen depletion and flammable vapor dilution
- Wetting and cooling of the fuel surface

Secondary mechanisms:
- Radiation attenuation
- Kinetic effects

Different hazards require different types of water mist, and take advantage of different combinations of these mechanisms.
How does it work?

Machinery Spaces

- Significant quantities of **Class B** hazards (flammable liquids)
- Limited **Class A** (solid) combustibles
- Typ. non-combustible construction
- Enclosed and highly obstructed
- **Contain valuable, mission critical equipment**

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Machinery Spaces

- **GOAL:** Minimize risk by extinguishing fires from **Class B** hazards **inside enclosures** containing valuable machinery.

- **Extinguish:** $O_2$ depletion, fuel vapor dilution, gas phase cooling.

Enclosure

Yields approx 1680 gal vapor

Big fire, small space, limited ventilation
How does it work?

Machinery Spaces

- **GOAL:** Minimize risk by extinguishing fires from Class B hazards inside enclosures containing valuable machinery.

- **Extinction:**
  - O<sub>2</sub> depletion
  - Fuel vapor dilution
  - Gas phase cooling

This is not how water mist typically works to protect occupancies in buildings!
How does it work?

LH/OH Occupancies

- **Class A** (solid) fuel hazards
- Variety of construction types, often including combustible materials
- Various ventilation conditions
- Wide range of sizes and configurations (hotel rooms to open office buildings!)
**LH/OH Occupancies**

- **GOAL:** Provide property protection and life safety by controlling fires and mitigating their damaging effects

- **Fire control:** *wetting* of Class A combustibles to limit fire size and prevent flame spread

- **Effects mitigation:** *absorb heat* from upper gas layer (UGL) to prevent flashover and help maintain tenable conditions
How does it work?

**LH/OH Occupancies**
- **System:** Wet pipe system using **automatic nozzles**
- **Mist characteristics:** Relatively larger droplets, with sprays designed to promote UGL cooling and fuel wetting

**Machinery Spaces**
- **System:** Deluge system utilizing **open nozzles**
- **Mist characteristics:** Relatively smaller smaller droplets with high momentum to promote mixing and evaporation
How is it tested?

UL 2167

STANDARD FOR SAFETY
Water Mist Nozzles for Fire Protection Service

Approval Standard for Water Mist Systems

Class Number 5560
November 2012
How is it tested?

**FM5560:**

Non-storage, non-mfg., Hazard Category 1 (Light Hazard)

- Small Compartment
- Large Compartment
- Open Space, ignition under 1
- Open Space, ignition between 2 nozzles
- Open Space, ignition between 4 nozzles
How is it tested?

FM5560 Small Compartment

FM5560 Open Space

FM5560 Large Compartment
### How is it tested?

**FM5560 fire test performance criteria:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Non-Storage HC1 (Light Hazard)</th>
<th>Machinery Space</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test</strong></td>
<td>Small Compartment</td>
<td>Large Compartment</td>
</tr>
<tr>
<td><strong>Fuel package</strong></td>
<td>Class A: Wood paneling, PU foam</td>
<td>Class A: Wood, plywood, PU foam</td>
</tr>
<tr>
<td><strong>Selected performance criteria</strong></td>
<td>Corridor nozzles shall not operate</td>
<td>Doorway nozzles shall not operate</td>
</tr>
<tr>
<td></td>
<td>40% max damage to ignition bunk</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>260°C max ceiling temp over ignition</td>
<td>265°C max ceiling temp over ignition</td>
</tr>
<tr>
<td></td>
<td>316°C max air temp over ignition</td>
<td>316°C max air temp over ignition</td>
</tr>
</tbody>
</table>
**FM5560 fire test performance criteria:**

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<tr>
<th>Category</th>
<th>Non-Storage HC1 (Light Hazard)</th>
<th>Machinery Space</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small Compartment</td>
<td>All tests</td>
</tr>
<tr>
<td>Test</td>
<td>Large Compartment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Open Space (3 tests)</td>
<td></td>
</tr>
<tr>
<td>Fuel package class</td>
<td>Class A: Wood, plywood, PU foam</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Class A: PU foam</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Class B: Diesel, Heptane</td>
<td></td>
</tr>
<tr>
<td>Selected performance criteria</td>
<td>260°C max ceiling temp over ignition</td>
<td>265°C max ceiling temp over ignition</td>
</tr>
<tr>
<td></td>
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**FM 4-2 (July 2013) section 3.1.3:**
“Water mist systems FM Approved for LHO are intended to **control fires** in these occupancies with less water than standard automatic sprinkler systems.”

*One test requires significant suppression
How is it tested?

**UL2167:**

**Residential**
- Compartment test nearly identical to UL1626 residential sprinkler test

**Light Hazard**
- Open space (public area) and corner fire test

** Ordinary Hazard Group 1 (OH1)**
- Open Space and corner fire test using storage commodity
## UL2167 OH1 test performance criteria:

<table>
<thead>
<tr>
<th>Category</th>
<th>Residential</th>
<th>OH1</th>
<th>OH1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>1626 type compartment</td>
<td>Open space (7 tests)</td>
<td>Corner fire</td>
</tr>
<tr>
<td>Fuel package</td>
<td>Class A: Plywood, wood, PU foam</td>
<td>Class A: Class II commodity</td>
<td>Class A: Class II commodity, paper</td>
</tr>
<tr>
<td>Selected performance</td>
<td>Only 1 nozzle is allowed to operate</td>
<td>Operating area not to exceed 1000 ft(^2)</td>
<td>-</td>
</tr>
<tr>
<td>criteria</td>
<td>316°C max air temp 76 mm below ceiling</td>
<td>Ceiling steel temp not to exceed 540°C for more than 5 min</td>
<td>5% max damage to target</td>
</tr>
<tr>
<td></td>
<td>93°C max and 54°C max 2 min average temp at 1.6 m from floor</td>
<td>50% max damage to commodity</td>
<td>50% max damage to commodity</td>
</tr>
<tr>
<td></td>
<td>260°C max ceiling temp over ignition</td>
<td>No breaching or flashover of ceiling</td>
<td>No breaching or flashover of ceiling</td>
</tr>
</tbody>
</table>
To summarize...

- There are many different types of water mist, and many different types of water mist systems.

- The type of hazard dictates the type of mist, and type of system used to deploy that mist.

- For light hazard, ordinary hazard, and residential type occupancies, water mist systems are designed and specifically tested to provide property protection and life safety by controlling fires and mitigating their damaging effects.

- This is achieved by using a wet pipe system with automatic (heat activated) nozzles that are specifically designed to provide wetting of Class A combustibles and significant compartmental cooling.
Thank you!

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References


