The Science Behind Water Mist Protection of Typical Building Hazards

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tyco Fire Protection Products

Presentation Goals

What is water mist?

How does it work?

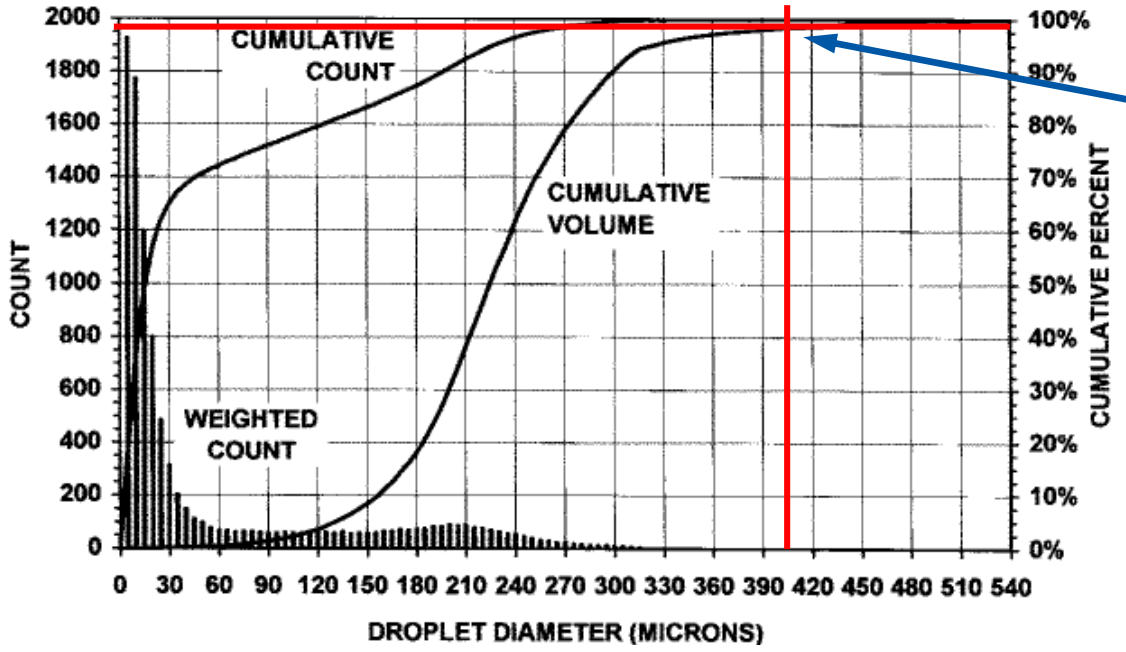
How is it tested to protect typical building occupancies?

- 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

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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

What is water mist?

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?

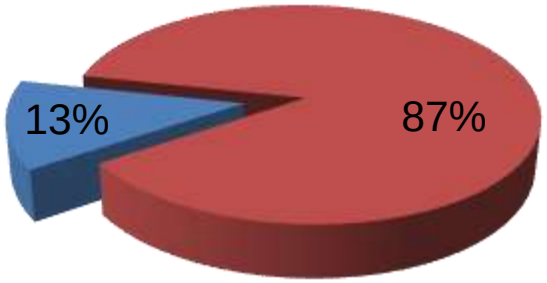
Why water?

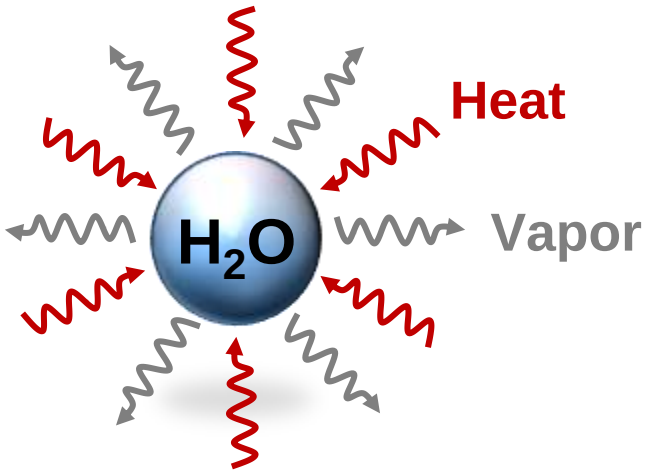
- Water is basically inert
- Extremely high latent heat of vaporization
- Evaporates at a relatively low temperature
- Expands nearly 1700 times in volume when it vaporizes

Why small water droplets?

- Low droplet mass promotes rapid heating
- Large surface area for heat penetration (~ 1/r)

Thermal Properties of H_2O





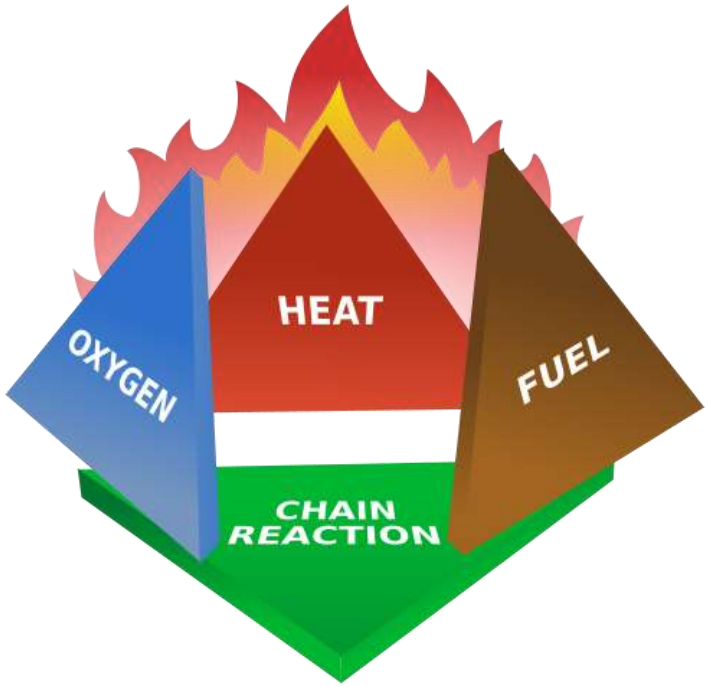
How does it work?

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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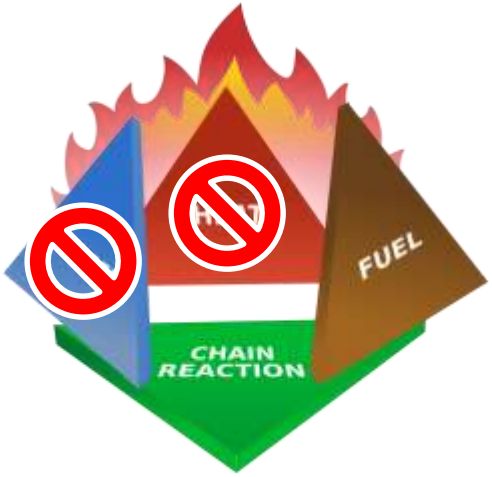
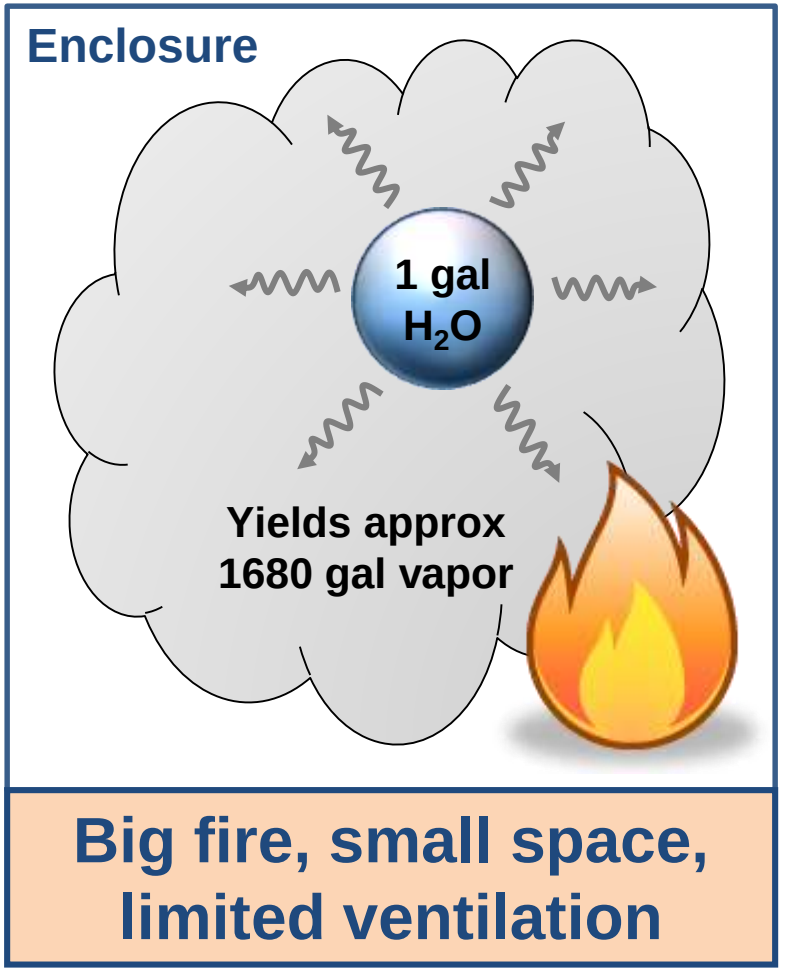
How does it work?

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





How does it work?

Machinery Spaces

- **GOAL: Minimize risk** by **extinguishing** fires from **Class B** hazards **inside enclosures** cont
- **Exti** vapo

This is not how water mist typically works to protect occupancies in buildings!

How does it work?

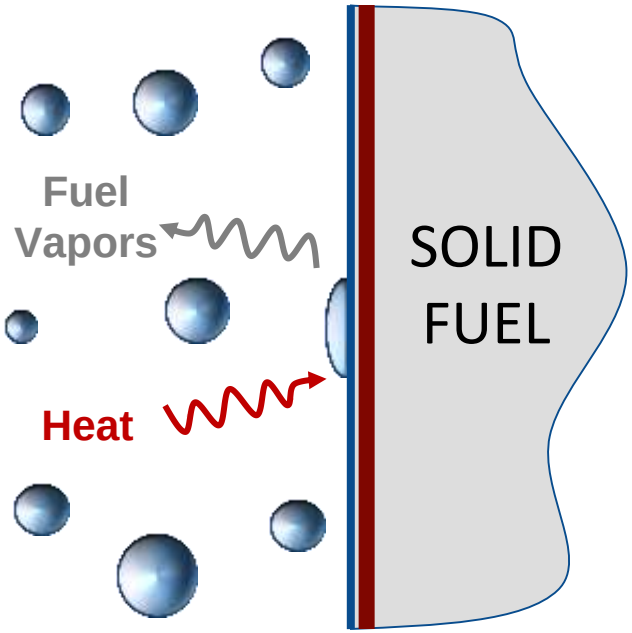
LH/OH Occupancies

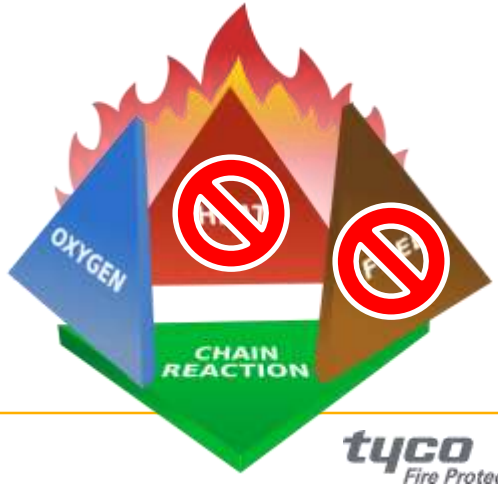
- **Class A** (solid) fuel hazards
- Variety of construction types, often including combustible materials
- Various ventilation conditions
- Wide range of sizes and configurations (hotel rooms to open office buildings!)

How does it work?

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?

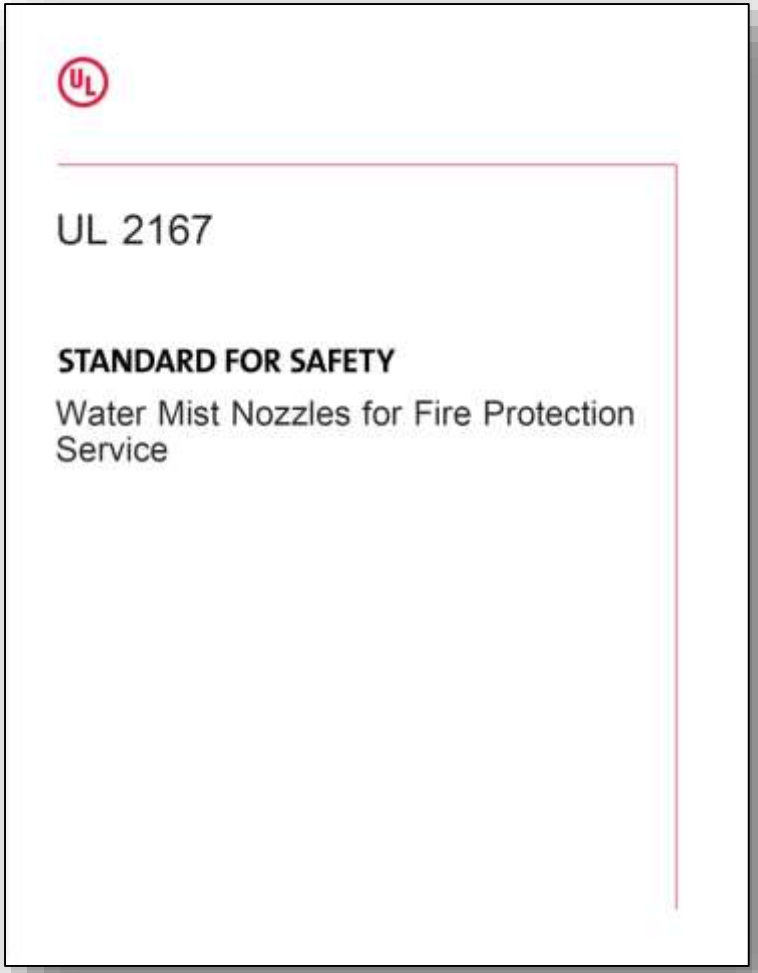
LH/OH Occupancies

- **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 droplets with high momentum to promote mixing and evaporation

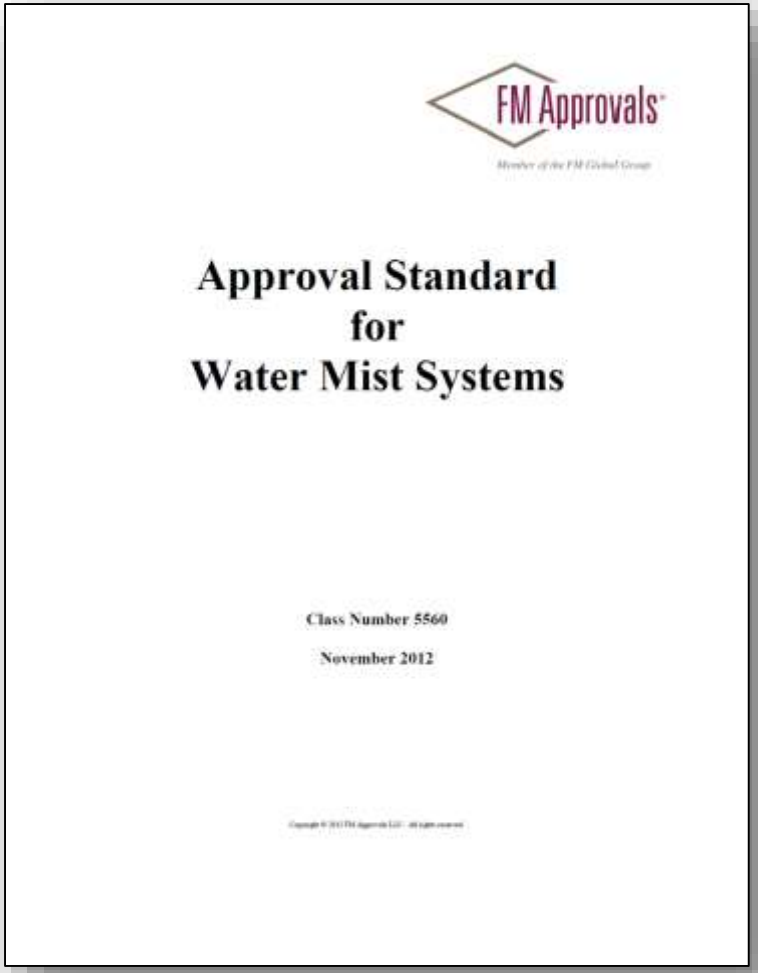
How is it tested?



UL 2167

STANDARD FOR SAFETY

Water Mist Nozzles for Fire Protection Service



FM Approvals

Approval Standard
for
Water Mist Systems

Class Number 5560

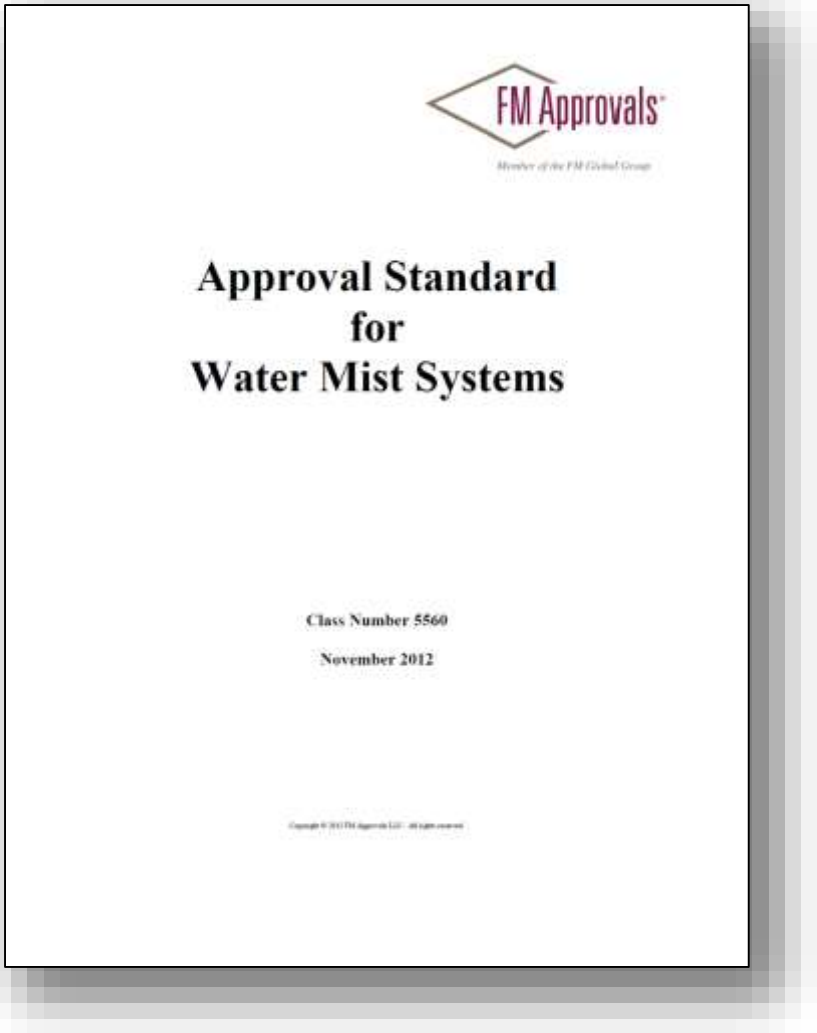
November 2012

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

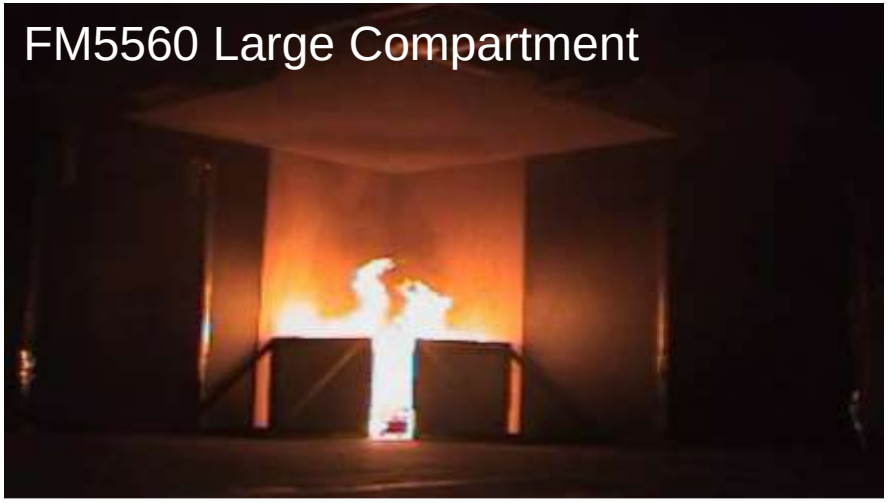


How is it tested?

FM5560 Small Compartment

FM5560 Open Space

FM5560 Large Compartment



How is it tested?

FM5560 fire test performance criteria:

Category	Non-Storage HC1 (Light Hazard)			Machinery Space
Test	**Small Compartment**	**Large Compartment**	**Open Space (3 tests)**	**All tests**
Fuel package	**Class A:** Wood paneling, PU foam	**Class A:** Wood, plywood, PU foam	**Class A:** PU foam	**Class B:** Diesel, Heptane
Selected performance criteria	Corridor nozzles shall not operate	Doorway nozzles shall not operate	No more than 5 nozzles shall operate	Fires must be extinguished*
	40% max damage to ignition bunk	-	**50% max** damage to fuel package	Key parameter: O_2 concentration
	260°C max ceiling temp over ignition	**265°C max** ceiling temp over ignition	**260°C max** ceiling temp over ignition	**One test requires significant suppression*
	316°C max air temp over ignition	**316°C max** air temp over ignition	**316°C max** air temp over ignition	

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	316°C max air temp over ignition	**316°C max** air temp over ignition	**316°C max** air temp over ignition	

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."

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

How is it tested?

UL2167 OH1 test performance criteria:

Category	Residential	OH1	OH1
Test	**1626 type compartment**	**Open space (7 tests)**	**Corner fire**
Fuel package	**Class A:** Plywood, wood, PU foam	**Class A:** Class II commodity	**Class A:** Class II commodity, paper
Selected performance criteria	Only **1 nozzle** is allowed to operate	Operating area not to exceed **1000 ft²**	-
	316°C max air temp **76 mm** below ceiling	Ceiling steel temp not to exceed **540°C** for more than **5 min**	**5%** max damage to target
	93°C max and **54°C max 2 min average** temp at **1.6 m** from floor	**50%** max damage to commodity	**50%** max damage to commodity
	260°C max ceiling temp over ignition	No breaching or flashover of ceiling	No breaching or flashover of ceiling

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

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- *Factory Mutual Approval Standard for Water Mist Systems, Class Number 5560, November 2012 Edition*, FM Approvals LLC
- ANSI / UL 2167 *Standard for Safety, Water Mist Nozzles for Fire Protection Service, 2011 Edition*, Underwriters Laboratories Inc.
- Mawhinney, J. R., Back III, G. G., Section 4, Chapter 16, Water Mist Fire Suppression Systems, in DiNenno, P. J. et. al. (2008) *SFPE Handbook of Fire Protection Engineering, Third Edition,* National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471