

REPORT

PLUMIS AUTOMIST – EQUIVALENCY REPORT

NFPA 13D, NFPA 750, and Plumis Automist



PREPARED FOR

Plumis Ltd
Phoenix Trading Estate - Unit 4
Bilton Road Perivale UB6 7DZ
United Kingdom

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PREPARED BY

Jarred Druzynski
11545 West Bernardo Court, Suite 300
San Diego, California 92127, USA

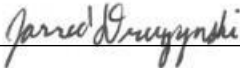
jarred.druzynski@jensenhughes.com
+1 858-232-5316



JENSEN HUGHES

Prepared by:

Reviewed by:

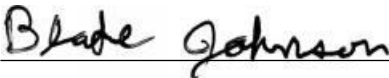


Jarred Druzynski, MS
Associate
Jarred.druzynski@jensenhughes.com



Digitally signed by Kelly Opert
DN: C=US,
E=kelly.opert@jensenhughes.com,
O=Jensen Hughes, OU=RD&E,
CN=Kelly Opert
Location: PE, IL 062.069389
Date: 2026.06.23 00:36:18-04'00'

Kelly Opert, PE
Engineering Manager
kelly.opert@jensenhughes.com



Blake Johnson, PE
Senior Fire Protection Engineer
bjohnson@jensenhughes.com

Revision Record Summary

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Acronyms and Abbreviations

Acronyms & Abbreviations	Full Name
AHJ	Authority Having Jurisdiction
NFPA	National Fire Protection Association
ICC	International Code Council

Executive Summary

Jensen Hughes has completed an equivalency analysis comparing the level of protection provided by a typical fire sprinkler system designed to NFPA 13D, the *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes* [3], a typical water mist system for one- and two-family homes designed to NFPA 750, the *Standard on Water Mist Fire Protection Systems* [4], and a Plumis Automist system, which is a targeted water mist system.

This report includes typical water mist systems as described in NFPA 750, details of the Plumis Automist system and how it differs from a typical water mist system, and the fire suppression mechanisms behind water mist and fire sprinkler systems. The equivalency analysis compares the requirements for an NFPA 13D sprinkler system and an NFPA 750 water mist system for one- and two-family homes with commentary on how the Plumis Automist system meets, exceeds, or is not affected by the requirements of these standards. The code analysis shows that the intent of both standards are the same, many areas of the requirements for one- and two-family dwellings require components to be in compliance with manufacturer specifications rather than giving specific requirements, and the minor differences between the two standards are either due to the structure of the code or technology specific considerations, e.g. filters and water quality consideration for water mist systems due to their relatively smaller orifice sizes. These differences are presented in Table A-1.

Many components common to both types of systems including tanks, pumps, filters, hangers, waterflow detection devices, and waterflow valves are exempt from being listed in both NFPA 13D and NFPA 750. Therefore, the testing required for the different types of systems to achieve UL listings for sprinklers, water mist nozzles, and targeting water mist systems are described in this report. The testing requirements for sprinklers (UL 199) and water mist nozzles (UL 2167) are shown to be almost the same, with some minor technology-specific differences, such as water mist systems measuring droplet sizes. Plumis Automist nozzles are subject to many of the testing requirements as laid out in UL 2167, but many of the tests meant to test the performance of the heat responsive elements in standard sprinklers and water mist nozzles are non-applicable to the Automist nozzle, so Plumis Automist nozzles are also subject to pertinent tests within UL 217 for Smoke Alarms.

This report includes details of the testing these systems are subjected to, showing similarities in the tests and detailing how passing the tests meet the intent of NFPA 13D and NFPA 750. The fire test setups are based on the manufacturer's listed spacing requirements and the test criteria are all similar and all ensure either flashover is prevented within the compartment of fire origin, i.e. the fire does not spread to adjacent compartments, and that occupants are able to escape the room of fire origin.

The purpose of this report is as a broad basis of comparison between NFPA 13D systems, NFPA 750 systems, and the Plumis Automist system. Some requirements for NFPA 13D and NFPA 750 are site specific and, as such, are outside the scope of this report.

1.0 Introduction

This report provides an equivalency analysis between sprinkler systems for one- and two-family dwellings as outlined in NFPA 13D (Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes) [3], water mist systems for one- and two-family dwellings as outlined in NFPA 750 (Standard on Water Mist Fire Protection Systems) [4], and the Plumis Automist system.

The equivalency analysis evaluates the commonalities and differences between the requirements for fire protection systems for one- and two-family dwellings as laid out in NFPA 13D and NFPA 750, calling out where the Plumis Automist system meets or fails to meet the requirements of NFPA 750 and what requirements are not applicable.

The equivalency analysis further explores the similarities between the listing requirements for fire sprinklers in UL 199, water mist nozzles in UL 2167, and the Plumis Automist system in UL 2167A. The component level tests are each briefly detailed, and the fire tests are compared in more detail to show the equivalency of their system performance and all three systems’ ability to meet the basic intent of both NFPA 13D and NFPA 750.

The main sections of the report and a description of the content are provided in Table 1-1.

Table 1-1: Report Organization

Section	Description
1.0 – Introduction	Presents the scope and outline of the report.
2.0 – Technology Overview	Provides an overview of water mist systems, the Plumis Automist system, and the basic physical mechanisms of fire suppression behind water mist systems and how they differ from sprinkler systems.
3.0 – Equivalency Analysis	Provides a comparison of NFPA 13D sprinkler systems, NFPA 750 water mist systems for one- and two- family homes, and the Plumis Automist system based on their code and testing requirements.
4.0 – Conclusions	Summarizes the report findings.
5.0 – References	Lists the references used in developing and completing the analysis.

2.0 Technology Overview

2.1 WATER MIST SYSTEMS

Water mist systems are fire suppression systems that use fine water droplets 0.01 mm to 1 mm in size to extinguish or control fires. These systems use less water and can use smaller piping than standard sprinkler systems owing to the increased cooling effects, oxygen displacement, and pre-wetting that the smaller droplets are able to provide. Though system pressure is typically higher than fire sprinkler systems, water mist systems can reduce water damage.

Water mist systems have already been listed for use for the following applications [8]:

- + Machinery spaces
- + Combustion turbines
- + Industrial oil cookers
- + Computer room raised floors
- + Data processing equipment rooms
- + Chemical fume hoods
- + Continuous wood board presses
- + Shipboard passenger cabins and corridors
- + Shipboard accommodation and public space areas
- + Road tunnels
- + Cable conduit tunnels

This section outlines different application types, water mist nozzle types, system types, and droplet production methods as outlined in NFPA 750 Chapter 3 and the “Water Mist Systems Overview” [8] blog post by NFPA.

2.1.1 Application

The different ways to apply water mist systems are similar to the way clean agent systems are applied. [8]

- + Local Application – The system is designed to discharge water mist to directly target an object or piece of equipment.
- + Total Compartment Application – Nozzles are positioned in a grid to discharge water mist uniformly throughout the entire volume.
- + Zoned Application – Water mist is configured to discharge from portions of a larger system as required to control fire in a specific part of a compartment.
- + Occupancy Protection Systems – A water mist system with automatic nozzles installed throughout a building or a portion of a building and intended to control, suppress, or extinguish a fire.

The Plumis Automist system is an occupancy protection system.

2.1.2 Nozzle Types

There are different types of nozzles utilized in water mist systems [8]:

- + Automatic - Nozzles that operate independently of other nozzles by means of a detection/activation device built into the nozzle. This activation device is typically a heat responsive element or actuator.
- + Nonautomatic - Nozzles that do not have individual actuators or heat-responsive elements. These types of nozzles are used in deluge systems where the nozzles are always open.
- + Multifunctional - Nozzles capable of operation using both automatic and nonautomatic means. The actuation of a multifunctional water mist nozzle can be by a built-in detection and activation device and/or by an independent means of activation.
- + Electronically-operated automatic - Nozzles that are normally closed and operated by electrical energy that is initiated and supplied by fire detection and control equipment.

The Plumis Automist system is an electronically-operated automatic nozzles where waterflow to an open nozzle actuated by smoke and infrared heat detection.

2.1.3 System Types

System types mirror the different types of sprinkler systems [8]:

- + Deluge System - A water mist system utilizing nonautomatic mist nozzles (open) attached to a piping network connected to the fluid supply(ies) directly or through a valve controlled by an independent detection system installed in the same area as the mist nozzles.
- + Wet Pipe System - A water mist system using automatic nozzles attached to a piping system containing water and connected to a water supply so that water discharges immediately from nozzles operated by the heat from a fire.
- + Preaction System - A water mist system using automatic nozzles attached to a piping system that contains air that might or might not be under pressure, with a supplemental detection system installed in the same areas as the mist nozzles. Preaction systems shall be one of the following types, as defined in NFPA 750 Section 7.4.3.2:
 - A non-interlock system, which admits water to the water mist system on operation of the detection devices or automatic water mist nozzles.
 - A single interlock system, which admits water to the water mist system piping on actuation of detection devices.
 - A double interlock system, which admits water to the water mist system piping on operation of both detection devices and automatic nozzles.
- + Dry Pipe System - A water mist system using automatic nozzles attached to a piping system containing air, nitrogen, or inert gas under pressure, the release of which (as from an opening of an automatic nozzle) allows the water pressure to open a dry pipe valve. The water then flows into the piping system and out through any open nozzles.

The Plumis Automist system is most comparable to a double-interlock preaction system, but with additional processing at the control unit to activate only the most effective nozzle(s).

2.1.4 Droplet Production Methods

Water mist may be produced in a variety of ways [8]:

- + The liquid is discharged at a high enough velocity relative to the surrounding air that it shears into small droplets.
- + A liquid stream is impinged upon a fixed surface.
- + Two liquid streams of similar composition collide with one another.
- + The liquid is either vibrated or electrically broken into small droplets (ultrasonic and electrostatic atomizers).
- + The liquid is heated above its boiling point in a pressure vessel and released suddenly to atmospheric pressure (flashing liquid sprays).

The Plumis Automist system works by high velocity discharge.

2.2 SYSTEM DESCRIPTION

The Plumis Automist System is a listed occupancy protection water mist system utilizing targeting electronically-operated automatic open nozzles each with individual infrared cameras used to target the fire.

On detection of a fire by a smoke detector, the controller “wakes up” the nozzle(s) to scan for fire using their thermal sensors. Once the Automist controller’s detection algorithm confirms a fire from the thermal sensor data, the high-pressure pump is activated and water is discharged from the nozzle best located to target the fire. The nozzles are wall mounted 3.94–4.27 feet away from finished floor to avoid unwanted evaporation of the mist in the hot upper layer of air near the ceiling and to allow the infrared sensors to better detect the fire.

The Plumis Automist system is a listed, pre-calculated, engineered system. Any number of nozzles and fittings may be used up to the maximum included in the system calculations and testing involved in listing the product. As a listed integrated system, components of the system were required to be tested to certify the system. Many of the components, including the pump, filters, and waterflow valves, are not typically required to be listed if used in one- and two-family dwellings in accordance with NFPA 750 Section 10.3.2.4.1, similar to NFPA 13D Section 5.1.2. These components were required to be tested to be included in the system listing, providing a stronger assurance of their efficacy. As part of the listing process, the system was put through fire testing comparable to the fire testing for sprinklers and basic water mist nozzles. The different code and testing requirements for the system are compared to the requirements from NFPA 750 and NFPA 13D in Section 3 of this report.

Figure 2-1 depicts the basic components of a standard Automist system, namely the pump, controller, smoke detectors, targeting nozzles, hydraulic lines, and electrical cabling. The system performance has been tested within and shall be installed within operational bounds outlined in Table 2-1 and depicted in Figure 2-2.

Plumis Automist has two model numbers listed in their UL listing [14], AP09 and AP12. AP09 is their 230V AC/50Hz system and AP12 is their 240V AC/60Hz system, which is what is typically installed in the United States. The system model numbers are the same as the pumps used within the system.

Table 2-1: Plumis Automist Operational Bounds [12]

Parameter	Operational Bound
Maximum number of spray heads	10
Maximum number of smoke sensors in the system	10
Maximum number of smoke sensors in a series chain	2
Maximum number of scanning spray heads at the same time	6
Maximum number of spray heads per zone	3
Zones per sensor	2 zones
Maximum sensor cable length	90 m (295.27 ft)
Maximum data cable length	80 m (262.47 ft)
Maximum high-pressure water pipe length	60 m (196.85 ft)
Maximum high-pressure water pipe length from the pump to the furthest spray head	30 m (98.42 ft)
Maximum sounder cable length	90 m (295.27 ft)
Room Temperature	Above 4°C (39.2°F) and below 44°C (11.2°F)

1. Smoke sensor (EVCA-PY-PL)
2. Spray head (SH12)
3. Pump (AP09)
4. Controller (CT03)
5. High-pressure pipe ¼" BSPP connection
6. 2 Core Sensor cable
7. 5 Core Data cable
8. Pump to controller cables (power and solenoid)

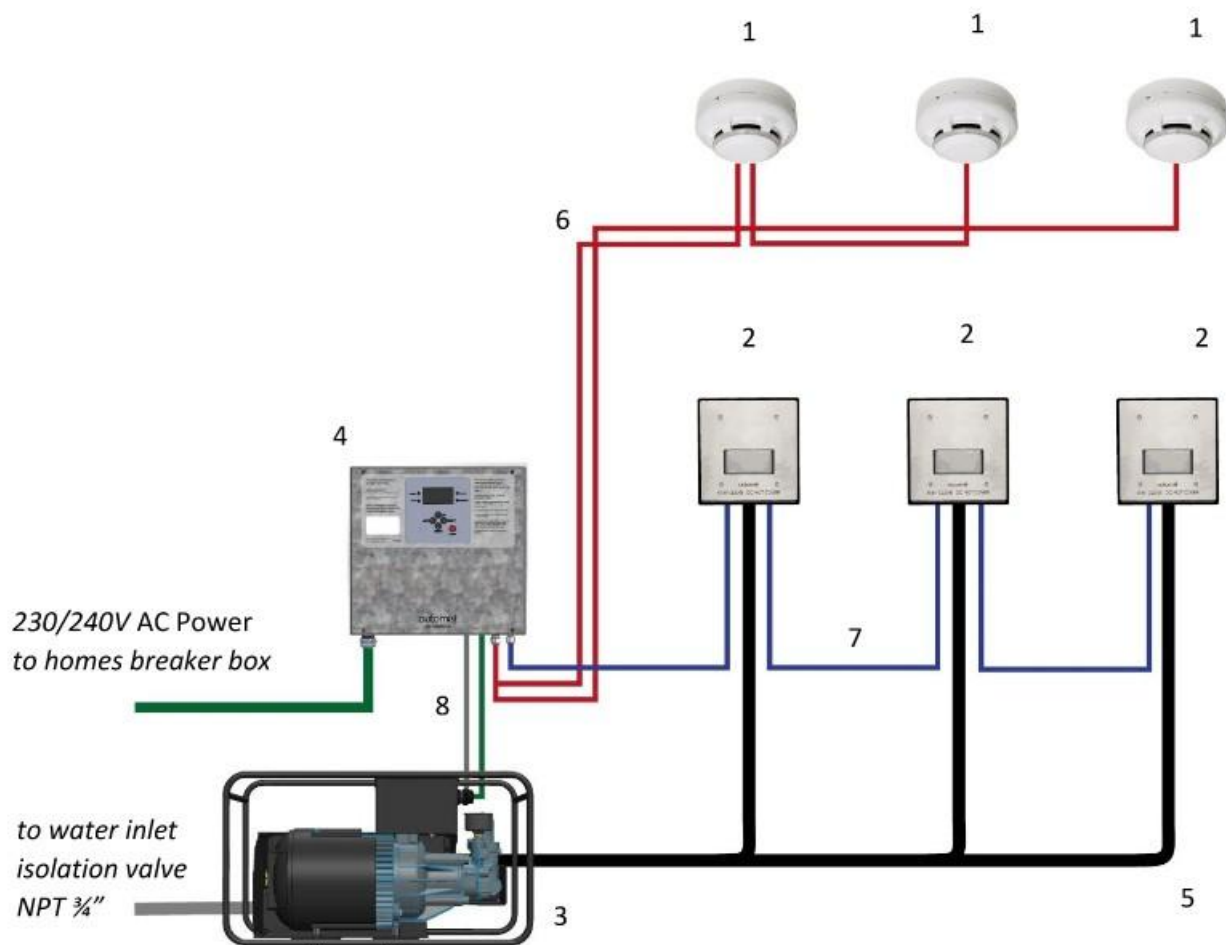


Figure 2-1: Plumis Automist System Diagram [12]

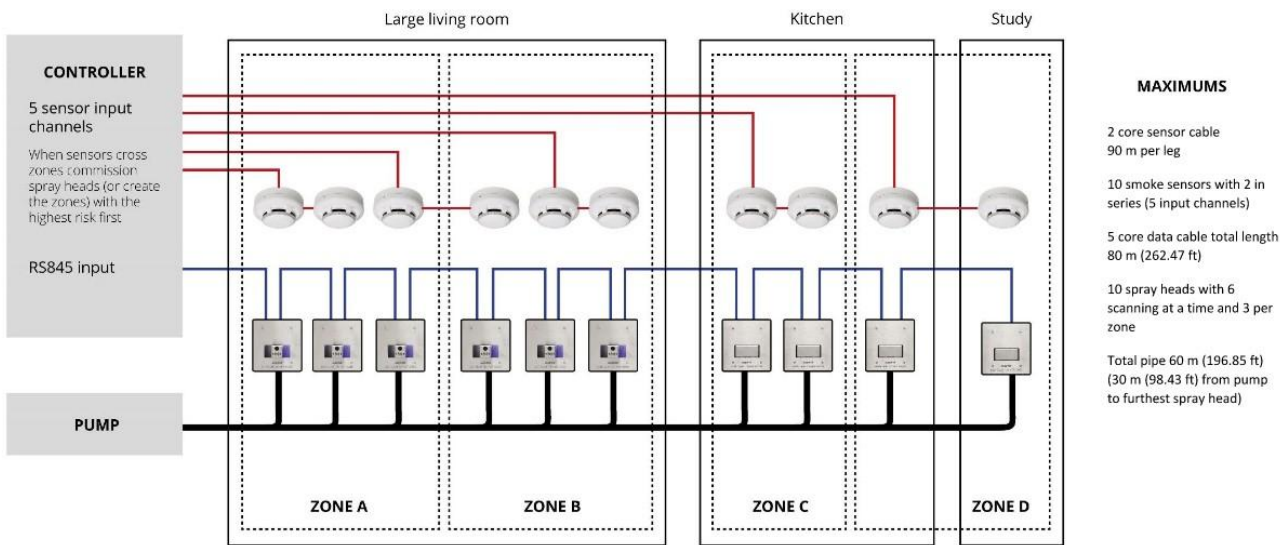


Figure 4: Technical Limitations Summary

Figure 2-2: Plumis Automist Operational Bounds [12]

2.2.1 Automist Spray Head



Figure 2-3: Automist Spray Head – SH12 [12]

The Plumis Automist spray head, depicted in Figure 2-3, is a targeting, wall mounted water mist nozzle which uses an IR camera above its orifice to allow the control system to determine the nozzle best suited to fight a fire in a compartment. It rotates laterally and sprays a 90° vertical blade of mist at the fire. This spray pattern means a clear space of 1.5 m (4.92 feet) must be maintained around the nozzle.

Table 2-2: Automist Spray Head – SH12 [12]

<i>Parameter</i>	<i>Value</i>
Operating Pressure	Operating Pressure 76 – 100 bar (1,102 – 1,450 Psi)
Flow rate	Flow rate 9 liters (2.37 gal) per minute
Spray Pattern	Spray Pattern 90° vertical blade
K Factor (Nominal)	1.04 lpm/(bar) ^(1/2) 0.072 gpm/(psi) ^(1/2)
Minimum nozzle waterway	1 mm
Input Voltage	24 VDC (reversed voltage protected)
Input Current Max	0.5 A
IR Sensor Resolution	750-Pixel
Clearance around spray head	1.5m (4.92 feet)
Mounting Height	1.2 m – 1.3 m (3.94 feet – 4.27 feet)

2.2.2 Automist Pump

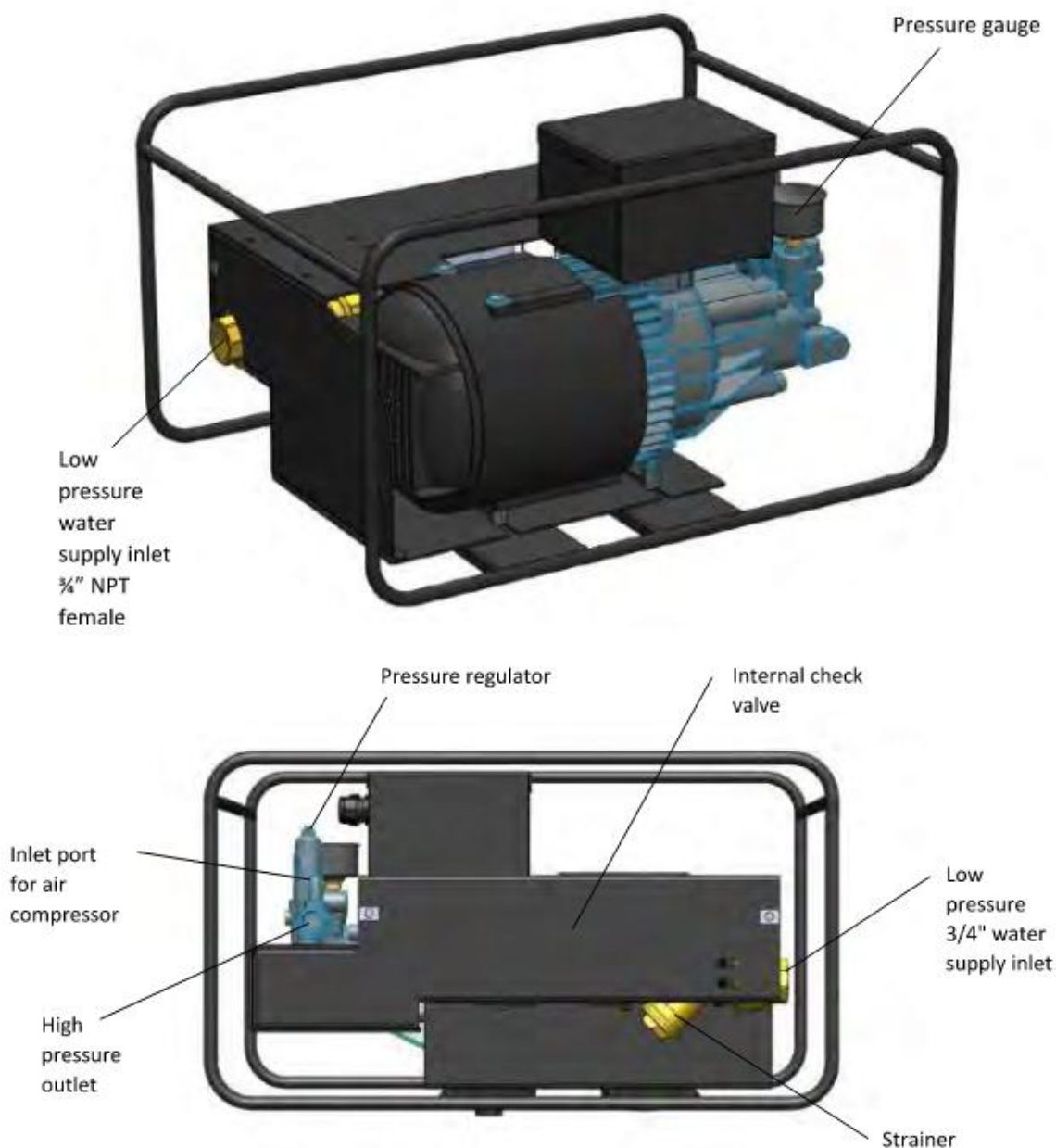


Figure 2-4: Automist Pump – AP09 (Comparable to AP12) [12]

There are two variations of the Plumis Automist pump, AP09 and AP12, which are the same model number as their respective system. AP09 is their 230V AC/50Hz system and AP12 is their 240V AC/60Hz system, which is what is typically installed in the United States. AP09 is depicted above in Figure 2-4, though the requirements listed in Table 2-3 are for AP12.

Table 2-3: Automist Pump (US) – AP12 [12]

Parameter	Value
Output Pressure	76 – 100 bar (1102 – 1450 Psi)
Flow rate	Flow rate 9 liters (2.37 gal) per minute
Inlet Pressure (Dynamic)	1 – 3 bar (14.5 – 43.51 Psi)
Rated Motor Speed	3,400 rpm
Input Voltage / Current / Power - Pump	240V AC/60Hz / Max 11.4 amp / Max 2.4 KW
Input Voltage - Solenoid	24 VDC
Type of Solenoid	Normally closed (NC)

2.2.3 Automist Controller



Figure 2-5: Automist Controller – CT03 [12]

The Plumis Automist Controller handles system logic and interfaces with the smoke detectors, water mist nozzles, and pump. It receives power from the house and transmits it to the pump, triggers the solenoid/relay that controls the pump state, receives trigger signals from system smoke detectors, handles data from the IR sensors within the nozzles, and determines which nozzles to trigger. The controller is supplied with a battery that can provide standby power for all system functions except pump operations for 24 hours.

Table 2-4: Automist Controller – CTo3 [12]

<i>Parameter</i>	<i>Value</i>
Input Supply	Single phase
Input Voltage	240V AC 60 Hz
Input Current Standby mode	Up to 0.5 A
Input Current Scanning mode	Up to 0.5 A
Input Current Pumping mode	11.6 A with 240V AC 60HZ pump (AP12)
Input Current Controller Inrush	60 A peak
Input Current Motor Starting	75 A peak <150ms
Input Current Locked Rotor	52 A <30 s (motor protected by thermal fuse)
Overload Protection	Protection is provided by incoming power feed 20A MCB, no breakers inside the control unit. MCB is current limiting type with limitation class 2.
Safety Classification	Class I device
Overvoltage Category	Overvoltage Category II (transient protection via MOVs and GDTs to Earth/Ground)
Battery	UL Recognized (BAZR2) lead acid, rechargeable NP7 12VDC 7-amp hour rated. Provides 24 hours standby time for all non-pump functions.

2.2.4 Smoke Sensor



Figure 2-6: Automist Smoke Sensor – EVCA-PY-PL [12]

The Plumis Automist system utilizes a conventional photoelectric 2-wire smoke sensor specifically manufactured by Nittan for the Plumis system. It is the only model of smoke or heat sensor can be used with the Automist system.

Table 2-5: Automist Smoke Sensor – EVCA-PY-PL [12]

Parameter	Value
Approved bases	EVA-UB4 or EVA-UB4-6
Input Voltage	24 VDC
Input Current Max	Quiescent - 50 μ A Alarm - 50mA

2.3 FIRE SUPPRESSION MECHANICS

It is beneficial to outline briefly the mechanisms of fire suppression utilized by fire sprinkler and water mist systems. All water-based fire protection systems work at least in part by utilizing water to absorb heat from the targeted fire. Water is exceptional for this method of suppression because it has a high capacity to absorb heat per unit temperature increase (specific heat capacity) and it has a high capacity to absorb heat before changing phase (latent heat of vaporization).

For residential fire hazards, the particle size observed with water mist systems has several advantages over the larger droplet size of traditional sprinkler systems:

1. The smaller particle size results in a larger total surface area for a unit quantity of water. This increases the rate of heat transfer to the particles of water compared to a typical sprinkler system, allowing a quantity of water to absorb heat faster than the same quantity of water put out by a sprinkler system.
2. The smaller particle size allows the particles to remain suspended in the air, where they are able to linger within the volume of the fire, which is a gas phase phenomenon, and more effectively extract heat from the primary chemical reaction. Droplets from a sprinkler system, on the other hand, fall through the fire, what heat they can along the way, and land on the surfaces under the fire. Once pooled on the ground, the sprinkler water can help prevent thermal damage to the surfaces but it has limited capacity to aid in extracting heat from the fire.
3. As the smaller particles of water fill the air, they displace some oxygen that would have fed the fire.
4. Water is good at absorbing infrared radiation (0.7-1000 μ m wavelength). At the typical temperature of most fires (approximately 1,000-2,000°F) most of the radiation from the fire is infrared radiation. This radiation absorption is a volumetric effect, meaning the more the water mist fills the air the greater the potential impact of this effect.

These characteristics of water mist systems allow them to use significantly less water than standard spray sprinkler systems.

The Plumis Automist system's mounting height, 4 feet away from the floor, allows it to direct its discharge of mist to reach the body of the fire without having to pass through the hotter upper layer of air and smoke that forms at the top of the room. The design intent behind this mounting height is to allow the mist to reach the fire at a lower temperature, improving its capacity to absorb heat from the fire. Excess mist is still able to be caught up in the updraft from the fire and provide cooling effects to the hot upper layer of air.

3.0 Equivalency Analysis

3.1 CODE ANALYSIS

IFC [2] Section 903.1.1 and NFPA 1 [13] Section 13.8 allow alternative automatic fire-extinguishing systems complying with IFC Section 904 or the standard detailed in NFPA 1 Table 13.8.1 to be permitted instead of automatic sprinkler system protection where recognized by the applicable standard and approved by the fire code official. This section identifies the similarities and differences between the requirements for one- and two-family dwellings as outlined in NFPA 13D (Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes) [3] and NFPA 750 (Standard on Water Mist Fire Protection Systems) [4]. Table 3-1 compares requirements between the two standards more granularly and Table A-1 summarizes these comparisons.

3.1.1 Scope and Intent

NFPA 13D is a residential sprinkler design standard focused on one- and two- family dwellings and manufactured homes; the intent is to provide an affordable sprinkler system in homes while maintaining a high level of life safety [3]. It is important to note that the purpose of NFPA 13D is to provide life safety only, and not property protection (as is the purpose of NFPA 13 and NFPA 13R).

Per NFPA 13D Section 1.2.2, the sprinkler system shall be designed and installed to prevent flashover in the room of fire origin and to improve the chance for occupants to escape or be evacuated. This section does not address water mist systems; however, Section 1.4.1 states the standard does not intend to restrict new technologies or alternate arrangements, provided the level of safety prescribed is not lowered.

Per NFPA 750 Section 1.2.3, the water mist system must be designed and installed in accordance with NFPA 750 to prevent flashover (total involvement) in the room of fire origin, where water mist nozzles are installed, and to improve the ability of occupants to escape or be evacuated. This section provides a similar intent of an NFPA 13D system. NFPA 750 does not provide specific guidance on how to design a system but offers minimum requirements the system design must achieve. The standard defers to product listings like that of the Plumis Automist system achieved through successful fire testing.

The Plumis Automist system is UL listed and intended “to provide a level of fire protection as described in NFPA 750, Water Mist Fire Protection Systems,” according to the guide information for the product category on UL Product iQ.

Both NFPA 13D and NFPA 750 systems are meant to be designed and installed to prevent flashover in the room of fire origin and to improve the chance for occupants to escape or be evacuated. The Plumis Automist System is designed to be in compliance with NFPA 750 for one- and two-family residences.

3.1.2 Sprinklers / Water Mist Nozzles

NFPA 13D Systems: Per NFPA 13D Section 5.1.2, all devices except those permitted by NFPA 13D Section 5.1.2.1 shall be listed. Per NFPA 13D Section 8.3.1, sprinklers shall be installed in all areas except where omission is permitted by NFPA 13D Sections 8.3.2 through 8.3.7. These exemptions are comparable to the exemptions of NFPA 13D systems with a few minor exceptions as listed in Table 3-1, namely the limiting volume of unprotected ceiling pockets and the omission of sprinklers in closets in garages, at the exterior, or in unheated secondary entranceways.

Per NFPA 13D Section 10.2.1, the design area for a sprinkler system shall be the most hydraulically demanding two sprinklers (or single sprinkler in a compartment) that correspond with each of the situations detailed in Table 3-1.

NFPA 750 Systems: Per NFPA 750 Section 6.6.1 and 10.3.2.5.3.1, nozzles shall be listed either individually or as part of a pre-engineered system. Per NFPA 750 Section 10.3.2.8.1.2, nozzles shall be installed in all areas except as permitted by NFPA 750 Sections 10.3.2.8.1.4 through 10.3.2.8.1.6, laid out in Table 3-1. These exemptions are comparable to the exemptions of NFPA 13D systems, with a minor exception. For NFPA 750 systems, the limiting volume of unprotected ceiling pockets is 100 ft³ per ceiling pocket given a minimum 10-foot spacing between ceiling pockets, whereas for NFPA 13D systems the limiting volume of unprotected ceiling pockets is 100 ft³ per compartment.

Per NFPA 750 Section 10.3.2.7.1, the number of design nozzles under flat, smooth, horizontal ceilings shall include all nozzles within a compartment, up to a maximum of two nozzles that require the greatest hydraulic

demand in accordance with the requirements of the listing. The Plumis Automist system has been tested by UL with compartment ceiling heights up to 8 feet high and specifies that it shall not be installed in rooms of different heights in the DIOM [12], though further fire testing has been conducted by the Baltic Fire Laboratory with ceiling heights up to 18 feet. It is outside the scope of this report to judge this testing.

Both water mist nozzles and sprinklers are required to be listed, and both have comparable installation location requirements in one- and two-family residences. Both have comparable exempt locations, though NFPA 13D offers more exempt locations. They both require up to two (2) design sprinklers to be considered in calculations, though NFPA 13D requires more types of layouts to be calculated than NFPA 750. The Plumis Automist system is pre-calculated and is not meant to be installed in any space with ceilings greater than 8 feet, which exclude many of the configurations outlined in NFPA 13D. Further fire testing has been completed with ceiling heights up to 18 feet, though providing an engineering judgement on this additional testing is beyond the scope of this report.

3.1.3 Water Supply

NFPA 13D Systems: Per Section 6.2, the water supply for a residential sprinkler system may be taken from:

- + A connection to a reliable waterworks system with or without an automatically operated pump,
- + An elevated tank
- + A pressure tank designed to American Society of Mechanical Engineers (ASME) standards for a pressure vessel with a reliable pressure source
- + A stored water source with an automatically operated pump
- + A well with a pump of sufficient capacity and pressure to meet the sprinkler system demand

Where using stored water as the sole source of supply, NFPA 13D Section 6.1.2 requires enough water to flow at the system demand rate for 10 minutes. This is the amount of time the pumps are required to run for during acceptance testing (Section 11.2.2.1.1), though there are no other explicit minimum system operation durations in NFPA 13D.

NFPA 13D systems have no specific requirements concerning fire department connections, except that if one is installed it shall be used to hydrostatically test the system to NFPA 13 standards.

NFPA 750 Systems: Per Section 12.5.1.1, the water supply for a water mist system shall be taken from a source that is equivalent in quality to a potable source with respect to particulate and dissolved solids or from a source of natural seawater. Due to the relatively smaller piping of NFPA 750 systems, they also require filters or strainers if their minimum waterway dimensions are less than 3/16 in (Section 12.5.1.4 and 12.5.1.5). The Plumis Automist system incorporates a strainer downstream of the pump and upstream of all nozzles.

Similar to NFPA 13D, per NFPA 750 Section 10.3.2.6.3 and 10.1.2.1.1 the pump shall flow water for at least 10 minutes. The amount of water available and whether a tank is provided is site specific and will need to be evaluated site by site for the Plumis Automist system.

NFPA 750 Section 12.5.5 requires a fire department connection (FDC) be installed for all water mist systems. The intent of this requirement, as described in NFPA 750 Section A12.5.5, is to provide an FDC wherever it would be of benefit. The intent of NFPA 13D is that the water supply provided for the system will allow occupants sufficient time to escape and that residential systems do not operate as manual fire suppression

systems for the fire department. Therefore, the FDC would not provide a benefit and it would not be the intent of NFPA 750 to require an FDC for an NFPA 13D system. However, an FDC may still be required by a local AHJ. Where an FDC is provided, it shall comply with strainer and filter requirements and shall be on the supply side of the system pump.

NFPA 13D details a number of different types of allowable water sources while NFPA 750 only requires the water be equivalent in quality to potable water and the use of filters or strainers to ensure minimal particulates. NFPA 13D does not require FDC's while NFPA 750 does for most cases. NFPA 13D requires 10 minutes of water flow stored if stored water is the only source of water, and any system pump is expected to run this long explicitly during acceptance testing. NFPA 750 is structured so the minimum required pump operation time is 10 minutes, not only explicitly during acceptance testing. Depending on the interpretation by the AHJ, this may require an NFPA 750 system to have more stringent requirements in terms of stored water and standby power for system pumps. Requirements for specific sites is out of scope of the Automist system but may be a site level requirement for any site where the product is installed.

3.1.4 Pump Systems

NFPA 13D Systems: Per Section 5.1.2(5), pumps for use in NFPA 13D systems are not required to be listed.

Per Section 6.2.1, where a pump is the source of pressure for the water supply for a fire sprinkler system but is not a portion of the domestic water system, the following shall be met:

- + A test connection shall be provided downstream of the pump that creates a flow of water equal to the smallest sprinkler K-factor on the system.
- + Pump motors using ac power shall be rated for 240 V and wired in accordance with the NEC (NFPA 70).
- + Any disconnecting means for the pump shall be approved.
- + The pump shall be located not less than 1-1/2 in. off the floor.

NFPA 750 Systems: Per Section 10.3.2.4.1, pumps for use in NFPA 750 systems are not required to be listed. Per Section 12.5.2.2(2), the pump is required to exceed the required flow rate demand of the system as determined by the hydraulic calculations by at least 10%.

Per NFPA 750 Section 10.3.2.6.4, where a pump and tank is the source of supply for a water mist system but is not a portion of the domestic water system, the following criteria shall be met:

- + A test connection shall be provided downstream of the pump that creates a flow of water equal to the smallest nozzle on the system and shall return water to the tank.
- + Pump motors using ac power shall be connected to a 240 V normal circuit.
- + Any disconnecting means for the pump shall be approved.
- + A method for refilling the tank shall be piped to the tank.
- + A method of seeing the water level in the tank shall be provided without having to open the tank.
- + The pump shall not be permitted to sit directly on the floor.

Of note, NFPA 13D differentiates between systems with a pump (NFPA 13D Section 6.2.1) and systems with a pump and tank (NFPA 13D Section 6.2.2), while NFPA 750 does not. By the letter of the code, it appears the requirements listed above are only valid if a pump and tank are used in conjunction for an NFPA 750 system, though that exclusivity may not have been the intent. The Plumis Automist system is compliant with the first two points, and the remaining points as applicable shall be coordinated at the site level.

Per NFPA 750 Section 12.5.2.3, discharge piping from water mist pumps and pump assemblies shall be equipped with valved test connection for the purpose connecting a flow metering device. Unlike NFPA 13D systems, the test connection is not required to be sized according to the smallest K-factor nozzle in the system, though the Plumis Automist system still meets this requirement from NFPA 13D by using the actual nozzles as test connections via a specialized attachment used during testing. Per NFPA 750 Section 12.5.2.4, electric pumps supplying water mist systems shall be supervised for pump running, loss of power, and phase reversal.

Neither NFPA 13D or NFPA 750 systems have a standby power requirement for pumps for one- and two-family dwellings. NFPA 750 Sections 6.10.2.2 and 8.9.2.3 require 24-hour standby for the operation of the detection, signaling, control, and actuation requirements of the system, though Section 10.3.2.3.1 states that system equipment designed and installed in accordance with NFPA 750 Section 10.3.2 (one- and two-family dwellings) shall not be required to comply with the requirements in NFPA 750 Chapters 6 through 9 unless required by the listing for the intended use. The Plumis Automist system has a standby battery that is sized to power the controller for 24 hours including the controller's display, alarms, and sounders. The controller will display the battery voltage and beep intermittently to notify the resident there is an AC power problem and the system is running from the battery. When the battery is low before the power is drained, the spray heads will move from the flush position to the locked inward position to give the resident a visual indication that a fault is present. This standby battery does not supply power to the pump.

NFPA 13D has a section defining the requirements of a system using a pump and a system using a pump in conjunction with a water tank, while NFPA 750 merges the requirements of these sections into a single section that is explicitly for systems with a pump and a water tank as a source. It is the interpretation of Jensen Hughes that these requirements are meant to be applied as applicable, whether a system has a tank, a pump, or both. The Plumis Automist system meets the requirements specific to pumps and test connections, while the remaining requirements may be a site level requirement for any site where the product is installed.

NFPA 13D systems and NFPA 750 systems intended for one- and two-family dwellings have no standby power requirements, though the requirements provided in Section 3.1.3 requiring the pump to be able to operate for 10 minutes may require a site to provide standby power for at least 10 minutes.

3.1.5 System Peripherals - Piping / Fittings / Valves / Hangers

NFPA 13D Systems: Per Section 5.1.2, valves, gauges, waterflow detection and notification devices, hangers, backflow prevention devices approved by the water authority, and water meters are not required to be listed.

Per Section 7.4, listed pipe shall be supported in accordance with any listing limitations and pipe that is not listed, and listed pipe with listing limitations that do not include piping support requirements, shall be supported from structural members using support methods comparable to those required by applicable local plumbing codes. Sprinkler piping shall be supported in a manner that prevents the movement of piping upon sprinkler operation.

NFPA 750 Systems: Per Section 10.3.2.4.1, hangers, waterflow detection devices, and waterflow valves shall be in accordance with manufacturers' requirements, but are not required to be listed.

Per Section 10.3.2.5.2, listed pipe shall be supported in accordance with any listing limitations and pipe that is not listed and listed pipe with listing limitations that do not include piping support requirements shall be supported from structural members using support methods in accordance with the design, installation, and operations manual. Unlike sprinkler piping which is required to be supported in a manner that prevents piping movement upon sprinkler activation, Section 10.3.2.5.3.3 instead requires water mist nozzles be supported in manner that prevents lateral and vertical movement of the nozzle itself, resulting in the same effect.

Neither NFPA 13D nor NFPA 750 requires most system peripherals to be listed. A minor distinction is made between supporting pipe adjacent to sprinklers to prevent movement on sprinkler activation and supporting the actual water mist nozzle itself to prevent lateral and vertical movement. All system peripherals are included in the listing for the Plumis Automist system, and the Automist nozzle is mounted in a way that prevents lateral and vertical movement.

3.1.6 Hydraulic Calculations

NFPA 13D Systems: Per Section 10.4.3, piping for NFPA 13D systems can be sized based on simplified calculations outlined in Section 10.4.4 (if the connection to the city main is at least 4 inches), a prescriptive method outlined in Section 10.4.9, the hydraulic calculation procedures from NFPA 13 (based on the Hazen–Williams formula for pipe friction losses), or by the manufacturer's listed installation instructions.

NFPA 750 Systems: Per Section 11.1.1, hydraulic calculations shall be performed using the procedures outlined in Section 11.2 utilizing the Darcy–Weisbach Calculation Method, though low pressure systems and systems with minimum pipe sizes greater than 16 mm may use the procedures outlined in Section 11.3 utilizing the Hazen–Williams calculation method.

NFPA 13D offers four calculation options for ensuring pipes are sized appropriately, while NFPA 750 provides a method that may be applicable to low pressure systems and systems with larger pipe diameters and a method applicable to higher pressure systems with smaller pipe diameters. The Plumis Automist system calculates the friction factor and pressure loss based on this method for higher pressure systems. At the site level, the installer needs to ensure the pump and water supply can exceed the required flow rate demand of the system as determined by the hydraulic calculations by at least 10% (See Section 3.1.4(2)).

3.1.7 System Acceptance

NFPA 13D Systems: Per Section 11.2, NFPA 13D systems have to undergo three primary types of test before acceptance:

- + Hydrostatic tests where the system must maintain system operating pressure if a pumper connection is not available or an elevated pressure defined by NFPA 13 Section 29.2.1 if a pumper connection is available without showing evidence of leaking or pressure loss in the system over a period of 2 hours.
- + A pump test where, upon opening the drain/test connection, the pump shall sense the flow, turn on, and flow water for the required duration, typically 10 minutes (NFPA 13D Section 6.1.2 or 6.1.3), without interruption.
- + System operational tests where any waterflow detection devices installed shall be flow tested through the inspector's test connection and shall result in an audible alarm on the premises. Additionally, where a dry

system is installed, a test shall be conducted to measure the time to trip the valve and the time for water to be discharged from the inspector's test connection.

NFPA 750 Systems: Per Section 14.2, NFPA 750 systems have to undergo a wider selection of system preparations and test before acceptance:

- + Flushing or cleaning of piping, including system piping, underground mains, and lead-in connections to water mist system piping.
- + Hydrostatic Tests where intermediate and high-pressure systems must maintain 1.5 times the working pressure for 10 minutes, followed by 110 minutes at the working pressure of the system without a drop in pressure or visible leakage.
- + In the case of dry and preaction systems, Air Tests at 40 PSI shall be conducted for 24 hours shall be conducted to ensure the leakage is no more than 1.5 PSI
- + A full visual review of components of both the hydraulic and electrical systems.
- + Preliminary Functional Tests focusing on all peripheral equipment, including detector responses, alarm sounding or displaying devices, remote annunciators, air-handling shutdown, and power shutdown.
- + A pump test where, upon opening the drain/test connection, the pump shall sense the flow, turn on, and flow water for the required duration, 10 minutes (NFPA 750 Section 10.1.2.1.1), without interruption.
- + System Operational Tests where, if a full flow is not possible, each test connection is flowed. All operating parts of the system shall be tested fully to ensure that they function as intended and are properly sequenced. After flow testing, all filters and strainers shall be inspected, and cleaned or replaced, as necessary.

The Plumis Automist system has its own commissioning procedure that aligns with parts of the NFPA 750 requirements. During commissioning:

- + The spray heads are addressed.
- + Spray head connection to the controller is tested.
- + Smoke detectors are set up.
- + Spray heads are flow tested.
- + The system is drained.
- + The IR sensors on each spray head are tested to ensure they can differentiate from a temperature of at least 6°C.

There are some differences between the Plumis Automist system's testing and the testing called for by NFPA 750, primarily due to technological differences. The Plumis system does not hold water in its pipes under typical conditions, so it foregoes the standard hydrostatic testing, instead checking for leaks during a 1-minute flow test of each nozzle. Instead of a single 10-minute pump flow test, every nozzle in the system (up to 10, see Table 2-1) for one minute.

NFPA 13D only requires a hydrostatic test where an FDC is installed, a pump test (as applicable), and a system operational test through the inspector's test connection. NFPA 750 requires a full system cleaning and flushing, a hydrostatic test at first 1.5 times system pressure then at system pressure, a

full visual inspection of all components, a preliminary functional test of all peripheral equipment, a pump test comparable to NFPA 13D, and a full operational test of each nozzle. NFPA 750 offers a more rigorous standard for system acceptance in general. The Plumis Automist system DIOM [12] details commissioning procedures unique to the Plumis Automist system. Hydrostatic testing and the 10-minute pump flow test are combined with the nozzle flow testing.

3.1.8 System Inspection, Testing, and Maintenance

NFPA 13D Systems: Per Section 12, the sprinkler system shall be inspected and tested periodically to make sure the system is in good working condition. NFPA 13D does not reference NFPA 25 for guidance on inspection, testing, and maintenance, and NFPA 25 explicitly states in Section 1.1.5 that NFPA 13D systems are not subject to the requirements of NFPA 25.

NFPA 13D required that any sprinkler that is operated, damaged, corroded, covered with foreign materials, or showing signs of leakage shall be replaced with a new listed sprinkler having the same performance characteristics as the original equipment. Additionally, sprinklers, listed escutcheons, and cover plates shall not be painted or decorated unless applied by the manufacturer.

NFPA 750 Systems: Per Section 15.1.2, a water mist system installed in one- and two-family dwellings shall be inspected, tested, and maintained in accordance with the instructions provided by the installer. The Plumis Automist system recommends annual inspection consisting of a visual inspection, smoke sensor tests, and recommissioning the spray heads.

NFPA 13D does not have strict requirements for system inspection, testing, and maintenance, while NFPA 750 points to manufacturer requirements. The Plumis Automist system recommends yearly inspections and maintenance including visual inspection, smoke sensor tests, and recommissioning the spray heads. Both NFPA 13D and the Plumis Automist DIOM prohibit painting of components.

3.1.9 NFPA 750 Systems Specifics

Per NFPA 750 Section 10.3.2.3.2, smoke alarms shall be provided in accordance with NFPA 72. The Plumis Automist system has smoke sensors for triggering their targeting nozzles.

Table 3-1: Code Requirements

<i>System/Requirement</i>	<i>NFPA 13D [3]</i>	<i>NFPA 750 [4]</i>
Sprinkler / Water Mist Nozzle		
Listing Requirements	Section 5.1.2 [P]: Required to be listed.	Sections 6.6.1 and 10.3.2.5.3.1 [P]: Required to be listed.
Exempt Locations	Section 8.3.2 [P]: Bathrooms less than 55 ft² Section 8.3.3 [P]: Clothes closets, linen closets, and pantries where all of the following apply: • That do not exceed 24 ft² • The walls and ceilings are surfaced with noncombustible or limited-combustible materials as defined in NFPA 220 • The closets without doors meet the definition of a compartment. (NFPA 13D 3.3.3) Section 8.3.4 [P]: Garages, open attached porches and balconies, carports, and similar structures. Section 8.3.5 [P]: Attics with or without storage, penthouse equipment rooms, elevator machine rooms, concealed spaces dedicated exclusively to and containing only dwelling unit ventilation equipment, floor/ceiling spaces, vertical chases, elevator shafts, crawl spaces, and other concealed spaces that are not used or intended for living purposes.	Section 10.3.2.8.1.3 [P]: Bathrooms less than 55 ft² Section 10.3.2.8.1.4 [P]: Clothes closets, linen closets, and pantries where all of the following apply: • That do not exceed 24 ft² • Where the least dimension does not exceed 3 ft The walls and ceilings are surfaced with noncombustible or limited-combustible materials as defined in NFPA 220 Section 10.3.2.8.1.5 [P]: Garages, open attached porches and balconies, carports, and similar structures. Section 10.3.2.8.1.6 [P]: Attics, penthouse equipment rooms, elevator machine rooms, concealed spaces dedicated exclusively to and containing only dwelling unit ventilation equipment, floor/ceiling spaces, elevator shafts, crawl spaces, and other concealed spaces that are not used or intended for living purposes.

<i>System/Requirement</i>	<i>NFPA 13D [3]</i>	<i>NFPA 750 [4]</i>
	Section 8.3.7 [P]: Ceiling pockets that meet the following conditions: • The total volume of all unprotected ceiling pockets in a compartment does not exceed 100 ft³. • The entire floor under the unprotected ceiling pocket is protected by sidewall or pendent sprinklers at the lower ceiling elevation. • The interior finish of the unprotected ceiling pocket excluding decorative treatments is noncombustible or limited-combustible material. • Skylights not exceeding 32 ft² shall be permitted to have a plastic cover.	Section 10.3.2.8.1.7 [P]: Ceiling pockets that meet the following conditions: • The total volume of unprotected ceiling pocket does not exceed 100 ft³ • The entire floor under the unprotected ceiling pocket is protected by the nozzles at the lower ceiling elevation. • Each unprotected ceiling pocket is separated from any adjacent unprotected ceiling pocket by a minimum 10 ft horizontal distance. • The interior finish of the unprotected ceiling pocket is noncombustible or limited-combustible material. • Skylights not exceeding 32 ft² shall be permitted to have a plastic cover.
	Section 8.3.8 [P]: Closets in garages and exterior closets (regardless of size) located on exterior balconies, exterior breezeways/corridors, or accessed from outdoors where the closet does not have doors or unprotected penetrations directly into the dwelling unit.	NA
	Section 8.3.6 [P]: Unheated enclosures at the building at entrances/exits as long as the dwelling unit has another entrance/exit.	NA

System/Requirement	NFPA 13D [3]	NFPA 750 [4]
Requirements around Fuel Equipment	- Where fuel-fired equipment is located above or on the same level but not within an occupied area of the dwelling unit, sprinkler protection shall not be required based on the presence of the fuel-fired equipment. - Where fuel-fired equipment is located within or beneath an occupied area of the dwelling unit, at least one quick-response or residential intermediate temperature sprinkler shall be installed above the equipment.	- Where fuel-fired equipment is above all of the occupied areas of the dwelling unit, no nozzles shall be required in the concealed space. - Where fuel-fired equipment is below or on the same level as occupied areas of the dwelling unit, at least one intermediate-temperature-rated nozzle shall be installed above the equipment or at the wall separating the space with the fuel-fired equipment from the occupied space.

**Design Sprinklers /
Nozzles**

Section 10.2.1 For each of the following situations, the number of sprinklers in the design area shall be all of the sprinklers within a compartment, up to a maximum of two sprinklers, that require the greatest hydraulic demand:

1. A flat, smooth, horizontal ceiling with no beams up to a maximum of 24 ft (7.3 m) above the floor.
 2. A flat, horizontal beamed ceiling, with a maximum ceiling height of 24 ft (7.3 m), with beams up to 14 in. (350 mm) deep with pendent sprinklers under the beams. The compartment containing the beamed ceiling shall be a maximum of 600 ft² (56 m²) in area. The highest sprinkler in the compartment shall be above all openings from the compartment into any communicating spaces.
 3. A smooth, flat, sloped ceiling with no beams up to a maximum slope of 8 in 12. The highest portion of the ceiling shall not be more than 24 ft (7.3 m) above the floor. The highest sprinkler in the sloped portion of the ceiling shall be above all openings from the compartment containing the sloped ceiling into any communicating spaces.
 4. A sloped ceiling with beams up to 14 in. (350 mm) deep with pendent sprinklers under the beams. The compartment containing the sloped, beamed ceiling shall be a maximum of 600 ft² (56 m²) in area. The slope of the ceiling shall be between 2 in 12 and 8 in 12. The highest portion of the ceiling shall not be more than 24 ft (7.3 m) above the floor. The highest sprinkler in
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Section 10.3.2.7.1 The number of design nozzles under flat, smooth, horizontal ceilings shall include all nozzles within a compartment, up to a maximum of two nozzles that require the greatest hydraulic demand in accordance with the requirements of the listing.

System/Requirement	NFPA 13D [3]	NFPA 750 [4]
	the sloped portion of the ceiling shall be above all openings from the compartment containing the sloped ceiling into any communicating spaces. A sloped ceiling with beams of any depth with sidewall or pendent sprinklers in each pocket formed by the beams. The compartment containing the sloped, beamed ceiling shall be a maximum of 600 ft² (56 m²) in area. The slope of the ceiling shall be between 2 in 12 and 8 in 12. The highest portion of the ceiling shall not be more than 24 ft (7.3 m) above the floor.	
Water Supply		
Source	Section 6.2: The following water supply sources shall be considered to be acceptable by this standard: - A connection to a reliable waterworks system with or without an automatically operated pump - An elevated tank - A pressure tank designed to American Society of Mechanical Engineers (ASME) standards for a pressure vessel with a reliable pressure source - A stored water source with an automatically operated pump - A well with a pump of sufficient capacity and pressure to meet the sprinkler system demand	Section 12.5.1.1: Unless the requirements of 12.5.1.2 or 12.5.1.3 are met, the water supply for a water mist system shall be taken from a source that is equivalent in quality to a potable source with respect to particulate and dissolved solids or from a source of natural seawater. NFPA 750 Sections 12.5.1.2 and 12.5.1.3 do not apply.

System/Requirement	NFPA 13D [3]	NFPA 750 [4]
Duration	Sections 6.1.2 and 6.1.3 [P]: Where stored water is used as the sole source of supply, the minimum quantity shall equal the water demand rate times 10 minutes unless the building is one story in height or less than 2000 ft², in which case the minimum quantity shall be permitted to equal the highest calculated water demand rate times 7 minutes.	Section 12.3.1 [P]: Design quantities of water, additives (if used), and atomizing media (if used) shall be capable of supplying the system in accordance with one of the following, as applicable: • A minimum duration of 30 minutes. • For pre-engineered systems, the design quantities of water, additives (if used), and atomizing media (if used) shall be capable of two complete discharges, or as required by the manufacturer's listing requirements, minimum 2 times the period to extinguish the fires during test, the rundown time of turbine, or the time necessary to secure fuel lines to the rotating equipment, whichever is greater. Section 10.3.2.6.3 and 10.1.2.1.1 [P]: The pump shall sense the flow, turn on, and flow water for the required duration of 10 minutes without interruption.

System/Requirement	NFPA 13D [3]	NFPA 750 [4]
Fire Department Connection	Section A.11.2.1: Fire department connections are not required for systems covered by this standard but can be installed at the discretion of the owner. In these cases, hydrostatic tests in accordance with NFPA 13 are necessary.	Section 12.5.5.1-12.5.5.5 [P]: A fire department connection shall be provided on all water mist systems, except for the following water mist systems: 1. Systems protecting less than 2000 ft². 2. Systems with design pressures in excess of 12 bar (175 psi) and supplied only by storage cylinders 3. Systems where the atomizing medium is essential for fire suppression The FDC shall comply with the strainer or filter requirements of NFPA 750 Section 12.5.1.5. and for water mist systems with system design pressures in excess of 12 bar (175 psi), the connection of the fire department connection to the system shall be made on the upstream (suction) side of the pressure source components.

<i>System/Requirement</i>	<i>NFPA 13D [3]</i>	<i>NFPA 750 [4]</i>
Warning Sign	Section 6.3.4: For multipurpose piping systems, a warning sign, with minimum 1/4 in. (6 mm) letters, shall be affixed adjacent to the main shutoff valve and shall state the following: WARNING: The water system for this home supplies fire sprinklers that require certain flows and pressures to fight a fire. Devices that restrict the flow or decrease the pressure or automatically shut off the water to the fire sprinkler system, such as water softeners, filtration systems, and automatic shutoff valves, shall not be added to this system without a review of the fire sprinkler system by a fire protection specialist. Do not remove this sign.	Section 10.3.2.6.9.3: For systems with common supply pipes, a warning sign, with minimum 6.4 mm (1/4 in.) letters, shall be affixed adjacent to the main shutoff valve and shall state the following: WARNING: The water system for this home supplies water mist nozzles that require certain flows and pressures to fight a fire. Devices that restrict the flow or decrease the pressure or automatically shut off the water to the water mist system, such as water softeners, filtration systems, and automatic shutoff valves, shall not be added to this system without a review of the water mist system by a fire protection specialist. Do not remove this sign.
Common Supply Pipes	Section 6.5.2: In common water supply connections serving more than one dwelling unit, 5 gpm (20 L/min) shall be added to the sprinkler system demand to determine the size of common piping and the size of the total water supply requirements where no provision is made to prevent flow into the domestic water system upon operation of a sprinkler.	Section 10.3.2.6.9.2: In common water supply connections serving more than one dwelling unit, and where no provision is made to prevent flow into the domestic water system upon activation of a nozzle, 19 L/min (5 gpm) shall be added to the water mist system demand to determine the size of common piping and the size of the total water supply requirements.
Pumps		
Listing Requirements	Section 5.1.2(5) [P]: Pumps are not required to be listed.	Section 10.3.2.4.1 [P]: Pumps in one- and two-family dwellings are not required to be listed.

<i>System/Requirement</i>	<i>NFPA 13D [3]</i>	<i>NFPA 750 [4]</i>
Pump as a source of pressure	Section 6.2.1: Where a pump is the source of pressure for the water supply for a fire sprinkler system but is not a portion of the domestic water system, the following shall be met: 1. A test connection shall be provided downstream of the pump that creates a flow of water equal to the smallest sprinkler K-factor on the system. 2. Pump motors using ac power shall be rated for 240 V and wired in accordance with the NEC (<i>NFPA 70</i>). 3. Any disconnecting means for the pump shall be approved. 4. The pump shall be located not less than 1 1/2 in. off the floor. Section 6.2.2: Where a pump and tank is the source of supply for a fire sprinkler system but is not a portion of the domestic water system, the requirements of 6.2.1 and the following shall be met: 1. The test connection shall return water to the tank. 2. A method for refilling the tank shall be piped to the tank. 3. A method of determining the water level in the tank shall be provided without having to open the tank.	Section 10.3.2.6.4: Where a pump and tank is the source of supply for a water mist system but is not a portion of the domestic water system, the following criteria shall be met: 1. A test connection shall be provided downstream of the pump that creates a flow of water equal to the smallest nozzle on the system and shall return water to the tank. 2. Pump motors using ac power shall be connected to a 240 V normal circuit. 3. Any disconnecting means for the pump shall be approved. 4. A method for refilling the tank shall be piped to the tank. 5. A method of seeing the water level in the tank shall be provided without having to open the tank. 6. The pump shall not be permitted to sit directly on the floor. *Note: NFPA 750 does not have a code section specific to only using a pump as a source of pressure for a one- or two- family home analogous to NFPA 13D Section 6.2.1. It may be up to the jurisdiction to decide how to interpret this section.

<i>System/Requirement</i>	<i>NFPA 13D [3]</i>	<i>NFPA 750 [4]</i>
Standby Power	There are no standby power requirements in NFPA 13D.	Sections 6.10.2.2 and 8.9.2.3: Approved primary and 24-hour minimum standby sources of energy shall be used to provide for the operation of the detection, signaling, control, and actuation requirements of the system. 10.3.2.3.1: System equipment designed and installed in accordance with 10.3.2 (one- and two-family dwellings) shall not be required to comply with the requirements in Chapters 6 through 9 unless required by the listing for the intended use. Section 10.3.2.6.3 and 10.1.2.1.1 [P]: The pump shall sense the flow, turn on, and flow water for the required duration of 10 minutes without interruption. Note: The sections in NFPA 13D analogous to 10.3.2.6.3 and 10.1.2.1.1 are specific to acceptance testing of systems where stored water is the sole source of water supply.
System Peripherals – Piping / Fittings / Valves / Hangers		
Listing Requirements	Section 5.1.2 [P]: Valves, gauges, waterflow detection and notification devices, hangers, backflow prevention devices approved by the water authority, and water meters are not required to be listed.	Section 10.3.2.4.1 [P]: Hangers, waterflow detection devices, and waterflow valves shall be in accordance with manufacturers' requirements, but are not required to be listed

System/Requirement	NFPA 13D [3]	NFPA 750 [4]
Pipe Support Requirements	Section 7.4 [P]: Listed pipe shall be supported in accordance with any listing limitations. Pipe that is not listed, and listed pipe with listing limitations that do not include piping support requirements, shall be supported from structural members using support methods comparable to those required by applicable local plumbing codes. Sprinkler piping shall be supported in a manner that prevents the movement of piping upon sprinkler operation.	Section 10.3.2.5.2 [P]: Listed pipe shall be supported in accordance with any listing limitations. Pipe that is not listed and listed pipe with listing limitations that do not include piping support requirements shall be supported from structural members using support methods in accordance with the design, installation, and operations manual. Nozzles shall be supported in manner that prevents lateral and vertical movement.

Hydraulic Calculations

Section 10.4.3 [P]: The pipes shall be sized using one of the following techniques:

- The simplified calculation method of 10.4.4, which can only be used for connections to a city water main of at least 4 in. (100 mm) in diameter
- The prescriptive pipe sizing method of 10.4.9
- The hydraulic calculation procedure for NFPA 13. (Hazen–Williams Calculation Method)
- The manufacturer's listed installation instructions

Section 10.1.1: The system shall provide at least the flow required to produce a minimum discharge density of 0.05 gpm/ft² (2.0 mm/min) or the sprinkler listing, whichever is greater, to the design sprinklers.

Section 11.1.1 [P]: System flow calculation procedures for water mist systems shall be in accordance with one of the following, as applicable:

- Hydraulic calculations shall be performed using the method provided in Section 11.2. (Darcy–Weisbach Calculation Method for Intermediate and High Pressure, Single Fluid, Single Liquid Phase Systems)
- Hydraulic calculations for systems with no additives and with working pressures not exceeding 12 bar (175 psi) shall be permitted to be performed utilizing either the method provided in Section 11.2 or the method provided in Section 11.3. (Hazen–Williams Calculation Method (Low-Pressure Systems))

Section 11.1.2: The minimum water demand requirements for engineered water mist systems shall be determined by adding concurrent water demands, if any, to the discharge rate and operating pressure of the system determined by hydraulic calculations conforming to this chapter.

Section 12.5.2.2: Electrical or diesel driven pumps supplying water mist systems shall be of sufficient capacity to exceed the system flow rate and pressure demands calculated by the hydraulic calculations as follows:

- (1) By a minimum of 10 percent in pressure and in flow rate for centrifugal pumps (See A.13.2.)
 - (2) By a minimum of 10 percent in flow rate for positive displacement pumps (See A.13.2.)
-

System/Requirement	NFPA 13D [3]	NFPA 750 [4]
System Acceptance		
Flushing or Cleaning of Piping.	NA	NFPA 750 Section 14.2.1 [P]: Where systems are connected to municipal or private water supplies, underground mains and lead-in connections to water mist system piping shall be flushed for a sufficient time to ensure thorough cleaning before connection is made to water mist piping. They shall be flushed at either the hydraulically calculated water demand rate of the system or the maximum flow rate available to the system under fire conditions. The piping network shall be free of particulate matter and oil residue before installation of nozzles or discharge devices. Each pipe section shall be internally cleaned prior to installation using an acceptable method as required by the manufacturer and Each pipe or tube section shall be inspected internally after preparation and before assembly.

<i>System/Requirement</i>	<i>NFPA 13D [3]</i>	<i>NFPA 750 [4]</i>
Hydrostatic Tests.	NFPA 13D Section 11.2.1 [P]: If the system has a fire department pumper connection then it shall be tested according to NFPA 13. (NFPA 13D Section 11.2.1) The testing pressure shall be 200 psi or 50 psi greater than the system working pressure, whichever is higher. If a fire pump is used in the system, the test pressure shall be the shutoff pressure of the pump. (NFPA 13 Section 29.2.1) If a pumper connection is not provided it shall be tested at system operating pressure. Evidence of leakage shall be determined by a drop in pressure at a gauge over a period of 2 hours or by visually checking the piping system for leakage.	NFPA 750 Section 14.2.2 [P]: The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested. Water used for testing shall be filtered or strained Intermediate and high pressure systems shall be permitted to be hydrostatically tested to 1.5 times the working pressure for 10 minutes, followed by 110 minutes at the working pressure without pressure loss in conformance with the ASME B31.1, Power Piping Code. A drop in pressure or visible leakage shall indicate pressure loss.
Air Tests.	NA	NFPA 750 Section 14.2.3 [P]: For dry and preaction systems, an air pressure leakage test at 2.8 bar (40 psi) shall be conducted for 24 hours in addition to the standard hydrostatic test, and any leakage that results in a loss of pressure in excess of 0.1 bar (1.5 psi) during the 24 hours shall be corrected.
Review of Components.	NA	NFPA 750 Section 14.2.4 [P]: A full visual inspection of the hydraulic and electrical components of the system shall be performed.

<i>System/Requirement</i>	<i>NFPA 13D [3]</i>	<i>NFPA 750 [4]</i>
Preliminary Functional Tests.	NA	NFPA 750 Section 14.2.5 [P]: Each detector shall be checked for proper response. All auxiliary functions such as alarm sounding or displaying devices, remote annunciators, air-handling shutdown, and power shutdown shall be checked for intended operation in accordance with system requirements and design specifications.
Pump Tests.	NFPA 13D Section 11.2.2 [P]: A system utilizing a pump shall be tested by opening the drain/test connection. The pump shall sense the flow, turn on, and flow water for the required duration, typically 10 minutes (NFPA 13D Section 6.1.2 or 6.1.3), without interruption.	NFPA 750 Section 10.3.2.6.2 [P]: A system utilizing a pump shall be tested by opening the drain/test connection. The pump shall sense the flow, turn on, and flow water for required duration, 10 minutes (NFPA 750 Section 10.1.2.1.1), without interruption.
System Operational Tests.	NFPA 13D Section 11.2.3 [P]: Where waterflow detection devices are installed, these devices, including the associated alarm circuits, shall be flow tested through the inspector's test connection and shall result in an audible alarm on the premises. Where a dry system is installed, a test shall be conducted in accordance with the valve manufacturer's instructions to measure the time to trip the valve and the time for water to be discharged from the inspector's test connection. All times shall be measured from the time the inspector's test connection is completely open.	NFPA 750 Section 14.2.6 [P]: If a full flow test is not possible, the connection to the water supply shall be permitted to be verified by flowing water from each test connection. All operating parts of the system shall be tested fully to ensure that they function as intended and are properly sequenced. After flow testing, all filters and strainers shall be inspected, and cleaned or replaced, as necessary.

System/Requirement	NFPA 13D [3]	NFPA 750 [4]
Inspection, Testing, and Maintenance	NFPA 13D Section 12 [P]: The sprinkler system shall be inspected and tested periodically to make sure the system is in good working condition. Any sprinkler that is operated, damaged, corroded, covered with foreign materials, or showing signs of leakage shall be replaced with a new listed sprinkler having the same performance characteristics as the original equipment. Sprinklers, listed escutcheons, and cover plates shall not be painted or decorated unless applied by the manufacturer.	NFPA 750 Section 15.1.2: A water mist system installed in one- and two-family dwellings shall be inspected, tested, and maintained in accordance with the instructions provided by the installer.

[P] = Paraphrased

3.2 TESTING REQUIREMENTS

One of the most widely recognized types of listing is the Underwriters Laboratories (UL) listing. To be UL listed, a product or system must undergo rigorous testing outlined in the UL standard applicable to that product. The UL standards associated with sprinklers, water mist nozzles, and the Plumis Automist system are laid out below in Table 3-2. The testing requirements of each standard will be discussed in this section. It should be noted, but UL 199 and UL 2167A are specific to the sprinkler or water mist nozzle, while UL 2167A outlines the testing requirements for the full Plumis Automist system. All three standards include a fire test that has comparable requirements.

Table 3-2: UL Requirements for Sprinklers, Water Mist Nozzles, and the Plumis Automist System

Component/System	UL Standard	UL Standard Title
Sprinkler	UL 199 [5]	Automatic Sprinklers for Fire-Protection Service
Water Mist Nozzle	UL 2167 [6]	Water Mist Nozzles for Fire Protection Service
Plumis Automist System	UL 2167A [7]	UL LLC Outline of Investigation for Targeting Water Mist System Units for One- and Two-Family Dwellings for Fire Protection Service

In both NFPA 13D and NFPA 750 systems meant for use in one- and two-family dwellings it should be noted that many components are exempt from being listed, save the actual sprinklers or water mist nozzles. Many components common to both types of systems including tanks, pumps, filters, hangers, waterflow detection devices, and waterflow valves are exempt from being listed. The Plumis Automist system is a listed system, and as such all major components of the system are a part of the UL listing, including the nozzle, strainer, control unit, smoke detector, valves and drains, and the pump and its motor.

3.2.1 Component Testing

The only components comparable between the three testing standards are the sprinklers and the water mist nozzles, and UL 2167A references UL 2167 for water head nozzle requirements. This section explains the component testing requirements for sprinklers and the water mist nozzles and then dive into the remaining subsystems outlined in the UL 2167A standard. As will be outlined below, most tests and requirements for sprinklers have direct analogs for water mist nozzles. Many of these tests are unapplicable to the Plumis Automist system as they are intended to test the heat responsive element of a typical sprinkler or water mist nozzle, which the Plumis Automist nozzles do not utilize.

3.2.1.1 Nozzles/sprinklers

Common Tests: A majority of the tests described in the standards are common to all systems:

- + **Exposure Tests On Nozzles Incorporating Polymeric Gaskets** – After each of the exposures listed below, each sample nozzle must then operate as intended at the minimum operating pressure within 5 seconds upon application of heat.
- **Corrosive Exposures** - Three groups of five samples are exposed to either 20% salt spray, hydrogen sulfide, or carbon dioxide-sulfur dioxide for 30 days.

- **Temperature Cycling Exposure** - Five samples are exposed to ten temperature cycles, each comprised of a 24-hour exposure to a low temperature of -40°C (-40°F) and a 24-hour exposure to a high temperature determined by the nozzle's or sprinkler's temperature rating.
- **Hydrocarbon Exposure Followed by Moist Air Exposure** – Two groups of five samples are to be exposed to a liquid mixture of saturated hydrocarbon chains ranging from C12 to C17 or a solid wax mixture of saturated hydrocarbon chains ranging from C18 to C25. Both groups of samples are then to be conditioned at 70 ±10°F (21 ±5.6°C) for a minimum of 72 hours. After these exposures, the samples are then to be subjected to the 90 day moist air test specified below with the sample installed in the pendent position and the hydrocarbon mixtures left in the inlet. Before the final operation test, these samples shall be examined for leakage for one minute.
- **Hydrocarbon Exposure Followed by Water Immersion Exposure** – Two groups of five samples are to be exposed to a liquid mixture of saturated hydrocarbon chains ranging from C12 to C17 or a solid wax mixture of saturated hydrocarbon chains ranging from C18 to C25. Both groups of samples are then to be conditioned at 70 ±10°F (21 ±5.6°C) for a minimum of 72 hours. The samples are then installed on a manifold and hydrostatically pressurized to a pressure value of 25 psig less than the rated pressure (or the maximum standby pressure for water mist nozzles rated at 500 psi or greater) and immersed for 90 days in tap water maintained at a temperature of 87 ±2°C (189 ±3°F). After 30 and 60 days, the hydrostatic pressure is to be released and then repressurized to a pressure value of 25 psig less than the rated pressure. (Or the maximum standby pressure for nozzles rated at 500 psi or greater) Before the final operation test, these samples shall be examined for leakage for one minute.
- + **Operating Temperature Test** – Nozzles and sprinklers are tested to show they open within 3.5% of their rated temperature. The Plumis Automist system relies on a smoke detector and thermal imaging cameras, so this test is unnecessary.
- + **Discharge Coefficient Test / Calibration Test** – The K-factor relating flow and pressure for a given nozzle or sprinkler is confirmed to be within 5% of its rated value for sprinklers and within 10% of its rated value for water mist nozzles.
- + **Water Distribution Test** – 1-ft by 1-ft pans are used to ensure the distribution of water produced by a sprinkler or water mist nozzle meets the required density throughout the area. The water distributions observed in these tests are used to size the rooms the fire tests, and changes of discharge patterns seen with changes in operating pressures help determine when additional fire tests may be necessary.
- + **Function Test / Operation – Lodgment** - Nozzles and sprinklers are tested to ensure any released parts are cleared within 5 seconds of activation when activated over a range of pressures. The Plumis Automist nozzle does not have any components that are released upon activation.
- + **Deflector/Orifice Assembly Test / Flow Endurance Test** – Nozzles and sprinklers are flowed for an extended period of time to ensure there is no evidence of cracking, deformation, or separation of any parts.
 - Water mist nozzles are tested at 125% of their operating pressure for at least 15 minutes
 - Sprinklers are tested at 200 psi for 30 minutes.
- + **Body Strength Test / Strength of Frame Test** – The nozzles and sprinklers are tested to ensure they do not show distortion of more than 0.2% of the distance between bearing points when subjected to loading equivalent to twice the rated hydrostatic pressure.

- + **Strength of Glass Bulb Elements / Fusible Elements** – The nozzles and sprinklers are tested to ensure their heat responsive elements (glass bulbs or heat responsive elements) are able to withstand their design load. The Plumis Automist nozzle does not have an applicable heat responsive element.
- + **Leak Resistance** - The nozzles and sprinklers are tested to ensure they can withstand approximately double their rated pressure without leakage. Sprinklers are held at this elevated pressure for 1 minute and water mist nozzles are held at this elevated pressure for 3 minutes.
- + **Hydrostatic Strength** - The nozzles and sprinklers are tested at higher pressures to ensure they do not rupture, operate, or release any parts.
 - Sprinklers and nozzles rated to less than 500 psi are tested at four times their rated pressure for 1 minute
 - Water mist nozzles rated greater than 500 psi, including the Plumis Automist nozzle, are tested at twice their rated pressures.
- + **Heat Exposure / High Temperature - Test For Uncoated Sprinklers** - Nozzles and sprinklers with heat responsive elements are tested at an elevated temperature (typically 20 °F less than their nominal operating temperature but at least 120 °F) for a period of 90 days. The Plumis Automist nozzle does not have an applicable heat responsive element.
- + **Thermal Shock** - Nozzles and sprinklers with glass bulbs are exposed to a rapid increase in temperature to ensure they do not break or fracture. The Plumis Automist nozzle does not have an applicable heat responsive element.
- + **Corrosion Tests** – Nozzles and sprinklers are subjected to 10 days of exposure to salt spray, hydrogen sulfide, and carbon dioxide-sulfur dioxide atmospheres.
 - Water mist nozzles, the Plumis nozzle included, then undergo a combination of leak tests, hydrostatic test, and functional test.
 - Sprinklers undergo a sensitivity test (described below) to make sure their response time of their heat reactive element does not change.
- + **Moist air exposure / 90-day Moist Air Test** – Nozzles and sprinklers are subjected to 98% humidity and a temperature of 203°F for 90 days and shall be shown to operate as required at their specified minimum operating pressure.
- + **Dezincification Test of Brass Parts** - Nozzles and sprinklers made of a copper alloy containing more than 15 percent zinc and normally exposed to system water are exposed to a copper chloride solution for 144 hours and ensured not to show dezincification depths exceeding 0.0079 or an average dezincification depth of 0.0039 in.
- + **Integrity of Nozzle / Sprinkler Coatings** - Nozzles and sprinklers and their wax coatings are tested to ensure they can be maintained through temperature swings without flaking, peeling, or ablating.
 - **Resistance to high temperature / High Temperature - Test For Wax Coated Sprinklers** - Nozzles and sprinklers are maintained at temperatures approximately 20°F less than their operating temperatures for 90 an observed for any signs of cracking, flaking, or flowing of the wax coating.

- **Evaporation of wax and bitumen used for atmospheric protection of nozzles / Evaporation Test For Sprinkler Coatings** - 50 milliliter samples of the protective coating are subject to 90 days as described in the prior test and shall be shown not to lose more than 5% of its starting mass.
- **Resistance to low temperatures** – Water mist nozzles exclusively are subjected to a 24-hour cycle of 14 °F followed by 30 minutes of normal ambient temperatures and their coating shall be shown not to crack or flake.
- + **Water Hammer** - The nozzles and sprinklers are exposed to 3,000 cycles of pressure swings from approximately 50 psi to at the pressure specified in the leak resistance test. The nozzles and sprinklers shall not leak during this process.
 - Water mist nozzles are then made sure they work as intended at their minimum operational pressure
 - Sprinklers are tested to ensure they do not leak after one (1) minute at the pressure required for leakage testing.
- + **Impact Test for Protective Covers** - Nozzles and sprinklers with glass bulbs are struck by a weight of mass falling directly onto them to ensure they do not break or fracture. The Plumis Automist nozzle does not have an applicable heat responsive element.
- + **Dynamic Heating / Plunge Test / Sensitivity Test / Oven heat test** – The Response Time Index (RTI), a metric of how quickly a sprinkler's or water mist nozzle's heat responsive element triggers during a fire, is determined using the Plunge test / Oven Heat Test. During the dynamic heating test and Sensitivity test the RTI is shown not to exceed 250% of its rated value at a 25 degree angular offset. The Plumis Automist nozzle does not have an applicable heat responsive element.
- + **Vibration Test** – The nozzles and sprinklers are exposed to a range of frequencies from 5 to 40 Hz for Water mist nozzles and from 18 to 37 Hz for sprinklers, stopping for 120 hours at any resonant frequencies. If no resonant frequencies are found, then the test will last for 120 hours.
 - Water mist nozzles are then subjected to the leakage tests and the functional tests defined above
 - Sprinklers are put through the leakage test and the oven Heat Test also defined above.
- + **Rough Usage Test** – The nozzles and sprinklers are placed in a tumbler along with hardwood cubes and tumbled at 1 revolution per second for 3 minutes and are subjected to a leakage test and a sensitivity test again to ensure proper function is maintained.
- + **Impact Test** – The nozzles and sprinklers are held in place as a weight of approximately their mass is dropped onto them. Following this impact, they are inspected for cracks, breaks, or other deficiencies; then both undergo a leakage test followed by an oven heat test for sprinklers and a Function test for water mist nozzles.
- + **Lateral Discharge** – The nozzles and sprinklers are tested to ensure the operation of a nozzle or sprinkler does not prevent the triggering of adjacent nozzles or sprinklers. The Plumis Automist nozzle does not have an applicable heat responsive element that would require this type of test.
- + **Thirty-Day Leakage Resistance** - The nozzles and sprinklers are tested at an increased pressure for 30 days.
 - Water mist nozzles are tested at twice their rated pressure
 - Sprinklers are tested at 50 to 100 psi less than twice their rated pressure.

- + **Vacuum Resistance** - The nozzles and sprinklers are tested at a decreased pressure of -8.84 psig for 1 minute and then subjected to a Leakage Test.
- + **Freezing Test** - The nozzles and sprinklers are subjected to -20°F for 24 hours. If they do not leak at their minimum functional pressure then they are subjected to the Leak Resistance test and Dynamic Heating / Sensitivity test.

UL 2167 and UL 2167A Specific Tests: Some tests are specific to water mist nozzles due to their smaller orifice size and the intentionality behind droplet size for water mist systems.

- + **Water Droplet Size and Velocity** – The water droplet size distribution is to be measured at the minimum and maximum rated nozzle pressures.
- + **Clogging Test** - The water mist nozzle shall remain within 10% of its intended value after being exposed to 30 minutes' flow of water at 232 psi with pipe scale, top soil, and sand contaminants up to 0.7mm in size.

UL 2167A Specific Tests: UL 2167A is specific to targeting water mist units which use a combination of smoke detectors in the room for activation and heat detection on the nozzles to target the fire, so the product must also be subjected to pertinent tests from UL 217 for Smoke Alarms.

3.2.1.2 System Peripherals

UL 2167A describes the requirements for a full targeting water mist system, requiring all other components to undergo testing. Most components shall undergo a combination of tests described in applicable UL standards, as outlined in Table 3-3. The pump, the full hydraulic system, and any polymeric functional parts also have testing specified below that are particular to UL 2167A.

Pump – The UL 2167A pump specific tests are meant to define its operational parameters.

- + **Hydraulic Performance Test** – The pump is tested at the minimum and maximum outlet pressures specified by the manufacturer. The flow, suction pressure, and pump speed or voltage and frequency are measured. The pump shall develop the nominal flow and pressure required for the nozzles to discharge water appropriately. Testing a range of suction pressures may be necessary.
- + **Endurance Test** – The pump shall be run for 24 hours at the rated voltage or speed without performance degradation, motor overheating, or physical damage.
- + **Normal Temperature Test** – The pump is operated under the operating condition that will maximize its power use until the pump temperature reaches steady state.
- + **Determination of Maximum Overpressure** – The pump is to be run with all outputs blocked and the outlet pressure is measured.

Hydrostatic Strength Tests – The pump and any unit device is to be filled with water and held at twice the maximum overpressure for one minute without any leakage or rupturing.

Polymeric Functional Parts – Aging Tests – Polymeric functional parts are to be put under the conditions listed below before being subjected to either the Hydraulic Performance Test if the part is in the pump assembly or the Hydrostatic Strength Test otherwise.

- + **Air Oven Aging** – The sample shall be held at 212°F for 180 days.

- + **Water Aging** – The sample shall be held in 188°F distilled water for 180 days.

Table 3-3: UL 2167A Peripheral System Testing Requirements

<i>Subsystem</i>	<i>UL Standard / Tests</i>
Smoke Detector	UL 268 Standard for Smoke Detectors for Fire Alarm Systems All Applicable (6 th edition for fire testing and the most recent edition of other tests)
System Control Valve	UL 268 Standard for Shutoff Valves for Trim and Drain Purposes for Fire Protection All Applicable
Strainer	UL 321 Outline of Investigation for Pipeline Strainers Leakage and hydrostatic tests based on the maximum permitted pressure and friction loss based on anticipated flows.
Electric Solenoid Valves	UL 1739, Standard for Pilot-Operated Pressure-Control Valves for Fire-Protection Services Operation Test and one Year Seat Leakage Test
	UL 985 Standard for Household Fire Warning System Units
	UL 864 Standard for Control Units and Accessories for Fire Alarm Systems
Unit Control	UL 218 Standard for Fire Pump Controllers All Applicable Releasing Service Operation Test, Trouble Signal Operation Test, Abnormal Operation Test All Applicable, except Electromagnetic Compatibility (EMC) requirements. (specific to the power circuitry of the pumping control unit)
Pump	UL 1004-1 Rotating Electrical Machines - General Requirements UL 2111 Standard for Overheating Protection for Motors ANSI/ASME B1.20.1 Standard for Pipe Threads, General Purpose UL 1776 Standard for High Pressure Cleaning Machines All Applicable For thermal protection, impedance protection, or whichever equivalent form of protection is provided. All Applicable (May substitute other national or international pipe thread standard) Shall comply with Normal Temperature Test requirements.

3.2.2 Fire Testing

To prove capability, the Automist system has been tested and listed to UL 2167A which assesses the system performance through a series of 17 fire tests. Compliance requires the temperatures in the test room to be managed below certain temperature thresholds. In this series of tests, the fuel loads varied between tests and included mock sofas at different locations within the room with a plywood wall, the UL standard water mist nozzle and residential sprinkler fuel package, cooking oil, and the standard fuel package with drapes. The tests with the most challenging conditions are repeated with obstructions between the nozzle and fire source. The repeated tests must comply with the same performance requirements as the tests conducted without the obstruction. The system was able to meet performance requirements, prevent compartment flashover, and received the UL listing.

This section will compare the basic requirements of the UL fire tests used for sprinklers, water mist nozzles, and the Plumis Automist system. The test requirements are almost the same, across the three UL certifications, with some minor differences that are expanded on below. Plumis Automist heads are wall mounted, so for a closer comparison only tests regarding sidewall sprinklers and sidewall water mist nozzles in residential applications are discussed.

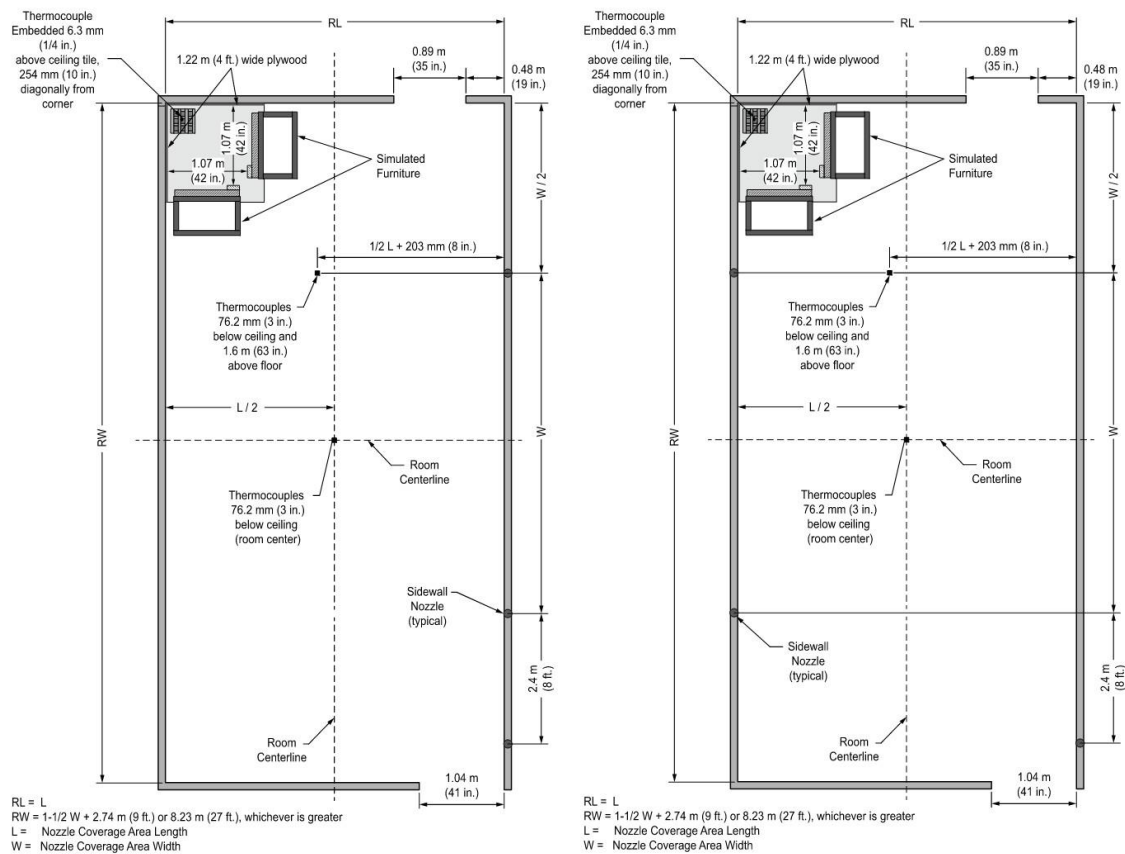
Table 3-4 lists the base requirements for test room dimensions, the number of sprinklers, water mist nozzles, and the temperature requirements that must be maintained throughout the test. Following that is a discussion of how the number of sprinklers or water mist nozzles and the dimension of the test room inform the listed spacing requirements, followed by how the temperature requirements ensure the intents of both NFPA 13D and NFPA 750 are met.

Table 3-4: Residential Fire Testing Requirements

	UL 199 [5]	UL 2167 [6]	UL2167A [7]
Room Dimension	The test room dimensions for sidewall sprinklers are to be the rated sprinkler coverage length by 1-1/2 times the rated sprinkler coverage width plus 9 feet by a nominal 8 ft high ceiling.	Tests shall be conducted in a test room having dimensions as specified in Figure 47.1 for pendent style nozzles and Figure 47.2 and Figure 47.3 for sidewall style nozzles. RL=L RW = 1-1/2 *W+9ft or 27 ft, whichever is greater L = Nozzle Coverage Length W=Nozzle Coverage Width	Tests shall be conducted in a test room having dimensions as indicated in Figure 23.15 that are based upon the fire detection and nozzle coverage limitations. The small room shall have dimensions to evaluate the fire test performance using the minimum number of nozzles and detectors. The large room shall have dimensions as indicated in Figure 23.16 to require the installation of not less than four nozzles to evaluate the performance of the system unit's algorithm to select and discharge water from a nozzle or nozzles that effectively attack the fire to comply with the requirements in 23.1.1 ¹
	Nominal 8 ft Ceiling Height	Minimum 8 ft ceiling, maximum specified by the manufacturer.	Nominal 8 ft Ceiling Height ³
	A maximum of two residential sprinklers shall operate.	Discharge from no more than one nozzle.	Discharge from no more than one nozzle or maximum number of nozzles if the unit is designed to discharge from two or more nozzles simultaneously. ¹

	<i>UL 199 [5]</i>	<i>UL 2167 [6]</i>	<i>UL2167A [7]</i>
Temperature Requirement 1 (Flashover Prevention)	The maximum temperature 3 inches (76 mm) below the ceiling at either location as illustrated in Figure55.6 – Figure55.8 shall not exceed 600°F (316°C).	The maximum temperature 76 mm (3 inches) below the ceiling at either location as illustrated in Figure47.1 – Figure47.3 shall not exceed 316°C (600°F).	The maximum temperature 3 inches (76 mm) below the ceiling at the center of the room shall not exceed 600°F (316°C).
Temperature Requirement 2 (Life Safety)	The maximum temperature 5-1/4 feet (1.6 m) above the floor shall not exceed 93°C(200°F).	The maximum temperature at the location 1.6 m (63 inches) above the floor shall not exceed 93°C(200°F).	The maximum temperature at the location 63 inches (1.6 m) above the floor as illustrated in Figure 23.1 shall be permitted to exceed 200°F (93°C) at only one of the two locations;
Temperature Requirement 3 (Life Safety)	The temperature at the location described in (b) shall not exceed 54 °C (130 °F) for more than any continuous 2-minute period	The temperature at the location described in (b) shall not exceed 54 °C (130 °F) for more than any continuous 2-minute period	The temperature at the location described in (b) shall not exceed 130 °F (54 °C) for more than any continuous 2-minute period at only one of the two locations.
Temperature Requirement 4 (Flashover Prevention)	The maximum ceiling material temperature 0.25 inches (6 mm) behind the finished ceiling surface shall not exceed 500°F (260°C).	The maximum ceiling material temperature 6 mm (0.25 inches) behind the finished ceiling surface directly over the center of the wood crib shall not exceed 260°C(500°F).	The maximum ceiling material temperature 0.25 inches (6 mm) behind the finished ceiling surface directly over ignition as illustrated in Figure 23.1 shall not exceed 500°F (260°C).

1. Plumis Automist System tested with a 15 ft x 26 ft x 8 ft room with a single nozzle, and an 18 ft x 38 ft x 8 ft room with 4 nozzles.
2. The wording within this table is the exact wording of the UL standards. All figure and section numbers in this table reference figures and sections in the respective standard.
3. Testing of higher ceiling heights may be requested.



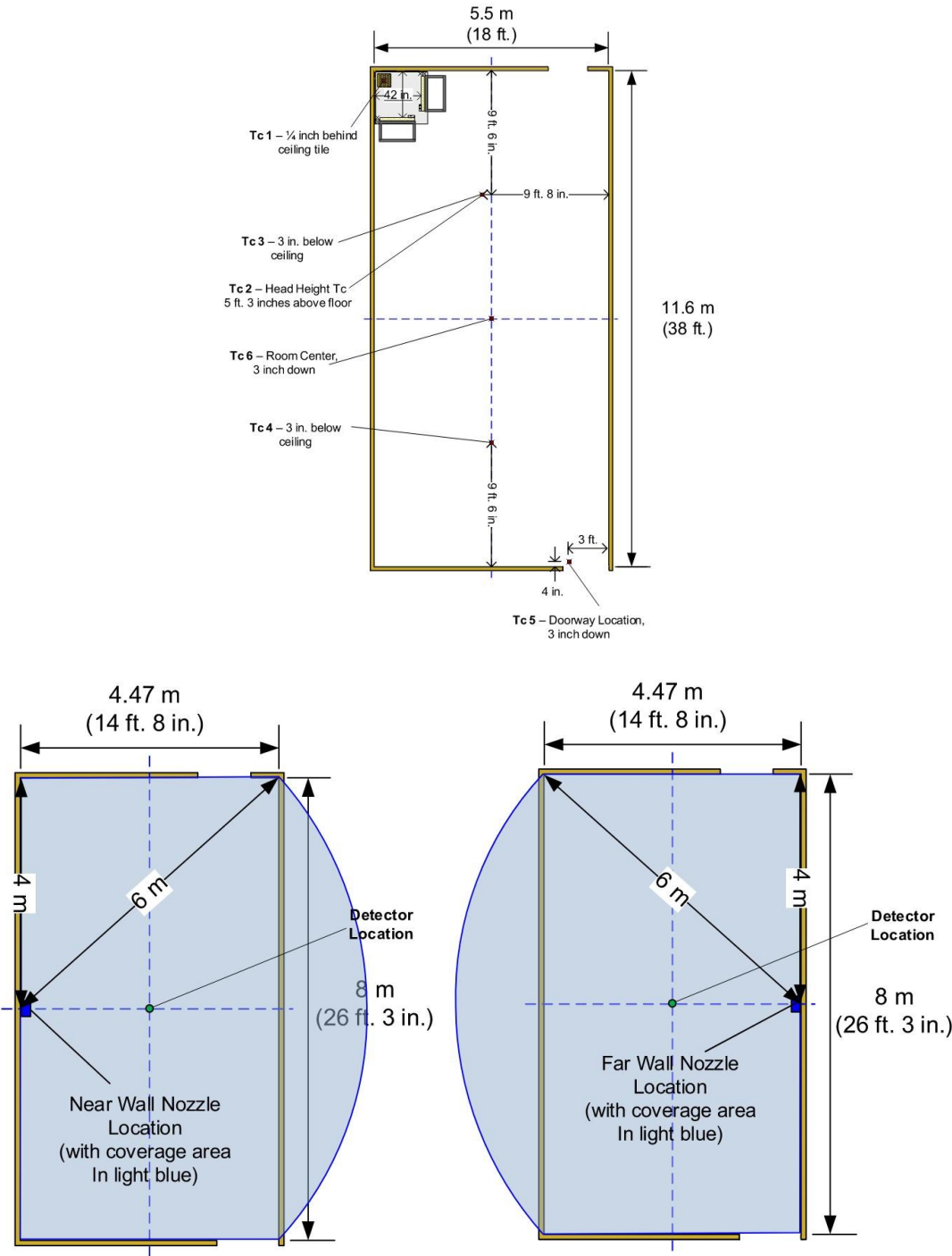


Figure 3-2: Residential Fire Testing Setups - UL 2167A – Small Room [11]

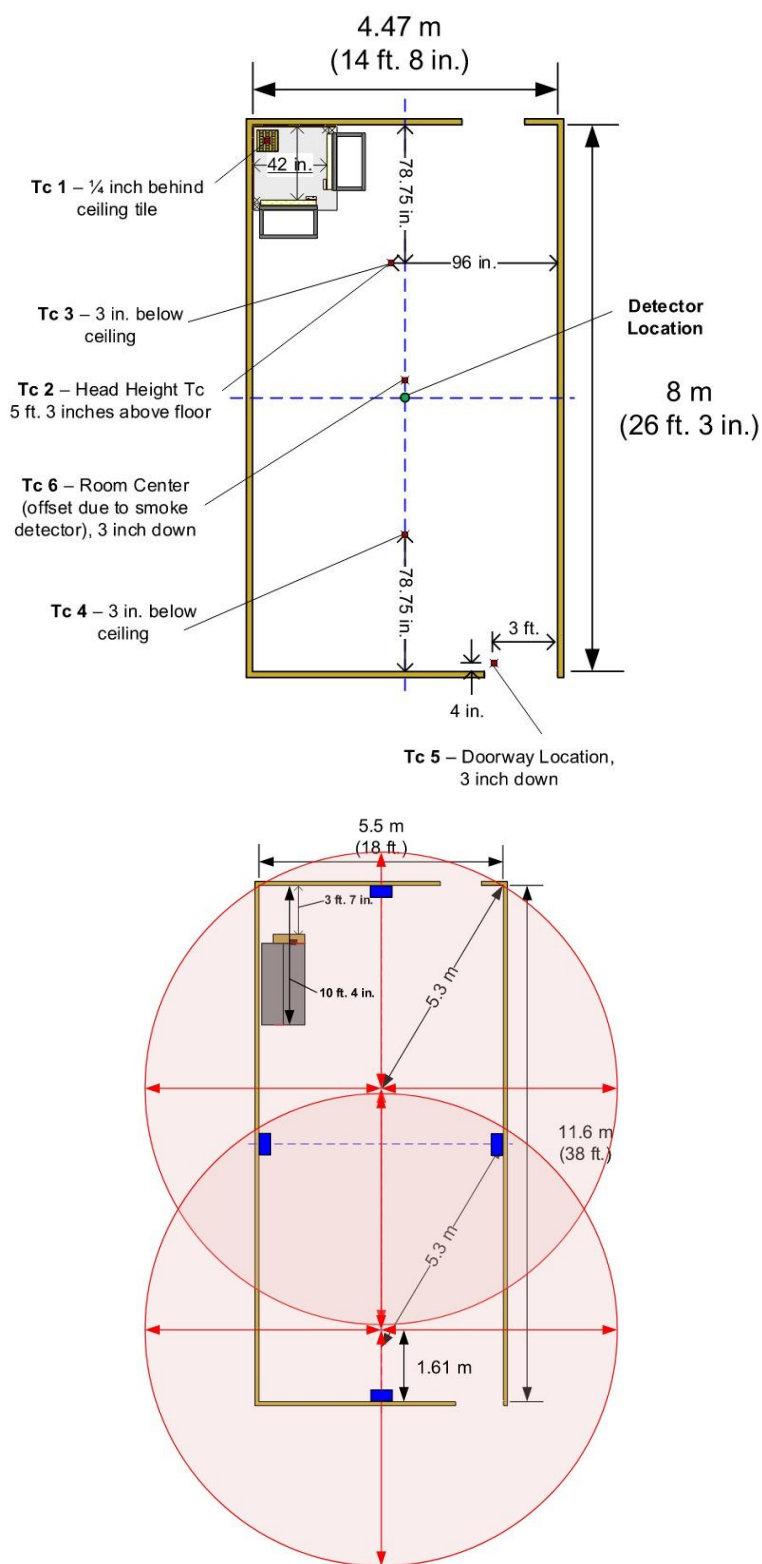


Figure 3-3: Residential Fire Testing Setups - UL 2167A – Large Room [11]

3.2.2.1 Number of Sprinklers/Nozzles

The number and placement of sidewall sprinklers, sidewall water mist nozzles, and Plumis Automist nozzles are the driving factors behind the test room dimensions and instrumentation placement. In testing for both sidewall sprinklers and sidewall water mist nozzles three sprinklers or nozzles are installed, two spaced their rated spray width away from each other and one mounted another 8 feet down the wall in line with the door. During a test for sidewall sprinklers two of the three sprinklers are allowed to trigger, while only one nozzle is allowed to trigger during a test for sidewall water mist nozzles.

Testing for Plumis Automist (UL 2167A) has two base configurations: a small room with a single Plumis Automist nozzle centered in a long wall, and a larger room with a nozzle centered in each of the four walls of the test chamber. The wording of the requirement makes it sound like any number of nozzles may trigger in the test with the larger room, though during actual testing only the nozzle closest to the fire was activated.

3.2.2.2 Room Dimensions

Test room dimensions are derived from the maximum spacing requirements as defined by the sprinkler or water mist nozzle manufacturers. Sprinkler and water mist nozzle manufacturers list their heads and nozzles based on the length and width of their throw, assuming a rectangular area. Plumis lists their head based on the width of throw and a radius centered at the head. (See Figure 3-2)

The testing room for both sidewall sprinklers and sidewall water mist nozzles is sized based on the rated spray width and length. The room width is the rated throw length of the sprinkler or nozzle, while the room length is one and a half times the rated throw width of the sprinkler or nozzle plus an additional 9 feet. (See Figure 3-1) This is meant to emulate the worst case spacing the sprinklers or nozzles are likely to see based on their manufacturer's spacing requirements.

UL 2167A specifies two room sizes: one room sized to evaluate the performance of the minimum number of nozzles and detectors, and one room with a minimum of four nozzles sized to evaluate the performance of the system unit's algorithm to select and discharge water from a nozzle or nozzles that effectively attack the fire. This results in one room sized based on the throw width and radius of nozzle and one room based on the maximum radius of a system smoke detector. (See Figure 3-3)

3.2.2.3 Flashover Prevention and Life Safety

The intent behind both NFPA 13D sprinkler systems and NFPA 750 water mist systems is to prevent flashover (the ignition of all combustible materials in an enclosed area) of the fire and to maintain a high level of life safety within the room of fire origin long enough for occupants to escape. All three tests have similar temperature requirements at different locations to ensure the intent is met. Any system with a UL 199, 2167, or 2167A certification have met all these criteria for the spacing they are listed for.

Flashover Prevention

The first temperature criterion requires the thermocouple in line with the sprinkler or water mist/Automist nozzle closest to the fire does not see temperatures above 600°F (588°K), and the final temperature criteria is that the temperature measured above the ceiling above the fire does not exceed 500°F. These requirements ensure the system prevents flashover and the spread of fire to adjacent areas (above the ceiling). According to fire protection engineering literature [10], the onset of flashover occurs when the upper layer temperature reaches around 935-1115°F (775-875°K), which is where chemical kinetics promote oxidation reactions. A comparable

rule of thumb is that a radiant heat flux of 20 kW/m² can indicate the onset of flashover, which correlates to an upper layer temperature of approximately 985°F (802°K). The first and last temperature requirements ensure the upper layer temperature and the temperature of the compartment above the fire will be maintained below 75% of the absolute temperature range indicative of the start of flashover.

Life Safety

The second temperature criterion requires (a) thermocouple(s) 5-¼ feet above the floor to not see temperatures above 200°F, and the third temperature criteria requires the same thermocouple(s) to not see temperatures above 130°F for longer than 2 minutes. All test setups have one of these thermocouples in line with the sprinkler or water mist nozzle, though due on the geometry of the test the UL 2167A test also has a thermocouple approximately where the comparable thermocouple would be for a sidewall sprinkler or water mist nozzle would be (1/4 of the length of the test room from the short wall closest the fire). These requirements ensure the occupants are able to escape the compartment of the fire.

Evaluation of the effects of exposure to radiant heat is more straightforward since its effects are external and physical in nature, including pain, redness, and burns. The results of several research projects provide data that indicates the limiting heat flux of approximately 2.5 kW/m², which corresponds to an upper layer temperature of approximately 400°F (204°C) for a typical room fire. The second temperature criterion ensures the temperature remains below 75% of the absolute temperature where radiant heat can cause serious skin pain.

Fires produce large amounts of water vapor due to the combustion process and sprinkler or water mist activation. Fire protection engineering literature [10] indicates 140°F (60°C) is the highest temperature at which 100% humidity air can be breathed. The third criterion ensures the air around head height in the room does not remain unbreathable for a sustained period.

4.0 Conclusions

The code analysis shows that the intents of both codes are the same, many areas of the code requirements for one- and two-family dwellings call for components to be in compliance with manufacturer specifications rather than giving specific requirements, and most minor differences between the two codes are either due to the structure of the code or technology specific considerations, e.g. filters and water quality consideration for water mist systems due to their relatively smaller orifice sizes. These differences are presented in Table A-1.

A few requirements for water mist systems are not in the scope of the Plumis Automist system as it is listed and may need to be addressed for each site, including the following:

- + Providing a warning sign on a common supply pipe required by NFPA 750 Section 10.3.2.6.9.3.
- + Showing that the available water supply and pump can exceed the required flow of the system (2.37 GPM) by at least 10 percent in accordance with NFPA 750 Section 12.5.2.2(2).

The Plumis Automist system has its own testing procedure tailored to it that fully assesses system performance and ensures the system is ready to perform as intended. It is at the discretion of the AHJ whether or not to incorporate a hydrostatic test and a longer pump flow test as outlined in NFPA 750 Sections 14.2.2 and 10.1.2.1.1.

The Plumis Automist system has been tested by UL with flat compartment ceiling heights up to 8 feet high and specifies that it shall not be installed in rooms with ceilings above this height in the DIOM [12], though further fire testing has been conducted by the Baltic Fire Laboratory with flat ceiling heights up to 18 feet. [15][16] It is

outside the scope of this report to judge this testing. As such, flat ceiling heights up to 8 ft is the limit of the application without further analysis.

The Plumis Automist system meets or exceeds all other applicable requirements in NFPA 750 for a water mist system in one- or two-family dwelling. Most components within a water mist system for one- or two-family dwellings are not required to be listed, although all functional components of the Plumis Automist system are included as part of the UL listing, which requires these components to be performance tested. The Plumis Automist system meets the intent of NFPA 750 and NFPA 13D to prevent flashover in the room of fire origin and to improve the ability of occupants to escape or be evacuated.

5.0 References

The following references were used in the development of this report:

1. ICC, 2024 *International Building Code, IBC*.
2. ICC, 2024 *International Fire Code, IFC*.
3. NFPA 13D, 2025 Edition: *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.
4. NFPA 750, 2027 Edition: *Standard on Water Mist Fire Protection Systems*.
5. Underwriters Laboratories (UL), 2025, *UL 199: Automatic Sprinklers for Fire-Protection Service*
6. UL, 2021, *UL 2167: Water Mist Nozzles for Fire Protection Service*
7. UL, 2025, *UL 2167A: UL LLC Outline of Investigation for Targeting Water Mist System Units for One- and Two-Family Dwellings for Fire Protection Service*
8. O'Connor, Brian. "Water Mist Systems Overview: NFPA." Nfpa.Org, National Fire Protection Association, 24 June 2022, www.nfpa.org/news-blogs-and-articles/blogs/2022/06/24/water-mist-systems-overview.
9. Klotz, Milke, Turnbull, Kashef, Phillips, Evans, Webb, and Roth ; *Handbook of Smoke Control Engineering* 2nd Edition; ASHRAE; 2024, page 158.
10. *The SFPE Handbook of Fire Protection Engineering ,5th Edition*, edited by Morgan J. Hurley, P.E.; et al., Society of Fire Protection Engineers, Quincy, MA (2016), pg.2380-2382.
11. Plumis Automist UL 2167A Fire Testing Report "*Letter Report – PI Fire Testing Project 4790418313 – Final*"
12. Plumis Automist DIOM "*Automist Design Installation & Operation Manual US Version v1.1*"
13. NFPA 1, 2024 Edition: *Fire Code*
14. Plumis Automist UL 2167A "*Certificate of Compliance*" Certificate # UL-US-2440774-0

Appendix A : Code Analysis Summary

Table A-1: Code Comparison Overview

System/Requirement	Identical / Different / Interpretation Dependent ² / Not Applicable ¹	Comment (NC=No Comment)
Sprinkler / Water Mist Nozzle		
Listing Requirements	Identical	NC The exemption of sprinklers/nozzles for clothes closets, linen closets, and pantries is contingent on the least dimension not exceeding 3 feet for NFPA 750 systems and a closet without doors meeting the requirements of a compartment for NFPA 13D systems. For NFPA 750 systems the limiting volume of unprotected ceiling pockets is 100 ft ³ per ceiling pocket given a minimum 10-foot spacing between ceiling pockets, whereas for NFPA 13D systems the limiting volume of unprotected ceiling pockets is 100 ft ³ per compartment.
Exempt Locations	Different (Minor)	NFPA 13D has two more locations exempt from sprinklers: • Closets in garages and exterior and in unheated • Unheated secondary entranceways. In the case of the first two exceptions, it is unclear the impact of the differences on the level of protection provided. The final exemption, which is NFPA 13D exclusive, means NFPA 750 provides a higher level of protection in those instances.
Requirements around Fuel Equipment	Different (Minor)	

<i>System/Requirement</i>	<i>Identical / Different / Interpretation Dependent² / Not Applicable¹</i>	<i>Comment (NC=No Comment)</i>
Design Sprinklers / Nozzles	Different (Minor)	Sprinkler systems require design sprinklers to be considered for a wider variety of configurations beside simple flat ceilings. For a standard water mist system, this may provide a lower level of protection, but the Plumis Automist system is only listed for use in spaces with 8-foot ceilings which will likely not have any of the more complicated geometries listed in NFPA 13D Section 10.2.1.

<i>System/Requirement</i>	<i>Identical / Different / Interpretation Dependent² / Not Applicable¹</i>	<i>Comment (NC=No Comment)</i>
Water Supply		
Source	Different (Minor) / Not Applicable	NFPA 750 specifies a minimum water quality rather than specific sources, while NFPA 13D specifies more specific sources rather than water quality This does not impact level of protection. Out of the scope of the Plumis Automist System. ¹
Duration	Different (Minor) / Not Applicable	NFPA 13D specifies that if stored water is the sole source of water, the minimum amount of water stored shall be enough to supply the system for 10 minutes (or 7 minutes if the building is one story or less than 2000 ft ²). This duration is then the required length of pump operation solely during acceptance testing. NFPA 750 has two relevant requirements. - There shall be enough water to supply the system for at least 30 minutes. - The pump shall sense the flow, turn on, and flow water for the required duration of 10 minutes without interruption. In this instance, NFPA 750 provides a higher level of protection. How it is structured, what is a flow requirement during acceptance testing and for systems with storage tanks in NFPA 13D if a general requirement for NFPA 750 systems in one- and two- family residences. Out of the scope of the Plumis Automist System. ¹
Fire Department Connection	Different / Not Applicable	NFPA 750 systems typically require an FDC, while NFPA 13D systems do not, though there are provisions if they are installed. Out of the scope of the Plumis Automist System. ¹
Warning Sign	Different (Minor) / Not Applicable	NFPA 750 systems require a warning sign for common supply pipes, while NFPA 13D systems require warning signs on multipurpose piping systems. These are effectively the same. This does not impact level of protection. Out of the scope of the Plumis Automist System. ¹

<i>System/Requirement</i>	<i>Identical / Different / Interpretation Dependent² / Not Applicable¹</i>	<i>Comment (NC=No Comment)</i>
Common Supply Pipes	Identical / Not Applicable	Out of the scope of the Plumis Automist System. ¹
Pumps		
Listing Requirements	Identical	NC
		NFPA 750 does not have a code section specific to only using a pump as a source of pressure for a one- or two- family home analogous to NFPA 13D Section 6.2.1. It may be up to the jurisdiction to decide how to interpret NFPA 750 Section 10.3.2.6.4, which appears specific to systems that use a pump in conjunction with a water storage tank.
Pump as a source of pressure	Different (Minor) / Interpretation Dependent	As the code is written, NFPA 13D offers a higher level of protection regarding the disconnecting means for the pump. Otherwise the provisions of this section do not effect the level of protection. The Plumis Automist system meets the first two requirements of both sections, and the remaining points are out of the scope of the Plumis Automist System and may be required by the AHJ. ¹
Standby Power	Different / Interpretation Dependent / Not Applicable	NFPA 13D does not require standby power. The sections of NFPA 750 that require 24-hour standby power for the operation of the detection, signaling, control, and actuation requirements of the system are overridden by NFPA 750 Section 10.3.2.3.1. This does not impact level of protection. Out of the scope of the Plumis Automist System. ¹

<i>System/Requirement</i>	<i>Identical / Different / Interpretation Dependent² / Not Applicable¹</i>	<i>Comment (NC=No Comment)</i>
Hydraulic Calculations	Different	NFPA 13D offers four (4) calculation options for ensuring pipes are sized appropriately, while NFPA 750 provides a method that may be applicable to low pressure systems and systems with larger pipe diameters and a method applicable to higher pressure systems with smaller pipe diameters. The Plumis Automist system calculates the friction factor and pressure loss based on this method for higher pressure systems. At the site level, the installer needs to ensure the pump and water supply can exceed the required flow rate demand of the system as determined by the hydraulic calculations by at least 10% (See Section 3.1.4). Plumis recommends a minimum water supply pressure and flow for their sites in their DIOM. It is recommended showing that this allows their pump the 10% buffer called for in the code.
System Peripherals – Piping / Fittings / Valves / Hangers		
Listing Requirements	Identical	NC
Pipe Support Requirements	Different (Minor)	NFPA 13D specifies supporting the pipe to prevent its movement upon sprinkler operation. NFPA 750 specifies supporting the water mist nozzle itself. This does not impact the level of protection.

<i>System/Requirement</i>	<i>Identical / Different / Interpretation Dependent² / Not Applicable¹</i>	<i>Comment (NC=No Comment)</i>
System Acceptance		
Flushing or Cleaning of Piping.	Different	An NFPA 750 requirement. Specifies the flushing or cleaning of piping, including system piping, underground mains, and lead-in connections to water mist system piping. This does not impact the level of protection.
Hydrostatic Tests.	Different (Minor)	Where an FDC is present, an NFPA 13D system is hydrostatically tested for 2 hours at at least 200 psi. If an FDC is not present, then the system shall be tested at its standard operating pressure. FDC's are not required, so testing to system pressure is more likely. NFPA 750 systems are tested at 1.5 times their operating pressure for 10 minutes then at their operating pressure for 110 minutes. The Plumis Automist pressure range is from 1102 to 1450 psi, so it needs to be tested at 2,175 psi for 10 minutes and then 1450 psi for 110 minutes. NFPA 750 offers a more stringent standard, as many water mist systems are at higher pressures than standard sprinkler systems.
Air Tests.	Different / Not Applicable	An NFPA 13D requirement specific to dry and preaction systems. Not applicable to the Plumis Automist System.
Review of Components.	Different	An NFPA 750 requirement. Specifies a full visual review of components of both the hydraulic and electrical systems. NFPA 750 offers a more stringent standard.
Preliminary Functional Tests.	Different	An NFPA 750 requirement. focusing on all peripheral equipment, including detector responses, alarm sounding or displaying devices, remote annunciators, air-handling shutdown, and power shutdown. This does not impact the level of protection as these systems are not a part of NFPA 13D systems.
Pump Tests.	Identical	NC

<i>System/Requirement</i>	<i>Identical / Different / Interpretation Dependent² / Not Applicable¹</i>	<i>Comment (NC=No Comment)</i>
System Operational Tests.	Different (Minor)	NFPA 13D only requires testing through the inspector's test connection to show the audible flow alarm triggers, while NFPA 750 requires a full flow test or a flow test for each test connection. For the Plumis Automist system, the nozzles operate as test connections. NFPA 750 offers a more stringent standard.
Inspection, Testing, and Maintenance	Different	NFPA 750 requires a system be inspected, tested, and maintained in accordance with the instructions provided by the installer while NFPA 13D simply says it should be inspected and tested periodically without pointing to any source of authority. NFPA 13D does provide some more guidance towards replacing sprinklers and not painting them. The Plumis Automist system recommends annual inspection consisting of a visual inspection, smoke sensor tests, and recommissioning the spray heads. NFPA 750, more specifically the Plumis Automist system, may offer a more stringent standard.

1. "Out of the scope of the Plumis Automist System" and "Not Applicable" means it is not applicable to the Plumis Automist system as listed. The requirement may still need to be met at the site level..
2. "Interpretation Dependent" requirements may depend on the AHJ's interpretation of the code.