

# NFPA 750 Standard on Water Mist Fire Protection Systems

2000 Edition



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An International Codes and Standards Organization

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## NFPA 750

### Standard on

## Water Mist Fire Protection Systems

### 2000 Edition

This edition of NFPA 750, *Standard on Water Mist Fire Protection Systems*, was prepared by the Technical Committee on Water Mist Fire Suppression Systems and acted on by the National Fire Protection Association, Inc., at its November Meeting held November 14–17, 1999, in New Orleans, LA. It was issued by the Standards Council on January 14, 2000, with an effective date of February 11, 2000, and supersedes all previous editions.

This edition of NFPA 750 was approved as an American National Standard on February 11, 2000.

### Origin and Development of NFPA 750

In 1993, representatives from the research and engineering communities, water mist system manufacturers, the insurance industry, enforcement authorities, and industrial users met and organized the NFPA Technical Committee on Water Mist Fire Suppression Systems. The committee started work on developing a new NFPA document that would begin to standardize water mist technology and provide for reliable design and installation of these systems.

Water mist systems were introduced in the 1940s and were utilized for specific applications such as on passenger ferries. The renewed interest in water systems is due partially to the phasing out of halon and their potential as a fire safety system for spaces where the amount of water that can be stored or that can be discharged is limited. In addition, their application and effectiveness for residential occupancies, flammable liquids storage facilities, and electrical equipment spaces continues to be investigated with encouraging results.

NFPA 750 contains elements that are similar to standards on other types of fire protection systems such as automatic sprinklers, fixed water spray, carbon dioxide, and halon. In many ways, water mist can be thought of as a hybrid of these systems. Overall, water mist systems utilize water as the extinguishing, suppression, or control medium, but do so in a nontraditional manner. In developing this standard, the committee addressed system components and hardware, system types, installation requirements, design objectives, hazard classifications, calculations, water supplies, atomizing media, plans, documentation, acceptance criteria, and maintenance considerations.

The 2000 edition of NFPA 750 represents a significant advancement in water mist technology and the knowledge base associated with its application. This edition includes a new definition for Water Mist and a complete rewrite and reorganization of Chapter 5, Design Objectives and Fire Test Protocols. Additionally, many new sections were added to address the design and safety considerations associated with positive displacement water mist pumps. New guidance has been provided for the measurement of the water mist spray characteristics including drop distribution. Finally, two new appendixes were added to address many of the current and proposed fire test protocols and the reliability of water mist systems.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

**Committee Scope:** This Committee shall have primary responsibility for documents on the design, installation, and maintenance of systems which use a water mist for the control, suppression or extinguishment of fire.

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## NFPA 750

## Standard on

## Water Mist Fire Protection Systems

## 2000 Edition

NOTICE: An asterisk (\*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Information on referenced publications can be found in Chapter 12 and Appendix E.

## Chapter 1 General Information

**1-1\* Scope.** This standard contains the minimum requirements for the design, installation, maintenance, and testing of water mist fire protection systems. This standard does not provide definitive fire performance criteria nor does it offer specific guidance on how to design a system to control, suppress, or extinguish a fire. Reliance is placed on the procurement and installation of listed water mist equipment or systems that have demonstrated performance in fire tests as part of a listing process.

**1-2\* Purpose.** The purpose of this standard is to provide protection for life and property from fire through the standardization of design, installation, maintenance, and testing requirements for water-based fire suppression systems that use a specific spray (mist) that absorbs heat, displaces oxygen, or blocks radiant heat to control, suppress, or extinguish fires as required by the application. This standard shall establish minimum requirements for water mist technology based on sound engineering principles, test data, and field experience. Nothing in this standard is intended to restrict new technologies or alternate arrangements, provided the level of safety prescribed by this standard is not lowered. Materials or devices not specifically designated by this standard shall be utilized in accordance with all conditions, requirements, and limitations of their listings.

**1-3 Retroactivity Clause.** The provisions of this document are considered necessary to provide a reasonable level of protection from loss of life and property from fire. They reflect situations and the state of the art at the time the standard was issued.

Unless otherwise noted, it is not intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of this document.

*Exception: In those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or property, this standard shall apply.*

## 1-4 Definitions.

**1-4.1\* Approved.** Acceptable to the authority having jurisdiction.

**1-4.2 Atomizing Media, Water Mist.** Compressed air or other gases that produce water mist by mechanical mixing with water.

**1-4.3\* Authority Having Jurisdiction.** The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

**1-4.4 Deluge System.** A water mist system using open nozzles attached to a piping system that is connected to a water supply through a valve that is opened by means of a detection system installed in the same area as the mist nozzles. When the valve opens, water flows into the piping system and discharges through all nozzles attached to the system.

**1-4.5\*  $D_{vf}$ .** A drop diameter such that the cumulative volume, from zero diameter to this respective diameter, is the fraction,  $f$ , of the corresponding sum of the total distribution.

**1-4.6 Enclosure.** The case, housing, partition, or walls that will substantially contain water mist in the vicinity of the hazard for a sufficient length of time to achieve the fire protection objectives.

**1-4.7 Fire Control.** The limitation of the growth of a fire by prewetting adjacent combustibles and controlling ceiling gas temperatures to prevent structural damage.

**1-4.8 Fire Extinguishment.** The complete suppression of a fire until there are no burning combustibles.

**1-4.9 Fire Suppression.** The sharp reduction of the rate of heat release of a fire and the prevention of regrowth.

**1-4.10 High Pressure System.** A water mist system where the distribution system piping is exposed to pressures of 500 psi (34.5 bar) or greater.

**1-4.11 Intermediate Pressure System.** A water mist system where the distribution system piping is exposed to pressures greater than 175 psi (12.1 bar) but less than 500 psi (34.5 bar).

**1-4.12\* Listed.** Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

**1-4.13 Low Pressure System.** A water mist system where the distribution piping is exposed to pressures of 175 psi (12.1 bar) or less.

**1-4.14 Shall.** Indicates a mandatory requirement.

**1-4.15\* Shall be Considered.** Requires an objective assessment, the results and basis of which are documented, to determine to what extent the specific factor, criterion, guideline, standard, etc., is incorporated into or satisfied by the design.

**1-4.16 Should.** Indicates a recommendation or that which is advised but not required.

**1-4.17 Single-Fluid System.** A water mist system utilizing a single piping system to supply each nozzle.

**1-4.18 Standard.** A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

**1-4.19 Total Compartment Application System.** A system designed to discharge water mist to protect all hazards in an enclosure.

**1-4.20 Twin-Fluid System.** A water mist system in which water and atomizing media are separately supplied to and mixed at the water mist nozzle.

**1-4.21\* Water Mist.** A water spray for which the  $Dv_{0.99}$ , for the flow-weighted cumulative volumetric distribution of water droplets, is less than 1000 microns at the minimum design operating pressure of the water mist nozzle. (See A-2-6.1.)

**1-4.22 Water Mist Nozzle.** A special purpose device, containing one or more orifices, designed to produce and deliver a water spray meeting either the definition of Water Mist or meeting the specific requirements of an approved water mist fire test protocol. (See Appendix C.)

**1-4.22.1 Water Mist Nozzles, Automatic.** Nozzles that operate independently of other nozzles by means of a detection/activation device built into the nozzle.

**1-4.22.2\* Water Mist Nozzles, Hybrid.** Nozzles capable of operation using both automatic and nonautomatic means.

**1-4.22.3 Water Mist Nozzles (Open), Nonautomatic.** Nozzles that operate as an entire system or grouping of nozzles, containing open orifices and activating the water flow to the nozzles by an independent detection system.

**1-4.23 Water Mist System.** A distribution system connected to a water supply or water and atomizing media supplies, that is equipped with one or more nozzles capable of delivering water mist intended to control, suppress, or extinguish fires and that has been demonstrated to meet the performance requirements of its listing and this standard.

**1-4.23.1 Water Mist System, Dry Pipe.** 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.

**1-4.23.2 Water Mist System, Engineered.** Those systems that need individual calculation and design to determine the flow rates, nozzle pressures, pipe size, area, or volume protected by each nozzle, discharge density of water mist, the number and types of nozzles, and the nozzle placement in a specific system.

**1-4.23.3 Water Mist System, Local-Application.** A water mist system arranged to discharge directly on an object or hazard in an enclosed, unenclosed, or open outdoor condition.

**1-4.23.4 Water Mist System, Preaction.** A water mist system using automatic nozzles attached to a piping system that contain air that might or might not be under pressure, with a supplemental detection system installed in the same areas as the mist nozzles. The actuation of the detection system opens a valve that allows water to flow into the piping system and discharges through all opened nozzles in the system.

**1-4.23.5\* Water Mist System, Pre-engineered.** Those systems having predetermined flow rates, nozzle pressures, and water quantities.

**1-4.23.6 Water Mist System, Wet Pipe.** 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.

**1-4.24 Zoned Application System.** A system designed to protect hazards in a predetermined portion of an enclosure.

## 1-5 Units.

**1-5.1\*** Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). Liter and bar units are outside of but recognized by SI and are commonly used in international fire protection. These units are provided with their conversion factors in Table 1-5.1.

**Table 1-5.1 Metric Conversion Factors**

Name of Unit	Unit Symbol	Conversion Factor
Millimeter	mm	1 in. = 25.4 mm
Square meter	m <sup>2</sup>	1 ft <sup>2</sup> = 0.0929 m <sup>2</sup>
Liter	L	1 gal = 3.785 L
Cubic decimeter	dm <sup>3</sup>	1 gal = 3.785 dm <sup>3</sup>
Cubic meter	m <sup>3</sup>	1 ft <sup>3</sup> = 0.028317 m <sup>3</sup>
Kilogram	kg	1 lb = 0.4536 kg
Kilograms per cubic meter	kg/m <sup>3</sup>	1 lb/ft <sup>3</sup> = 16.0183 kg/m <sup>3</sup>
Pascal	Pa	1 psi = 6895 Pa
Bar	bar	1 psi = 0.0689 bar
Bar	bar	1 bar = 10 <sup>5</sup> Pa
Liter per minute per square meter	L/min/m <sup>2</sup>	1 gpm = 40.746 L/min/m <sup>2</sup>
Micron	μ	1 mm = 1000μ (1000 microns)

**1-5.2** If a value for a measurement provided in this standard is followed by an equivalent value in other units, the first stated value shall be regarded as the requirement. A given equivalent value shall be considered an approximate value.

## 1-6\* General.

**1-6.1** A water mist system is a fire protection system using very fine water sprays (i.e., water mist). The very small water droplets allow the water mist to control or extinguish fires by cooling of the flame and fire plume, oxygen displacement by water vapor, and radiant heat attenuation.

## 1-6.2 Use and Limitations.

**1-6.2.1** Water mist systems are used for a wide range of performance objectives, including the following:

- (1) Fire extinguishment
- (2) Fire suppression
- (3) Fire control
- (4) Temperature control
- (5) Exposure protection

**1-6.2.2\*** Water mist systems shall not be used for direct application to materials that react with water to produce violent reactions or significant amounts of hazardous products. These materials include the following:

- (1) Reactive metals, such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium and plutonium
- (2) Metal alkoxides, such as sodium methoxide
- (3) Metal amides, such as sodium amide
- (4) Carbides, such as calcium carbide



- (5) Halides, such as benzoyl chloride and aluminum chloride
- (6) Hydrides, such as lithium aluminum hydride
- (7) Oxyhalides, such as phosphorus oxybromide
- (8) Silanes, such as trichloromethylsilane
- (9) Sulfides, such as phosphorus pentasulfide
- (10) Cyanates, such as methylisocyanate

**1-6.2.3** Water mist systems shall not be used for direct application to liquefied gases at cryogenic temperatures (such as liquefied natural gas), which boil violently when heated by water.

### 1-7 Safety.

**1-7.1\* Hazards to Personnel.** In the event of a fire, safeguards shall be provided to ensure the following:

- (1) prompt evacuation of trapped personnel
- (2) prevention of entry by personnel into hazardous atmospheres
- (3) provision of means for prompt rescue of any trapped personnel.

Safety factors such as personnel training, warning signs, discharge alarms, self-contained breathing apparatus, evacuation plans, and fire drills shall be considered.

### 1-7.2\* Electrical Clearances.

**1-7.2.1\*** All system components shall be located to maintain minimum clearances from unenclosed and uninsulated energized electrical components in accordance with NFPA 70, *National Electrical Code*<sup>®</sup>.

**1-7.2.2** Where the design basic insulation level (BIL) is not known and where nominal voltage is used for the design criteria, the highest minimum clearance specified for this group shall be used.

**1-7.2.3** The selected clearance to ground shall satisfy the greater of the switching surges or BIL duty, rather than being based on nominal voltage.

**1-7.2.4** The clearance between uninsulated energized parts of the electrical system equipment and any portion of the water mist system shall not be less than the minimum clearance provided elsewhere for electrical system insulation on any individual component.

**1-7.3\* Positive Displacement Pumps.** Where positive displacement pumps are used in a water mist system, suitable safeguards shall be provided to prevent pressure generation in excess of maximum system pressure rating.

**1-8 Environmental Factors.** When selecting water mist to protect a hazard area, the effects of water runoff on the environment shall be considered. Particular attention shall be given to any water additives or any chemicals that can be carried out of the hazard area by the water.

## Chapter 2 System Components and Hardware

**2-1 General.** This chapter provides requirements for the correct use of water mist system components.

**2-1.1 Component Listing.** All components shall be listed for their intended use.

*Exception No. 1: Where approval of system components is specifically permitted to be substituted for listing.*

*Exception No. 2: Where components are part of a listed, pre-engineered system.*

**2-1.2 Working Pressure.** System components shall be rated for the maximum working pressure to which they are exposed but not less than 175 psi (12.1 bar).

*Exception: Where components are part of a listed, pre-engineered system with a self-contained water supply.*

**2-1.3 Corrosion Resistance.** Where components are subjected to severe corrosive atmospheres, corrosion protection such as special corrosion-resistive materials or coating shall be required.

### 2-2 Gas and Water Containers.

**2-2.1 Capacity.** Gas and water containers, if provided, shall be sized to supply quantities of gas and water as required by Chapter 7.

#### 2-2.2 Design.

**2-2.2.1\*** Gas and water containers shall be designed for installation according to the manufacturer's installation manual, including provision for attachment of seismic restraint.

**2-2.2.2\*** Gas and water containers shall be made, tested, approved, equipped, and marked in accordance with the current specifications of the ASME *Boiler and Pressure Vessel Code*, Section VIII, or the requirements of the U.S. Department of Transportation, 49 *CFR* 171-190, 178.36-178.37, or other approved international standards. Containers used as shipping containers shall be designed to meet the requirements of the U.S. Department of Transportation or of Transport Canada or other approved international standards. The design pressure shall be based on the maximum pressure developed by the water mist system at 130°F (54°C).

**2-2.2.3** Each pressurized container shall be provided with a safety device to release excess pressure.

**2-2.2.4** Each water container shall have a permanent nameplate or other permanent marking specifying the liquid held in the container (including additives) and the nominal water volume and pressurization level (where applicable) of the container.

*Exception: Marking shall not be required on each water container if the information is provided on a nameplate or placard permanently installed on the system at a location convenient for servicing or content measuring.*

**2-2.2.5** External sight glasses on water containers shall be protected against mechanical damage.

**2-2.2.6** Each gas container shall have a permanent nameplate or other permanent marking specifying the type of gas, weight of gas, weight of container, nominal gas volume, and pressurization level of the container.

*Exception: Marking shall not be required on each gas container if the information is provided on a nameplate or placard permanently installed on the system at a location convenient for servicing or content measuring.*

**2-2.2.7** A reliable means shall be provided to indicate the pressure in refillable, pressurized gas containers.

**2-2.3 Multiple Container Systems.** All containers supplying the same manifold outlet shall be interchangeable and of the same size and charge.

## 2-3 Piping and Tube.

**2-3.1\*** All piping, valves and fittings, from the system strainer to the nozzle shall have corrosion resistance at least equivalent to piping specified in Table 2-3.3.1. Wherever the word *pipe* is used, it shall be understood also to mean *tube*.

**2-3.2** Other types of pipe or tube investigated for suitability in water mist system installations and listed for this service shall be permitted where installed in accordance with their listing limitations, including installation instructions. Bending of the pipe shall be permitted as provided by the listing. Pipe or tube shall not be listed for portions of an occupancy classification.

### 2-3.3 Low Pressure Systems.

**2-3.3.1** Pipe or tube used in low pressure water mist systems shall meet or exceed one of the standards in Table 2-3.3.1 or shall be in accordance with 2-3.2. The chemical properties, physical properties, and dimensions of the materials given in Table 2-3.3.1 shall conform to a minimum to the standards cited in the table. Pipe and tube used in water mist systems shall be designed to withstand a working pressure of not less than 175 psi (12.1 bar).

**Table 2-3.3.1 Pipe or Tube Standards**

Materials and Dimensions and Standard Titles	Standard No.
<b>Copper Tube (Drawn, Seamless)</b>	
<i>Standard Specification for Solder Metal [95-5 (Tin-Antimony-Grade 95TA)]</i>	ASTM B 32
<i>Standard Specification for Seamless Copper Tube<sup>1</sup></i>	ASTM B 75
<i>Standard Specification for Seamless Copper Water Tube<sup>1</sup></i>	ASTM B 88
<i>Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube</i>	ASTM B 251
<i>Standard Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper-Alloy Tube</i>	ASTM B 813
<i>Specification for Filler Metals for Brazing and Braze Welding (Classification BCuP-3 or BCuP-4)</i>	AWS A5.8
<b>Stainless Steel</b>	
<i>Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service</i>	ASTM A 269
<i>Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service</i>	ASTM A 632
<i>Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products</i>	ASTM A 778
<i>Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service</i>	ASTM A 789/ A 789M

<sup>1</sup>Denotes pipe or tube suitable for bending (see 2-3.6) according to ASTM standards.

**2-3.3.2** Copper tube as specified in the standards referenced in Table 2-3.3.1 shall have a wall thickness of Type K, L, or M where used in water mist systems.

## 2-3.4 Intermediate and High Pressure Systems.

**2-3.4.1** Pipe or tube shall be of noncombustible material having physical and chemical characteristics such that its deterioration under stress can be predicted with reliability. The piping shall be in accordance with ANSI B31.1, *Power Piping Code*. The internal pressure used for calculation of pipe wall thickness shall be the maximum operating pressure of the water mist systems at a pipe temperature of 130°F (54°C).

**2-3.4.2\*** Flexible piping, tubing, or hoses (including connections) shall be listed for their intended use.

### 2-3.5 Pipe or Tube Identification.

**2-3.5.1** All pipe or tube, including specially listed pipe or tube, shall be marked continuously along its length by the manufacturer in such a way as to identify the type of pipe or tube. This identification shall include the manufacturer's name, model designation, or schedule.

**2-3.5.2** Pipe or tube marking shall not be painted, concealed, or removed prior to approval by the authority having jurisdiction.

**2-3.6 Pipe or Tube Bending.** Bending of Type K and Type L copper tube shall be permitted where bends are made with no kinks, ripples, distortions, reductions in diameter, or any noticeable deviations from a round shape. The minimum radius of a bend shall be six pipe diameters for pipe sizes of 2 in. (51 mm) and smaller and five pipe diameters for pipe sizes larger than 2 in. (51 mm).

## 2-4 Fittings.

**2-4.1\* General.** All fittings used on piping described in 2-3.1 shall have a corrosion resistance at least equivalent to wrought copper fittings conforming to ANSI B16.22, *Wrought Copper and Copper Alloy Solder Joint Pressure Fittings*.

### 2-4.2 Low Pressure Systems.

**2-4.2.1** Fittings used in water mist systems shall meet or exceed the standards in Table 2-4.2.1 or shall be in accordance with 2-4.2.2.

**Table 2-4.2.1 Fitting Standards**

Materials and Dimensions and Standard Titles	Standard No.
<b>Copper</b>	
<i>Cast Copper Alloy Solder Joint Pressure Fittings</i>	ANSI B16.18
<i>Wrought Copper and Copper Alloy Solder Joint Pressure Fittings</i>	ANSI B16.22
<b>Stainless Steel</b>	
<i>Standard Specification for Castings, Austenitic, Austenitic-Ferritic (Duplex) for Pressure-Containing Parts</i>	ASTM A 351/A 351M
<i>Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings</i>	ASTM A 403/A 403M
<i>Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures</i>	ASTM A 774/A 774M
<i>Standard Specification for Wrought Ferritic, Ferritic/Austenitic, and Martensitic Stainless Steel Piping Fittings</i>	ASTM A 815/A 815M

**2-4.2.2\*** Other types of fittings investigated for suitability in water mist installations and listed for this service shall be permitted where installed in accordance with their listing limitations, including installation instructions.

**2-4.2.3** Screwed unions shall not be used on pipe larger than 2 in. (51 mm). Couplings and unions of other than the screwed type shall be listed for the intended use.

**2-4.2.4** A one-piece reducing fitting shall be used wherever a change is made in the size of pipe.

*Exception: Hexagonal or face bushings shall be permitted in reducing the size of openings of fittings where standard fittings of the required size are not produced.*

**2-4.2.5** All threads used in joints and fittings shall conform to ANSI B1.20.1, *Pipe Threads, General Purpose (Inch)*. Joint compound, tape, or thread lubricant shall be applied only to the male threads of the joint.

**2-4.2.6** Soldering fluxes shall be in accordance with Table 2-3.3.1. Brazing fluxes, if used, shall not be of a highly corrosive type.

**2-4.2.7** Welding shall be performed in accordance with AWS D10.9, *Specification for Qualification of Welding Procedures and Welders for Piping and Tubing*, Level AR-3.

#### **2-4.3 Intermediate and High Pressure Systems.**

**2-4.3.1** Fittings shall have a minimum-rated working pressure equal to or greater than the maximum operating pressure of the water mist systems at 130°F (54°C). For systems that employ the use of a pressure regulating device in the distribution piping, the fittings downstream of the device shall have a minimum-rated working pressure equal to or greater than the maximum anticipated pressure in the downstream piping.

**2-4.3.2** All threads used in joints and fittings shall conform to ANSI B1.20.1, *Pipe Threads, General Purpose (Inch)*. Joint compound, tape, or thread lubricant shall be applied only to the male threads of the joint.

**2-4.3.3** Welding and brazing alloys shall have a melting point above 1000°F (538°C).

**2-4.3.4** Welding and brazing shall be performed in accordance with Section IX of the ASME *Boiler and Pressure Vessel Code*.

**2-4.3.5** Where acceptable tubing is joined with compression-type fittings, the manufacturer's pressure temperature ratings for the fitting shall not be exceeded.

#### **2-5 Hangers.**

**2-5.1** Hangers shall be listed for use with the pipe or tube involved.

*Exception: Hangers certified by a registered professional engineer to include the following shall be permitted where*

(a) *Hangers are designed to support five times the weight of the pipe or tube when filled with gas or water, based on the system's use of the pipe or tube, plus 250 lb (114 kg) at each point of piping support;*

(b) *These points of support are able to support the water mist system; and*

(c) *Hanger components are ferrous.*

*Detailed calculations shall be submitted, where required by the authority having jurisdiction, showing the stresses developed both in the hangers and the piping and the safety factors provided.*

**2-5.2** Hanger components shall be ferrous.

*Exception: Nonferrous components that have been proven by fire tests to be able to support the piping for the hazard application, that are listed for this purpose, and that are in compliance with the other requirements of this section shall be permitted.*

**2-5.3** The components of hanger assemblies that attach directly to the pipe or to the building structure shall be listed. Threaded portions of hangers shall not be bent.

*Exception: Mild steel rods that connect pipe and building attachment components shall be permitted to be of an approved type.*

**2-5.4** The use of listed inserts set in concrete to support hangers shall be permitted.

**2-5.5** Power-driven fasteners shall not be used to attach hangers to the building structure where systems are required to be protected against earthquakes.

*Exception: Power-driven fasteners shall be permitted where they are specifically listed for service in seismic areas.*

#### **2-6 Nozzles.**

**2-6.1\*** Nozzles shall be listed either individually or as a part of a pre-engineered system. Listing information shall include the following:

- (1) Specific hazards and protection objectives
- (2) Volumetric flow rate characteristics of water discharge for each nozzle
- (3) Maximum height of protected space
- (4) Minimum distance between nozzle tip or diffuser, as applicable, and plane of protection
- (5) Maximum spacing between nozzles
- (6) Maximum coverage area per nozzle
- (7) Minimum spacing between nozzles
- (8) Maximum height between ceiling and nozzle diffuser or tip, as applicable
- (9) Nozzle obstruction spacing criteria
- (10) Maximum spacing of nozzles from walls
- (11) Minimum- and maximum-rated operating pressures of nozzles
- (12) Allowable range of nozzle orientation angle from vertically down
- (13) Classification of automatic nozzle thermal response characteristics as fast, special, or standard response
- (14) Maximum compartment volume, if applicable
- (15) Maximum time delay for water mist delivery to the most remote nozzle

**2-6.2** Only new nozzles shall be installed in water mist systems.

**2-6.3** Nozzles shall be permanently marked to identify the manufacturer, type, and size of the orifice(s) or part number.

**2-6.4** Additional corrosion protection, such as special corrosion-resistant materials or coatings, shall be required in severely corrosive atmospheres. Where protective coatings are used to meet the requirements of 2-1.3, the coatings shall be applied by the nozzle manufacturer and the coated nozzle shall be listed.

**2-6.5** Where clogging by external, foreign materials is possible, discharge nozzles shall be provided with frangible discs, blow-off caps, or other listed devices. These devices shall provide an unobstructed opening upon system operation and shall be located so they cannot injure personnel.

**2-6.6** The standard temperature ratings of individual, thermally activated nozzles are shown in Table 2-6.6. Individual, thermally activated nozzles shall be colored in accordance with the color code designated in Table 2-6.6.

**2-6.7** The stock of spare, individual, thermally activated nozzles shall include all types and ratings installed and shall be as follows:

- (1) For systems having fewer than 50 nozzles, not fewer than 3 nozzles
- (2) For systems having 50 to 300 nozzles, not fewer than 6 nozzles
- (3) For systems having 301 to 1000 nozzles, not fewer than 12 nozzles
- (4) For systems having over 1000 nozzles, not fewer than 24 nozzles

## 2-7 Valves.

**2-7.1 Valve Listing.** All valves shall be listed for their intended use.

*Exception: Valves used only for drains or test connections shall be permitted to be approved.*

**2-7.2 Compatibility.** All gaskets, O-rings, sealants, and other valve components shall be constructed of materials that are compatible with the gas or water and any additives contained in the water.

**2-7.3 Identification of Valves.** All control, drain, and test connection valves shall be provided with permanently marked, weatherproof, metal or rigid plastic identification signs. The sign shall be secured with corrosion-resistant wire, chain, or other approved means.

## 2-8 Strainers and Filters.

**2-8.1** A system strainer shall be provided downstream of each water supply system, water supply tank, pump, pipe section, fitting, valve, or other piping component having a wetted surface that does not have corrosion resistance equivalent to the materials given in Table 2-3.3.1 or Table 2-4.2.1.

**2-8.2\*** The strainer or filter shall be sized for continuous operation at the required minimum flow and pressure, as verified by hydraulic calculations, for the minimum water supply duration.

**2-8.3** Each system strainer shall have corrosion resistance equivalent to the materials given in Table 2-4.2.1.

**2-8.4** Pipeline strainers and filters shall be listed for use in water supply connections.

**2-8.5** Pipeline strainer and filter designs shall incorporate a flush-out connection.

**2-8.6** Pipeline strainers and filters shall be sized in accordance with 7-5.1.2 and 7-5.1.4.

**2-8.7** Individual strainers or filters for water mist nozzles, where required by the manufacturer, shall be listed as a part of a nozzle.

**2-8.8** Spare pipeline and individual nozzle strainers and filters for water mist nozzles, if replaceable, shall be provided and shall include all types and sizes installed. Spare strainers and filters shall be provided to service the nozzles, if replaceable, for the largest single hazard or group of hazards to be protected simultaneously.

## 2-9 Pump Systems.

### 2-9.1 Pumps.

**2-9.1.1** Pumps for water mist systems shall be installed in accordance with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.

**2-9.1.2** Pumps shall be designed with capacities in accordance with 7-5.2.

**2-9.1.3** Pumps capable of overpressurizing the system shall be provided with an approved means of pressure relief to prevent excessive increase in pressure and temperature. Overpressure shall not exceed the working pressure of the piping system.

**2-9.1.4** Pumps shall start automatically upon system actuation.

**2-9.1.5** Pumps shall not take suction under a static lift condition.

### 2-9.2 Power Supply.

**2-9.2.1** The power supply for pump drivers shall be installed in accordance with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*; NFPA 70, *National Electrical Code*, and with the manufacturer's listing.

*Exception: Power supplies for water mist system pumps shall not be required to be fed by an independent service feed to the building.*

**2-9.2.2** Power supplies for pumps shall be arranged so that if the power supply within the protected facility itself must be disconnected during a fire, the power supply to the pump feeder circuit will not be interrupted.

**Table 2-6.6 Temperature Ratings, Classifications, and Color Coding of Individual, Thermally Activated Nozzles**

Maximum Ambient Temperature		Nozzle Temperature Rating		Temperature Classification	Color Code	Glass Bulb Colors
°F	°C	°F	°C			
100	38	135 to 170	57 to 77	Ordinary	Uncolored or black	Orange or red
150	66	175 to 225	79 to 107	Intermediate	White	Yellow or green
225	107	250 to 300	121 to 149	High	Blue	Blue
300	149	325 to 375	163 to 191	Extra high	Red	Purple
375	191	400 to 475	204 to 246	Very extra high	Green	Black
475	246	500 to 575	260 to 302	Ultra high	Orange	Black
625	329	650	343	Ultra high	Orange	Black

### 2-9.3 Controllers.

**2-9.3.1** Controllers for pumps shall be listed fire pump controllers or listed limited-service controllers installed in accordance with NFPA 20, *Standard for the Installation of Stationary Fire Pumps for Fire Protection*.

**2-9.3.2** A service-disconnecting means in the feeder circuit to controllers shall be permitted where acceptable to the authority having jurisdiction, provided the disconnecting means is supervised for the proper position. Supervision for proper position shall be by one of the following methods:

- (1) Central station, proprietary, or remote station signaling electrical supervision service
- (2) Local electrical supervision through use of a signaling service that causes the sounding of an audible signal at a constantly attended location
- (3) Locking of the disconnecting means in the proper position, with monthly recorded inspections

### 2-10 Detection, Actuation, Alarm, and Control Systems.

#### 2-10.1 General.

**2-10.1.1** Detection, actuation, alarm, and control systems shall be installed, tested, and maintained in accordance with the following protective signaling systems standards as applicable:

- (1) NFPA 70, *National Electrical Code*
- (2) NFPA 72, *National Fire Alarm Code*<sup>®</sup>
- (3) CAN/ULC S524-M86, *Standard for the Installation of Fire Alarm Systems (in Canada)*
- (4) CAN/ULC S529-M87, *Smoke Detectors for Fire Alarm Systems (in Canada)*

**2-10.1.2** Where a detection system is used to actuate the water mist system, detection and actuation shall be automatic.

*Exception: Manual-only actuation shall be permitted if approved by the authority having jurisdiction.*

#### 2-10.2 Automatic Detection.

**2-10.2.1\*** Automatic detection shall be by listed equipment installed in accordance with NFPA 72, *National Fire Alarm Code*.

**2-10.2.2** Adequate and reliable primary and 24-hour minimum standby sources of energy shall be used to provide for operation of the detection, signaling, control, and actuation requirements of the systems.

**2-10.2.3** If an existing detection system is used in a new water mist system, the detection system shall comply with the requirements of this standard.

#### 2-10.3 Operating Devices.

**2-10.3.1** Operating devices shall include water mist releasing devices or valves, discharge controls, and shutdown equipment necessary for successful performance of the system.

**2-10.3.2** Operation shall be by listed mechanical, electrical, or pneumatic equipment. An adequate and reliable source of energy shall be used.

**2-10.3.3** Devices shall be designed for the service they are to encounter and shall not be rendered inoperative or susceptible to accidental operation. Devices shall be designed to func-

tion from  $-20^{\circ}\text{F}$  to  $130^{\circ}\text{F}$  ( $-29^{\circ}\text{C}$  to  $54^{\circ}\text{C}$ ) or shall be marked to indicate temperature limitations.

**2-10.3.4** An emergency release device for the system shall be provided. The emergency release device shall be activated by a single manual operation. This operation shall be accomplished by a mechanical manual release or by an electrical manual release when the control equipment that monitors the battery voltage level of the standby battery supply indicates a low battery signal. The release shall cause simultaneous operation of automatically operated valves that control agent release and distribution. The battery shall be sized to accomplish all functions.

*Exception: Dry and wet pipe systems utilizing individual, thermally activated nozzles.*

**2-10.3.5** The manual release device(s) shall be located so as to be accessible at all times. The manual release device(s) shall be of distinct appearance and clearly recognizable for the purpose intended. Operation of any manual release device shall cause the system to operate in accordance with the design or listing.

**2-10.3.6** The manual release device(s) shall not require a force of more than 40 lbf (178 N) nor a movement of more than 14 in. (356 mm) to cause activation. At least one manual release device for activation shall be located not more than 4 ft (1.2 m) above the floor.

**2-10.3.7** All devices for shutting down supplementary equipment shall be integral parts of the system and shall function with the system in operation.

**2-10.3.8** All manual devices shall be identified as to the hazard they protect.

#### 2-10.4 Control Equipment.

**2-10.4.1 Electrical Control Equipment.** Automatic control equipment shall be listed and installed in accordance with NFPA 72, *National Fire Alarm Code*.

**2-10.4.2 Listing.** The control unit shall be listed for release device service.

#### 2-10.4.3 Pneumatic Control Equipment.

**2-10.4.3.1\*** Pneumatic control lines shall be protected against crimping and mechanical damage.

**2-10.4.3.2** Pneumatic control lines used to activate the system shall be supervised.

*Exception No. 1: Pneumatically operated control lines immediately adjacent to the pressurizing source are not required to be supervised.*

*Exception No. 2: Pneumatic control lines from master to slave cylinders that are located in close proximity to one another are not required to be supervised.*

**2-10.4.3.3** The control equipment shall be specifically listed for the number and type of actuating devices utilized, and their compatibility shall have been listed.

**2-11\* Unwanted System Operation.** Care shall be taken to thoroughly evaluate and correct any factors that could result in unwanted system discharge.

**2-12 Compatibility.** All components of pneumatic, hydraulic, or electrical systems shall be compatible.

## Chapter 3 System Requirements

**3-1 General.** Water mist systems shall be described by the following four parameters:

- (1) System application
- (2) Nozzle type
- (3) System operation method
- (4) System media type

**3-2 System Applications.** System applications shall consist of one of the following three categories:

- (1) Local-application systems
- (2) Total compartment application systems
- (3) Zoned application systems

**3-2.1 Local-Application Systems.** Local-application systems are designed and installed to provide complete distribution of mist around the hazard or object to be protected.

**3-2.1.1** Local-application systems shall be designed to protect an object or a hazard in an enclosed, unenclosed, or open outdoor condition.

**3-2.1.2** Local-application systems shall be actuated by automatic nozzles or by an independent detection system.

**3-2.2 Total Compartment Application Systems.**

**3-2.2.1** Total compartment application systems are designed and installed to provide complete protection of an enclosure or space.

**3-2.2.2\*** The complete protection of an enclosure or space shall be achieved by the simultaneous operation of all nozzles in the space by manual or automatic means.

**3-2.3 Zoned Application Systems.** Zoned application systems are a subset of the compartment system and are designed to protect a predetermined portion of the compartment by the activation of a selected group of nozzles.

**3-2.3.1** Zoned application systems shall be designed and installed to provide complete mist distribution throughout a predetermined portion of an enclosure or space. This shall be achieved by simultaneous operation of a selected group of nozzles in a predetermined portion of the space by manual or automatic means.

**3-2.3.2** Zoned application systems shall be actuated by automatic nozzles or by an independent detection system.

**3-3 Nozzle Types.** Water mist nozzles shall be classified as one of the following three types:

- (1) Automatic
- (2) Nonautomatic
- (3) Hybrid

**3-4 System Operation Methods.** Water mist systems shall operate by means of one of the following methods:

- (1) Deluge
- (2) Wet pipe
- (3) Preaction
- (4) Dry pipe

**3-4.1 Deluge Systems.** Deluge systems shall employ nonautomatic nozzles (open) attached to a piping network connected to the fluid supply(ies) through a valve controlled by an independent detection system installed in the same area as the mist nozzles. When the valve(s) is activated, the fluid shall flow into

the piping network and discharge from all nozzles attached thereto.

**3-4.2 Wet Pipe Systems.** Wet pipe systems shall employ automatic nozzles attached to a piping network pressurized with water up to the nozzles.

**3-4.3 Preaction Systems.** Preaction systems shall employ automatic nozzles attached to a piping network containing a pressurized gas with a supplemental, independent detection system installed in the same area as the nozzles. Operation of the detection system shall actuate a tripping device that opens the valve, pressurizing the pipe network with water to the nozzles.

**3-4.4 Dry Pipe Systems.** Dry pipe systems shall employ automatic nozzles attached to a piping network containing a pressurized gas. The loss of pressure in the piping network shall activate a control valve, which causes water to flow into the piping network and out through the activated nozzles.

**3-5\* Media System Types.** Water mist systems shall be classified by two media system types:

- (1) Single fluid
- (2) Twin fluid

## Chapter 4 Installation Requirements

**4-1 General.** This chapter provides requirements for the correct installation of water mist system components.

**4-1.1** All listed materials and devices shall be installed in accordance with their listing. All other materials and devices shall be installed in accordance with the system design manual. Systems installed in corrosive environments shall comply with 2-1.3.

**4-1.2** System components shall be located, installed, or suitably protected so they are not subject to mechanical, chemical, or other damage that could render them inoperative.

**4-1.3** Manufacturers shall provide installation and testing procedures to ensure that the system is installed and will operate as intended.

**4-2 Nozzles.**

**4-2.1 General.** Nozzles shall be installed in accordance with the manufacturer's listing.

**4-2.2 Nozzle Height Limitations.** The minimum and maximum heights shall be in accordance with the manufacturer's listing.

**4-2.3 Nozzle Spacing Limitations.** The minimum and maximum distances between nozzles shall be in accordance with the manufacturer's listing.

**4-2.4 Distance from Walls.** The minimum and maximum distance from nozzles to walls or partitions shall be in accordance with the manufacturer's listing.

**4-2.5 Obstructions to Nozzle Discharge.** The location of nozzles with respect to obstructions shall be in accordance with the manufacturer's listing.

**4-2.6 Distance Below Ceilings.** The distance between the nozzle and the ceiling shall be in accordance with the range (minimum and maximum) identified in the manufacturer's listing.

**4-2.7 Spacing under Pitched or Curved Surfaces.** The distance between nozzles in or under a pitched or curved surface shall be in accordance with the manufacturer's listing.

**4-2.8 Nozzle Protection.** Nozzles subject to mechanical damage shall be protected with listed guards. Guards shall not significantly reduce the effectiveness of the nozzle.

**4-2.9 Escutcheon Plates.**

**4-2.9.1** Escutcheon plates used in a recessed or flush-type nozzle installation shall be a part of a listed nozzle assembly.

**4-2.9.2** Nonmetallic escutcheon plates shall be listed.

**4-2.10 Thermally Activated Nozzle Temperature Ratings.**

**4-2.10.1** Ordinary temperature nozzles shall be used.

*Exception No. 1: Where maximum ceiling temperatures exceed 100°F (38°C), nozzles with temperature ratings in accordance with the maximum ambient temperatures of Table 2-6.6 shall be used.*

*Exception No. 2: High temperature nozzles shall be permitted to be used throughout.*

*Exception No. 3: Nozzles of intermediate and high temperature classifications shall be installed in specific locations as required by 4-2.10.2.*

**4-2.10.2** The following practices shall be observed to provide nozzles of other than ordinary temperature classification unless other temperatures are determined or unless high temperature nozzles are used throughout [see Tables 4-2.10.2(a) and (b) and Figure 4-2.10.2].

(a) Nozzles in the high temperature zone shall be of the high temperature classification, and nozzles in the intermediate temperature zone of the intermediate temperature classification.

(b) Nozzles located within 12 in. (305 mm) to one side or 30 in. (762 mm) above an uncovered steam main, heating coil, or radiator shall be of the intermediate temperature classification.

(c) Nozzles within 7 ft (2.1 m) of a low pressure blowoff valve that discharges free in a large room shall be of the high temperature classification.

(d) Nozzles under glass or plastic skylights exposed to the direct rays of the sun shall be of the intermediate temperature classification.

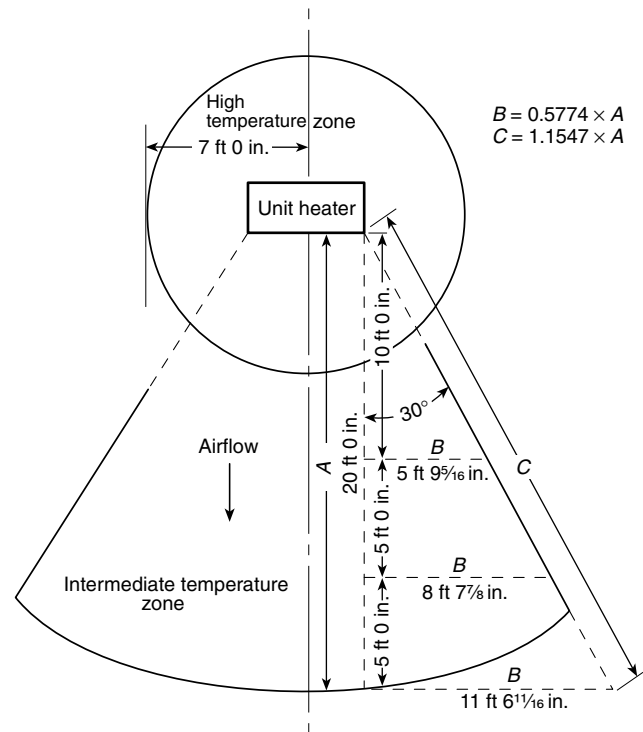
(e) Nozzles in an unventilated, concealed space, under an uninsulated roof, or in an unventilated attic shall be of the intermediate temperature classification.

(f) Nozzles in unventilated show windows having high-powered electric lights near the ceiling shall be of the intermediate temperature classification.

(g) Nozzles protecting commercial-type cooking equipment and ventilation systems shall be of the high or extra high temperature classification as determined by use of a temperature measuring device.

**4-2.10.3** In case of occupancy change involving temperature change, the nozzles shall be changed accordingly.

**FIGURE 4-2.10.2 High temperature and intermediate temperature zones at unit heaters.**



For SI units: 1 in. = 25.4 mm; 1 ft = 0.31 m.

**4-3 Pipe and Tubing.**

**4-3.1** Piping and tubing for water mist systems shall be installed in accordance with the manufacturer's installation manual.

**4-3.1.1** All water and atomizing media piping and tubing for water mist systems shall be installed in accordance with ANSI B31.1, *Power Piping Code*.

*Exception No. 1: Piping in low pressure systems installed in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems. This exception does not apply to piping conveying atomizing media.*

*Exception No. 2: Piping installed in accordance with a water mist system listing where the listing provides installation criteria different from ANSI B31.1, Power Piping Code.*

**4-3.1.2** All system piping, tubing, and hose shall be rated for the maximum working pressure to which they are exposed.

**4-3.1.3** Any flexible piping, tubing, hose, or combination thereof shall be constructed and installed in accordance with the manufacturer's listing.

**4-3.2 Piping Support.** The system piping shall be supported by structural elements that are independent of the ceiling sheathing to prevent lateral and horizontal movement upon system actuation.

**4-3.3 System Drainage.** All system piping and fittings shall be installed so that the entire system can be drained.

**Table 4-2.10.2(a) Temperature Ratings of Nozzles Based on Distance from Heat Sources**

Type of Heat Condition	Ordinary Degree Rating	Intermediate Degree Rating	High Degree Rating
<b>1. Heating Ducts</b>			
(a) Above	More than 2 ft 6 in.	2 ft 6 in. or less	
(b) Side and below	More than 1 ft 0 in.	1 ft 0 in. or less	
(c) Diffuser	Any distance except as shown under Intermediate Degree Rating column	Downward Discharge: Cylinder with 1 ft 0 in. radius from edge, extending 1 ft 0 in. below and 2 ft 6 in. above Horizontal Discharge: Semi-cylinder with 2 ft 6 in. radius in direction of flow, extending 1 ft 0 in. below and 2 ft 6 in. above.	
<b>2. Unit heater</b>			
(a) Horizontal discharge		Discharge Side: 7 ft 0 in. to 20 ft 0 in. radius pie-shaped cylinder [see Figure 4-10.2] extending 7 ft 0 in. above and 2 ft 0 in. below heater; also 7 ft 0 in. radius cylinder more than 7 ft 0 in. above unit heater	7 ft 0 in. radius cylinder extending 7 ft 0 in. above and 2 ft 0 in. below unit heater
(b) Vertical downward discharge		7 ft 0 in. radius cylinder extending upward from an elevation 7 ft 0 in. above unit heater	7 ft 0 in. radius cylinder extending from the top of the unit heater to an elevation 7 ft 0 in. above unit heater
<b>3. Steam mains (uncovered)</b>			
(a) Above	More than 2 ft 6 in.	2 ft 6 in. or less	
(b) Side and below	More than 1 ft 0 in.	1 ft 0 in. or less	
(c) Blowoff valve	More than 7 ft 0 in.		7 ft 0 in. or less

**Table 4-2.10.2(b) Ratings of Nozzles in Specified Locations**

Location	Ordinary Degree Rating	Intermediate Degree Rating	High Degree Rating
Skylights		Glass or plastic	
Attics	Ventilated	Unventilated	
Peaked roof: Metal or thin boards, concealed or not concealed, insulated or uninsulated	Ventilated	Unventilated	
Flat roof: Metal, concealed; insulated or uninsulated	Ventilated or unventilated	Note: For uninsulated roof, climate and occupancy may necessitate intermediate nozzles. Check on job.	
Flat roof: Metal, concealed, insulated or uninsulated	Ventilated	Unventilated	
Show Windows	Ventilated	Unventilated	

**4-3.4 Location of Hangers and Supports.** Hangers and supports shall be located in accordance with the system’s design manual.

*Exception: For low pressure and intermediate systems, steel pipe and copper tubing shall be supported in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems.*

**4-3.4.1** The length of an unsupported arm over to a nozzle shall not exceed 2 ft (0.6 m) for steel pipe or 1 ft (0.3 m) for steel tubing.

**4-3.5 Protection of System Components against Damage where Subject to Earthquakes.** Where subject to earthquakes, water mist systems shall be protected to prevent pipe breakage in accordance with 4-14.4.3 of NFPA 13, *Standard for the Installation of Sprinkler Systems.*



#### 4-4 Fittings.

**4-4.1** All system fittings shall be installed in accordance with the manufacturer's listing.

*Exception: All fittings installed in low pressure water mist systems shall conform to NFPA 13, Standard for the Installation of Sprinkler Systems.*

**4-4.2** All fittings shall be rated for the maximum working pressure to which they are exposed.

#### 4-5 Gas and Water Storage Containers.

**4-5.1** Storage containers shall be installed, mounted, and braced in accordance with the manufacturer's listing.

**4-5.2** Storage containers and accessories shall be installed so that inspection, testing, recharging, and other maintenance are facilitated and interruption to protection is held to a minimum.

**4-5.3\*** Storage containers shall be located as close as possible to the hazard or within the hazards they protect and shall not be exposed to fire or mechanical damage in a manner that affects performance.

#### 4-5.4 Protection.

**4-5.4.1** Storage containers shall be protected from severe weather conditions and from mechanical, chemical, or other damage.

**4-5.4.2** Where excessive climatic or mechanical exposures are expected, guards or enclosures shall be provided.

#### 4-5.5 High Pressure Storage Containers.

**4-5.5.1** High pressure containers or cylinders shall be constructed, tested, and marked in accordance with recognized, international standards, such as the U.S. Department of Transportation, 49 *CFR*, 171-190, 178.36-178.37, specifications (in effect upon date of manufacture and test) for DOT-3A, 3AA-1800, or higher, seamless steel cylinders. Charged cylinders shall be tested for tightness before shipment in accordance with an approved procedure.

**4-5.5.2** Where manifolded, cylinders shall be mounted and supported in a rack provided for this purpose, including facilities for convenient, individual servicing or weighing of contents. When any cylinder is removed for maintenance, automatic means shall be provided to prevent leakage from the manifold if the system is operated.

**4-5.5.3** Storage temperatures shall be maintained within the range specified in the manufacturer's listing. External heating or cooling shall be an approved method to keep the temperature of the storage container within desired ranges.

**4-5.5.4** Containers shall be secured with manufacturer-listed supports to prevent container movement and possible physical damage.

#### 4-5.6 Low Pressure Storage Cylinders.

**4-5.6.1** The pressure container shall be made, tested, approved, equipped, and marked in accordance with the current specifications of the ASME *Boiler and Pressure Vessel Code*, Section VIII, or the requirements of U.S. Department of Transportation, 49 *CFR*, 171-190, 178.36-178.37, or other approved international standards. The design working pressure shall be in accordance with the manufacturer's listing.

*Exception: Pressure containers for heated water mist systems shall be in accordance with the manufacturer's listing.*

**4-5.6.2** Each pressure container shall be equipped with a liquid level gauge, a pressure gauge, and a high/low pressure supervisory alarm set at the values identified in the manufacturer's listing.

*Exception: Media storage containers that become pressurized only during system activation shall not require high/low pressure supervisory alarms.*

**4-5.7** Storage temperatures shall be maintained within the range specified in the manufacturer's listing. External heating or cooling shall be an approved method to keep the temperature of the storage container within desired ranges.

**4-5.8** Containers shall be secured with manufacturer-listed supports to prevent container movement and possible physical damage.

#### 4-6 Pumps and Pump Controllers.

**4-6.1\*** Pumps shall be sized to meet the required system water flow rate, at the minimum system pressure, as determined by hydraulic calculations.

**4-6.2** Pumps shall start automatically and shall supply water to the water mist system until manually shut off or automatically shut off in accordance with the manufacturer's listing.

**4-6.3** Pumps shall be provided with supervisory service from a listed central station, proprietary, or remote station system or equivalent.

*Exception: Pumps for single family dwellings.*

**4-6.4** Pumps shall be equipped with a test fitting or hose outlet on the discharge side of the pump to facilitate the annual full flow pump test required in Table 10-2(b).

**4-7 Strainers and Filters.** Strainers and filters shall be provided at all water supply connections in accordance with Chapter 7. Filters and strainers shall be installed to minimize potential head loss due to accumulation of particulates.

#### 4-8 Valves and Pressure Gauges.

##### 4-8.1 General.

**4-8.1.1** All valves shall be installed in accordance with the manufacturer's listing.

**4-8.1.2** Valves having components that extend beyond the valve body shall be installed in a manner that does not interfere with the operation of any system components.

**4-8.1.3** All valves shall be listed for their particular application and installation.

*Exception: Valves forming part of a listed system.*

**4-8.1.4** All control, drain, and test connection valves shall be provided with permanently marked, weatherproof, metal or rigid plastic identification signs. The sign shall be secured by corrosion-resistant wire or chain or by other approved means.

**4-8.1.5** System valves and gauges shall be installed such that they are accessible for operation, inspection, and maintenance.

**4-8.1.6** At least one listed indicating valve shall be installed in each source of water supply.

*Exception: Systems with a single water supply source composed of a self-contained system (cylinders, containers).*

**4-8.1.7** Valves on connections to water supplies, sectional control valves, and other valves in supply pipes to nozzles shall be locked open or equipped with tamper-monitoring devices.

*Exception:\** Normally closed, automatic water control valves.

#### **4-8.2 Control and Activation Valves.**

**4-8.2.1** Control and activation valves shall include any device or valve that automatically opens to supply water to the nozzles after the detection of a fire.

**4-8.2.2** Control and activation valves shall operate by an approved mechanical, electrical, or pneumatic means.

**4-8.2.3** Control and activation valves shall be installed such that they are not subject to mechanical, chemical, or other damage that would render them inoperative.

#### **4-8.3 Pressure Regulating and Pressure Relief Valves.**

##### **4-8.3.1 Water Pressure Regulating Valves.**

**4-8.3.1.1** Pressure regulating valves shall be installed in any portion of the system where the potential exists for the system pressure to exceed the maximum-rated working pressure of the system or system components, or both. These valves shall open when the system pressure reaches 95 percent of the system-rated pressure.

**4-8.3.1.2** A relief valve of not less than  $\frac{1}{2}$  in. (13 mm) shall be provided on the discharge side of the pressure regulating valve that is set to operate at a pressure not exceeding the system-rated pressure.

**4-8.3.1.3** A listed indicating valve shall be provided on the inlet side of each pressure reducing valve.

*Exception: A listed indicating valve shall not be required where the pressure regulating valve meets the listing requirements for use as an indicating valve.*

**4-8.3.1.4** A water flow test valve that is sized to produce the designed flow of the pressure reducing valve shall be installed on the downstream side of the pressure reducing valve.

**4-8.3.1.5** A sign indicating the correct discharge pressure for static and residual pressures shall be attached to the pressure reducing valve.

##### **4-8.3.2 Compressed Gas Pressure Regulating Valves (PRVs).**

**4-8.3.2.1** PRVs shall be installed in accordance with the manufacturer's listing.

**4-8.3.2.2** PRVs shall be installed when the supply pressure is higher than the design operating pressure of the water mist system.

**4-8.3.2.3** PRVs shall be capable of providing a stable regulating output at the rated flow capacity and design set point over the full range of input pressures that will be experienced over the course of the discharge period.

**4-8.3.2.4** Downstream pressure drift under no-flow conditions shall not exceed the lesser of the downstream components pressure rating or the pressure relief valve set point, if provided.

**4-8.3.2.5** Pressure set, point-adjusting mechanisms on the PRVs shall be tamper resistant, and the adjustment shall be indicated by a permanent marking. A means to indicate evidence of tampering shall be provided.

**4-8.3.2.6** The PRVs set point shall be set by the manufacturer.

**4-8.3.2.7** Permanent markings shall indicate the inlet and outlet connections of the PRVs.

#### **4-8.4 Check Valves and Backflow Preventers.**

**4-8.4.1** Check valves shall be installed in accordance with the manufacturer's listing.

**4-8.4.2** A check valve shall be installed between the system and the point of permanent connection to a potable water supply.

*Exception: Where additives are used in the water mist system, either by injection into flowing lines or by premixing into stored water sources, a backflow preventer shall be installed between the system control valve or stored water supply and a permanent connection to a potable water supply.*

**4-8.4.3** Check valves shall be installed in the main feed lines, near the control valves of both the water and pneumatic system piping of a twin-fluid system, to prevent the backflow of water or atomizing fluid into the companion piping.

#### **4-8.5 Pressure Gauges.**

**4-8.5.1** Pressure gauges shall be installed in the following locations:

- (1) On both sides of a pressure regulating valve
- (2) On the pressurized side of all supply connections
- (3) On the pressurized side of all system control valves
- (4) On all pressurized storage containers
- (5) On all air supplies for dry pipe and preaction systems

**4-8.5.2** The required pressure gauges shall be compatible with their intended use and shall have an operating range not less than twice the working pressure of the system.

#### **4-9 Electrical Systems.**

##### **4-9.1 Electrical Equipment.**

**4-9.1.1** Water mist systems shall be installed in accordance with the requirements of NFPA 70, *National Electrical Code*.

**4-9.1.2\*** All signaling system circuits and wiring shall be installed in accordance with NFPA 72, *National Fire Alarm Code*.

**4-9.1.3\*** All signaling line circuits and wiring shall be installed in accordance with NFPA 72, *National Fire Alarm Code*, Style 6.

##### **4-9.2 Control Equipment.**

**4-9.2.1** Electrical fire detection and control equipment used to activate water mist systems shall be installed in accordance with NFPA 70, *National Electrical Code*; NFPA 72, *National Fire Alarm Code* or other approved, recognized standards; and the manufacturers' recommendations.

**4-9.2.2** All circuitry that is monitoring or controlling the water mist system shall be electrically supervised in accordance with NFPA 72, *National Fire Alarm Code*.

**4-9.2.3** 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.

**4-9.2.4** Alarms shall be provided to indicate system waterflow and system trouble. Trouble and supervisory signals shall include power failure, operation (closing) of monitored valving, and electrical faults in the detection/activation of pump power control systems. These alarms shall be both visible and

audible inside the protected space, at the location of the primary system components (e.g., pumps, storage tanks), and in a continuously attended location. The system activation alarm shall be distinctly different from the system trouble signal to prevent confusion.

#### 4-9.3 Fire Detection.

**4-9.3.1\*** Where electrically operated automatic fire detection systems are used, the installation shall be in accordance with NFPA 72, *National Fire Alarm Code*.

**4-9.3.2** Approved primary and 24-hour minimum standby sources of energy shall be used to provide for operation of the detection, signaling, control, and actuation requirements of the system.

**4-9.3.3** Where a new water mist system is installed in a space that has an existing detection system, an analysis shall be made of the detection devices to ensure that the detection system meets the requirements of the water mist system listing and that the detection system is in operating condition.

#### 4-9.4 Automatic and Manual Activation.

**4-9.4.1** A means of automatic operation of the water mist system shall be provided. This shall be accomplished by means of automatic nozzles (independently thermally activated), automatic group control valves, or an independent automatic fire detection system, coupled with a listed system activation panel.

*Exception: Manual-only actuation shall be permitted if approved by the authority having jurisdiction.*

**4-9.4.2** A means of manual release of the system shall be installed and arranged in accordance with 2-10.3.

#### 4-10 Test Connections.

**4-10.1\*** A test connection shall be provided at the most hydraulically remote point on the water mist system. The inside diameter shall not be less than the largest orifice diameter used in the water mist system. Discharge from the test connection shall be piped to a safe discharge location.

*Exception: Where occupancy conditions prohibit water from being discharged from the most hydraulically remote point, a test connection shall be provided immediately upstream of each hazard area protected.*

### Chapter 5 Design Objectives and Fire Test Protocols

**5-1\* General.** Water mist protection systems shall be designed and installed in accordance with their listing for the specific hazards and protection objectives specified in the listing. The characteristics of the specific application (compartment variables and hazard classification) shall be consistent with the listing of the system. An evaluation of the compartment geometry, fire hazard, and system variables described in this chapter shall be performed to ensure that the system design and installation are consistent with the system listing.

#### 5-2\* Listing Evaluations.

**5-2.1 Scope.** Listing of water mist fire protection systems shall be based on a comprehensive evaluation designed to include fire test protocols, system components, and the contents of the manufacturer's design and installation manual.

**5-2.2\* Fire Test Protocols.** Fire test protocols shall be designed to address performance objectives of the application

specified in the listing, and the application parameters described in Section 5-4.

**5-2.3 Application Parameters.** Application parameters are the features that define an application. Application parameters shall include compartment variables (such as height, volume, obstructions, and ventilation), fire hazard (fuel type and configuration), and occupancy, with consideration of performance objectives specific to the application.

**5-2.4 Applicability.** Fire test protocols shall be designed to replicate the range of the application parameters associated with a particular hazard or occupancy. The system hardware shall be listed for the intended application.

**5-2.5 Testing.** Test protocols shall be conducted to verify the working limits and installation parameters of the system and its components, as described in the manufacturer's design and installation manual.

**5-2.6 Design and Installation Manual.** The system design and installation manual evaluated by the listing tests shall identify the working limits and parameters of the system, the fire hazards, and the range of compartment variables for which the listing is applicable. It shall also include recommended installation, testing, inspection, and maintenance procedures and by reference the requirements of NFPA 750, *Standard on Water Mist Fire Protection Systems*.

#### 5-3 Performance Objectives.

**5-3.1\* Fire Performance Objectives.** The fire-fighting performance objectives of a water mist system shall be described using at least one of the following three terms:

- (1) Control
- (2) Suppression
- (3) Extinguishment

**5-3.1.1 Fire Control.** Fire control shall be measured using three basic approaches:

- (1) A reduction in the thermal exposure to the structure, where the primary objective is to maintain the structural integrity of the building (e.g., prevent flashover)
- (2) A reduction in the threat to occupants, where the primary objective is to minimize the loss of life
- (3) A reduction in a fire-related characteristic, such as heat release rate, fire growth rate, or spread to adjacent objects

**5-3.1.2 Fire Suppression.** Fire suppression is the sharp reduction in the heat release rate of a fire and the prevention of its regrowth by a sufficient application of water mist.

**5-3.1.3 Fire Extinguishment.** Fire extinguishment is the complete suppression of a fire until there are no burning combustibles.

#### 5-4 Application Parameters.

**5-4.1\* Compartment Variables.** Compartment variables shall include both the geometry of the compartment and the ventilation conditions in the compartment.

**5-4.1.1 Compartment Geometry.** The compartment geometry (floor area, compartment volume, ceiling height and aspect ratio) shall be considered when designing such parameters as nozzle locations, system flow rate, and total water use needs of the system.

**5-4.1.2 Ventilation.** Ventilation considerations shall include both natural and forced ventilation parameters.

**5-4.1.2.1\* Natural Ventilation.** The number, size, and location of the openings in the space (e.g., door, windows) shall be addressed in the design and installation of the system. In some cases, special precautions are necessary to minimize the effects of these openings. These precautions include, but are not limited to, automatic door closures and water mist curtains.

**5-4.1.2.2 Forced Ventilation.** The magnitude of the forced ventilation in the compartment shall be addressed in the design and installation of the water mist system. In some cases, consideration shall be given to shutting down the forced ventilation prior to mist system activation.

**5-4.2 Fire Hazard Classification.** The fire hazard shall be classified by both the combustible loading and fuel type.

**5-4.2.1 Combustible Loading.** A fire hazard analysis shall be conducted to determine both the design parameters of the water mist system and the type of detection and activation scheme employed by the system. The system shall be based on the fuel type, combustible loading, and anticipated fire growth rate as well as the desired fire-fighting performance objectives.

**5-4.2.2 Fuel Type.** Overall fire hazard is directly related to the type and quantity of the fuel present in a space. The ease of ignition and reignition of the fuel, the fire growth rate, and the difficulty of achieving control, suppression, extinguishment, or any combination thereof, shall be considered when selecting or designing a water mist system.

**5-4.2.2.1 Class A Fires.** Fuel loading and configuration shall be considered when selecting and designing a system to protect a space or area containing Class A materials. If fire extinguishment is desired, consideration shall be given to the potential for deep-seated fires as well as to the potential for smoldering fires.

**5-4.2.2.2 Class B Fires.** The hazard associated with Class B fires is related primarily to the fuel loading, fuel configuration, flashpoint, and burning rate of the fuel. Preburn time also affects the overall characteristics of the fire. Class B fires are grouped into two categories: two-dimensional pool fires and three-dimensional spray and running fuel fires. The parameters associated with each category are as follows:

(a) Class B two-dimensional fires:

- (1) Fuel loading and configuration
- (2) Fuel flashpoint
- (3) Preburn time pool/spill size

(b) Class B three-dimensional fires:

- (1) Fuel loading and configuration
- (2) Fuel flashpoint
- (3) Preburn time
- (4) Cascade/running fuel fires
- (5) Fuel flow rate
- (6) Fire configuration
- (7) Spray fires
- (8) Fuel line pressure
- (9) Fuel spray angle
- (10) Fuel spray orientation
- (11) Reignition sources

When designing and installing water mist systems to protect Class B hazards, the parameters specified in 5-4.2.2.2(a) and (b) shall be considered.

**5-4.2.2.3 Class C Fires.** Electrical conductivity of water and water mist shall be addressed when considering applications where the primary fire is a Class C fire.

**5-4.2.2.4 Combination Fires.** Combinations in fuel loadings and hazards shall be addressed.

**5-4.3 Fire Location.** The location of the fuel in the space shall be considered when selecting and designing a water mist system. Some of the locations of concern include the following:

- (1) Fuel located at higher elevations in the space
- (2) Fuel located in close proximity to vent openings
- (3) Fuel located in the corners of the space
- (4) Fuel stacked against walls

**5-4.4 Obstructions and Shielding.** Water mist nozzles shall be positioned to distribute mist to all locations in the area or around the object being protected. The presence of obstructions and the potential for shielding of misting spray patterns shall be evaluated to ensure that the system performance is not affected.

**5-5\* Reliability.** See Appendix D.

## Chapter 6 Calculations

**6-1 General.** System flow calculation procedures for water mist systems shall be in accordance with Section 6-2.

*Exception No. 1: Hydraulic calculations for systems with no additives and with working pressures not exceeding 175 psi (12 bar) shall be permitted to be performed using the method provided in Section 6-3.*

*Exception No. 2: Calculations for piping carrying atomizing media in twin-fluid systems shall be performed in accordance with Section 6-4.*

**6-1.1\*** Where any modification is made that alters the system flow characteristics of an existing, engineered water mist system, system flow calculations shall be furnished indicating the previous design, volume, and pressure at points of connection, and calculations also shall be provided to indicate the effect on existing systems.

**6-1.2** Pre-engineered systems shall not be modified outside the limits of the listing.

### 6-2\* Darcy-Weisbach Calculation Method for Intermediate and High Pressure, Single Fluid, Single Liquid Phase Systems.

**6-2.1** Pipe friction losses shall be determined using the formulae in Table 6-2.1.

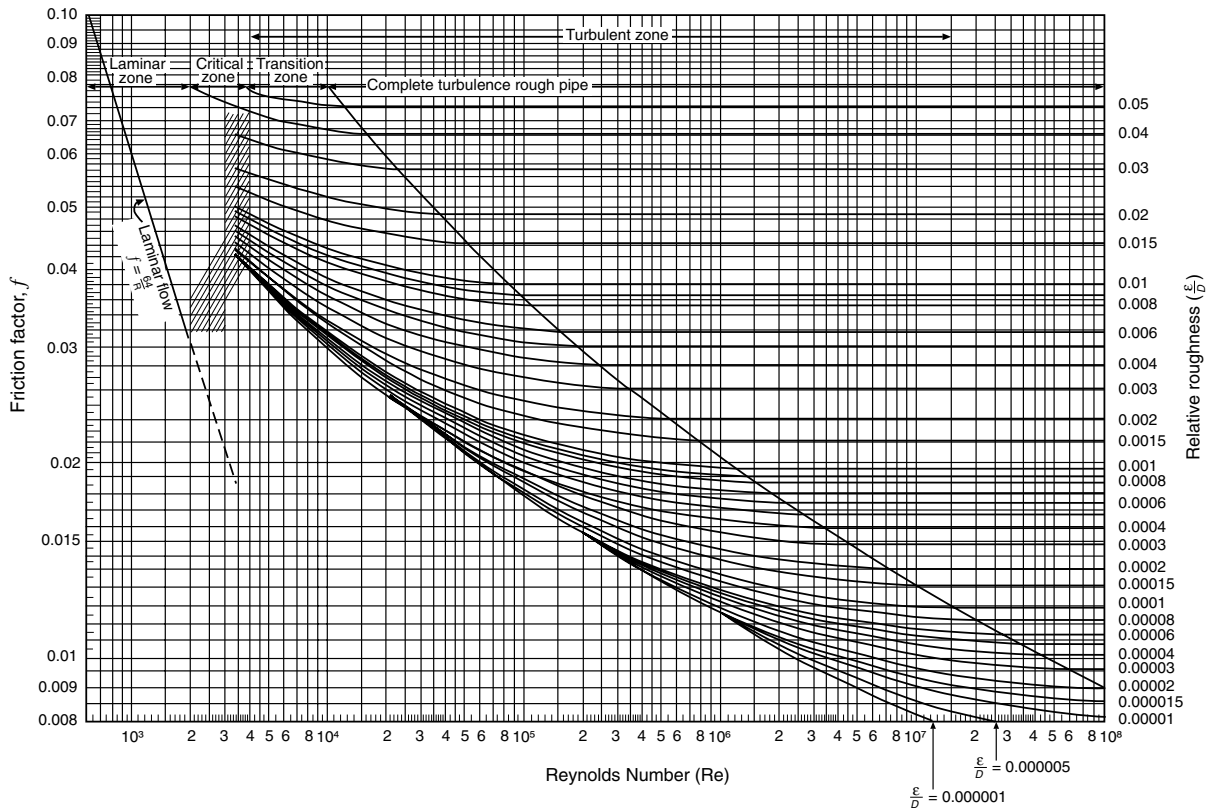
*Exception: Hydraulic calculations can be performed using the Hazen-Williams calculation method for intermediate and high pressure systems having a minimum 3/4 in. (20 mm) pipe size, provided that the maximum flow velocity through the system piping does not exceed 25 ft/sec (7.6 m/s).*

**6-2.2** Figure 6-2.2 (moody diagram) shall be used to determine the value of the friction factor,  $f$ , in the Darcy-Weisbach equation, where the Reynolds number and relative roughness are calculated as shown in Table 6-2.1, using coefficients provided in Tables 6-2.2(a) and 6-2.2(b).

**Table 6-2.1 Darcy-Weisbach and Associated Equations for Pressure Loss in Intermediate and High Pressure Systems**

U.S. Custom Units	SI Units
<b>Darcy-Weisbach equation:</b>	
$\Delta p = 0.000216 \frac{fL\rho Q^2}{d^5}$	$\Delta p_m = 2.252 \frac{fL\rho Q^2}{d^5}$
<b>Reynolds number:</b>	
$Re = 50.6 \frac{Q\rho}{d\mu}$	$Re = 21.22 \frac{Q\rho}{d\mu}$
<b>Relative roughness:</b>	
relative roughness = $\frac{\epsilon}{D}$	relative roughness = $\frac{\epsilon}{d}$
where: $\Delta p$ = friction loss (psi gauge) $L$ = length of pipe (ft) $f$ = friction factor (psi/ft) $Q$ = flow (gpm) $d$ = internal pipe diameter (in.) $D$ = internal pipe diameter (ft) $\epsilon$ = pipe wall roughness (ft) $\rho$ = weight density of fluid (lb/ft <sup>3</sup> ) $\mu$ = absolute (dynamic) viscosity [centipoise (cP)]	where: $\Delta p_m$ = friction loss (bar gauge) $L$ = length of pipe (m) $f$ = friction factor (bar/m) $Q$ = flow (L/min) $d$ = internal pipe diameter (mm) $\epsilon$ = pipe wall roughness (mm) $\rho$ = weight density of fluid (kg/m <sup>3</sup> ) $\mu$ = absolute (dynamic) viscosity [centipoise (cP)]

**FIGURE 6-2.2 Moody diagram.**



**Table 6-2.2(a) Recommended Values of Absolute Roughness or Effective Height of Pipe Wall Irregularities, for Use in Darcy-Weisbach Equation**

Pipe Material (New)	Design Value of $\epsilon$	
	ft	mm
Copper, copper nickel, drawn tubing	0.000 005	0.0015
Stainless steel	0.000 15	0.045

**6-2.3** Minimum and maximum operating pressure at each nozzle shall be within the listed operating range.

**6-2.4** System piping shall be hydraulically designed to deliver the water flow requirements in accordance with the manufacturer's listing and the provisions of Chapter 5.

**6-3\* Hazen-Williams Calculation Method (Low Pressure Systems).**

**6-3.1 Working Pressure Limits.** Hydraulic calculations for water mist systems with working pressures not exceeding 175 psi (12 bar) shall be permitted to be performed using the Hazen-Williams calculation method.

**6-3.2 Friction Loss Formula.** Friction losses for water-filled pipe shall be determined on the basis of the Hazen-Williams formula:

$$P_f = \frac{4.52 Q^{1.85}}{C^{1.85} d^{4.87}}$$

where:

- $P_f$  = frictional resistance (psi/ft of pipe)
- $Q$  = flow (gpm)
- $d$  = actual internal diameter of pipe (in.)
- $C$  = friction loss coefficient

For SI units:

$$P_m 6.05 \frac{Q_m^{1.85}}{C^{1.85} d_m^{4.87}} \times 10^5$$

where:

- $P_m$  = frictional resistance (bar/m of pipe)

- $Q_m$  = flow (L/min)
- $d_m$  = actual internal diameter of pipe (mm)
- $C$  = friction loss coefficient

**6-3.3 Velocity Pressure Formula.** Velocity pressure for water-filled pipe shall be determined on the basis of the following formula:

$$P_v = \frac{0.001123 Q^2}{D^4}$$

where:

- $P_v$  = velocity pressure (psi)
- $Q$  = flow (gpm)
- $D$  = inside diameter (in.)

For SI units:

$$P_v = 5.61(10)^{-7} \frac{Q^2}{D^4}$$

where:

- $P_v$  = velocity pressure (bar)
- $Q$  = flow (L/min)
- $D$  = inside diameter (mm)

**6-3.4 Normal Pressure Formula.** Normal pressure,  $P_n$ , shall be determined on the basis of the following formula:

$$P_n = P_t - P_v$$

where:

- $P_n$  = normal pressure
- $P_t$  = total pressure [psi (bar)]
- $P_v$  = velocity pressure [psi (bar)]

**6-3.5 Hydraulic Junction Points.** Pressures at hydraulic junction points shall balance within 0.5 psi (0.03 bar). The highest pressure at the junction point, and the total flows as adjusted, shall be used in the calculations.

**Table 6-2.2(b) Approximate Values of  $\mu$ , Absolute (Dynamic) Viscosity, and  $\rho$  for Clean Water, over the Temperature Range 40°F to 100°F (4.4°C to 37.8°C)**

Temperature		Weight Density of Water		Absolute (Dynamic) Viscosity, $\mu$ (Centipoise)
°F	°C	lb/ft <sup>3</sup>	kg/m <sup>3</sup>	
40	4.4	62.42	999.9	1.5
50	10.0	62.38	999.7	1.3
60	15.6	62.34	998.8	1.1
70	21.1	62.27	998.0	0.95
80	26.7	62.19	996.6	0.85
90	32.2	62.11	995.4	0.74
100	37.8	62.00	993.6	0.66

**Table 6-3.6.1 Equivalent Length of Pipe for Copper Fittings and Values**

Nominal or Standard Size		Fittings								Valves									
		Standard Ell				90° Tee				Coupling		Ball		Gate		Butterfly		Check	
		90°		45°		Side Branch		Straight Run											
in.	mm	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m		
3/8	9.53	0.5	0.15	—	—	1.5	0.46	—	—	—	—	—	—	—	—	1.5	0.46		
1/2	12.7	1	0.31	0.5	0.15	2	0.61	—	—	—	—	—	—	—	—	2	0.61		
3/8	15.88	1.5	0.46	0.5	0.15	2	0.61	—	—	—	—	—	—	—	—	2.5	0.76		
3/4	19.05	2	0.61	0.5	0.15	3	0.91	—	—	—	—	—	—	—	—	3	0.91		
1	25.4	2.5	0.76	1	0.31	4.5	1.37	—	—	0.5	0.15	—	—	—	—	4.5	1.37		
1 1/4	31.75	3	0.91	1	0.31	5.5	1.68	0.5	0.15	0.5	0.15	0.5	0.15	—	—	5.5	1.68		
1 1/2	38.1	4	1.22	1.5	0.46	7	2.13	0.5	0.15	0.5	0.15	0.5	0.15	—	—	6.5	1.98		
2	50.8	5.5	1.68	2	0.61	9	2.74	0.5	0.15	0.5	0.15	0.5	0.15	0.5	0.15	7.5	2.29		
2 1/2	63.5	7	2.13	2.5	0.76	12	3.66	0.5	0.15	0.5	0.15	—	—	1	0.31	10	3.05		
3	76.2	9	2.74	3.5	1.07	15	4.57	1	0.31	1	0.31	—	—	1.5	0.46	15.5	4.72		
3 1/2	88.9	9	2.74	3.5	1.07	14	4.27	1	0.31	1	0.31	—	—	2	0.61	—	12.5		
4	101.6	12.5	3.81	5	1.52	21	6.40	1	0.31	1	0.31	—	—	2	0.61	16	4.88		

Note:

1. Allowances are for streamlined, soldered fittings and recessed threaded fittings. For threaded fittings, double the allowances shown.
2. The equivalent lengths presented in the table are based upon a C factor of 150 in the Hazen-Williams friction loss formula. The lengths shown are rounded to the nearest half foot.

**6-3.6 Equivalent Pipe Lengths of Valves and Fittings.**

**6-3.6.1** Table 6-3.6.1 shall be used to determine the equivalent length of pipe for fittings and devices, unless the manufacturer’s test data indicate that other factors are appropriate. For saddle-type fittings having friction loss greater than that shown in Table 6-3.6.1, the increased friction loss shall be included in hydraulic calculations. For internal pipe diameters that differ from copper tubing, the equivalent feet shown in Table 6-3.6.1 shall be multiplied by a factor derived from the following formula:

$$\left[ \frac{\text{Actual inside diameter}}{\text{Type K copper tube I.D.}} \right]^{4.87} = \text{Factor}$$

The factor thus obtained shall be modified further in accordance with Table 6-3.6.2.

**6-3.6.2** Table 6-3.6.1 shall be used with Hazen-Williams only where C = 150. For other values of C, the values in Table 6-3.6.1 shall be multiplied by the factors in Table 6-3.6.2.

**Table 6-3.6.2 C Value Multiplier**

Value of C	100	120	130	140
Multiplying Factor	0.472	0.662	0.767	0.880

Note: The multiplying factor is based upon the friction loss through the fitting being independent of the C factor available to the piping.

**6-3.6.3** Specific friction loss values or equivalent pipe lengths for special valves, strainers, and other devices shall be made available to the authority having jurisdiction.

**6-3.6.4** Pipe friction loss shall be calculated in accordance with the Hazen-Williams formula C values from Table 6-3.6.4.

**Table 6-3.6.4 Hazen-Williams C Values**

Pipe or Tube	C Value <sup>1</sup>
Plastic (listed per 2-3.2 or 2-3.4.2) — all types	150
Copper tube or stainless steel	150

<sup>1</sup>The authority having jurisdiction is permitted to consider other C values.

**6-4 Pneumatic Calculation Procedures for Atomizing Media in Twin-Fluid Systems.**

**6-4.1** Calculations shall be performed to determine the maximum and minimum pneumatic pressures and flow rates (at standard temperature and pressure) at the atomizing media inlet of each twin-fluid nozzle in a multi-nozzle system. Maximum and minimum pressures at each nozzle shall be within the performance tolerances for the nozzle, as provided by the nozzle manufacturer. The following iterative procedure is described as one approach.

**6-4.2** A pneumatic calculation procedure shall be based on standard engineering methods for sizing of compressed air piping systems. Air flow at each nozzle is dependent on water pressure at the same nozzle. To start the calculation, the air pressure and air flow rate at the hydraulically most remote nozzle shall be set at the optimum air pressure and flow rate for the corresponding water pressure and water flow rate at that nozzle.

**6-4.3** The initial water pressure condition at the most hydraulically remote nozzle shall be taken from hydraulic calculations performed independently (i.e., treating the water piping as a single fluid system), using assumed nozzle discharges. Once the water pressure and flow rate at each nozzle are determined, the corresponding required air pressure and flow rate

to allow the assumed water flow rate shall be estimated from information provided by the nozzle manufacturer.

**6-4.4** Having determined the nominal air pressure and flow requirements at each nozzle, the pneumatic piping system shall be calculated independently, to verify that the pipe sizes are adequate to provide the required pressure and flow at each nozzle location. Using the calculated pressures at each nozzle, the effect on the water discharge rate must be checked. If the water flow rate at the calculated air pressure is within 10 percent of the assumed flow rate in 6-4.3, no correction is required. If not, the nozzle discharge shall be adjusted, and the hydraulic calculation of 6-4.3 shall be repeated. This procedure is iterative, and must be repeated until calculated air and water pressures are within the desired range and ratio.

**6-4.5** The ratio of the air pressure to water pressure at each nozzle shall be maintained within 10 percent of the manufacturer's recommended operating ratio as provided by the nozzle manufacturer.

**6-4.6** The results of the hydraulic and pneumatic calculations shall indicate the total water demand as a flow rate and pressure at the system supply point, and the total air flow rate (in scfm) and initial air pressure at the atomizing media supply point.

## Chapter 7 Water Supplies and Atomizing Media

**7-1 General.** Unless otherwise specified, the following requirements shall apply to the water supplies, the atomizing media, and any additives necessary for fire-extinguishing performance.

**7-1.1** Every water mist system shall have at least one automatic water supply.

**7-1.2\*** Compressed gas or other atomizing medium, where used as part of a twin-fluid water mist system, shall be automatically supplied in concurrence with the water.

**7-2\* Quantity.** The minimum quantities of water, water additives in listed concentrations (if used), and of atomizing media (if used) shall be capable of supplying the largest single hazard or group of hazards to be protected simultaneously.

**7-3\* Duration.** Design quantities of water, additives (if used), and of atomizing media (if used), shall be capable of supplying the system for a minimum of 30 minutes. Pumps suction supply shall be sized to supply the actual delivered flow rate for the required duration at the required pressure.

*Exception No. 1: For pre-engineered systems the design quantities of water, additives (if used) and of atomizing media (if used), shall be capable of two complete discharges, as required by the listing.*

*Exception No. 2: Where the hazard has been evaluated by a fire protection engineer using standard methods of fire hazard analysis, the water supply duration shall be determined by the specified performance characteristics of the water mist system. It shall be permitted for this method to result in water supply duration requirements greater than or less than those specified in Section 7-3.*

### 7-4 Reserve Supplies.

**7-4.1\*** A reserve supply shall be provided where the extinguishing agent cannot otherwise be replaced within 24 hours following system operation.

**7-4.2** Where a reserve supply is provided, it shall be connected to the system piping at all times. If a manual changeover is necessary, the mechanism shall be accessible from outside of the protected space.

**7-4.3** Means shall be provided to prevent discharge of reserve supplies from open manifold connections when supplies are removed for servicing.

### 7-5 Water Supplies.

#### 7-5.1\* Water Quality.

**7-5.1.1** 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.

*Exception No. 1: In areas which are normally occupied, liquid or dissolved chemicals are permitted to be added to the water supplies in accordance with the listing, provided they are used at concentrations for which the manufacturer can demonstrate to the satisfaction of the U.S. Environmental Protection Agency that no adverse toxicological or physiological effects have been observed.*

*Exception No. 2: For systems which protect normally unoccupied areas, liquid or dissolved chemicals are permitted to be added to the water supplies in accordance with the listing.*

**7-5.1.2** A filter or strainer shall be provided at the supply side of each nozzle.

*Exception: Nozzles with multiple orifices and with minimum waterway dimensions greater than 800  $\mu\text{m}$  per opening shall not be required to be provided with a strainer or filter at each nozzle.*

**7-5.1.3** A filter or a strainer shall be provided at each water supply connection or system riser. The filter or strainer shall be installed downstream (on the system side) of all piping that is not corrosion resistant. Such strainers shall be provided with a cleanout port and shall be arranged to facilitate inspection, maintenance, and replacement.

**7-5.1.4** The maximum filter rating or strainer mesh opening shall be 80 percent of the minimum nozzle waterway dimension.

**7-5.1.5** Systems that utilize nozzles with a minimum nozzle waterway dimension less than 51  $\mu\text{m}$  shall be supplied with demineralized water.

#### 7-5.2 Pumps.

**7-5.2.1** Pumps supplying water mist systems shall be automatically controlled.

**7-5.2.2\*** Pumps supplying water mist systems shall be of sufficient capacity to meet the system demand.

**7-5.2.3 Supervision.** Pumps supplying water mist systems shall be supervised for the conditions specified in 7-5.2.3.1 and 7-5.2.3.2.

**7-5.2.3.1 Electric Pumps.** Supervisory conditions shall include the following:

- (1) Pump running
- (2) Loss of power
- (3) Phase reversal

**7-5.2.3.2 Diesel-Driven Pumps.** Supervisory conditions shall include the following:

- (1) Pump running



- (2) Power failure
- (3) Controller not in automatic position
- (4) Low oil pressure
- (5) High water temperature
- (6) Failure to start/overcrank
- (7) Overspeed
- (8) Fuel level (set at 75 percent capacity)

### 7-5.3 Tanks.

**7-5.3.1** Water tanks shall be arranged in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection*.

**7-5.3.2** Water tanks shall be supervised for the following conditions:

- (1) Water level
- (2) Water temperature (for tanks located in unheated areas)
- (3) Air pressure (for pressure tanks)

### 7-5.4 Storage Containers.

**7-5.4.1** Storage containers and accessories shall be located and arranged to facilitate inspection, testing, recharging, and other maintenance. Interruption to protection shall be held to a minimum.

**7-5.4.2** Storage containers shall not be located where they are subject to severe weather conditions or to mechanical, chemical, or other damage.

**7-5.4.3** Where excessive climatic or mechanical exposures are expected, approved safeguards or enclosures shall be provided.

**7-5.4.4** Storage containers shall be installed in accordance with the manufacturer's installation manual. This shall include mounting the container on the appropriate mounting surface.

**7-5.4.5** Each pressurized container or cylinder shall be provided with a safety device to release excess pressure.

**7-5.4.6** A reliable means shall be provided to indicate the pressure and level in all storage containers.

*Exception: Containers that will not be pressurized shall not be required to have a pressure indicator.*

**7-5.5\* Fire Department Connection.** A fire department connection shall be provided on the discharge side of the pressure source components. The connection to the system shall be made on the upstream (supply) side of the system strainer or filter.

*Exception No. 1: For systems with operating pressures in excess of 175 psi (12 bar), the connection shall be made on the suction side of the pressure source components.*

*Exception No. 2: Fire department connections shall not be required for systems protecting less than 2000 ft<sup>2</sup> (200 m<sup>2</sup>).*

*Exception No. 3: Fire department connections shall not be required for systems with operating pressures in excess of 175 psi (12 bar) and supplied only by storage cylinders.*

*Exception No. 4: Fire department connections shall not be required for systems where the atomizing medium is essential for fire suppression.*

### 7-6 Atomizing Media for Twin-Fluid Systems.

#### 7-6.1 General.

**7-6.1.1** Atomizing media essential to the production of water mist shall be taken from a dedicated source.

*Exception: Where the facility has an air supply that meets or exceeds the requirements of a dedicated main and reserve air supply, both meeting the quality, quantity, pressure, and reliability requirements of the listing and the approval of the authority having jurisdiction. Plant air used as an atomizing medium for a water mist system shall be monitored by the fire control panel, with the low air alarm set at a point at least 50 percent above the availability of two full system discharge requirements.*

**7-6.1.2** Atomizing media shall be supervised for high and low pressure.

**7-6.1.3** Moisture content in the atomizing medium shall not exceed 25 ppm.

**7-6.1.4** Regulators controlling the supply of water for the atomizing medium shall be listed for the intended purpose.

**7-6.1.5** A check valve or other means shall be installed in the piping at the supply point to prevent the entrance of water into the atomizing medium.

**7-6.1.6** Filters or other means to protect nozzles from obstructions shall be provided in accordance with 7-5.1.2.

#### 7-6.2 Air Compressors.

**7-6.2.1** Air compressors used as a dedicated source shall be listed for use on fire protection systems.

**7-6.2.2** Compressors used as a dedicated supply shall be connected to a backup power supply.

**7-7 Pressure Gauges.** A pressure gauge shall be provided for each water supply and each atomizing medium.

## Chapter 8 Plans and Documentation

### 8-1 Working Plans.

**8-1.1** Working plans shall be submitted for approval to the authority having jurisdiction before any equipment is installed or remodeled. Deviation from approved plans shall require permission of the authority having jurisdiction.

**8-1.2** Working plans shall be drawn to specified scale on sheets of uniform size. Special symbols shall be defined and used to identify components of the water mist system clearly. The plans shall provide the following information that pertains to the design of the system:

- (1) Name of owner and occupant
- (2) Location, including street address
- (3) Point of compass and symbol legend
- (4) Location and construction of protected enclosure walls and partitions
- (5) Location of fire walls
- (6) Enclosure cross section, with full height or schematic diagram, including location and construction of building floor/ceiling assemblies above and below, raised access floor, and suspended ceiling
- (7) Description of occupancies and hazards being protected, designating whether or not the enclosure is normally occupied
- (8) Description of exposures surrounding the enclosure
- (9) Description of water and gas storage containers used including make, internal volume, storage pressure, and nominal capacity expressed in units of mass or volume at standard conditions of temperature and pressure

- (10) Description of nozzles used including manufacturer, size, orifice port configuration, and orifice size or part number
- (11) Description of pipe and fittings used including material specifications, grade, and pressure rating
- (12) Description of wire or cable used including classification, gauge (AWG), shielding, number of strands in conductor, conductor material, and color coding schedule. The segregation requirements of various system conductors shall be clearly indicated. The required method of making wire terminations shall be detailed
- (13) Description of the method of detector mounting
- (14) System equipment schedule or system bill of material indicating device name, manufacturer, model or part number, quantity, description and documentation of approval or listing for the application
- (15) Plan view of the protected area showing enclosure partitions (full and partial height); water distribution system including storage containers or pumps; gas distribution system including gas storage containers; piping; nozzles; type of pipe hangers and rigid pipe supports; detection, alarm, and control system including all devices; end-of-line device locations; location of controlled/ interlocked devices such as dampers and shutters; and location of instructional signage
- (16) Isometric view of the water mist distribution system showing the length and diameter of each pipe segment; node reference numbers relating to the flow calculations; fittings including reducers and strainers; orientation of tees; and nozzles including size, orifice port configuration, and flow rate
- (17) Seismic building joints, if any, showing where water mist distribution or supply piping crosses the joint; expected movement of the seismic joint; details of the piping arrangement; and flexible connectors used to accommodate seismic movement
- (18) The calculation of seismic loads if seismic restraint is required by the authority having jurisdiction
- (19) Scale drawing showing the layout of the annunciator panel graphics if required by the authority having jurisdiction
- (20) Details of each unique rigid pipe support configuration showing method of securement to the pipe and to the structure
- (21) Details of the method of container securement showing method of securement to the container and to the structure
- (22) Complete step-by-step description of the system sequence of operations including functioning of abort and maintenance switches, delay timers, and emergency power shut-down
- (23) Schematic diagrams and point-to-point wiring diagrams showing all circuit connections to the system control panels, detectors, system devices, controlled devices, external and add-on relays, and graphic annunciator panels
- (24) Schematic diagrams and point-to-point wiring diagrams of the system control panels
- (25) Complete calculations to determine enclosure volume for the application of water mist
- (26) Complete calculations to determine the size of backup batteries; the method used to determine the number and location of audible and visual indicating devices; and number and location of detectors

**8-1.3** Symbols used on plans shall comply with NFPA 170 and ISO Standard 1219, "Fluid power systems and components — graphics symbols and circuit diagrams — Part 1: Graphic symbols" and "Fluid power systems and components — graphics symbols and diagrams — Part 2: Circuit diagrams," as shown in Figures 8-1.3(a) through (e).

### **8-2\* Hydraulic Calculation Documentation.**

**8-2.1 Hydraulic Calculation Sheets.** Hydraulic calculations shall be prepared on form sheets that include a summary sheet, detailed work sheets, and a graph sheet.

*Exception: Pre-engineered systems.*

**8-2.2 Summary Sheet.** The summary sheet shall contain the following information:

- (1) Date
- (2) Location
- (3) Name of owner and occupant
- (4) Building number or other identification
- (5) Description of hazard
- (6) Name and address of contractor or designer
- (7) Name of approving agency
- (8) System design requirements, including:
  - a. Design area of water application or volume of space protected
  - b. Minimum rate of water application (density)
  - c. Area per nozzle
- (9) Total water requirements as calculated
- (10) Limitations (dimension, flow, and pressure) resulting from the use of automatic sprinkler systems or other water fire suppression systems

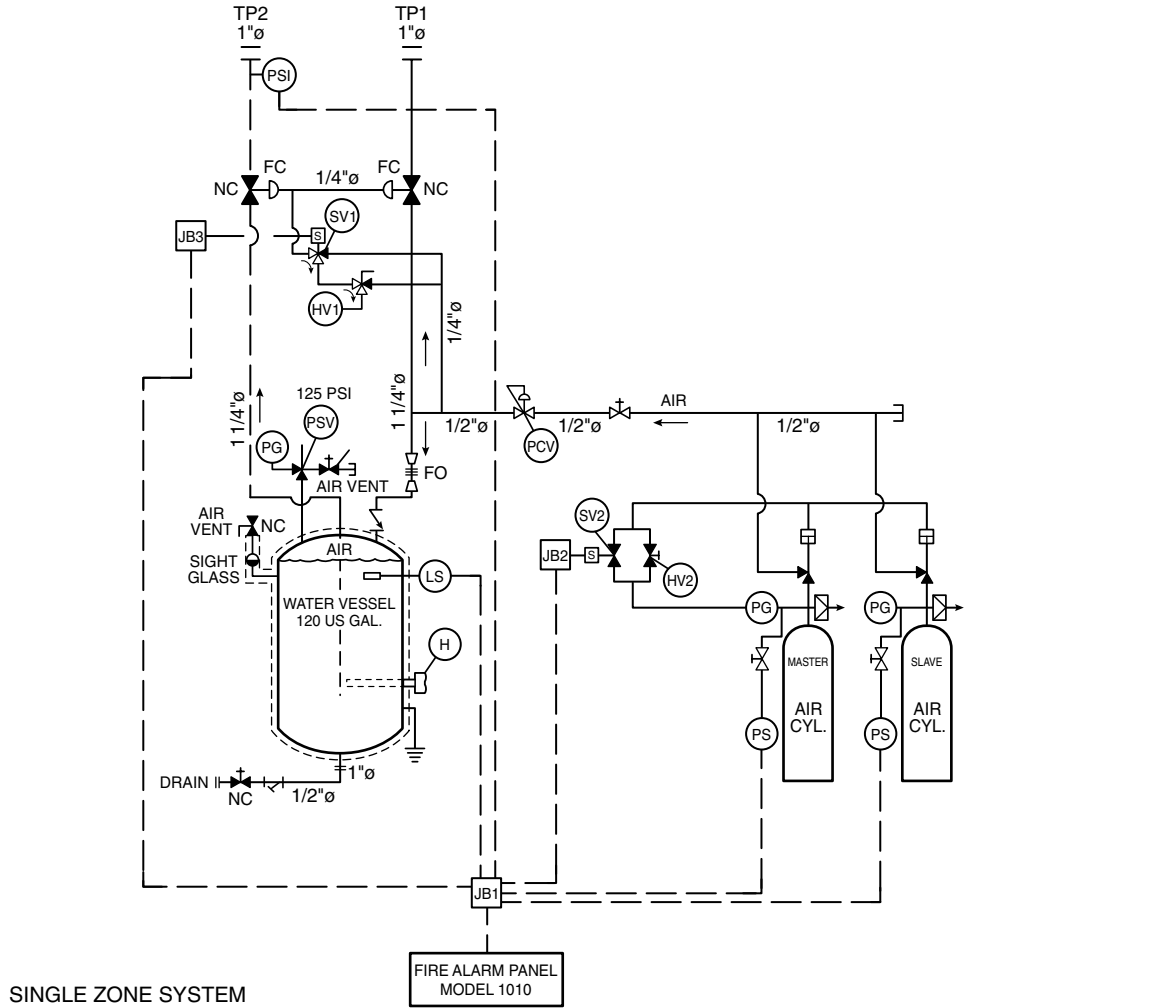
**8-2.3 Detailed Work Sheets.** The detailed work sheets or computer printouts shall contain the following information:

- (1) Sheet number
- (2) Nozzle description
- (3) Hydraulic reference points
- (4) Flow in gpm (L/min)
- (5) Pipe size
- (6) Pipe lengths, center to center of fittings
- (7) Equivalent pipe lengths for fittings and devices
- (8) Friction loss in psi/ft (bar/m) of pipe
- (9) Total friction loss between reference points
- (10) Elevation head in psi (bar) between reference points
- (11) Required pressure in psi (bar) at each reference point
- (12) Velocity pressure and normal pressure if included in calculations
- (13) System flushing locations
- (14) Notes to indicate starting points, reference other sheets, or clarify data shown
- (15) Diagram to accompany gridded system calculations to indicate flow quantities and directions for lines with water mist nozzles operating in the remote area
- (16) Other calculations necessary for design of the water mist system

**8-2.4 Graph Sheet.** A graphic representation of the complete hydraulic calculation shall be plotted on semilogarithmic ( $Q^{1.85}$ ) graph paper and shall include the following:

- (1) Water supply curve
- (2) Water mist system demand

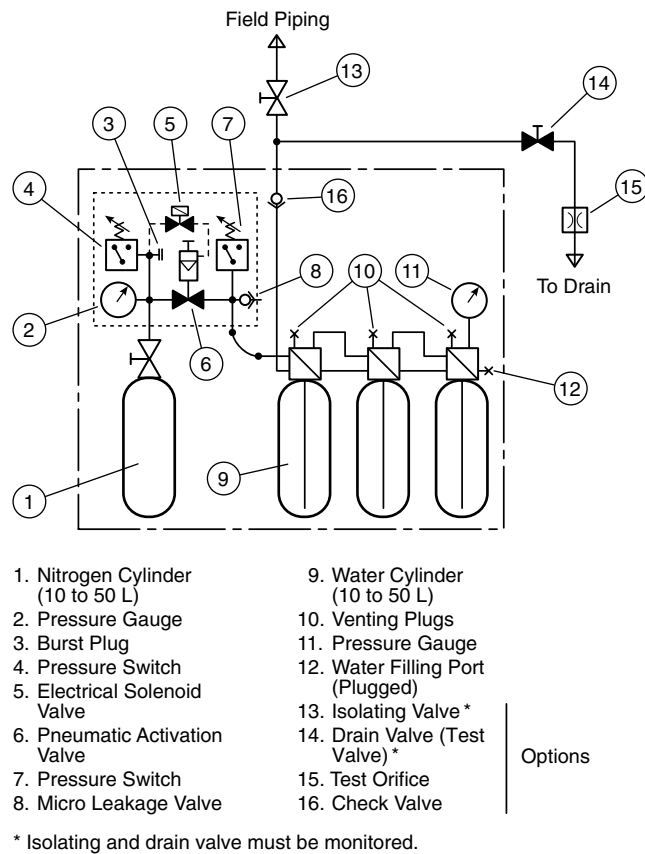
FIGURE 8-1.3(a) Typical water mist plans. (Courtesy of Securiplex.)



**LEGEND**

- |                                    |  |                              |
|------------------------------------|--|------------------------------|
| (SV1) SOLENOID VALVE LOW PRESSURE  | LO LOCKED OPEN                               | AIR ACTUATED GLOBE VALVE, NC |
| (SV2) SOLENOID VALVE HIGH PRESSURE | FC FAIL CLOSE                                | AIR CYLINDER VALVE           |
| (HV1) MANUAL RELEASE VALVE         | FO FAIL OPEN                                 | CHECK VALVE                  |
| (HV2) CYLINDER BANK MANUAL RELEASE | NC NORMALLY CLOSED                           | TWO WAY SOLENOID VALVE       |
| (PCV) PRESSURE CONTROL VALVE       | ----- WIRING                                 | THREE WAY SOLENOID VALVE     |
| (PSV) SAFETY RELIEF VALVE          | ———— TUBING                                  | PRESSURE RELIEF VALVE        |
| (LS) LEVEL SWITCH                  | ———— AIR FLOW                                | BALL VALVE, 3-WAY            |
| (PG) PRESSURE GAUGE                | ——— WATER FLOW                               | 2-WAY VALVE                  |
| (PS) PRESSURE SWITCH               | STRAINER                                     | AIR VENT                     |
| (H) IMMERSION HEATER               | [JB] JUNCTION BOX                            | SIGHT GLASS                  |
|                                    | CYLINDER BURSTING DISC<br>190 BAR (2757 PSI) | INSULATION                   |
|                                    | BALL VALVE                                   |                              |
|                                    | AIR PRESSURE CONTROL VALVE                   |                              |
|                                    | RO (RESTRICTION ORIFICE)                     |                              |
|                                    | REDUCER                                      |                              |

**FIGURE 8-1.3(b) Typical water mist plans. (Courtesy of Marioff.)**



### 8-3 Pneumatic Calculation Documentation.

**8-3.1 Pneumatic Calculation Sheets.** Pneumatic calculations shall be prepared on form sheets that include a summary sheet and detailed work sheets.

*Exception: Pre-engineered systems.*

**8-3.2 Summary Sheet.** The summary sheet shall contain the following information:

- (1) Date
- (2) Location
- (3) Name of owner and occupant
- (4) Building number or other identification
- (5) Description of hazard
- (6) Name and address of contractor or designer
- (7) Total gas volume required

### 8-3.3 Detailed Work Sheets (for pneumatic calculations).

The detailed work sheets or computer printouts shall contain the following information:

- (1) Sheet number
- (2) Nozzle description
- (3) Pneumatic reference points
- (4) Atomizing media flow rate (in scfm) and pressure at each nozzle
- (5) Air pressure to water pressure ratio at each nozzle
- (6) Pipe size
- (7) Pipe lengths

- (8) Total pressure loss between reference points
- (9) Required pressure in psi (bar) at each reference point
- (10) Notes to indicate starting points, reference other sheets, or clarify data shown

**8-4 Detection, Actuation, and Control Systems Documentation.** After successful completion of acceptance tests satisfactory to the authority having jurisdiction, as-built installation documentation shall be prepared and provided to the system owner or the owner's designated representative, including as-built installation drawings, operation and maintenance manuals, a written sequence of operation, and reports.

**8-4.1 As-Built Installation Drawings.** A set of as-built installation drawings, reproducible and drawn to a scale specified on sheets of uniform size, shall provide the as-built configuration of detection, actuation, and control systems and shall include the following:

- (1) Name of owner and occupant
- (2) Location, including street address
- (3) Plan view of the protected area showing all detector locations; end-of-line device locations; location of detector indicating lights if separate from the detectors; location of audible and visual indicating devices; location of control panels; location of manual release and abort switches; location of controlled/ interlocked devices such as dampers and shutters; location of maintenance and emergency power shutdown switches; and location of the annunciator panel
- (4) Equipment schedule or bill of materials for each piece of equipment or device indicating the device name, manufacturer, model or part number, quantity, and description
- (5) Description of wire or cable used including classification, gauge (AWG), shielding, number of strands in conductor, conductor material, and color coding schedule. The segregation requirements of various system conductors shall be clearly indicated. The as-built method of making wire terminations shall be detailed
- (6) Scale drawing showing the graphics layout of all annunciator panels
- (7) Schematic diagrams and point-to-point wiring diagrams showing all circuit connections to the system control panels, detectors, system devices, controlled devices, external and add-on relays, and graphic annunciator panels
- (8) Schematic diagrams and point-to-point wiring diagrams of the system control panels
- (9) Size and type of backup batteries
- (10) Details of any special features

**8-4.2 Documentation.** Design, installation, operation, and maintenance manuals shall be provided to the user. Design and installation manuals shall provide information to allow the user or a third party to verify the system has been designed and installed properly. Operation and maintenance manuals shall include operation and maintenance instructions for each piece of equipment or device of the as-built system.

**8-4.3 Written Sequence of Operation.** The written sequence of operation of the as-built system shall include a complete step-by-step description of the functioning of abort and maintenance switches, delay timers, and emergency power shutdown features. A logic diagram shall be provided.

**8-4.4 Reports.** Reports shall include inspection, testing, and maintenance reports.

FIGURE 8-1.3(c) Typical water mist plans. (Courtesy of Marioff.)

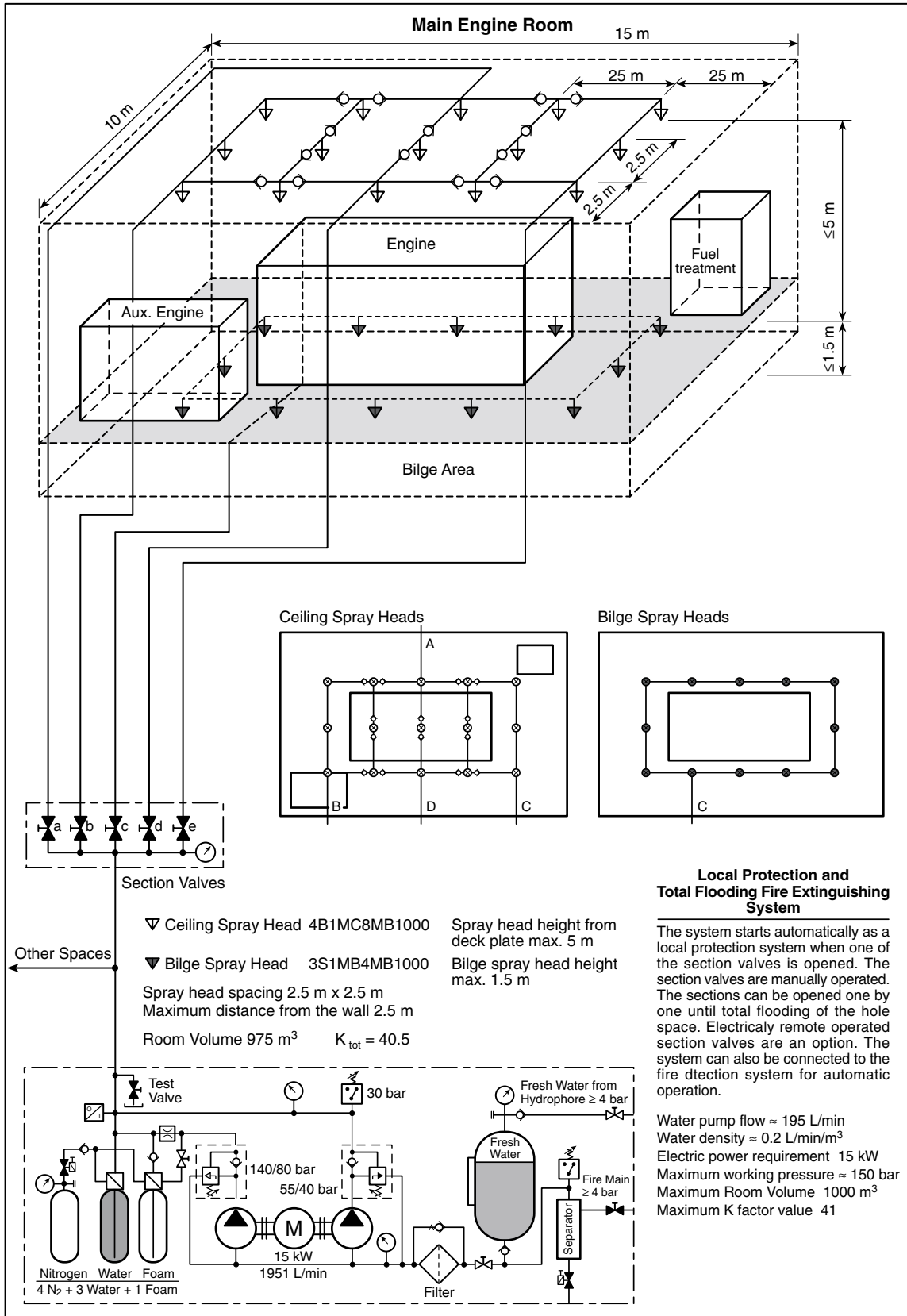
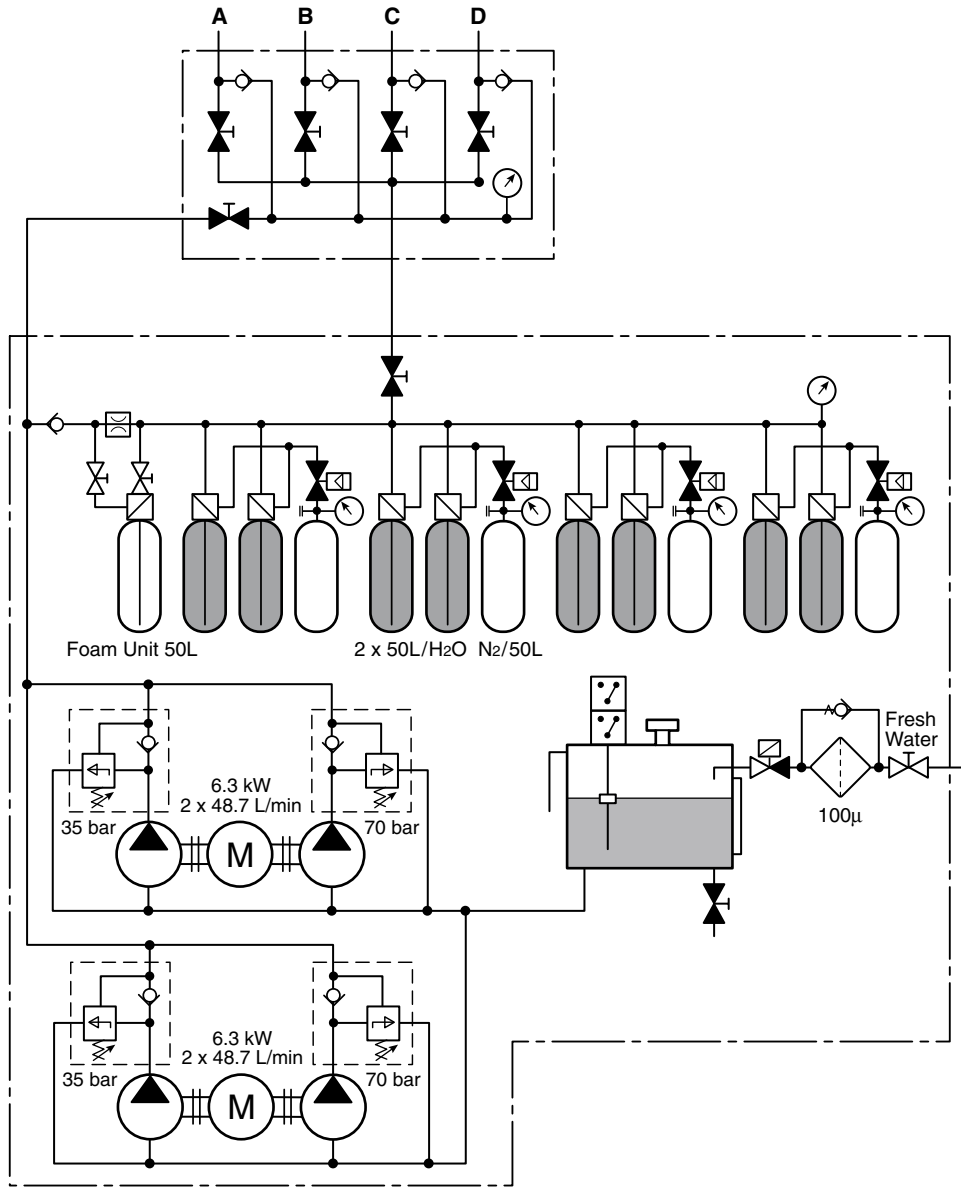
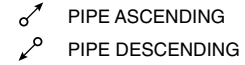
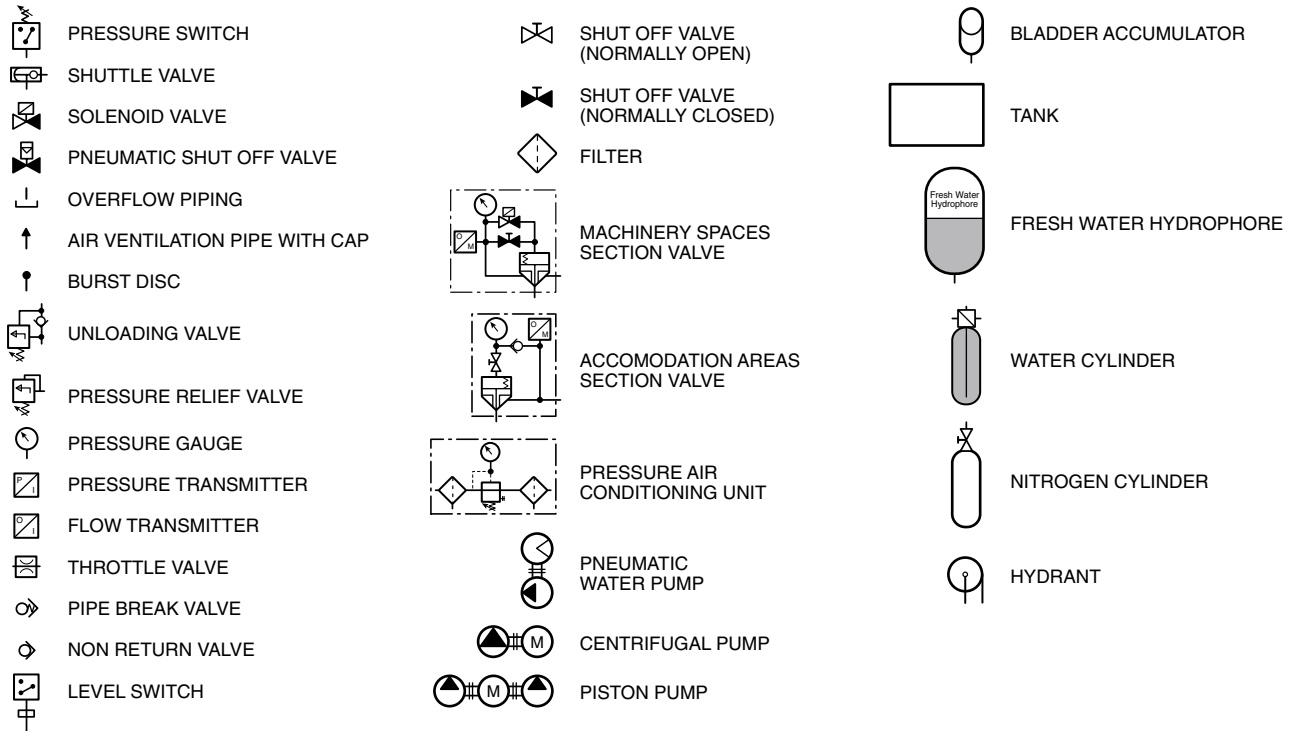


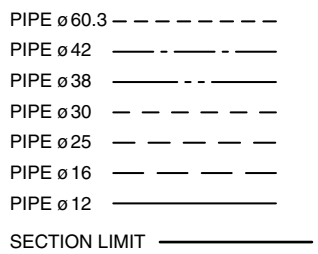
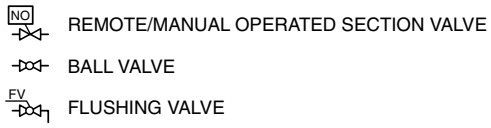
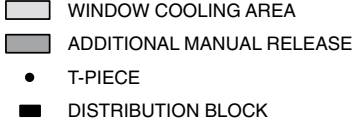
FIGURE 8-1.3(d) Typical water mist plans. (Courtesy of Marioff.)



**FIGURE 8-1.3(e) Legend for typical water mist plans. (Courtesy of Marioff.)**



	HI-FOG SPRINKLER HEAD FOR ACCOMODATION AREA (FIRE CATEGORY 1-12; 57 °C FUSE)	<b>MARIOFF TYPE CODE</b>	1B 1MB 6MB 100A
	HI-FOG SPRINKLER HEAD FOR ACCOMODATION AREA, EQUIPPED WITH WINDOW COOLING NOZZLE (FIRE CATEGORY 1-12; 57 °C FUSE)		1B 1MB 6MB 10WA
	HI-FOG SPRINKLER HEAD FOR GALLERY AREA (79 °C FUSE)		1B 1MB 6MB 100C
	HI-FOG SPRINKLER HEAD FOR STORE AREA (FIRE CATEGORY 13-14 57 °C FUSE)		1B 1MC 6MC 100A
	HI-FOG SPRINKLER HEAD FOR SAUNA (FIRE CATEGORY 141 °C FUSE)		1B 1MB 6MB 100D
	HI-FOG SPRAY HEAD FOR MACHINERY SPACE (HEIGHT 3 m)		4S 1MB 6MB 1000
	HI-FOG SPRAY HEAD FOR MACHINERY SPACE (HEIGHT 5 m)		4S 1MC 8MB 1000
	HI-FOG SPRAY HEAD FOR MACHINERY SPACE, BILGE (HEIGHT 1.5 m)		3S 1MB 4MB 1000



## Chapter 9 System Acceptance

**9-1 Approval of Water Mist Systems.** The completed system shall be reviewed and tested by qualified personnel to meet the approval of the authority having jurisdiction.

These personnel shall confirm that listed equipment and devices have been used in the system where required by this standard. To determine that the system has been properly installed and functions as specified, the installing contractor shall

- (1) Notify the authority having jurisdiction and the owner's representative of the time and date testing is to be performed
- (2) Perform all required acceptance tests

### 9-2\* Acceptance Requirements.

#### 9-2.1 Flushing or Cleaning of Piping.

**9-2.1.1 Water Supply Connection.** Where systems are connected to municipal or private water supplies, underground mains and lead-in connections to water mist system piping shall be flushed completely before connection is made to water mist piping. The flushing operation shall be continued for a sufficient time to ensure thorough cleaning. The minimum rate of flow shall be one of the following, whichever is greater:

- (1) The hydraulically calculated water demand rate of the system
- (2) The maximum flow rate available to the system under fire conditions

**9-2.1.2 System Pipe or Tube.** Each pipe or tube section shall be cleaned internally after preparation and before assembly in accordance with the manufacturer's installation manual. The piping network shall be free of particulate matter and oil residue before installation of nozzles or discharge devices.

#### 9-2.2 Hydrostatic Tests.

##### 9-2.2.1 General.

**9-2.2.1.1** The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

**9-2.2.1.2** Water used for testing shall be filtered or strained in accordance with 7-5.1.2, 7-5.1.3, and 7-5.1.4.

**9-2.2.1.3** Additives, corrosive chemicals such as sodium silicate or derivatives of sodium silicate, brine, or other chemicals shall not be used while hydrostatically testing systems or for stopping leaks.

**9-2.2.1.4** Test blanks shall have painted lugs protruding in such a way as to clearly indicate their presence. The test blanks shall be numbered, and the installing contractor shall have a recordkeeping method to ensure the removal of the test blanks after work is completed.

**9-2.2.2 Low Pressure System.** All interior piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 200 psi (13.8 bar) and shall maintain that pressure without loss for 2 hours. Loss shall be determined by a drop in gauge pressure or visible leakage.

*Exception No. 1: Portions of systems subjected to working pressures in excess of 150 psi (10.4 bar) shall be tested as described above at a pressure of 50 psi (3.5 bar) in excess of the working pressure.*

*Exception No. 2: Where cold weather does not allow testing with water, an interim air test shall be conducted as described in 9-2.3.*

**9-2.2.3\* Intermediate and High Pressure Systems.** All interior piping and attached appurtenances subjected to system pressure shall be hydrostatically tested to 150 percent of the normal working pressure, and they shall maintain that pressure without loss for 2 hours. Loss shall be determined by a drop in gauge pressure or visible leakage.

*Exception: Intermediate and high pressure systems shall be permitted to be tested in conformance with the ANSI B31.1, Power Piping Code.*

**9-2.3\* Air Tests.** For dry and preaction systems, an air pressure leakage test at 40 psi (2.8 bar) shall be conducted for 24 hours in addition to the standard hydrostatic test. Any leakage that results in a loss of pressure in excess of 1 1/2 psi (0.1 bar) during the 24 hours shall be corrected.

#### 9-2.4 Review of Components.

##### 9-2.4.1 Review of Mechanical Components.

**9-2.4.1.1** The piping system shall be inspected to determine that it is in compliance with the design and installation documents and hydraulic calculations.

**9-2.4.1.2** Nozzles and pipe size shall be in accordance with system drawings. The means of pipe size reduction and the attitudes of tees shall be checked for conformance to the design.

**9-2.4.1.3** Piping joints, discharge nozzles, and piping supports shall be restrained to prevent unacceptable vertical or lateral movement during discharge. Discharge nozzles shall be installed in such a manner that piping cannot become detached during discharge.

**9-2.4.1.4** The discharge nozzle shall be oriented in such a manner that optimum water mist application can be effected.

**9-2.4.1.5** The discharge nozzles, piping, and mounting brackets shall be installed in such a manner that they do not potentially cause injury to personnel.

**9-2.4.1.6** All water and gas storage containers shall be located in accordance with an approved set of system drawings.

**9-2.4.1.7** All containers and mounting brackets shall be fastened in accordance with the manufacturer's requirements.

##### 9-2.4.2 Review of Electrical Components.

**9-2.4.2.1** All wiring systems shall be checked for proper installation in conduit and in compliance with the approved drawings. It shall be confirmed that ac wiring and dc wiring are not combined in a common conduit or raceway unless properly shielded and grounded.

**9-2.4.2.2** All field circuits shall be confirmed to be free of ground faults and short circuits. Where measuring field circuitry, all electronic components, such as smoke and flame detectors or special electronic equipment for other detectors or their mounting bases, shall be removed, and jumpers shall be installed properly to prevent the possibility of damage within these devices. Components shall be replaced after measuring.

**9-2.4.2.3** The detection devices shall be checked for proper type and location as specified on the system drawings.

**9-2.4.2.4** The detectors shall be installed in a professional manner and in accordance with technical data regarding their installation. NFPA 72, *National Fire Alarm Code*, shall be referenced for installation requirements. In Canada, CAN/ULC S524-M86, *Standard for the Installation of Fire Alarm Systems*, and CAN/ULC S529-M87, *Smoke Detectors for Fire Alarm Systems*, shall be referenced.



**9-2.4.2.5** Manual pull stations shall be confirmed as accessible, accurately identified, and properly protected to prevent damage.

**9-2.4.2.6** For systems using abort switches, the switches shall be confirmed to be of the deadman type that necessitates constant manual pressure, properly installed, accessible within the hazard area, and clearly identified. Switches that remain in the abort position when released shall not be permitted for this purpose. Verification that normal and manual emergency control overrides the abort function shall be made.

**9-2.4.2.7** Polarity shall have been observed on all polarized alarm devices and auxiliary relays.

**9-2.4.2.8** All end-of-line resistors shall have been installed across the detection and alarm bell circuits where required.

**9-2.4.2.9** The control unit shall be checked for proper installation and accessibility.

**9-2.4.2.10\*** All wiring systems shall be checked for proper grounding and shielding. It shall be verified that the water mist system branch piping has not been used as an electrical ground.

### **9-2.5 Preliminary Functional Tests.**

**9-2.5.1** If the system is connected to an alarm receiving office, the alarm receiving office shall be notified that the fire system test is to be conducted and that an emergency response by the fire department is not desired. All concerned personnel at the end-user's facility shall be notified that a test is to be conducted and shall be instructed as to the sequence of operation.

**9-2.5.2** Each water mist release mechanism shall be disabled so that activation of the release circuit does not release water mist. The release circuit shall be reconnected with a functional device in lieu of each water mist release mechanism. For electrically actuated release mechanisms, these devices can include 24-volt lamps, flash bulbs, or circuit breakers. For pneumatically actuated release mechanisms, these devices can include pressure gauges. The manufacturer's installation manual shall be referenced for recommended procedures and test methods.

**9-2.5.3** Each detector shall be checked for proper response.

**9-2.5.4** 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.

**9-2.5.5** Manual pull stations shall be checked to confirm that they override abort switches.

**9-2.5.6** All supervised circuits shall be checked for proper trouble response.

### **9-2.6 System Operational Tests.**

**9-2.6.1** Full flow tests of the system piping using water shall be made as a means of checking the nozzle layout, discharge pattern, and any obstructions; determining the relationship between design criteria and actual performance; and ensuring against the clogging of the smaller piping and nozzles by foreign matter carried by the water.

*Exception: Where a full flow test using water is not possible, connection to the water supply shall be verified by flowing water from each test connection.*

**9-2.6.2** Where practicable, the maximum number of systems that are expected to operate in case of fire shall be in full operation simultaneously when checking the adequacy and condition of the water supply.

**9-2.6.3** All operating parts of the system shall be tested fully to ensure that they function as intended. It shall be verified that all devices function properly and that they are properly sequenced.

**9-2.6.4** After flow testing, all filters and strainers shall be inspected, and cleaned or replaced, as necessary.

## **Chapter 10 System Maintenance**

### **10-1 Responsibility of the Owner or Occupant.**

**10-1.1** The responsibility for properly maintaining a water mist fire protection system shall be the obligation of this property owner. By means of periodic inspection, tests, and maintenance, in accordance with the standard and manufacturers' requirements this equipment shall be shown to be either in good operating condition and that defects or impairments exist.

**10-1.2** Inspection, testing, and maintenance activities shall be implemented in accordance with procedures meeting or exceeding those established in this document and in accordance with the manufacturer's instructions. These tasks shall be performed by personnel who have developed competence through training and experience.

**10-1.3** The owner or occupant shall notify the authority having jurisdiction, the fire department (if required), and the alarm receiving facility before shutting down a system or its supply. The notification shall include the purpose for the shutdown, the system or component involved, and the estimated time needed. The authority having jurisdiction, the fire department, and the alarm receiving facility shall be notified when the system, supply, or component is returned to service.

**10-1.4** The owner or occupant shall promptly correct or repair deficiencies, damaged parts, or impairments found while performing the inspection, test, and maintenance requirements of this standard. Corrections and repairs shall be performed by qualified maintenance personnel or a qualified contractor.

**10-1.5** The owner or occupant shall give special attention to factors that might alter the requirements for a continued approved installation. Such factors shall include, but shall not be limited to, the following:

- (1) Occupancy changes
- (2) Process or material changes
- (3) Structural revisions such as relocated walls, added horizontal or vertical obstructions, or ventilation changes
- (4) Removal of heating systems in spaces with piping subject to freezing

**10-1.6** Where changes in the occupancy, hazard, water supply, storage arrangement, structural modification, or other condition that affects the installation criteria of the system are identified, the owner or occupant shall promptly take steps to evaluate the adequacy of the installed system to protect the hazard in question, such as contacting a qualified contractor, consultant, or engineer. Where the evaluation reveals a defi-

ciency, the owner shall notify the insurance underwriter, the authority having jurisdiction, and the local fire department.

**10-1.7** Where a water mist system is returned to service following an impairment, it shall be verified that it is working properly. Chapter 9 shall be referenced to provide guidance on the type of inspection or test, or both, that is required.

**10-2 Inspection and Testing.** All components and systems shall be inspected and tested to verify that they function as intended. The frequency of inspections and tests shall be in accordance with Tables 10-2(a) and (b) or as specified in the

manufacturer’s listing, whichever is more frequent. Following tests of components or portions of water mist systems that require valves to be opened or closed, the system shall be returned to service, with verification that all valves are restored to their normal operating position. Plugs or caps for auxiliary drains or test valves shall be replaced.

**10-2.1** Test results shall be compared with those of the original acceptance test and with the previous test results.

**10-2.2** Inspection and testing requirements for each component are provided in Tables 10-2(a) and (b).

**Table 10-2(a) Inspection Frequencies**

Item	Activity	Frequency
Water tank (unsupervised)	Check water level	Weekly
Air receiver (unsupervised)	Check air pressure	Weekly
Dedicated air compressor (unsupervised)	Check air pressure	Weekly
Water tank (supervised)	Check water level	Monthly
Air receiver (supervised)	Check air pressure	Monthly
Dedicated air compressor (supervised)	Check air pressure	Monthly
	Check pressure and indicator disk	Monthly
Air pressure cylinders (unsupervised)	Inspect	Monthly
System operating components, including control valves (locked/unsupervised)	Check pressure and indicator disk	Quarterly
Air pressure cylinders (supervised)	Inspect	Quarterly
System operating components, including control valves	Inspect	Quarterly
Waterflow alarm and supervisory devices	Inspect	Semiannually
Initiating devices and detectors	Inspect	Semiannually
Batteries, control panel, interface equipment	Inspect	Annually
System strainers and filters	Inspect	Annually
Control equipment, fiber optic cable connections	Inspect	Annually
Piping, fittings, hangers, nozzles, flexible tubing	Inspect	Annually

**Table 10-2(b) Testing Frequencies**

Item	Activity	Frequency
Pumps	Operation test (no flow)	Weekly
Compressor (dedicated)	Start	Monthly
Control equipment (functions, fuses, interfaces, primary power, remote alarm) (unsupervised)	Test	Quarterly
System main drain	Drain test	Quarterly
Remote alarm annunciation	Test	Annually
Pumps	Function test (full flow)	Annually
Batteries	Test	Semiannually
Pressure relief valve	Manually operate	Semiannually
Control equipment (functions, fuses, interfaces, primary power, remote alarm) (supervised)	Test	Annually
Water level switch	Test	Annually
Detectors (other than single use or self-testing)	Test	Annually
Release mechanisms (manual and automatic)	Test	Annually
Control unit/programmable logic control	Test	Annually
Section valve	Function test	Annually
Water	Analysis of contents	Annually
Pressure cylinders (normally at atmospheric pressure)	Pressurize cylinder (discharge if possible)	Annually
System	Flow test	Annually
Pressure cylinders	Hydrostatic test	5–12 years
Automatic nozzles	Test (random sample)	20 years

**10-2.3** Specialized equipment required for testing shall be in accordance with the manufacturer's specifications.

**10-2.4** High pressure cylinders used in water mist systems shall not be recharged without a hydrostatic test (and remarking) if more than 5 years have elapsed from the date of the last test. Cylinders that have been in continuous service without discharging shall be permitted to be retained in service for a maximum of 12 years, after which they shall be discharged and retested before being returned to service.

### 10-3 Maintenance.

**10-3.1** Maintenance shall be performed to keep the system equipment operable or to make repairs. As-built system installation drawings, original acceptance test records, and device manufacturer's maintenance bulletins shall be retained to assist in the proper care of the system and its components.

**10-3.2** Preventive maintenance includes, but is not limited to, lubricating control valve stems, adjusting packing glands on valves and pumps, bleeding moisture and condensation from air compressors and air lines, and cleaning strainers. Scheduled maintenance shall be performed as outlined in Table 10-3.2.

**Table 10-3.2 Maintenance Frequencies**

Item	Activity	Frequency
Water tank	Drain and refill	Annually
System	Flushing	Annually
Strainers and filters	Clean or replace as required	After system operation

**10-3.3** Corrective maintenance includes, but is not limited to, replacing loaded, corroded, or painted nozzles, replacing missing or loose pipe hangers, cleaning clogged fire pumps, replacing valve seats and gaskets, and restoring heat in areas subject to freezing temperatures where water-filled piping is installed.

**10-3.4** Emergency maintenance includes, but is not limited to, repairs due to piping failures caused by freezing or impact damage, repairs to broken water mains, and replacing frozen or fused nozzles, defective electric power, or alarm and detection system wiring.

**10-3.5** Specific maintenance activities, where applicable to the type of water mist system, shall be performed in accordance with the schedules in Table 10-3.2.

**10-3.6** Replacement components shall be in accordance with the manufacturer's specifications and the original system design. Spare components shall be accessible and shall be stored in a manner to prevent damage or contamination.

**10-3.7\*** After each system operation, a representative sample of operated water mist nozzles in the activated zone shall be inspected.

**10-3.8** After each system operation due to fire, the system filters and strainers shall be cleaned or replaced.

**10-4 Training.** All persons who might be expected to inspect, test, maintain, or operate water mist systems shall be trained thoroughly in the functions they are expected to perform. Refresher training shall be provided as recommended by the manufacturer or by the authority having jurisdiction.

## Chapter 11 Marine Systems

**11-1 General.** This chapter outlines the deletions, modifications, and additions that are necessary for marine applications. All other requirements of NFPA 750, *Standard on Water Mist Fire Protection Systems*, shall apply to shipboard systems except as modified by this chapter.

**11-1.1** The following definitions shall be applicable to this chapter.

**11-1.1.1 Flammable Liquid Hazard Systems.** Systems protecting spaces where the predominant hazard consists of flammable and combustible liquids. Examples include machinery spaces, flammable liquid store rooms, cargo pump rooms and paint lockers.

**11-1.1.2 Sprinkler Equivalent Systems.** Systems protecting spaces where the predominant hazard consists of Class A combustibles. Examples include accommodation spaces, public spaces, galleys, and store rooms.

**11-1.2\*** The efficacy and reliability of all marine water mist system arrangements and their components shall be tested in accordance with standards developed by the International Maritime Organization (IMO).

**11-1.2.1** Sprinkler equivalent systems shall comply with the fire suppression and component manufacturing tests of IMO Assembly Resolution A.800(19).

**11-1.2.2** Flammable liquid hazard systems shall comply with fire suppression and components manufacturing tests contained in IMO 668, *Maritime Safety Committee Circular*, as amended by IMO FP40/WP.9 Annex 3, *Report of the 40th Session of the Subcommittee on Fire Protection*.

**11-1.3** All marine water mist systems and their components shall be listed or approved.

**11-1.4** The system and equipment shall be suitably designed to withstand ambient temperature changes, vibrations, humidity, shock, impact, clogging, and corrosion normally encountered in ships.

**11-1.5\*** Equipment and piping systems mounting and hanging shall be in accordance with internationally recognized standards for marine applications.

**11-1.6\*** The required water mist pumps shall be arranged such that with the largest pump out of service, the greatest system demand can still be satisfied.

### 11-1.7 Controls and Alarms.

**11-1.7.1** Pump systems shall have the following:

- (1) Automatic pump start-up
- (2) Manual pump start and annunciation at the following locations:
  - a. Within sight of the pump
  - b. Engine control room
  - c. Central control station where provided

**11-1.7.2** Annunciation shall include the following (as applicable):

- (1) Power available/power failure
- (2) Water flow and location
- (3) Pump run
- (4) Diesel driver oil pressure

**11-1.7.3** Any flow condition shall sound an alarm on the bridge or at a constantly manned control station.

**11-1.7.4** On the bridge and in the engine control room there shall be a pressure monitor consisting of one of the following:

- (1) Pressure gauge
- (2) Transducer system
- (3) High/low/OK pressure switch

**11-1.8\* Pipe Penetrations.** Pipe penetrations through bulkheads and decks shall be in accordance with US Coast Guard Navigation and Vessel Inspection Circular (NVIC) 9-97.

#### **11-1.9 Shore Connection.**

**11-1.9.1** Shore connection shall be provided in accordance with 7-5.5. At least one shore connection shall be located on the main deck in an area likely to be visible to shore responders.

**11-1.9.2** The shore connection shall consist of both a 2<sup>1</sup>/<sub>2</sub> in. (63.5 mm) diameter NST siamese with a check valve and an international shore connection with a check valve. Each shore connection manifold shall have a drain to prevent freezing. Check valves shall be provided and arranged such that standing water is not closer than 4 ft (1219 mm) from the through-bulkhead penetration where the piping becomes exposed to freezing weather.

**11-1.9.3\*** The shore connection shall be painted red or fitted with red bands. It shall be fitted with a permanent, engraved sign identifying it as the sprinkler system shore connection. The sign shall specify the recommended pressure to be maintained by shore responders or fire-fighting vessels at the connection. The lettering of the sign shall be minimum 1 in. (25.4 mm) high block letters.

**11-1.10\* Pump Test Connection.** Each system served by one or more dedicated pumps shall be provided with a means for measuring the discharge flow rate and pressure from each pump.

**11-1.11 Piping.** Piping between a vessel's sea chest and the first shutoff valve shall be schedule 80 steel or schedule 40 galvanized steel in accordance with 46 CFR 56.50-95(3).

#### **11-1.12 Copper Pipe.**

**11-1.12.1** Copper pipe shall be routed to avoid mechanical damage, especially situations that could cause the piping to become pinched.

**11-1.12.2** Copper pipe shall not be located in cargo holds.

**11-1.12.3** Copper pipe on vehicle decks shall be protected against damage from moving vehicles.

**11-1.12.4** The prevention of galvanic corrosion shall be considered by the system designer. In areas where the exterior of the pipe is regularly subject to extreme humidity, moisture, or spray, pipe hangers shall be resistant to galvanic corrosion. Dielectric pipe hanger insulators, such as nonmetallic bands between the hangers and the pipe wall, or stainless steel hangers shall be used.

**11-1.12.5** Copper pipe shall conform to ASTM B 88, *Standard Specification for Seamless Copper Water Tube*, types M, L, or K or ASTM B 42, *Standard Specification for Seamless Copper Pipe*, Standard Sizes.

**11-1.12.6** Connections of joints and fittings shall be resistant to mechanical damage and degradation when exposed to fire conditions.

**11-1.12.7** Joints and connections in ASTM B 88 tubing shall be brazed. Fittings in ASTM B 42 tubing shall be permitted to be brazed, threaded, or joined using a mechanical connector listed for the intended purpose.

**11-1.12.8** Filler materials in joints in copper pipe shall not melt at a temperature below 1700°F (927°C).

*Exception: Brazed joints shall be permitted in systems that comply with all of the following:*

(a) *Brazed joints are made in accordance with 46 CFR 56.75 using a filler material having a melting temperature above 1000°F (538°C).*

(b) *All shutoff valves upstream of, or within, copper piping having brazed joints are electrically supervised with an audible and visual signal at a control station.*

(c) *Each shutoff valve shall be located within an enclosed stair or outside the protected zone.*

(d) *The system shall be wet pipe automatic.*

(e) *Brazed joints shall not be located in machinery spaces, spaces containing pressurized oil lines, areas subject to flammable liquid or gas fires, or other areas having high fire risks.*

(f) *Each section capable of being isolated shall be fitted with a relief valve set at the maximum working pressure of the system.*

#### **11-2 Sprinkler Equivalent Systems.**

**11-2.1** The system shall be automatic.

**11-2.2\*** A pressure tank system shall be provided to meet the functional requirements for Safety of Life at Sea (SOLAS) Regulation II-2/12.4.1.

**11-2.3\*** Systems arranged with an automatic supply of fresh water for the entire design area for 30 minutes shall be permitted to allow manual intervention for continued operation after the 30-minute water supply is exhausted. Manual intervention shall be limited to the actions of opening valves and starting or engaging pumps.

**11-2.4** The system shall be fitted with a permanent sea inlet and shall be capable of continuous operation using sea water for a period of at least 120 minutes.

**11-2.5** Strainers and filters shall be provided and sized for the worst case water quality conditions expected.

**11-2.6\*** The system shall be of the wet pipe type.

*Exception: Where environmental conditions dictate, small sections are permitted to be of another approved type.*

**11-2.7** The system shall be provided with main and emergency sources of power.

**11-2.8** Pumps and alternate supply components shall be sized to be capable of maintaining the required flow.

**11-2.9** The system's water supply and the system piping shall be capable of maintaining the minimum required operating pressure for each type of nozzle, at the highest elevation of each type of nozzle. Hydraulic sizing calculations shall be based on the hydraulically most demanding 1500 ft<sup>2</sup> (140 m<sup>2</sup>) deck area of nozzle operation occurring concurrently within each of any two main vertical fire zones. Reference shall be made to the marine regulatory authority having jurisdiction

for guidance on the hydraulic sizing of the system's water supply and piping for small ships with a total protected deck area of less than 1500 ft<sup>2</sup> (140 m<sup>2</sup>).

**11-2.9.1** For ordinary hazard spaces, the design area shall be the deck area of the most hydraulically demanding compartment up to a maximum of 3000 ft<sup>2</sup> (280 m<sup>2</sup>).

**11-2.9.2** For light hazard public and accommodation spaces, the design area shall be the deck area of the most hydraulically demanding compartment up to a maximum of 1500 ft<sup>2</sup> (140 m<sup>2</sup>).

*Exception: The water supply requirements for nozzles only shall be based upon the room that creates the greatest demand. The density selected shall be in accordance with the listing. To utilize this method, all rooms shall be enclosed with walls having a fire resistance rating of an A-15 or B-15 rating.*

**11-2.9.3** Minimum protection of opening shall be as follows:

(a) *Light hazard.* Automatic or self-closing doors with appropriate fire resistance ratings for the enclosure.

*Exception: Where opening is not protected, calculations shall include the nozzle in the room plus two nozzles in the communication space nearest each such unprotected opening unless the communication space has only one nozzle, in which case calculations shall be extended to the operation of that nozzle. The selection of the room and communication space nozzles to be calculated shall be that which produces the greatest hydraulic demand.*

(b) *Ordinary and extra hazard.* Automatic or self-closing doors having fire resistance ratings for the enclosure.

**11-2.10** Spaces shall be permitted to be protected with alternate, approved fire suppression systems where such areas are separated from mist protected areas with a 1-hour rated assembly.

**11-2.11** Water mist supply components shall be located outside Category A machinery spaces. This shall apply to pumps, pressure tanks, cylinder tanks, emergency power cables, and controllers.

**11-2.12\*** Concealed spaces that are constructed of combustible materials or materials with combustible finishes or contain combustible materials shall be protected.

*Exception: Concealed spaces protected by automatic sprinklers installed in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, or other listed or approved automatic fire suppression system.*

### 11-3 Flammable Liquids.

**11-3.1** Section 11-3 applies to systems protecting spaces where the predominant hazard is from flammable liquids.

*Exception: The requirements of 11-3.3.1, 11-3.4, 11-3.5.3, 11-3.5.4, 11-3.5.7, and 11-3.6 shall not apply to systems protecting paint lockers having containers not larger than a 50 liter (13 gal) individual capacity.*

**11-3.2** Flammable liquid hazard systems shall be shown by test to be capable of extinguishing a variety of fires that can occur in spaces where the predominate hazard consists of flammable liquids.

**11-3.2.1** Systems for machinery spaces and cargo pump rooms shall be capable of fire extinguishment as demonstrated by testing in accordance with IMO Fire Test Procedures. Systems for flammable liquid store rooms, paint lockers, and other flammable liquid hazards shall be based on tests acceptable to the authority having jurisdiction. Nozzle locations, types of

nozzles, and spray characteristics shall be within the limits tested.

**11-3.3\*** The system shall be capable of manual actuation, allowing water to discharge into the protected space without the necessity of further human intervention.

**11-3.3.1\*** After 30 minutes of system activation, manual intervention shall be permitted for continued operation.

**11-3.4\*** Where time delays are provided, audible and visual signals shall be provided throughout the protected space.

### 11-3.5 Water Supply.

**11-3.5.1** The system's water supply shall be available for immediate use.

**11-3.5.2** The water supply shall be based on complete protection of the space demanding the greatest quantity of water.

**11-3.5.3** Pressure tank(s) shall be provided to immediately supply the system at the design flow and pressure for not less than 60 seconds.

**11-3.5.4** The water supply shall supply the system with fresh water for a period of at least 30 minutes. The vessel's potable water supply shall be permitted to satisfy the 30-minute demand period.

**11-3.5.4.1** The fresh water supply shall meet the water quality requirements of 7-5.1.

**11-3.5.5** Where the water mist system is designed for uniform cycling, the maximum-reduced discharge period shall be 60 seconds.

**11-3.5.6\*** The minimum quantity of water and atomizing media used in uniform cycling systems shall be the maximum system flow for a 15-minute constant duration.

**11-3.5.7\*** The system shall be fitted with a permanent sea inlet and shall be capable of continuous operation using sea water.

*Exception: Systems protecting spaces smaller than 3000 m<sup>3</sup> where the system is listed without a sea inlet or where tests have been conducted to the satisfaction of the authority having jurisdiction.*

**11-3.5.7.1** The permanent sea inlet shall be constructed of corrosion-resistant materials per paragraph 2-1.3 and shall be fitted with a control valve and a strainer having maximum mesh openings of 0.236 in. (6 mm). The permanent sea inlet shall be located in the same space as the system pump. When the vessel is underway, it shall not be necessary to shut off the supply of sea water to the system pump for any purpose other than the inspection or repair of the system pump.

**11-3.6\* Power Supplies.** The system shall be provided with both main and emergency sources of power and shall be provided with automatic changeover. One of those sources of power shall be wholly provided from outside the protected space.

**11-3.7** Pressure source components of the system shall be located outside the protected space.

**11-3.8** A means to allow for periodic testing of the operation of the system for ensuring the required pressure and flow shall be provided.

**11-4\* Human Factors.** Human factors shall be considered to the extent practicable during the design of water mist systems on marine vessels.

## 11-5\* Requirements for Water Mist Systems on Combatant Vessels.

11-5.1 Combatant vessels require more stringent design requirements than merchant ships. Water mist system design features for combatant vessels shall be determined by the authority having jurisdiction of the military service involved.

## Chapter 12 Referenced Publications

12-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix E.

**12-1.1 NFPA Publications.** National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1999 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 1999 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 1998 edition.

NFPA 70, *National Electrical Code*<sup>®</sup>, 1999 edition.

NFPA 72, *National Fire Alarm Code*<sup>®</sup>, 1999 edition.

NFPA 170, *Standard for Fire Safety Symbols*, 1999 edition.

### 12-1.2 Other Publications.

**12-1.2.1 ANSI Publications.** American National Standards Institute, Inc., 11 West 42nd Street, 13th floor, New York, NY 10036.

ANSI B1.20.1-83, *Pipe Threads, General Purpose (Inch)*, 1992.

ANSI B16.18-84, *Cast Copper Alloy Solder Joint Pressure Fittings*, 1994.

ANSI B16.22-89, *Wrought Copper and Copper Alloy Solder Joint Pressure Fittings*, 1989.

ANSI B31.1-95, *Power Piping Code*, 1995.

**12-1.2.2 ASME Publication.** American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME *Boiler and Pressure Vessel Code*, 1995.

**12-1.2.3 ASTM Publications.** American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

ASTM A 269, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*, 1994.

ASTM A 351/ASTM A 351M, *Standard Specification for Castings, Austenitic, Austenitic-Ferritic (Duplex) for Pressure-Containing Parts*, 1994.

ASTM A 403/ASTM A 403M, *Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings*, 1995.

ASTM A 632, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service*, 1990.

ASTM A 774/ASTM A 774M, *Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures*, 1995.

ASTM A 778, *Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products*, 1990.

ASTM A 789/ASTM A 789M, *Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service*, 1995.

ASTM A 815/ASTM A 815M, *Standard Specification for Wrought Ferritic, Ferritic/Austenitic, and Martensitic Stainless Steel Piping Fittings*, 1995.

ASTM B 42, *Standard Specification for Seamless Copper Pipe, Standard Sizes*, 1995.

ASTM B 32, *Standard Specification for Solder Metal*, 1995.

ASTM B 75, *Standard Specification for Seamless Copper Tube*, 1995.

ASTM B 88, *Standard Specification for Seamless Copper Water Tube*, 1995.

ASTM B 251, *Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube*, 1993.

ASTM B 813, *Standard Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper-Alloy Tube*, 1993.

**12-1.2.4 AWS Publications.** American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

AWS A5.8, *Specification for Filler Metals for Brazing and Braze Welding*, 1992.

AWS D10.9, *Specification for Qualification of Welding Procedures and Welders for Piping and Tubing*, 1980.

**12-1.2.5 IMO Publications.** International Maritime Organization, 4 Albert Embankment, London, SE1 7SR, United Kingdom.

IMO FP40/WP.9 Annex 3, *Report of the 40th Session of the Subcommittee on Fire Protection*.

IMO MSC Cir 668, *Maritime Safety Committee Circular*.

SOLAS Regulation 11-2/12.4.1, Consolidated Edition 1992.

### 12-1.2.6 ISO Publications.

ISO 1219, "Fluid power systems and components — graphics symbols and circuit diagrams — Part 1: Graphic symbols" "Fluid power systems and components — graphics symbols and circuit diagrams — Part 2: Circuit diagrams."

**12-1.2.7 ULC Publications.** Underwriters Laboratories of Canada, 7 Crouse Road, Scarborough, ON M1R 3A9.

CAN/ULC S524-M86, *Standard for the Installation of Fire Alarm Systems*.

CAN/ULC S529-M87, *Smoke Detectors for Fire Alarm Systems*.

**12-1.2.8 U.S. Government Publication.** U.S. Government Printing Office, Washington, DC 20402.

Title 49, *Code of Federal Regulations*.

## Appendix A Explanatory Material

*Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.*

**A-1-1** Other NFPA standards should be referenced for additional requirements relating to underground or lead-in connections to water mist systems from municipal or private water supplies.

**A-1-2** Water mist systems are specialized fire protection systems. Design and installation of these systems necessitates specialized training, knowledge, and experience.

Water mist systems offer potential benefits for many specialized applications, particularly where available water supplies are

limited or where the application of water needs to be restricted. Potential benefits also might exist for applications previously protected by gaseous and other fire suppressant agents.

**A-1-4.1 Approved.** The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

**A-1-4.3 Authority Having Jurisdiction.** The phrase “authority having jurisdiction” is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

**A-1-4.5 D<sub>v</sub>.** D<sub>v0.50</sub> is the volume median diameter; that is, 50 percent of the total volume of liquid is in drops of smaller diameter and 50 percent is in drops of larger diameter.

**A-1-4.12 Listed.** The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

**A-1-4.15** Such documentation should be retrievable and can be in the form of engineering studies, meeting minutes, reports, internal memoranda, etc.

**A-1-4.21 Water Mist.** This standard addresses the use of fine water sprays for the efficient control, suppression, or extinguishment of fires using limited volumes of water. Properly designed water mist systems can be effective on both liquid fuel (Class B) and solid fuel (Class A) fires. Research indicates that fine (i.e., smaller than 400 microns) droplets are essential for extinguishment of Class B fires, although larger drop sizes are effective for Class A combustibles, which benefit from extinguishment by fuel wetting. For this reason the definition of water mist in this standard includes sprays with D<sub>v0.99</sub> of up to 1000 microns.

This standard’s interpretation of “water mist” includes some water sprays used in NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protections*, some sprays produced by standard sprinklers operating at high pressure, as well as light mists suitable for greenhouse misting and HVAC humidification systems. This range in drop size distribution is so broad

that some important differences in the performance of sprays with finer different distributions are not distinguished.

The relationship between drop size distribution and extinguishing capacity of a water mist is complex. In general, very fine particles enhance heat absorption and generation of water vapor. With liquid (Class B) fuels, too many “large” drops could agitate the surface of the fuel and increase burning intensity. On the other hand, larger drops could assist the spray to penetrate and wet charred, smoldering Class A fuels. Larger drops could also entrain finer drops in their wake, and improve the transport of much smaller drop sizes into the seat of the fire.

Drop size distribution alone does not determine the ability of a spray to extinguish a given fire. Factors such as fuel properties, enclosure effects (which are a function of ventilation and heat confinement), spray flux density, and spray velocity (momentum) are all involved in determining if a fire will be extinguished. The “momentum” of an element of spray is the product of its velocity and the mass of dispersed water droplets (i.e., the mass flow rate). It must be stressed that the term *velocity* implies direction as well as speed. It is the momentum of a mist in a particular direction, relative to the direction of flow of the hot fire gases, which enhances cooling and suppression effectiveness. Opposing directional flows bring about turbulent mixing, hence improved cooling. Therefore, all three variables, drop size distribution, flux density, and velocity, are involved in determining the ability to extinguish a fire in a given scenario.

**A-1-4.22.2** The actuation of a hybrid water mist nozzle can be by a built-in detection and activation device and/or by an independent means of activation.

**A-1-4.23.5** These systems have the specific pipe size, maximum and minimum pipe lengths, flexible hose specifications, number of fittings, and number and types of nozzles prescribed by a testing laboratory. Systems are provided with either a self-contained or external water supply. Based on actual test fires, the hazards protected by these systems are specifically limited as to type and size by a testing laboratory. Limitations on hazards that are allowed to be protected by these systems are contained in the manufacturer’s installation manual, which is referenced as part of the listing.

**A-1-5.1** For additional conversions and information, see ASTM E 380, *Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)*, and in Canada, refer to CSA CAN3-A234.1, *Canadian Metric Practice Guide*.

The abbreviation “gal” in Table 1-5.1 indicates the U.S. gallon measure.

**A-1-6 Applications of Water Mist Systems.** Water mist systems have been proven effective in controlling, suppressing, or extinguishing many types of fires. Potential applications include the following:

- (1) Gas jet fires
- (2) Flammable and combustible liquids
- (3) Hazardous solids, including fires involving plastic foam furnishings
- (4) Protection of aircraft occupants from an external pool fire long enough to provide time to escape
- (5) Ordinary (Class A) combustible fires such as paper, wood, and textiles
- (6) Electrical hazards, such as transformers, switches, circuit breakers, and rotating equipment
- (7) Electronic equipment, including telecommunications equipment

**A-1-6.2.2 Water Reactive Materials.** In special cases, where adequate safeguards have been provided, water mist systems for the protection of structures, equipment, or personnel in the presence of such materials as described in 1-6.2.2 may be permitted.

**A-1-7.1** Water mist is unlikely to present any significant hazard to personnel in most applications; however, direct impingement of the water mist could present an eye hazard. Noise during operation of the water mist systems could be a hazard to hearing. Water mist can reduce visibility and increase the time and difficulty in egress from an affected compartment. Additionally, whipping or swinging of broken piping, tubing, and hose could be a hazard, particularly for intermediate and high pressure systems.

**A-1-7.2 Electrical Clearances.** As used in this standard, *clearance* is the air distance between water mist system equipment, including piping and nozzles, and unenclosed or uninsulated live electrical components at other than ground potential. The minimum clearances provided are for the purpose of electrical clearance during non-emergency operating conditions; they are not intended for use as clearance distances during water mist system operation.

**A-1-7.2.1 Electrical Clearances.** All system components should be located so as to maintain minimum clearances from live parts, as shown in Table A-1-7.2.1.

The clearances in Table A-1-7.2.1 are for altitudes of 3300 ft (1000 m). The clearance should be increased at the rate of 1 percent for each 330 ft (100 m) increase in altitude above 3300 ft (1000 m).

**Table A-1-7.2.1 Clearance from Water Mist Equipment Live Uninsulated Electrical Components<sup>1</sup>**

Nominal System Voltage (kV)	Maximum System Voltage (kV)	Design BIL <sup>2</sup> (kV)	Minimum Clearance <sup>1</sup>	
			in.	mm
To 13.8	14.5	110	7	178
23	24.3	150	10	254
34.5	36.5	200	13	330
46	48.5	250	17	432
69	72.5	350	25	635
115	121	550	42	1067
138	145	650	50	1270
161	169	750	58	1473
230	242	900	76	1930
		1050	84	2134
345	362	1050	84	2134
		1300	104	2642
500	550	1500	124	3150
		1800	144	3658
765	800	2050	167	4242

<sup>1</sup>For voltages up to 161 kV, the clearances are taken from NFPA 70, *National Electrical Code*. For voltages 230 kV and above, the clearances are taken from Table 124 of ANSI C2, *National Electrical Safety Code*.

<sup>2</sup>BIL values are expressed as kilovolts (kV), the number being the crest value of the full wave impulse test that the electrical equipment is designed to withstand. For BIL values that are not listed in the table, clearances can be found by interpolation.

**A-1-7.3** High pressure systems utilizing positive displacement pumps involve unique design considerations and safety features. Table A-1-7.3 shows some important differences between positive displacement pumps and centrifugal pumps.

**A-2-2.2.1** Local building codes specify minimum requirements for seismic restraint or bracing.

**A-2-2.2.2** Independent inspection and certification is recommended for gas and water containers.

**A-2-3.1** It is important to select pipe or tube for water mist systems that exhibits minimal corrosion because of the potential for the clogging of water mist nozzles.

**A-2-3.4.2** Listed flexible connections may be permitted. Flexible connections for water mist installations should be kept as short as possible and should be protected against mechanical injury.

**A-2-4.1** It is important to select fittings for water mist systems that exhibit minimal corrosion because of the potential for the clogging of water mist nozzles.

**A-2-4.2.2** Rubber-gasketed pipe fittings and couplings should not be installed where ambient temperatures can be expected to exceed 150°F (66°C) unless listed for such service. If the manufacturer further limits a given gasket compound, those recommendations should be followed.

**A-2-6.1** In recognition of the future value of scientifically based fire protection system engineering or design methods but in consideration of the fact that the present water mist technology base is likely incomplete for general system design purposes, it is recommended that the nozzle-listing agencies collect and report to the manufacturer the following data for possible future use as required listing information:

(a) The cumulative volumetric distribution of water droplets is to be reported as the flow rate per unit area weighted distribution of water droplets measured at the 24 locations shown in Figure A-2-6.1(a), as a minimum. The radial array of measurement locations is to be positioned symmetrically about the central axis of the water mist nozzle. Additional data can be included in the weighted average calculation by rotating the complete measurement location array (totaling 48 locations) by 22.5 degrees relative to the first set of locations. The nozzle spray patterns diameter *D*, utilized for calculating the radial distances to the measurement locations is to be determined utilizing the spray envelope methodology of A-2-6.1(c) at 39.4 in. (1.0 m) below the tip of the nozzle.

Water discharge distribution measurements in a plane oriented perpendicular to the central axis of the nozzle and 39.4 in. (1.0 m) below the tip, are to be conducted using 1-ft × 1-ft (0.305-m × 0.305-m) collection pans centered on the radial measurement locations and oriented as shown in Figure A-2-6.1(a). In the case of spray pattern diameters less than 10 ft (3.05 m), multiple discharge tests are to be performed to avoid physical interference between the pans.

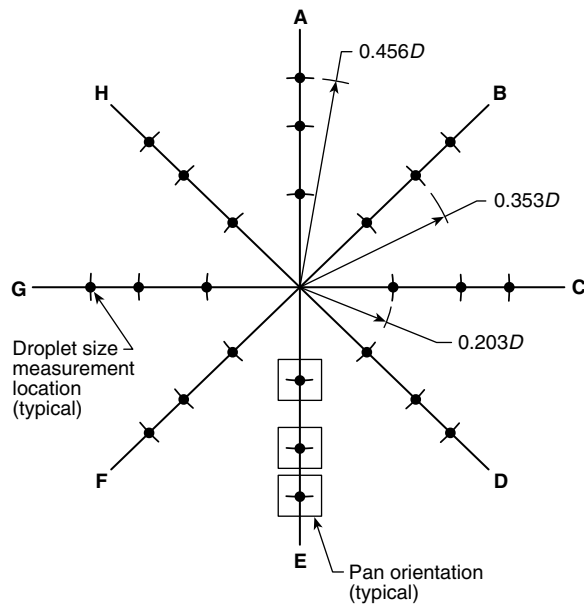
Droplet size distribution measurements in a plane oriented perpendicular to the central axis of the nozzle and 39.4 in (1.0 m) below the tip, are to be conducted at each of the 24 measurement locations shown in Figure A-2-6.1(a).



**Table A-1.7.3 Design Considerations for Centrifugal and Positive Displacement Pumps**

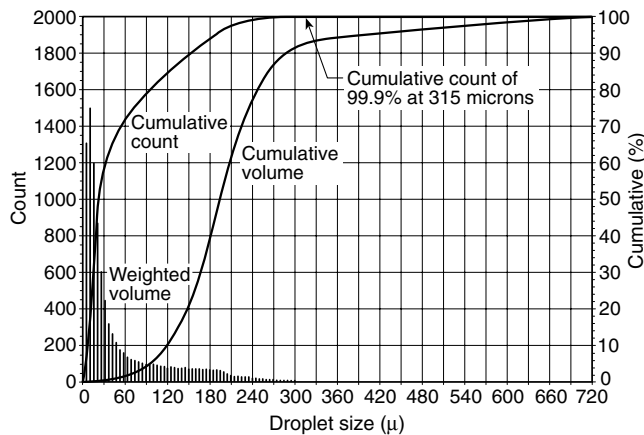
Feature	Centrifugal Pump	Positive Displacement Pump
Ability to achieve high pressure	High pressure requires high speed and/or multi-stage design.	High pressure inherently available.
Pressure and flow pulsations	Pressure and flow are smooth, varying only with system backpressure or pump speed. Pulsation dampers are unnecessary. Gauges and instruments can be directly mounted.	Pressure and flow are sinusoidal, varying with each plunger stroke. Pulsation damper in the suction piping can improve NPSH-A. Pulsation damper in the discharge piping can reduce vibratory stress to system and relief valve. Gauges and instruments should take their signals via flexible tubing or wiring and should not be mounted on the piping.
Head Curve	Flow from pump depends on backpressure from system. For any given pump speed, there is a maximum pressure that can be achieved. If operated at no-flow shutoff condition and maximum pressure, pump will vibrate and experience accelerated wear but will not fail catastrophically.	Pump is positive displacement type. Flow from pump is proportional to pump speed and nearly independent of system backpressure. If flow from the pump is blocked partially or completely, discharge pressure will increase until full flow is forced past the blockage or something breaks.
Relief valve	Not needed in pump or water mist system. System is designed to accommodate the maximum pressure achievable from the pump.	Pressure relief valve is needed. Design of relief valve must tolerate pressure pulsations produced by the pump.
Net Positive Suction Head (NPSH)	Required suction head is specified by manufacturer. Most centrifugal pumps used in fire service can tolerate a wide range of available NPSH. Ordinary design of suction piping is acceptable.	Required suction head is specified by manufacturer. In general, positive displacement pumps are more sensitive to NPSH than centrifugal pumps. Special care with the design of the suction piping must be taken to provide as much NPSH as possible.
Pump start-up	Inherent in the design, centrifugal pump starts in the unloaded condition. Starting torque not critical.	Maximum pressure can be achieved with the first plunger stroke. Unloader valve in the discharge piping is common. Manufacturers recommend motors with high starting torque.
Strainers; sensitivity to dirty water	Silty or murky water is not critical for pump flow passages. Some pumps have water-lubricated surfaces that could be adversely affected. Strainer for the protection of water mist nozzles could be on suction or discharge side.	Silty or murky water is not critical for pump flow passages. Pumps are oil-lubricated. Strainer for the protection of water mist nozzles could need to be on discharge side, to avoid reduction in NPSH-A.
Foundation	Ordinary	Compared to centrifugal pumps, additional rigidity and mass are helpful because of vibration caused by pulsating flow.
Pump–motor link	Typically operate at motor speed. Close-coupled or direct drive via flexible coupling.	Typically operate at less than motor speed. Belt drive or geared speed reducer is typical. Pulsations and starting torque are considerations in the design of the speed reducer.

FIGURE A-2-6.1(a) Droplet size measurement locations.



The droplet size distribution and water discharge distribution measurements are to be made at the minimum and maximum rated pressure of the nozzle. The droplet size distribution at each measurement location and pressure is to be weighted proportionally against the corresponding relative flow rate per unit area of water discharge. The nozzle droplet size distribution is to be reported as a single summation of the weighted cumulative count and volume percent droplet distributions for all measurement locations. The summation can be calculated using the following series of formulas and presented in a chart such as that shown in Figure A-2-6.1(b).

FIGURE A-2-6.1(b) Example of flow rate per unit area weighted droplet size distribution.



For a single measurement location,  $x$ , and bin size,  $y$ :

- Cumulative count percent (single bin),  $c_y = n_y/n_x + c_{y-1}$  where:

$n_y$  = number of droplets in a single bin size for location  $x$

$n_x$  = total number of droplets in the sample at location  $x$

- Proportional flow rate per unit area,  $p_x = f_x / F$  where:

$f_x$  = flow rate per unit area at location  $x$

$F$  = total cumulative flow rate for all locations ( $\sum f_x$ )

- Flow weighted cumulative count percent (single bin),  $w_y = c_y p_x + w_{y-1}$

The above equations are to be used for all locations and all bin sizes.

For the summation of all measurement location data:

- Flow weighted cumulative count percent (single bin),  $c_y = \sum w_y$

- Flow weighted cumulative volume (single bin),

$$V1_y = (\pi b_y^3) / 6 (c_y - c_{y-1}) + V_{y-1}$$

where:  $b_y$  = minimum diameter for bin size  $y$

- Flow weighted cumulative volume percent (single bin),  $V2_y = V1_y / \sum V1_y$

ASTM E 799, *Standard Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis*, is to be used for guidance in performing the droplet size distribution measurements, including determination of appropriate size class bounds and the minimum-to-maximum droplet diameter range at each location.

(b) **Method 2 for Calculating A Weighted Average Drop Size Distribution Curve.** The following spreadsheet method can be used to obtain a statistically representative measurement of the drop size distribution of a water spray.

- (1) Determine the diameter ( $D$ ) of the spray cone at a distance 1 m below the nozzle.
- (2) As shown in Figure A-2-6.1 (a) the locations for measuring drop size distribution are calculated as  $0.203 \times D$ ;  $0.353 \times D$ ; and  $0.456 \times D$ , from the center axis of the spray cone. Measuring at these locations guarantees that all the sample areas  $A_i$  are equal. Calculate  $A_i$  as the area of the cone of diameter ( $D$ ) divided by the number of sample points (preferably 24).
- (3) Measure the flux density ( $V_i$ ) at each position at which the drop size distribution will be measured. This can be done by placing collector pans exactly at the points of interest. If the pan locations do not coincide exactly with the drop size measurement locations, plot the flux density profile along the axis of interest and read off the  $V_i$  value for the correct location.

The method for calculating the weighted average is expressed in Equation 1:

$$R_k = \frac{\sum_i (R_{j,i} \times A_i \times V_i)}{\sum_i (A_i \times V_i)}$$

where:

$R_k$  = weighted cumulative volume percent readings for drop sizes equal to and less than  $d_{upper}$

$R_{j,i}$  = cumulative volume percent readings for drop sizes equal to and less than  $d_{upper}$  at location  $i$

$A_i$  = area centered at location  $i$  in which the drop size distribution can be closely represented by  $R_k$

$V_i$  = water flux density measured at location  $i$

- (4) Use a drop sizing instrument conforming to ASTM E 799, *Standard Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis*, to measure the drop size distribution at the point determined in step (2). One of the outputs from such an instrument is a table of cumulative

percent volume versus diameter *bins*, defined by the upper and lower diameter of a range of drop sizes. Using the upper bin diameter ( $d_{upper}$ ), ensures that the resulting plot can be interpreted as “R percent of the mass . . . in drops of diameter ‘less than’  $d_k$ .” This data must be input into a spreadsheet as shown in Table A-2-6.1. Then using the  $V_i$ , or flux density measured at the location  $i$ , and the area  $A_i$  that the measurement represents, calculate the weighted average drop size distribution  $R_k$ .

(c) Water discharge distribution in a plane 3.3 ft (1.0 m) below and perpendicular to the central axis of the nozzle using 1-ft x 1-ft (0.305-m x 0.305-m) collection pans. The water distribution measurements are to be made at the minimum- and maximum-rated operating pressures of the nozzle and over an area sufficient to collect at least 90 percent of the water discharge.

(d) Profile of the nozzle spray envelope encompassing at least 90 percent of the water discharge, measured from the tip of the nozzle and extending over the effective range deter-

mined from the listing investigation. The profile of the nozzle spray envelope is to be provided at the minimum- and maximum-rated operating pressures of the nozzle as well as over the intended range of orientation angles, if in other than the vertically down orientation.

(e) Spray thrust force as measured in a plane perpendicular to the central axis of the nozzle, at a distance of 1 ft (0.305 m) below the nozzle and over an area sufficient to capture at least 90 percent of the water discharge. The measurements are to be made at the minimum- and maximum-rated operating pressures of the nozzle.

For fire test purposes, the maximum distance from test fires should be considered as one of the following:

- (1) The manufacturer’s maximum spacing of nozzles from walls or one-half of the manufacturer’s recommended maximum spacing between nozzles, whichever is greater
- (2) The manufacturer’s recommended placement of nozzles with regard to local hazard protection.

**Table A-2-6.1 Sample Spreadsheet Illustrating the Calculation of a Weighted Average Drop Size Distribution Plot, Using Drop Size Distribution Data for Two Measurement Points Only**

Diameter microns	First measurement location, $V_i = 6.7; A_i = 0.10$				Second measurement location $V_i = 10.0; A_i = 0.10$				Denomin- ator L/min	Numerator $\Sigma(R_{j,i} \times V_i \times A_i)$	Wtd’ $R_k(\%)$
	$R_{j,i} = 1\%$	$V_i$ L/min/m <sup>2</sup>	$A_i$ m <sup>2</sup>	$R_{j,i} \times V_i \times A_i$	$R_{j,i} = 2$	$V_i = 2$ L/min/m <sup>2</sup>	$A_i$ m <sup>2</sup>	$R_{j,i} \times V_i \times A_i$			
Upper Diameter									$\Sigma(V_i \times A_i)$		$R_k\%$
1128	100.0	6.7	0.10	67.0	100.0	10.0	0.10	100.0	1.67	167.0	100.0
973	100.0	6.7	0.10	67.0	100.0	10.0	0.10	100.0	1.67	167.0	100.0
840	99.9	6.7	0.10	66.9	100.0	10.0	0.10	100.0	1.67	166.9	100.0
724	99.9	6.7	0.10	66.9	100.0	10.0	0.10	100.0	1.67	166.9	100.0
625	99.9	6.7	0.10	66.9	100.0	10.0	0.10	100.0	1.67	166.9	99.9
539	99.9	6.7	0.10	66.9	99.9	10.0	0.10	99.9	1.67	166.8	99.9
465	99.8	6.7	0.10	66.9	99.9	10.0	0.10	99.9	1.67	166.8	99.8
401	99.1	6.7	0.10	66.4	99.9	10.0	0.10	99.9	1.67	166.3	99.6
346	97.7	6.7	0.10	65.5	99.8	10.0	0.10	99.9	1.67	165.4	99.0
299	95.4	6.7	0.10	63.9	99.6	10.0	0.10	99.8	1.67	163.7	98.0
258	92.7	6.7	0.10	62.1	99.4	10.0	0.10	99.6	1.67	161.7	96.8
222	86.2	6.7	0.10	57.8	98.9	10.0	0.10	99.4	1.67	157.2	94.1
192	73.1	6.7	0.10	49.0	97.1	10.0	0.10	98.9	1.67	147.9	988.6
165	55.8	6.7	0.10	37.4	93.5	10.0	0.10	97.1	1.67	134.5	80.5
143	37.4	6.7	0.10	25.1	88.3	10.0	0.10	88.3	1.67	113.4	67.9
123	24.4	6.7	0.10	16.3	77.2	10.0	0.10	77.2	1.67	93.5	56.0
106	19.2	6.7	0.10	12.9	62.9	10.0	0.10	62.9	1.67	75.8	45.4
91.7	15.7	6.7	0.10	10.5	48.8	10.0	0.10	48.8	1.67	59.3	35.5
79.1	13.4	6.7	0.10	9.0	38.4	10.0	0.10	38.4	1.67	47.4	28.4
68.2	11.1	6.7	0.10	7.4	31.4	10.0	0.10	31.4	1.67	38.8	23.2
58.9	7.8	6.7	0.10	5.2	26.2	10.0	0.10	26.2	1.67	31.4	18.8
50.8	5.4	6.7	0.10	3.6	21.4	10.0	0.10	21.4	1.67	25.0	15.0
43.8	4.4	6.7	0.10	2.9	16.7	10.0	0.10	16.7	1.67	19.6	11.7
37.8	3.9	6.7	0.10	2.6	12.7	10.0	0.10	12.7	1.67	15.3	9.2
32.6	3.6	6.7	0.10	2.4	9.9	10.0	0.10	9.9	1.67	12.3	7.4
28.1	3.0	6.7	0.10	2.0	8.4	10.0	0.10	8.4	1.67	10.4	6.2
24.3	2.2	6.7	0.10	1.5	7.4	10.0	0.10	7.4	1.67	8.9	5.3
20.9	1.4	6.7	0.10	0.9	6.5	10.0	0.10	6.5	1.67	7.4	4.4
18.1	0.9	6.7	0.10	0.6	5.6	10.0	0.10	5.6	1.67	6.2	3.7
15.6	0.6	6.7	0.10	0.4	4.3	10.0	0.10	4.3	1.67	4.7	2.8
13.4	0.4	6.7	0.10	0.3	2.9	10.0	0.10	2.9	1.67	3.2	1.9
11.6	0.0	6.7	0.10	0.0	0.0	10.0	0.10	0.0	1.67	0.0	0.0

**A-2-8.2** The strainer or filter should be sized to include the head loss for a period that is estimated to be ample, taking into account the type of protection provided, the condition of the water, and similar local circumstances.

**A-2-10.2.1** Detectors installed at the maximum spacing as listed or approved for fire alarm use could result in excessive delay in water mist system actuation, especially where more than one detection device is required to be in alarm before automatic actuation results.

**A-2-10.4.3.1** Where installations are exposed to conditions that lead to loss of integrity of the pneumatic lines, special precautions shall be taken to ensure that no loss of integrity occurs.

**A-2-11** In zoned water mist systems, the effect of water mist migrating into adjacent zones could activate unwanted releases with standard smoke detectors. Care needs to be given to match detection devices to the environment in both normal and release conditions.

**A-3-2.2.2** The simultaneous operation of all nozzles in the space should be achieved by the use of pilot activation nozzles, automatic nozzles, or by an independent detection system.

**A-3-5** Single-fluid and twin-fluid systems can be operated in the low, intermediate, or high pressure range.

(a) *Single-Fluid Media Systems.* A single-fluid media system requires one set of distribution piping to transport the fluid to each nozzle.

Single-fluid media systems should produce water mist (droplet production) by one of the means specified as follows.

Liquid should be discharged at a high velocity with respect to the surrounding air. The difference in velocities between the liquid and surrounding air should shear the liquid into small droplets.

A liquid stream is impinged upon a fixed surface. The impact of the liquid on the surface breaks the liquid stream into small droplets.

Two liquid streams of similar composition collide with one another. The collision of the two streams breaks the individual streams into small droplets.

Liquid is either vibrated or electrically broken into small droplets (ultrasonic and electrostatic atomizers).

Liquid is heated above its boiling point in a pressurized container and released suddenly to atmospheric pressure (flashing liquid sprays).

(b) *Twin-Fluid Media Systems.* Twin-fluid media systems produce water mist (droplet production) by impingement of two fluids delivered from separate piping systems. One set of piping provides a liquid (water) to the nozzle, and the second piping network provides an atomizing fluid/media.

**A-4-5.3** When the storage container(s) is placed in the hazard area being protected, provisions should be made to ensure that the system operation is not adversely affected by its location.

**A-4-6.1** To assure that pump output is sufficient for the maximum system demand, it is common engineering practice to provide a margin of safety by selecting a pump whose performance curve falls above the maximum system demand. For further discussion concerning the sizing and selection of pumps, see A-7-5.2.2.

**A-4-8.1.7 Exception.** Sectional control valves and group control valves that are intended to be normally closed, and to be automatically opened by an electrical or pneumatic or hydrau-

lic signal from the system control center, do not have to be locked open. Such control valves should be tested as integral parts of the system and described in the listing literature. The tests for listing of systems incorporating normally closed, remotely activated sectional valves should address concerns about reliability of function.

**A-4-9.1.2** In order to prevent system impairment from two or more ground faults or a single open circuit condition, Class A circuits should be considered.

**A-4-9.1.3** Where signaling line circuits are used for zoned (multiple input and output) water mist systems it is important that circuits be capable of transmitting an alarm signal during a single open or a non-simultaneous ground fault on a circuit conductor to ensure reliable performance.

**A-4-9.3.1** Detectors installed at the maximum spacing as listed or approved for fire alarm use can result in excessive delay in agent release, especially where more than one detection device is required to be in alarm before automatic actuation results.

**A-4-10.1** The test connection is intended to permit a flow of agent to the most hydraulically remote point, to confirm that piping is properly connected and in service. This connection will also permit testing of flow alarms for the system.

**A-5-1** Currently, no generic design method is recognized for water mist protection systems. The relationship between flux density or nozzle spacing, and performance in controlling fires is not consistent between systems designed by different manufacturers. The system features such as nozzle spacing, flow rate, drop size distribution, cone angle and other characteristics, need to be determined for each manufacturer's system through full scale fire testing to obtain a listing for each specific application.

**A-5-2 Results.** The results of the listing testing should identify the following:

- (1) System flow rate (minimum and maximum)
  - a. Flow rate per unit area (if applicable)
  - b. Flow rate per unit volume (if applicable)
- (2) System operating pressure (minimum and maximum)
  - a. Nozzle operating pressure range
  - b. Pump/cylinder operating pressure range
  - c. Pump inlet and outlet pressure and flow rate requirements
- (3) General water requirements
  - a. Quantity/duration
  - b. Quality
  - c. Temperature
- (4) Nozzle characteristics
  - a. Type(s)/model numbers
  - b. Flow rate (minimum and maximum)
  - c. Operating pressure (minimum and maximum)
- (5) Nozzle spray characteristics
  - a. Spray angle
  - b. Drop size distribution
  - c. Momentum/velocity
- (6) Nozzle installation parameters
  - a. Distance above floor (minimum and maximum)
  - b. Distance below ceiling (minimum and maximum)
  - c. Distance above hazard (minimum and maximum)
  - d. Nozzle spacing (minimum and maximum)

- e. Orientation
- f. Minimum distance from walls
- g. Minimum distance from obstructions
- (7) Activation device
  - a. Type/model number
  - b. Activation, temperature
  - c. Activation, smoke obscuration
- (8) General design parameters
  - a. Pipe requirements
    - 1. Size
    - 2. Operating pressures/wall thicknesses
  - b. Fittings
    - 1. Type
    - 2. Operating pressure
  - c. Pumps
    - 1. Valves, fittings, and filters
    - 2. Power requirements
    - 3. Operating pressure and flow rates
    - 4. Water requirements
  - d. Cylinders
    - 1. Valves and fittings
    - 2. Capacity
    - 3. Operating pressures

**A-5-2.2 Test Fire Hazard.** The test fire hazard reflects the application specified in the listing. The test fires should be chosen such that the performance objectives of the system can be determined. If fire suppression or fire extinguishment is the preferred performance objective, and the fire tests are conducted inside a compartment, the test fires should be chosen such that the influence from the compartment is minimized (i.e., fire size not too large). If fire control is the preferred performance objective, the test fire sizes should be chosen in a way that the system's ability to limit the exposure from the fire can be evaluated (i.e., fire size not too small).

**A-5-3.1** For some hazards fire control could be sufficient; for others, extinguishment could be essential. Additional objectives applicable to specific applications can be considered, such as the following:

- (1) Minimize collateral damage
- (2) Minimize spread of products of combustion
- (3) Reduce radiation intensity on vital equipment
- (4) Improve visibility

**A-5-4.1** The construction of the enclosure should substantially contain the water mist in the vicinity of the hazard for a sufficient length of time to achieve the fire protection objectives of the water mist system.

**A-5-4.1.2.1** Natural ventilation and openings in the compartment allow the hot gases layer (ceiling jet) to exhaust mist from the compartment, decreasing the extinguishing potential. The flow of gases into and out of the compartment also alters the mixing characteristics of the system, which, in turn, might require the additional momentum of the mist in order to overcome this alteration. Forced ventilation also significantly reduces the amount of mist in the compartment as well as affects the mixing characteristics of the system.

Prior to or concurrent with the operation of the water mist system, consideration should be given to automatic closing of doors and dampers, shutdown of electrical equipment, and shutdown of HVAC equipment.

**A-5-5** See Appendix D.

**A-6-1.1** The addition of piping and nozzles to an existing water mist system can render the system ineffective if it leads to reduced pressure and flow. The existing piping does not have to be increased in size to compensate for additional nozzles, provided that the new work is calculated, and the calculations include that portion of the existing system that is necessary to carry water or atomizing medium (if used) to the new work.

**A-6-2** The Hazen-Williams (H-W) equation cannot be corrected for flow velocity, water temperature, viscosity, or pipe-wall roughness factors, all of which significantly affect the degree of turbulence, hence the pressure losses in piping. Water mist systems in general, and intermediate and high pressure systems in particular [ $> 175$  psi to  $4000$  psi ( $> 12$  bar to  $270$  bar)], are likely to create conditions where there could be higher velocities, different water properties, or smaller diameter pipe than are used in low pressure systems. (As pipe diameters decrease, the relative effect of wall roughness increases). Because it allows for input of actual fluid properties, the Darcy-Weisbach (D-W) equation should be used instead of the H-W equation for intermediate and high pressure systems.

**A-6-3** Many low pressure water mist systems will be similar to standard fire protection systems, such as sprinklers (NFPA 13, *Standard for the Installation of Sprinkler Systems*) and water spray systems (NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*). It is expected that piping materials, fittings, valves, and pipe sizes will be selected in accordance with those standards. These expectations imply that velocities in the piping will be in the same range as in sprinkler piping. This assumed similarity to sprinkler piping is the reason this standard accepts the use of the H-W equation for low pressure water mist systems.

Not all low pressure water mist system piping will necessarily be similar to sprinkler piping, however. The designer can choose to use small diameter piping in order to reduce system weight, or, to live with high friction losses in piping in order to be able to install piping in a restricted space, as in an aircraft cargo compartment. Use of small diameter piping will put the velocities higher than is "normal" in sprinkler piping, which introduces the probability that the H-W equation will not be accurate. Values of the friction loss coefficient,  $C$ , which is used in the H-W equation, are accurate only if the flow velocity is close to that at which the value of  $C$  was measured. It is a matter of judgement as to what velocity is too high for the H-W equation. American Water Works Association (AWWA) data lists  $C$  factors measured at a velocity of  $3$  ft/sec ( $0.9$  m/sec), yet it is accepted practice in sprinkler calculations to have velocities in sprinkler piping between  $10$  ft/sec and  $30$  ft/sec ( $3.05$  m/sec and  $9.1$  m/sec). Similarly, the tables of equivalent lengths for fittings and valves, used by sprinkler system designers, are based on fittings and valve types typical of sprinkler system. Water mist systems can incorporate different types of fittings and valves, for which the H-W-based equivalent length values will be incorrect. In the interest of "good practice," the water mist system designer should use the D-W equation for low pressure system calculations when pipe sizes or other system features, such as the use of solenoid valves, differ significantly from normal sprinkler practices.

It is also important to note that the H-W equation contains no terms that account for the temperature. Hence, density and viscosity of the liquid also are not taken into account. It assumes that the water contains no additives and is close to

60°F (15.6°C). If viscosity or water temperature depart significantly from typical sprinkler system water supply conditions, the D-W equation should be used instead, regardless of the pressure regime or flow velocities.

**A-7-1.2** Although some water discharge might continue after the atomizing medium has been exhausted, it is not effective for fire suppression.

**A-7-2** Some water mist systems protect single hazards or areas. Other system designs are based on multiple zones with overlapping protection at the zone boundaries. It is also possible for one water mist system to provide local application protection for several individual hazards. Quantities of water and of atomizing media should be based on the most demanding location for the fire. For example, if a fire could start at the intersection of four zones, the water supply and the atomizing medium (if used) should be able to supply all four zones simultaneously. If a water mist system protects several individual hazards that are located in close proximity, it might be necessary to design for simultaneous operation of multiple local-application zones.

**A-7-3** The 30-minute water supply requirement applies to water supply capacity and does not require that the system actually discharge for 30 minutes. This minimum duration should be provided for all water mist systems that are installed for life safety purposes or for structural protection. For water mist systems designed to protect equipment or other special hazards in unoccupied areas, Exception No. 1 allows the water supply duration to be determined in accordance with Chapter 5. Exception No. 2 provides for performance-based design of water mist systems by qualified fire protection engineers. It should be noted that, currently, there is no generally accepted method for performance-based design of a water mist system.

**A-7-4.1** An extra supply (connected reserve) of extinguishing agent (including additives and atomizing medium, if used) piped to feed into the automatic system should be considered on all installations. The reserve supply is normally actuated by manual operation of the main/reserve switch on either electrically operated or pneumatically operated systems. A connected reserve is desirable for the following reasons:

- (1) Provides improved reliability for systems used for protection of life safety
- (2) Provides protection should a reflash occur
- (3) Provides reliability should the main bank malfunction
- (4) Provides protection of other hazards, if selector valves are involved and multiple hazards are protected by the same set of cylinders

**A-7-5.1** Algae and bacteriological growth in stored water can clog the system by blocking the filters or strainers. Annual sampling or replacement of stored water is required by Table 10-2(b).

**A-7-5.2.2** See A-8-2.

**A-7-5.5** It is the intention of this subsection to require a fire department connection wherever it would be of benefit. Exception No. 2 provides for local area protection where the fire department could effectively respond with small hose streams or portable fire extinguishers. Exception No. 3 provides for systems where the pressures available from fire department pumpers would not be adequate to supply the water mist system. Exception No. 4 exempts systems where the

atomizing medium is essential for fire suppression, and water alone would be of no benefit.

**A-8-2** As Table A-1-7.3 illustrates, there are significant differences between how centrifugal fire pumps and positive displacement (PD) pumps operate. Methods for properly sizing centrifugal fire pumps in relation to the piping system and the design flow rate are well established in fire protection design practice. Fire protection systems designers are less familiar with PD pumps, however. The following discussion reviews some of the factors that are involved in selecting and sizing positive displacement pumps.

For constant-speed drivers, the discharge rate of a PD pump is constant. Water mist systems, however, can have a variable demand flow, depending on how many nozzles open. The problem of using a constant discharge pump on a variable demand piping system is resolved by combining the positive displacement pump with an “unloader” valve and treating it as a composite unit. An unloader valve opens at a pre-set pressure and allows the unused portion of the pump discharge to bypass the distribution system. By including the unloader function, the PD pump “curve” can be plotted as a horizontal line, similar to a centrifugal pump curve.

Important points to consider when selecting positive displacement pumps for a water mist system include the following:

- (1) The System Head Curve(s) (SHCs) for the water mist system under different nozzle-open arrangements must be calculated and plotted with the PD pump curve.
- (2) The actual discharge from the system is determined by the intersection of the SHC and the pump supply curve (i.e., the operating point). The operating point always has to be greater than the theoretical demand that is calculated for a system. The hydraulic calculations documentation should include a plot showing the SHCs, the pump supply curve (or line), the calculated demand point, and the operating point for each condition.
- (3) In sizing the suction supply to the pump, and in calculating the total water storage required for a given duration of protection, the flow rate at the operating point has to be used, not the theoretical or calculated design flow rate.

**A-9-2** All tests should be made by the contractor in the presence of an authorized inspector. When an inspector is not available, tests may be permitted to be witnessed by the owner or owner’s representative.

Before asking for final approval of the protective equipment, installing companies should furnish a written statement to the effect that the work covered by its contract has been completed, and all specified flushing of underground, lead-in, and system piping has been completed, successfully, together with specified hydrostatic pressure tests.

**A-9-2.2.3** The allowable drop in gauge pressure should take into consideration the total volume of the system and environmental conditions. Smaller systems could see a slight drop in gauge pressure as a result of microscopic leaks that would not affect larger systems. Large systems could be affected by temperature changes that could raise or lower the hydrostatic pressure.

The *Power Piping Code* allows hydrostatic testing at 1.5 times the working pressure for 10 minutes, followed by 110 minutes at the system working pressure.

**A-9-2.3** The following caution should be heeded:

**CAUTION**

Pneumatic pressure testing creates a potential risk of injury to personnel in the area as a result of airborne projectiles if rupture of the piping system occurs. Prior to the pneumatic pressure test being conducted, the area should be evacuated and appropriate safeguards should be provided for test personnel.

**A-9-2.4.2.10** Proper shielding and grounding is particularly important if ac and dc wiring are combined in a common conduit or raceway.

**A-10-3.7** The representative sample should include 10 percent of the water mist nozzles in the activated zone. If contamination of filters or strainers is found on inspection, it is recommended that all nozzles within the activated zone also be inspected.

**A-11-1.2** Reference is made to standards developed by the International Maritime Organization.

**A-11-1.5** Refer to ASTM F 1547, *Standard Guide Listing Relevant Standards and Publications for Commercial Shipbuilding*, 1994, and ANSI B361 *Power Piping Code*.

**A-11-1.6** Consideration should be given to physically separating the pumping units. It is recommended that not less than 40 percent of the maximum system's flow demand be provided from any single pumping location. Consideration should be given to using designs incorporating looped systems or arrangements that allow a section to be taken out of service for maintenance. When pumps from another onboard fire protection system, such as fire main pumps, are used to satisfy this requirement, they should be sized to simultaneously supply both systems.

**A-11-1.8** When applying NVIC 9-97, copper pipe is not considered heat sensitive; however, brazed joints are. Therefore, there are limitations on the proximity of brazed joints to deck and bulkhead penetrations. In general, brazed joints should be 300 mm or more from the penetration.

**A-11-1.9.3** A representative arrangement of the shore connections is shown in Figure A-9-6.3.6(a) of NFPA 13. The internal shore connection dimensions are shown in Figure A-9-1.1 of NFPA 13.

**A-11-1.10** The preferred arrangement for pump flow measurement is given in Figure A-9-6.3.7 of NFPA 13.

**A-11-2.2** The charge of air or gas for the hydropneumatic tank should be such that the last gallon of water in the tank leaves the tank at the system demand pressure. The tank can be arranged with an internal charge of gas or an external gas supply with a regulator. If an internal charge of air or gas is provided, the equation  $P_1 V_1 = P_2 V_2$  should be used to calculate the required gas pressure. In all cases arrangements should be provided to avoid filling the system piping with gas when the hydropneumatic tank is empty. Under normal circumstances, the pump should be arranged to provide water at a pressure greater than the gas pressure before the tank is empty. The reference to SOLAS requires an arrangement to prevent seawater from entering the hydropneumatic tank.

**A-11-2.3** An example of an acceptable arrangement is manual operation of a sea chest valve (outside the protected space) to

allow continued operation using seawater following the 30-minute stored fresh water operation.

**A-11-2.6** Deluge or antifreeze systems could be needed where protected areas are subject to freezing. Piping subject to freezing could be subject to clogging by ice.

**A-11-2.12** If combustibles are present such that they constitute a threat, the space should be protected. One example would be the presence of large bundles of exposed computer or electrical cable.

Typical amounts of lighting or control cabling should not be considered to constitute a fire threat.

**A-11-3.3** It is assumed that water mist systems for flammable liquid hazards and compartments require the simultaneous release of water mist from all nozzles in groups of nozzles in the manner of total flooding systems. If systems that operate using individually, thermally actuated nozzles are shown by test to have the capability of extinguishing the variety of fires of the machinery space fire test protocol, then manual actuation should cause sufficient nozzles to operate to achieve protection not less effective than that demonstrated in the test protocol.

**A-11-3.3.1** An example of an acceptable arrangement is manual operation of a sea chest valve (outside the protected space) to allow continued operation on sea water following the 30-minute stored fresh water discharge.

**A-11-3.4** Time delays are optional on water mist systems.

**A-11-3.5.6** For systems that cycle, the 15-minute requirement represents 15 minutes at the maximum flow rate, as if the duty cycle was 100 percent for 15 minutes.

Examples include the following:

- (a) *Constant*. Such as supplied by a pump
- (b) *Decaying*. Occurs when a pressure cylinder discharges
- (c) *Uniform cycling*. When a timing device is used to periodically change the pressure or the flow rate
- (d) *Nonuniform cycling*. Such as when a heat detector cycles a system on and off

**A-11-3.5.7** Following the depletion of the 30-minute fresh water supply, if continuous sea water operation is provided at a pressure other than that used to successfully perform the machinery space fire tests of 11-3.2.1, the nozzle spray characteristics should be capable of maintaining the cooling of the compartment. Flow rates need not equal those of Safety of Life at Sea (SOLAS) Resolution 10, *Fixed Pressure Water Spray Systems*.

**A-11-3.6** It is recommended that on passenger ships designed to carry more than 36 persons and on all tank vessels, both the main and emergency sources of power should be from outside the protected space.

**A-11-4** The ship's crew will be called upon to inspect, test, maintain, react to, and use some or all parts of the water mist fire suppression system. Therefore, the crew is an integral part of the system. Historically, the crew is the part of the system that system designers and installers have little or no control over. Much of the system will be designed to maintain readiness and operate without human intervention. However, system readiness and operation during an emergency will always involve human interaction with the system. Systems should include design and component features incorporating human factors so as to maximize readiness and utility during a fire.

**A-11-5** Examples of water mist system design features unique to combatant vessels are as follows:

- (1) Extended duration water supply
- (2) Dedicated fresh water storage tanks
- (3) Dual source water supply for combat redundancy
- (4) Enhanced shock and vibration resistance
- (5) Dual system activation means
- (6) Corrosion resistance
- (7) Two source power supply with automatic bus transfer feed
- (8) Combat survivability features
- (9) Increased structural integrity for piping valves, fittings, and hangers
- (10) Redundancy and separation of controls and valves
- (11) Augmentation with foam bilge sprinkering
- (12) Full flow end-of-line test fittings
- (13) Ventilation interlock
- (14) Remote tank level monitoring

## Appendix B Research Summary

*This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.*

**B-1 Water Mist Droplet Size Characterization and Measurement.** A key mechanism in the successful use of water mist fire protection systems is the increased surface area per unit water volume afforded with the generation and application of small droplets. The increased surface area dramatically increases the rate of heat transfer from the fire to the water mist droplet, cooling the combustion reaction and diluting the oxygen concentration with the generation of water vapor in the vicinity of the fire. It is important to characterize the droplet size distribution produced in listed nozzles for use in the future design and application of water mist systems. It will be valuable in assessing the ability of water mist droplets to control, suppress, and extinguish fires of all types and sizes.

Presently, there are three basic techniques used for the characterization of droplet sizes in a nozzle spray: optical imaging; diffraction; and Doppler refraction.

The first technique uses optical technology to photograph or electronically image the droplets in a small volume of the mist. The image is then analyzed to determine the size distribution of droplets on the image.

The second technique uses a collimated light source passed through the water mist. The water droplets diffract the light into a series of detectors. The angle of diffraction is a function of the size of the droplets in the light beam. By measuring the relative light intensities on the detectors, the distribution of droplet sizes can be determined.

The third technique uses a pair of crossed laser beams to generate a small sample volume through which the water droplets pass. The laser light is refracted inside the droplets and detected off-axis. The detector signal is processed to define the droplet size and velocity distributions.

All three techniques are automated in most commercially available measuring instruments, sampling tens of thousands of droplets for the determination of a droplet size distribution. The instruments typically divide the sizes into categories, or "bind," defined by a range of diameters assigned to each bin. Results are then reported as the number of droplets in each bin or as a fractional distribution of number count or total volume in each bin.

Most commercially available measuring instruments also present additional measurements of size distribution significant to the characterization of a water mist. One of these is the Sauter Mean Diameter (SMD), defined as the total volume of the measured droplet population divided by the total surface area of the population. SMD is often used as a characteristic dimension when mass transfer (including phase change) is the key process. Another important measurement is the maximum diameter at which a specified fraction of the total volume is accumulated. For example,  $Dv_{0.10}$  represents the diameter at which 10 percent of the total volume of the water mist is contained in droplets at or less than the specified diameter. By this definition,  $Dv_{0.10}$  represents the volumetric median diameter, that is 50 percent of the total volume of the total water mist is contained in droplets equal to or less than this diameter and 50 percent is contained in droplets of greater diameter.

## Appendix C Examples of Fire Test Protocols

*This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.*

**C-1 General.** In the absence of a generalized design method based on engineering first principles, water mist systems must be listed for specific hazards and protection objectives. It is the intent of NFPA 750 that such listings be obtained through full-scale fire tests and system component evaluations conducted by internationally recognized laboratories to demonstrate that performance objectives can be met. New potential applications of water mist arise continuously, for which ad-hoc test procedures have been developed. Only a limited number of such ad-hoc fire test protocols meets the intent of this standard, which is as follows:

(a) Test protocols should be based on a fire protection engineering evaluation of the fire hazard, the compartment conditions, and the performance objectives for the system.

(b) Test protocols should be developed, carried out, and interpreted by internationally recognized fire testing laboratories.

Only test protocols developed in that manner are recognized as the basis of a listing. The full listing consists of an approval report describing the results of the performance-based fire testing and the component evaluations, and a manufacturer's design installation and maintenance manual. The nozzle characteristics, spacing between nozzles, distances from ceilings, walls or obstructions, minimum operating pressures and water supply requirements, are all established by the approval report.

**C-1.1** Testing and certification laboratories should extend their system evaluation to components other than the nozzle, based on a customized evaluation or review. Where such evaluations are done, details of the evaluation criteria should be included in the approval report. It is the intent of NFPA 750 that all components not included in the approval report be listed or approved equipment. However, some types of equipment utilized in water mist systems, but which are not fully evaluated in the approval process, are new to fire protection applications and no prior listings exist. An example includes the piston-type pumps used in high pressure systems. Such gaps in the approval process are gradually being addressed through changes to other standards (such as NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*), and



by case-by-case evaluations conducted by the recognized testing laboratory.

**C-1.2** Table C-1.2 identifies several organizations with wide international recognition that currently develop or administer test protocols for water mist fire suppression systems. The following sections provide brief descriptions of the scope of

application and the acceptance criteria of the test protocols that are the basis for the 1998 listings for water mist systems. The testing laboratories can add or subtract certain fire tests, at their discretion, based on their interpretation of the system performance limits. The reader should refer to the original test protocols for complete test details.

**Table C-1.2 Internationally recognized agencies with published fire test protocols for water mist fire protection systems**

Agency	Water Mist Fire Test Protocol
<p>1 International Maritime Organization London, England</p>	<p>IMO MSC/Circular 668: Alternative Arrangements for Halon Fire-extinguishing Systems in Machinery Spaces and Pump-rooms.</p> <p>(a) Appendix A, "Component Manufacturing Standards of Equivalent Water-based Fire Extinguishing Systems," 1994.</p> <p>(b) Appendix B, "Interim Test Method for Fire Testing Equivalent Water-based Fire-extinguishing Systems for Machinery Spaces of Category A and Cargo Pump-rooms," 1994.</p> <p>As amended in MSC/Circ. 728: Amendments to the Test Method for Equivalent Water-based Fire-extinguishing Systems for Machinery Spaces of Category A and Cargo Pump-rooms contained in MSC/Circ. 668, Annex, Appendix B, June, 1996.</p> <p>IMO Res. A.800 (19), <i>Revised Guidelines for Approval of Sprinkler Systems</i> Equivalent to that referred to in SOLAS Regulations II-2/12.</p> <p>(a) Appendix 1, "Component Manufacturing Standards for Water Mist Nozzles."</p> <p>(b) Appendix 2, "Fire Test Procedures for Equivalent Sprinkler Systems in Accommodation, Public Space and Service Areas on Passenger Ships," December, 1995.</p>
<p>2 Factory Mutual Research Corporation Norwood, MA, USA</p>	<p>(a) <i>Draft Protection Requirements for Fine Water Spray Systems for the Protection of Gas Turbines in Enclosures — Class 5560.</i></p> <p>(b) <i>Draft Performance Requirements for Fine Water Spray Systems for the Protection of C Combustion Machinery Spaces and Special Hazard Machinery Spaces — Class 5560.</i></p> <p>(c) <i>Proposed Draft Performance Requirements for Fine Water Spray Systems for the Protection of Light Hazard Occupancies.</i></p> <p>(d) <i>Fire Performance Tests for Fine Water Spray Protection for Wet Benches, 1997.</i></p>
<p>Underwriters Laboratories Inc., Northbrook, IL, USA</p>	<p>UL 2167, <i>Proposed First Edition of the Standard for Water Mist Nozzles for Fire Protection Service</i>, June 1998.</p> <p>(a) Machinery Spaces</p> <p>(b) Passenger Cabin Fire Tests</p> <p>(c) Passenger Cabins Greater than 12 m<sup>2</sup>.</p> <p>(d) Public Space Fire Tests</p> <p>(e) Residential Area Fire Tests</p> <p>(f) Light Hazard Area Fire Test</p> <p>(g) Ordinary Hazard I and II Tests</p> <p>(h) Nozzle Construction Design, Marking and Performance Requirements</p>
<p>4 Verband der Schadenversichen eV (VDS, Germany)</p>	<p>VDS 2498, <i>Guidelines for Water Extinguishing Systems Requirements and Test Methods for Fine Spray Nozzles</i>, 8/96 edition.</p> <p>(a) Fine Spray Nozzles for Cable Conduits</p>

## C-2 International Maritime Organization Test Protocols.

**C-2.1** The International Maritime Organization does not conduct fire tests, but is the body responsible for the content of IMO MSC/Circular 668, *Maritime Safety Committee Circular*, which contains fire test protocols intended to ensure that water mist systems provide protection “equivalent to” conventional sprinkler systems on ships. The actual fire tests can be conducted by any recognized fire test laboratory, such as SP (Sweden), VTT (Finland), SINTEF (Norway), or other agencies in Europe, and FM or ULI in North America. For a water mist system to be accepted in lieu of conventional sprinklers by maritime authorities having jurisdiction, it has to meet the performance criteria described in the test protocols. A formal report by the testing laboratory describing the outcome of the fire tests, certifying that the system performance met the performance limits of the test protocol, and along with the evaluation of components and system hardware, constitutes the basis for “approval” of the system by marine regulatory authorities. IMO MSC/Circular 668 covers not only the fire test results, but also the evaluation of the water mist nozzles.

**C-2.2** Copies of the IMO/MSC Circular 668, *Fire Test Protocols*, can be obtained through the IMO publications office in London.

### C-2.3 Machinery Compartments.

**C-2.3.1** Test Method for Equivalent Sprinkler System for Class 1, 2, and 3, Category A Machinery Compartments” addresses liquid fuel fires in machinery compartments of 500 m<sup>3</sup>, main diesel machinery in spaces up to 3000 m<sup>3</sup> and in larger volume diesel machinery spaces on oil tankers and container ships. The test compartment has a 2 m × 2 m ventilation opening in one wall. A mock-up of a large diesel engine with associated bilge space is constructed in the center of the test enclosure. Liquid fuels include low and high pressure fuel lines, lubrication oil lines, and hydraulic oil lines, with spray, spill, and pool fires. Some of the fires are shielded from direct water spray by steel plates. Thirteen fire scenarios are described: eight use commercial fuel oil or light diesel oil (‘high’ flash point fuels); four use heptane fuel (‘low’ flash point fuels), and one involves a wood crib and heptane igniter. Spray, pool and spill fires are tested.

**C-2.3.2** The IMO machinery space water mist system has to extinguish all test fires, including small hidden bilge fires, and prevent reignition. This test protocol requires full extinguishment of all fires. Systems that have passed the IMO machinery space test protocol are permitted to utilize combinations of total flooding ceiling nozzles and screening nozzles over the ventilation opening, as well as the addition of foaming agent to the water supply (for hidden fires in the bilge areas). Systems can also incorporate a separate bilge protection system. Nozzles are generally of the non-automatic type (open) and the systems are permitted to be activated manually. Water supply is provided using stored water in pressurized cylinders to provide the first minute of operation without electric power. After one minute, it is assumed that pumps will be started to meet the water flow demand for up to 30 minutes, from either stored fresh water or sea-water sources.

### C-2.4 Cabin and Corridor Fires.

**C-2.4.1 The Test Protocol for Equivalent Sprinkler Systems for Cabin and Corridor Fires.** Describes fire tests involving polyether mattresses with cotton covers in sleeping quarters on ships. Compartment sizes range from 16 m<sup>2</sup> to 25 m<sup>2</sup> and

up to 52 m<sup>2</sup> in luxury cabins. The luxury cabin test includes a wood crib and simulated furniture, which is the residential fuel package. Nozzles are of the automatic type (activated by heat in the manner of a sprinkler). The system is tested with cabin and corridor nozzles. In one test, cabin nozzles are disabled, and the corridor nozzles have to prevent fire from spreading along the corridor.

**C-2.4.2** It is important to note that, unlike the machinery space tests, pass/fail criteria for the cabin and corridor fires are not based on full extinguishment. The cabin and corridor fires have to be controlled by the water mist system for up to 10 minutes, after which time the test operators manually extinguish any remaining fire. The average of damage to the mattresses over all tests must not exceed 35 percent, with no test resulting in losses greater than 50 percent of the original material.

### C-2.5 Water-Based Fire Extinguishing Systems in Accommodation and Public Space Areas on Board Ships.

**C-2.5.1** The Public Space Tests evaluate the ability of water mist to control fires in open public spaces on ships, with ceiling heights of one or two deck heights (2.5 m or 5.0 m respectively). The open public space tests involve simulated couches with cotton-covered polyether mattresses on steel frames, representing a lounge-type setting in the center of large rooms. Tests are done under one, between two, and between four nozzles, at either 2.5 m or 5.0 m ceiling heights. Nozzles are of the automatic type (thermally activated). A corner fire scenario is included, which involves fire in the corner of a room with combustible wall and ceiling panels. The water mist system has to prevent fire spread to target couches and limit ceiling temperatures. The corner test includes a disabled nozzle, such that the fire control is achieved through operation of the functioning nozzles.

**C-2.5.2** The water mist system has to control the fire for 10 minutes, after which time the operators manually extinguish any remaining fire. Damage to the mattresses has to be within prescribed limits, with the average for all tests of 35 percent or less, with no single test exceeding 50 percent damage.

**C-2.5.3** Shopping and storage areas on ships involve much higher fuel loading than encountered in open public areas. The IMO test protocol for shopping and storage areas involves plastic cups in cardboard cartons (standard Group A plastic commodity) stacked 1.5 m high in the same array as used for ordinary hazard sprinkler fire tests. Target arrays of empty cartons surround the main fuel piles.

**C-2.5.4** The fire in the stacked boxes has to be controlled for up to 10 minutes, after which time the operators manually extinguish the remaining fire. Fire cannot spread to the target boxes, nor can charring of any of the target arrays occur. In any one test, damage to the boxes and plastic cups in the fire source cartons cannot exceed 50 percent. This test fire represents a challenge to any water based suppression systems, including conventional sprinklers.

### C-2.6 IMO Component Standards.

**C-2.6.1** Annex A of IMO MSC/668, “Component Manufacturing Standards of Equivalent Water-Based Fire Extinguishing Systems,” describes tests for evaluating the water mist nozzles. Rigorous tests are performed on the nozzle to determine hydraulic characteristics, water flux and drop size distributions, responsiveness of thermal sensing elements (for

automatic nozzles), structural strength, resistance to impact, corrosion, and clogging, and so forth. The tests described in Annex A are the basis for the component evaluations conducted by ULI under UL 2167, *Proposed Standard for Water Mist Nozzles for Fire Protection Service*. Components other than the nozzle, such as water or gas storage cylinders, pump, control valves, pressure-reducing valves, or special actuators are not part of the Annex A protocol.

### C-3 Factory Mutual Research Corporation Test Protocols.

**C-3.1 General.** Factory Mutual Research Corporation (FMRC) has developed the following test protocols, which are the basis for current listings of water mist systems and components [denoted by FMRC as Fine Water Spray (FWS) systems].

(a) FMRC *Draft Performance Requirements for Fine Water Spray Systems for the Protection of Combustion Turbine Enclosures, Machinery Spaces, and Special Hazard Machinery Spaces with Volumes Not Exceeding 2825 ft<sup>3</sup> (80 m<sup>3</sup>)*.

(b) FMRC *Draft Performance Requirements for Fine Water Spray Systems for the Protection of Combustion Turbine Enclosures, Machinery Spaces, and Special Hazard Machinery Spaces with Volumes Not Exceeding 9175 ft<sup>3</sup> (260 m<sup>3</sup>)*.

(c) FMRC *Draft Performance Requirements for Fine Water Spray Systems for the Protection of Combustion Turbine Enclosures, Machinery Spaces, and Special Hazard Machinery Spaces with Volumes Not Exceeding 9175 ft<sup>3</sup> (260 m<sup>3</sup>)*.

(d) FMRC *Draft Performance Requirements for Fine Water Spray Systems for the Protection of Light Hazard Occupancies*.

(e) FMRC *Draft Performance Requirements for Fine Water Spray Systems for the Protection of Wet Benches and Other Processing Equipment*.

**C-3.1.1** Note that the terminology *machinery space* refers to flammable liquid hazards no greater than those of diesel fuel and the term *special hazard machinery space* refers to flammable liquid hazards no greater than those of n-heptane. These terms should not be confused with the term *machinery space* used in the International Maritime Organization (IMO) documents relating to fine water spray. They are not intended to be interchangeable.

**C-3.1.2** The standards describe fire test performance criteria and methods. Because each fine water spray system is unique in its design and use of components, the component testing of each fine water spray system is evaluated on a case-by-case basis. The components are tested for functionality, performance, integrity, and reliability. The manufacturers' design, installation, and maintenance manual(s) are reviewed for technical content and clarity. The supplied hydraulic calculations are also reviewed.

**C-3.2 FMRC Draft Performance Requirements for Fine Water Spray Systems for the Protection of Combustion Turbine Enclosures, Machinery Spaces, and Special Hazard Machinery Spaces with Volumes Not Exceeding 2825 ft<sup>3</sup> (80 m<sup>3</sup>)**.

**C-3.2.1** The objective of this standard is to assure that the fine water spray system extinguishes spray and pool fires that can occur, for example, due to breaks in lubrication, hydraulic, or fuel lines. Typically, these fires are highly shielded. While spray fires can only occur as the result of a supply line break, pool fires can occur as a result of a breakage or as a result of a small leak over a large period of time. This standard is limited to volumes not exceeding 2825 ft<sup>3</sup> (80 m<sup>3</sup>). The FMRC standard assumes automatic interlocks for the following:

- (1) All fuel supply lines (for combustion turbines, bearing lubrication may be left on to allow the turbine to coast down)
- (2) Door closures
- (3) Ventilation shut down
- (4) Electrical systems

**C-3.2.2** The water supply required is dependent upon the application. For combustion turbines, the water supply has to be sufficient to protect the turbine for the duration of its coast down time. For machinery spaces and special hazard machinery spaces, the protection time is 10 minutes.

**C-3.2.3** The detection is by means of heat detectors. The detection is so designed as to detect the fire and activate the fine water spray system within 60 seconds of the ignition.

**C-3.2.4** The fine water spray system has to extinguish all spray and pool fires within 5 minutes from time of ignition. Tests are conducted in closed enclosures as well as enclosures with natural ventilation. For optional protection of insulated combustion turbines, the insulation mat can be suppressed rather than extinguished.

**C-3.2.5** In addition to the fire performance criteria, fine water spray systems used for the protection of combustion turbines cannot cause damage to the turbine by means of thermal shock, cracking of the turbine casing, or induce blade rubbing. The rate of cooling of the steel test plate (1 m × 2 m × 5 cm thick) must not exceed limits set by FMRC. It can be more difficult to successfully pass the cooling test than to pass the fire tests and the results of the cooling test often indicate the number, type, and placement of the fine water spray nozzles.

**C-3.3 FMRC Draft Performance Requirements for Fine Water Spray Systems for the Protection of Combustion Turbine Enclosures, Machinery Spaces, and Special Hazard Machinery Spaces with Volumes Not Exceeding 9175 ft<sup>3</sup> (260 m<sup>3</sup>)**.

**C-3.3.1** The objective is to assure that the fine water spray system extinguishes spray and pool fires that can occur, for example, due to breaks in lubrication, hydraulic or fuel lines. Typically, these fires are highly shielded. While spray fires can only occur as the result of a supply line break, pool fires can occur as a result of a breakage or as a result of a small leak over a large period of time. This standard is limited to volumes not exceeding 9175 ft<sup>3</sup> (260 m<sup>3</sup>). The FMRC standard assumes automatic interlocks for the following:

- (1) All fuel supply lines (for combustion turbine, bearing lubrication may be left on to allow the turbine to coast down)
- (2) Door closures
- (3) Ventilation shut down
- (4) Electrical systems

**C-3.3.2** The water supply required is dependent upon the application. For combustion turbines, the water supply has to be sufficient to protect the turbine for the duration of its coast down time. For machinery spaces and special hazard machinery spaces, the protection time is 10 minutes.

**C-3.3.3** The detection is by means of heat detectors. The detection is so designed as to detect the fire and activate the fine water spray system within 60 seconds of the ignition.

**C-3.3.4** The fine water spray system has to extinguish all spray and pool fires within 5 minutes from time of ignition. Tests are conducted in closed enclosures as well as enclosures with natu-

ral ventilation. For optional protection of insulated combustion turbines, the insulation can be suppressed rather than extinguished. In addition to demonstrating performance in volumes not exceeding 9175 ft<sup>3</sup> (260 m<sup>3</sup>), systems have to also demonstrate the capability to perform in small [4590 ft<sup>3</sup> (130 m<sup>3</sup>)] enclosures.

**C-3.3.5** In addition to the fire performance criteria, fine water spray systems used for the protection of combustion turbines cannot cause damage to the turbine by means of thermal shock, cracking of the turbine casing, or induce blade rubbing. The rate of cooling of the steel test plate (1 m × 2 m × 5 cm thick) cannot exceed limits set by FMRC. It can be more difficult to successfully pass the cooling test than to pass the fire tests and the results of the cooling test often indicate the number, type, and placement of the fine water spray nozzles.

**C-3.4 FMRC Draft Performance Requirements for Fine Water Spray Systems for the Protection of Combustion Turbine Enclosures, Machinery Spaces, and Special Hazard Machinery Spaces with Volumes Exceeding 1975 ft<sup>3</sup> (260 m<sup>3</sup>).**

**C-3.4.1** The objective is to assure that the fine water spray system extinguishes spray and pool fires that can occur, for example, due to breaks in lubrication, hydraulic, or fuel lines. Typically, these fires are highly shielded. Although spray fires can only occur as the result of a supply line break, pool fires can occur as a result of a breakage or as a result of a small leak over a large period of time. The FMRC standard assumes automatic interlocks for the following:

- (1) All fuel supply lines (for combustion turbines, bearing lubrication may be left on to allow the turbine to coast down)
- (2) Door closures
- (3) Ventilation shut down
- (4) Electrical systems

**C-3.4.2** This standard is based on the IMO *Standard For Shipboard Machinery Spaces*, although the hazards discussed in both documents are different. Due to differences in system design and performance, extrapolation of results to larger room sizes is not permitted by FMRC at this time.

**C-3.4.3** The water supply required is dependent upon the application. For combustion turbines, the water supply has to be sufficient to protect the turbine for the duration of its coast down time. For machinery spaces and special hazard machinery spaces, the protection time is 60 minutes. Typically, the volumes tested exceed 28,230 ft<sup>3</sup> (800 m<sup>3</sup>).

**C-3.4.4** The detection is by means of heat detectors. The detection is so designed as to detect the fire and activate the fine water spray system within 60 seconds of the ignition.

**C-3.4.5** The fine water spray system has to extinguish all spray, pool, and crib fires within 30 minutes from time of ignition. The exception is a small shielded diesel pool fire that has to be suppressed. Tests are conducted in enclosures with natural ventilation. For optional protection of insulated combustion turbines, the insulation mat can be suppressed rather than extinguished.

**C-3.4.6** In addition to the fire performance criteria, fine water spray systems used for the protection of combustion turbines cannot cause damage to the turbine by means of thermal shock, cracking of the turbine casing, or induce blade rubbing. The rate of cooling of the steel test plate (1 m × 2 m × 5 cm thick) cannot exceed limits set by FMRC. It can be more difficult to

successfully pass the cooling test than to pass the fire tests and the results of the cooling test often indicate the number, type, and placement of the fine water spray nozzles.

**C-3.5 FMRC Draft Performance Requirements for Fine Water Spray Systems for the Protection of Light Hazard Occupancies.**

**C-3.5.1** The objective is to assure that the fine water spray system controls fires typically found in light hazard occupancies and prevents the spread of the fire beyond the room, or area, of origin. These fires typically involve furnishings and wall coverings. This standard limits the heights of enclosed spaces to 8 ft (2.4 m) and the heights of unrestricted spaces to 16 ft 5 in. (5 m).

**C-3.5.2** This standard is based on the IMO *Standard For Shipboard Corridors, Cabins, and Public Spaces*, although the hazards discussed in both documents are different.

**C-3.5.3** The water supply required is 60 minutes for the most remote nine nozzles at the rated operating pressure.

**C-3.5.4** The detection is by means of individual heat responsive elements on the nozzles. The nozzles should meet FMRC requirements for quick response sprinklers and are limited to a maximum nominal temperature rating of 225°F (107°C). Nozzle spacing is to be uniform with uniform spacing, preferably one-half of the standard nozzle spacing, from the wall.

**C-3.5.5** The fire performance tests consist of three test areas: small compartment, large compartment, and open space.

**C-3.5.5.1** The small compartment [10 ft × 13 ft × 8 ft high (3 m × 4 m × 2.4 m high)] has a small door 2 ft 6 in. × 7 ft 2 in. high (0.8 m × 2.2 m high) and represents a small ship cabin. The fuel package for this room consists of two bunk beds identical to the IMO specification. The purpose of this test is to delineate mist nozzles from sprinklers. The fire is ignited on the lower mattress and the test methodology is identical to that specified in the IMO test series. Pass/fail criteria are based on damage of the lower bunk (maximum of 40 percent), ceiling surface temperature over ignition [maximum of 500°F (260°C)], and a maximum gas temperature 3 in. (76 mm) below the ceiling of 600°F (315°C).

**C-3.5.5.2** The large compartment [having equal sides not exceeding 20 ft (6 m) and a height of 8 ft (2.4 m)] has two doors [each 2 ft 6 in. × 7 ft 2 in. high (0.8 m × 2.2 m high)] located in diagonally opposite corners. A nozzle is placed in the doorway opposite the fuel package. The fuel package and test method are identical to the IMO specification. The heptane under the wood crib is ignited first then followed, forty seconds later, by the ignition of the excelsior. The doorway nozzles do not operate (hence indicating that the fire would not have spread to an adjacent area). Additional pass/fail criteria include ceiling surface temperature over ignition [maximum of 510°F (265°C)], and a maximum gas temperature 3 in. (76 mm) below the ceiling of 600°F (315°C).

**C-3.5.5.3** The open space test is conducted under a ceiling with a minimum area of 860 ft<sup>2</sup> (80 m<sup>2</sup>) in order to simulate an uninterrupted area and a ceiling height of 16 ft 5 in. (5 m). At least sixteen nozzles are installed in the ceiling and the fuel package (sofas as outlined in the IMO specification) are to be arranged per the IMO specification. The test is conducted three times; once each with the ignition under one nozzle, between two nozzles, and between four nozzles. Pass/fail criteria are based on less than five nozzles operating, at least one unoperated nozzle beyond those that operate, damage of the

sofa cushions (maximum of 50 percent), ceiling surface temperature over ignition [maximum of 500°F (260°C)], and a maximum gas temperature 3 in. (76 mm) below the ceiling of 600°F (315°C).

**C-3.6 FMRC Draft Performance Requirements for Fine Water Spray Systems for the Protection of Wet Benches and Other Processing Equipment.**

**C-3.6.1** The objective is to assure that the fine water spray system extinguishes pool fires typically found in wet benches and other similar clean room processing equipment.

**C-3.6.2** The detection system has to be approved specifically for use in wet bench applications. Fine water spray systems used for this application are typically of the zoned, deluge type. Operating elements currently used in automatic sprinklers have not been shown to be sufficiently fast enough to prevent significant nonthermal damage.

**C-3.6.3** The simulated clean room is 18 ft × 12 ft × 12 ft high (5.5 m × 3.7 m × 3.7 m high) with porous ceiling and floor plates. An airflow (downward) with a velocity of 60 ft/min is maintained throughout the test. The minimum airflow by the open face of the wet bench is 150 ft<sup>3</sup>/min/linear ft (4.5 m<sup>3</sup>/min/linear m). The wet bench measures approximately 7.5 ft × 4.5 ft × 6.5 ft high (2.3 m × 1.4 m × 2 m high) and is divided into two areas; the ventilated subsurface (or plenum) area and the working surface area. The subsurface dimensions are 2.6 ft × 7.5 ft × 2 ft high (0.8 m × 2.3 m × 0.6 m high). The working surface area is 2.6 ft × 7.5 ft (0.8 m × 2.3 m).

**C-3.6.4** All fires have to be extinguished in less than 60 seconds.

**C-3.6.5** Various fire scenarios are conducted to test the fine water spray system for the ventilated subsurface area. These include 5 pool fires (various sizes) utilizing polypropylene beads and solid coupons for fuel, and at least one pool fire for each of the following flammable liquids; acetone, isopropyl alcohol (IPA), and n-heptane. The pan sizes and fire locations for the flammable liquid pool fire are at the discretion of FMRC based upon observations made of the fine water spray system. Obstructions are placed within the subsurface area such that approximately 50 percent of the nozzle discharge is blocked.

**C-3.6.6** Two tests are conducted to determine the effectiveness of a single nozzle in an unventilated space utilizing the subsurface area as a test chamber. The first test utilizes a polypropylene pool fire and the second test uses a flammable liquid pool fire. Pan size and flammable liquid are at the discretion of FMRC based on the outcome of the ventilated subsurface tests. Suitable barriers are placed in the test area to prevent direct impingement on the fire and to provide 50 percent blockage of the discharge.

**C-3.6.7** Several fire scenarios are conducted to test the fine water spray system for the working surface area. These include 5 pool fires (various sizes) utilizing polypropylene beads and solid coupons for fuel, and at least one pool fire for each of the following flammable liquids: acetone, isopropyl alcohol (IPA), and n-heptane. The pan sizes and fire locations for the flammable liquid pool fire are at the discretion of FMRC based upon observations made of the fine water spray system. The flammable liquid fires are also tested at the minimum and maximum nozzle heights, as specified by the manufacturer. A splashing test is conducted in which a single nozzle, located at the minimum vertical height above a pan of liquid containing

dye, is discharged at the maximum pressure. None of the contents of the liquid pool is splashed outside a 16 in. (0.4 m) diameter circle centered on the pool.

**C-4 Underwriters Laboratories Inc., Northbrook, IL, Fire Test Protocols.**

**C-4.1 General.** UL 2167, Proposed First Edition of the *Standard for Water Mist Nozzles for Fire Protection Service*, contains a series of fire test protocols for evaluating water mist nozzles for listing purposes for the following types of hazards.

- (1) Shipboard machinery spaces
- (2) Shipboard passenger cabins
- (3) Shipboard passenger cabins >12 m
- (4) Shipboard public spaces
- (5) Residential areas
- (6) Light Hazard areas
- (7) Ordinary Hazard Group 1
- (8) Ordinary Hazard Group 2
- (9) Nozzle construction, design and performance
- (10) Water mist nozzle markings
- (11) Design and installation manual
- (12) Manufacturing and production tests

**C-4.2** The UL 2167, “Shipboard Test Protocols” closely resemble the IMO test protocols with some modifications in the number of tests and final acceptance criteria.

**C-4.3 Residential Areas.** The UL 2167, “Test Protocol for Residential Areas” is very similar to that for residential sprinklers. A residential fuel package is used, in a compartment fitted with combustible wall panels and ceiling tiles. Six nozzles are installed in the room that has two open doors on opposite sides with the fuel package located in a corner. The nozzle closest to the fuel package is installed at its maximum spacing and the remaining five nozzles are installed using their minimum permitted spacing. Performance criteria include maximum temperatures at several locations and the fuel package cannot be completely consumed. If only one nozzle operates, the manufacturer’s design and installation manual has to specify at least a two-nozzle design. If two or three nozzles operate, at least a four-nozzle design is to be specified.

**C-4.4 Light Hazard Areas.** The proposed UL 2167, “Test Protocol for Light Hazard Areas,” in addition to complying with the shipboard public space light hazard fire tests, requires a series of fire tests to measure the ability of the nozzles to limit fire growth in wood cribs.

**C-4.5 Ordinary Hazard Group 1.** The proposed UL 2167, “Test Protocol for Ordinary Hazard Group 1 Hazard Areas” requires the conduct of fire tests both under an open ceiling and in a corner arrangement. The first series of fire tests is conducted under a smooth flat ceiling at least 232 m<sup>2</sup> in area set at the maximum height specified in the manufacturer’s design and installation manual. The fire source consists of a 3 m wide × 5 m long × 2 m high array of Class II commodity (double tri-wall corrugated paper cartons with a five-sided steel liner on a 107 cm × 107 cm × 12.7 cm high hardwood pallet). During the 45-minute test, ceiling steel temperatures cannot exceed 282°C (540°F) for more than 5 minutes; the number of operating nozzles cannot exceed a design area of 93 m<sup>2</sup>, and damage to the commodity cannot exceed 50 percent. The corner fire tests are similar to the IMO public space corner tests except that empty cardboard cartons are used in lieu of the sofas. The corner fire test series also includes a disabled nozzle fire test.

**C-4.6 Ordinary Hazard Group 2.** The UL 2167, “Proposed Test Protocol for Ordinary Hazard Group 2 Hazard Areas,” are similar to the Ordinary Hazard Group 1 fire tests except that the Group A plastic commodity and test array described in the IMO public space shopping and storage area fire tests is used as the open area test commodity.

**C-4.7 Nozzle Design, Construction and Performance Requirements.** These requirements are very similar to those specified by IMO. They also include requirements for open nozzles that were not specifically addressed by IMO.

**C-4.8 Nozzle Marking Requirements.** The proposed UL 2167 contains requirements for the marking of water mist nozzles. In the field, these markings provide a method of verifying that the proper nozzles have been installed.

**C-4.9 Design and Installation Manual.** The proposed UL 2167 requires the nozzle manufacturer to prepare a design and installation manual containing the following information:

- (1) Description and operating details of each nozzle and all accessory equipment
- (2) Nozzle limitations for each fire use type including maximum area and height of the hazard or enclosure
- (3) Type of pipe, tube and fittings
- (4) Nozzle installation limitations including maximum and minimum spacing and area coverage, minimum and maximum installation heights and nozzle location in the protected volume
- (5) Operating pressure and water flow rates
- (6) Information on the inspection of a nozzle after installation

**C-4.10 Manufacturing and Production Tests.** The proposed UL 2167 requires the manufacturer to provide an acceptable production control, inspection, and test program. All automatic nozzles are subjected to a production leakage test at twice rated pressure but not less than 3.45 MPa. In addition, as part of a follow-up service program, samples are randomly selected on a periodic basis for follow-up inspections and tests.

## **C-5 Verband der Schadenversichen eV (VDS, Germany).**

**C-5.1 General.** VDS 2498, *Guidelines for Water Extinguishing Systems Requirements and Test Methods for Fine Spray Nozzles*, contains several fire test protocols. One that has been recognized in Europe includes: Fine Spray Nozzles for Cable Conduits.

**C-5.2 Fine Spray Nozzles For Cable Conduit Tunnels.** This test incorporates a propane burner flame as ignition source, at one end of an array of plastic sheathed cables.

## **C-6 Bridging the Gap Between Test Protocols and Actual Installations.**

**C-6.1** One of the greatest challenges to engineering of water mist fire suppression systems lies in determining whether the conditions of a particular test protocol are rep-

resentative of the actual conditions in a given application. An engineering analysis should be applied to evaluate the scale and significance of variations, based on an understanding of the dynamics of the interaction of water mist with fire. At least the following application parameters should be considered:

- (a) Is the fuel similar to the test protocol (liquid or solid fuel, flash point, combustibility, quantity, arrangement)?
- (b) Is the compartment volume equal to or less than the volume of the test room?
- (c) Is the compartment height equal to or less than the test protocol?
- (d) Is the compartment ventilation condition similar. . . (area of openings, position of openings. . .)?
- (e) Are there more obstructions to the distribution of mist than the test protocol?
- (f) Is the duration of protection provided by the listed system appropriate for the actual level of protection desired?

**C-6.2 Extrapolation.** It is recommended that questions about the match between test conditions upon which the listing is based, and the conditions of the actual installation, be addressed through consultation with the listing agency, the authority having jurisdiction, or other agencies with demonstrated qualifications in the field.

## **Appendix D Reliability**

*This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.*

**D-1 General.** There are two methods used to determine reliability: operating experience and predictive techniques.

**D-1.1 Operating Experience.** The Committee contacted Department of Energy, Department of Defense, National Aeronautics and Space Administration, Coast Guard, passenger cruise ship companies, and other organizations known to have installed water mist systems. The purpose was to determine the number of systems in service, and to obtain as much detail as possible for these installations (Listed/approved, acceptance test results, loss experience, accidental operations, and so forth).

Using these sources a total of 35 installations were identified, for which varying degrees of detail were obtained. The information is summarized in Table D-1.1.

One fire was reported involving a hydraulic oil leak in an engine test cell, and two fires were reported for a system protecting a thermal oil system on a fiberboard press. Several fires were reported in combustion turbines on offshore oil platforms. Water mist systems operated properly in all cases.

One accidental operation was reported. The accidental operation was attributed to location of a heat detector too close to the exhaust stack in an engine test cell. (See Table D-1.1.)

**Table D-1.1 Operating Experience**

OPERATING EXPERIENCE												
Protected Hazard	No. of Systems	Time in Operation	Fires		Accidental Operation	Application		Detection/Actuation	Listed		Acceptance Test (Y/N)	Notes
			Success	Fail		Flood	Local		Yes	No		
600 HP engine	1	mid 96	n/a	n/a	no		X	IR Flame		X	Y-discharge	1
Compressor lube oil system	1	Feb 96	n/a	n/a	no		X	Smoke		X	Y-discharge	2
Engine test cells			1	no	1	X?		Heat det.				3
7 combustion turbines (on oil platforms)	7	spring 93	several	no	unknown	X?						4
5 diesel fire pumps (on oil platforms)	5	spring 93	n/a	n/a	unknown							
5 diesel generators (on oil platforms)	5	spring 93	n/a	n/a	unknown							
2 deep fat fryers (on oil platforms)	2	spring 93	n/a	n/a	unknown							
6 cruise ships	?	unknown	none	none	1							5
Lube oil systems for 6 combustion turbine driven compressors (natural gas pipeline)	6	1996 (2) 1997(2) 1998(2)	none	none	none	combination						
Thermal oil system on fiberboard press	1		2	none	none		X?			X		6

Notes:

1. At some time after acceptance test, white residue was noted in pipe. Laboratory tests determined it to be zinc oxide. Piping was flushed but residue remained.
2. During acceptance test, system failed to operate due to low pressure. Investigation determined that a 1/4 in. copper tube had separated from a brass fitting. On second discharge test, 3 of 25 nozzles were plugged, possibly due to use of pipe joint compound. System remained out of service 22 months after installation due to concern for accidental operation during cutting and welding operations. Chalk like material has formed on interior surface of pipe; believed to be oxide.
3. Fire activation: A hydraulic line break occurred on an engine under test. System operated properly and extinguished the fire. Accidental activation: System operated 50 hours into engine test, near end of test cycle. One heat detector may have been located too close to exhaust stack.
4. Systems are tested periodically with limited discharge of a few seconds to verify the system is operational.
5. Six vessels have water mist protection for engine rooms, dining areas, ballrooms, and escape routes. Engine room systems are manually controlled. One accidental operation, in dining room.
6. Oil spray fire burned 2-3 hours, fought unsuccessfully by plant personnel using hose streams. Water mist system was manually activated and extinguished fire within 20 seconds. When press was placed back in service, a second fire developed at an undetected crack in thermal oil system piping. This fire was also extinguished by the water mist system.

**D-1.2 Predictive Techniques.** Predictive techniques outlined in ISA-S84.01, "Application of Safety Instrumentation to the Process Industries," provide guidance to determine the safety integrity level (SIL) of a protection system. The main document establishes SILs needed for various safety systems (SIS). Parts 2 to 4 of ISA-S84.01 provide information on three different methods that can be used to determine reliability: simplified equations, fault tree analysis, and Markov analysis. Part 5 of ISA-S84.01 determines the probability of failure on demand (PFD) of Logic Solvers via Markov analysis.

The average probability of failure of a system at various SILs is shown in Table D-1.2.

**Table D-1.2 Safety Integrity Levels**

SIL	PFD (avg)
1	10 <sup>-1</sup> to 10 <sup>-2</sup>
2	10 <sup>-2</sup> to 10 <sup>-3</sup>
3	10 <sup>-3</sup> to 10 <sup>-4</sup>

The user of the system should designate the safety level desired based on either dollar loss or personnel injury. Where a high level of safety is required, the analysis should be done by an independent third party. For lower safety levels the manufacturer could do the analysis.

The Navy used reliability studies to evaluate the reliability of halon systems for shipboard use. Approval for service was depen-

dent on a reliability study. The main advantage to the analysis was the identification of single points of failure. Failure rates were determined for the systems designed, but these appeared to be less meaningful than identifying single points of failure. Reliability was improved by eliminating abort valves and installing a manual actuation system to bypass the time delay for the pre-discharge alarm. Manual activation was acceptable because the protected areas on board ship are constantly occupied.

**D-1.3 Conclusions.** The following conclusions were derived from the review of operating experience:

(a) Systems are being installed to protect applications for which they have not been tested.

(b) Users do not have adequate information to determine whether the system has been properly designed and installed. The following additional information is needed:

- (1) List of system components
- (2) Design, installation, and maintenance manual
- (3) Logic diagram

(c) Acceptance tests are critical to the reliability of the system. Full flow tests are the best indication a system has been properly installed. There are installations where this cannot be done. For these applications water should be flowed as close to the nozzles as possible then diverted to a safe area. The rest of the system should be visually inspected or gas should flow through the system to be sure it is clear.

FIGURE D-1.3 Water mist system questionnaire form.

**Water Mist System Questionnaire**

Questionnaires will be used to determine the reliability of water mist systems. The questionnaire should be completed by the user and forwarded to Staff Liaison, NFPA 750 Water Mist Reliability, 1 Batterymarch Park; P.O. Box 9101; Quincy, MA 02269-9101. Phone: (617) 770-3000

1. Date of installation \_\_\_\_\_
2. The protection is for (combustion turbine, engine test cell, etc.) \_\_\_\_\_  
\_\_\_\_\_
3. Type of system (check box)     Total Compartment     Zoned     Local Application
4. Acceptance test  
Was a full discharge test done (check box)     Yes     No  
What were the results? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
5. The system is listed by a nationally recognized testing lab:     Yes     No     Unknown
6. The system is actuated by (check box)     heat     smoke     flame     manual
7. How long has the system been in service? \_\_\_\_\_
8. Has the system actuated (check box)?     Yes     No
9. If yes the operation was due to (check box)     Fire     Accidental     Other
10. The system operated properly (check box)     Yes     No
11. If the system failed, or operated accidentally, please explain: \_\_\_\_\_  
\_\_\_\_\_

Contact: \_\_\_\_\_                      Date: \_\_\_\_\_

Phone: \_\_\_\_\_

NOTE: This information will be utilized for statistical information only and will not be available outside of NFPA.

(d) Operating experience is more accurate than predictive techniques in determining the reliability of a system. There is not enough operating experience to date for water mist systems. A questionnaire as shown in Figure D-1.3, distributed to users of water mist systems and returned to the committee, would be helpful in gathering information.

(e) Where a water mist system is used for life safety, a predictive method should be used to justify the system is as reliable as the protection system required by code.

### Appendix E Referenced Publications

**E-1** The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not considered part of the requirements of this standard unless also listed in Chapter 12. The edition indicated here for each reference is the current edition as of the date of the NFPA issuance of this standard.

**E-1.1 NFPA Publications.** National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1999 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 1996 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 1999 edition.

NFPA 70, *National Electrical Code*<sup>®</sup>, 1996 edition.

“Water Mist Suppression Systems,” *Fire Protection Handbook*, 18th Edition.

#### E-1.2 Other Publications.

**E-1.2.1 ANSI Publications.** American National Standards Institute, Inc., 11 West 42nd Street, 13th floor, New York, NY 10036.

ANSI B 31.1, *Power Piping Code*, 1995.

ANSI C2, *National Electrical Safety Code*, 1993.



**E-1.2.2 ASTM Publications.** American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 380, *Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)*, 1993.

ASTM E 799, *Standard Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis*, 1992.

ASTM F 1547, *Standard Guide Listing Relevant Standards and Publications for Commercial Shipbuilding*, 1994.

**E-1.2.3 CSA Publication.** Canadian Standards Association, Rexdale, Ontario, Canada.

CAN3-A234.1, *Canadian Metric Practice Guide*, 1979.

**E-1.2.4 IMO Publications.** International Maritime Organization, 4 Albert Embankment, London, SE1 7SR, United Kingdom.

IMO Fire Test Procedures

SOLAS Resolution 10, *Fixed Pressure Water Spray Systems*.

IMO Resolution A.800(19), *Revised Guidelines for Approval of Sprinkler Systems*.

**E-1.2.5 FMRC Publications.** Factory Mutual Research Corporation, 1151 Boston-Providence Turnpike, Norwood, MA 02061.

*Draft Protection Requirements for Fire Water Spray Systems for the Protection of Gas Turbines in Enclosures — Class 5560.*

*Draft Performance Requirements for Fire Water Spray Systems for the Protection of C Combustion Machinery Spaces and Special Hazard Machinery Spaces — Class 5560.*

*Proposed Draft Performance Requirements for Fine Water Spray Systems for the Protection of Light Hazard Occupancies.*

*Fire Performance Tests for Fine Water Spray Protection for Wet Benches*, 1997.

**E-1.2.6 UL Publication.** Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 2167, Proposed First Edition of the Standard for Water Mist Nozzles for Fire Protection Service, June 1998.

**E-1.2.7 VDS Publication.** VDS, Pasteurstrabe 17A, Koln 50735, Germany

VDS 2498, *Guidelines for Water Extinguishing Systems Requirements and Test Methods for Fine Spray Nozzles*, 1996 edition.

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