



UL 2167

STANDARD FOR SAFETY

Water Mist Nozzles for Fire Protection Service

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UL Standard for Safety for Water Mist Nozzles for Fire Protection Service, UL 2167

Second Edition, Dated March 9, 2021

Summary of Topics

This new edition of ANSI/UL 2167 has been updated to incorporate the ANSI approval of March 9, 2021. The new edition also includes the following:

- Revisions to Clarify Requirement, Enhance Alignment With UL Sprinkler Standards, And Update Testing Details***
- Hydrostatic Strength***
- Revisions to Shipboard Light and Ordinary Hazard Area Fire Tests***
- Light Hazard Area Fire Test***
- Revisions to Performance Based Acceptance Criteria for Ordinary Hazard Fire Tests and Installation Instructions***

The requirements are substantially in accordance with Proposal(s) on this subject dated September 11, 2020.

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MARCH 9, 2021



ANSI/UL 2167-2021

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UL 2167

Standard for Water Mist Nozzles for Fire Protection Service

First Edition – December, 2002

Second Edition

March 9, 2021

This ANSI/UL Standard for Safety consists of the Second Edition.

The most recent designation of ANSI/UL 2167 as an American National Standard (ANSI) occurred on March 9, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 This Standard contains requirements for water mist nozzles for use with water mist fire-protection systems intended for the protection of residential, light and ordinary hazard areas as well as shipboard machinery, control spaces, service areas, and public spaces. The intended application and use of a water mist nozzle is referenced in the Manufacturer's Design and Installation Instructions. See Section 49, Design and Installation Instructions.

1.2 This Standard is intended to address minimum fire-protection performance, construction, and marking requirements for water mist nozzles.

2 Units of Measurement

2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component.

3.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

3.3 A component shall be used in accordance with its rating established for the intended conditions of use.

3.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

5 Glossary

5.1 For the purpose of this standard, the following definitions apply.

5.2 CONDUCTIVITY FACTOR – A measure of the conductance between the nozzle's heat responsive element and the fitting expressed in units of (m/s)^{0.5}.

5.3 CONTROL SPACES – Shipboard areas such as the bridge, radio room, and emergency power room.

5.4 CORROSION RESISTANT MATERIAL – A material (such as bronze, brass, stainless steel, or plastic) which has a low propensity for corrosion when used in its anticipated application.

5.5 DESIGN LOAD – The force exerted on the release element at the service load of the nozzle.

5.6 ENGINEERED WATER MIST SYSTEMS – A system which requires individual design and calculation to determine the flow rates, nozzle pressures, pipe size, area or volume protected by each nozzle, discharge density, the number and type of nozzles, and the nozzle placement in order to protect a specific hazard.

5.7 FIRE CONTROL – Limiting the growth of a fire and controlling ceiling gas temperatures to prevent structural damage.

5.8 FIRE SUPPRESSION – The sharp reduction of the heat release of a fire and the prevention of its regrowth.

5.9 FLAME SPREAD INDEX (FSI) – A fire spread characteristic measured in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, ANSI/UL 723.

5.10 FLASHOVER – A stage in the development of a contained fire in which all exposed surfaces reach ignition temperatures more or less simultaneously and fire spreads rapidly throughout the space.

5.11 FUEL PACKAGE – The combustible materials in which the fire is ignited and also the combustible materials covering the walls and ceiling.

5.12 LIGHT HAZARD AREA – An area where the quantity or combustibility of its contents is low and where fires with low rates of heat release are expected.

5.13 MACHINERY SPACES – Shipboard engine rooms and cargo pump rooms containing combustible or flammable liquids having flammability characteristics no more severe than light diesel oil or heptane.

5.14 NOZZLES – The nozzles covered by this Standard are intended to generate water mist to control, extinguish, or suppress fire and consist of the following types:

- a) Automatic – A thermosensitive device designed to react at a predetermined temperature by automatically releasing water mist into a designated area or volume.
- b) Coated – A nozzle which has a factory applied coating for corrosion protection.
- c) Concealed – A recessed nozzle with a ceiling cover plate.
- d) Flush – A nozzle in which all or part of the body, including the inlet thread, is mounted above the lower plane of the ceiling.
- e) Fusible Element – A nozzle that opens under the influence of heat by the melting of a component.
- f) Glass Bulb – A nozzle that opens under the influence of heat through pressure resulting from expansion of the enclosed fluid.
- g) Hybrid – A nozzle that opens by the influence of heat or by an independent fire detection system.
- h) Multiple Orifice – A nozzle having two or more outlet orifices.
- i) Open – A nozzle without a thermosensitive element which discharges water mist.
- j) Pendent – A nozzle that is arranged in such a way that water mist is directed downward by striking a distribution plate or by nozzle orientation.

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k) Pilot – A heat actuated nozzle which also controls the flow of water to one or more connected nozzles.

l) Recessed – A nozzle of which all or part of the body, other than the inlet thread, is mounted within a recessed housing.

m) Sidewall – A nozzle which is designed to be installed adjacent to a wall.

n) Upright – A nozzle that is arranged in such a way that water mist is initially directed upwards against a distribution plate.

5.15 ORDINARY HAZARD GROUP 1 AREA – An area where the quantity and combustibility of the contents is moderate and where fires with moderate rates of heat release are expected.

5.16 ORDINARY HAZARD GROUP 2 AREA – An area where the quantity and combustibility of contents is moderate to high and where fires with moderate to high rates of heat release are expected.

5.17 PASSENGER CABINS – Shipboard areas with sleeping facilities assigned to passengers for their private use.

5.18 PRE-ENGINEERED WATER MIST SYSTEM – A system having predetermined flow rates, nozzle pressures, volumes, discharge patterns, and spray flux densities. These systems have specific pipe sizes, pipe lengths, flexible hose specifications, number of fittings, and number and type of nozzles prescribed in the manufacturer's design and installation instructions.

5.19 PRESSURE –

a) MINIMUM FUNCTIONAL PRESSURE – The minimum pressure at which a nozzle intended to release its operating parts and allow for the discharge of water.

b) OPERATING PRESSURE – The pressure at which a nozzle is intended to operate to control, suppress or extinguish a fire.

c) RATED PRESSURE – Maximum service pressure at which a nozzle is intended to operate.

d) STANDBY PRESSURE – The pressure maintained in a water mist system under a non-fire or standby condition.

5.20 PUBLIC SPACES – Shipboard areas where people gather such as restaurants, dining rooms, lounges, corridors, and offices.

5.21 RESIDENTIAL AREA – A dwelling unit including hotel rooms, dormitory rooms, apartments, condominiums, sleeping rooms in nursing homes, and similar living units.

5.22 RESPONSE TIME INDEX (RTI) – A measure of nozzle sensitivity is expressed in units of $(m \cdot s)^{0.5}$. The RTI is used in combination with the conductivity factor (C) to predict the response of a nozzle in fire environments defined in terms of gas temperature and velocity versus time.

5.23 SERVICE LOAD – The combined force exerted on the nozzle body due to the assembly load of the nozzle and the equivalent force of the rated pressure applied at the inlet.

5.24 SERVICE SPACES – Shipboard areas where a ship's crew perform their duties, such as galleys, laundries, lockers, storerooms, and baggage rooms.

5.25 STANDARD ORIENTATION – The orientation in which the air flow is perpendicular to the axis of the nozzle's waterway and the plane of the frame arms, when provided, in order to produce the shortest response time.

5.26 WATER MIST FIRE SUPPRESSION SYSTEM – A fire-protection system consisting of a water supply, a water distribution system, and nozzles, in which the system is designed to discharge water mist from one or more nozzles in order to control or suppress a fire.

5.27 WORST CASE ORIENTATION – The orientation in which the axis of the nozzle waterway is perpendicular to the air flow, and the nozzle is positioned about this axis, in order to produce the longest response time.

CONSTRUCTION

6 General

6.1 All nozzles shall be made from corrosion resistant materials. Consideration shall be given to the effects of corrosive atmospheres, vibration, and intended use when materials are chosen.

6.2 The load on the heat responsive element in an automatic nozzle shall be set by the manufacturer in such a manner to prevent field adjustment or replacement. The nozzle orifice/deflector shall be permanently attached to the nozzle to prevent field adjustment or replacement.

6.3 A nozzle shall be provided with a nominal DN6 or 6 mm (0.25 inch) or larger inlet threads or pipe/tube/fitting arrangement. The dimensions of all threaded connections shall comply with international standards. When international standards are not applicable, national standards shall be used.

6.4 The omission of any single part or group of parts from a nozzle shall be obvious under normal, charged (non-operating) system conditions. (For example, leakage or discharge of water when the nozzle is subjected to normal operating pressures.)

6.5 An automatic nozzle shall be constructed to effect closure of its water seat for extended periods of time without leakage and to open as intended and release all parts at the minimum functional pressure to the rated pressure. The closure of the water seat shall not be achieved by the use of the dynamic O-ring or similar seal (an O-ring or similar seal that moves during operation or is in contact with a component that moves during operation).

6.6 Nozzles shall have a rated pressure of not less than 12 bar (175 psi).

6.7 The minimum functional pressure of a nozzle shall not be greater than 66.7 percent of the minimum standby pressure intended for use with the nozzle.

6.8 For automatic nozzles incorporating a glass bulb heat responsive element, the filling end tip of the bulb shall be completely encased in an enclosure to minimize the potential for breakage or damage.

7 Protective Covers

7.1 Nozzles with glass bulb type heat responsive elements shall be equipped with protective covers that are designed to remain in place during installation and be removed before the spray nozzle system is placed in service.

Exception: Certain automatic nozzle designs that are constructed to provide protection for the glass bulb during handling, such as nozzles with guards, may not be required to have protective covers.

8 Strainer and Filter

8.1 A nozzle shall be provided with a strainer or filter constructed from corrosion resistant materials. The maximum dimension of an opening in the strainer or filter shall not exceed 80 percent of the smallest orifice diameter being protected.

Exception: This requirement does not apply to nozzles having water passages at least 5.3 mm (0.21 inch) in diameter.

PERFORMANCE

9 General

9.1 Water mist nozzles shall be tested for compliance with one or more of the Fire Tests described in Sections [40](#) – [47](#).

9.2 Unless other temperatures are indicated, tests are to be conducted at an ambient temperature of 20 ± 5 °C (68 ± 9 °F). Fire tests are to be conducted at an ambient temperature of 20 ± 10 °C (68 ± 18 °F). Fuel temperatures are to be 20 ± 10 °C (68 ± 18 °F).

9.3 Water mist nozzles normally supplied from a declining pressure or from a high pressure pump system are to be tested at their maximum rated pressure and at their minimum functional pressure, if applicable, as specified in the Manufacturer's Design and Installation Manual.

9.4 Water delivery delay times associated with water mist systems normally operating at standby pressures or those fitted with open nozzles shall be taken into account when conducting the fire performance tests described in Section [40](#) – [47](#).

10 Water Mist Nozzle Requirements

10.1 The tests in Sections [11](#) – [39](#) shall be conducted for each type of nozzle. Before testing, precise drawings of parts and the assembly shall be submitted together with the appropriate specifications and a copy of the manufacturer's design and installation instructions.

10.2 Nozzles shall be tested with all components required by their design and intended installation.

10.3 Before testing, nozzles shall be examined visually with respect to the following points:

- a) Marking;
- b) Conformity of the nozzles with the manufacturer's drawings and specifications; and
- c) Obvious defects.

11 Exposure Tests On Nozzles Incorporating Polymeric Gaskets

11.1 Nozzles with polymeric seals

11.1.1 A nozzle that incorporates a polymeric material to effect the closure of the orifice shall not leak when exposed to the pressures specified in [11.2](#) – [11.5](#), and shall operate at its minimum functional pressure after being exposed, in separate groups of samples, to the exposures specified in [11.2](#) – [11.5](#).

11.2 Corrosive exposures

11.2.1 Three groups, each consisting of five samples, are to be assembled. One group is to be exposed to 20 percent salt spray as specified in [26.5.2](#), the second to hydrogen sulfide as specified in [26.4.2](#) and [26.4.3](#), and the third to carbon dioxide-sulfur dioxide as specified in [26.3.2](#) and [26.3.3](#). Each exposure period is to be 30 days.

11.2.2 Following the exposure, each nozzle is to be supplied with water at its minimum functional pressure. Each nozzle is then to be operated by exposing the heat responsive element to a uniform application of heat. The operating parts in contact with polymeric material of each test sample shall operate as intended within 5 seconds.

11.3 Temperature cycling exposure

11.3.1 Five samples are to be exposed to ten temperature cycles, each comprised of a 24-hour exposure to a low temperature of minus 40 °C (minus 40 °F) and a 24-hour exposure to a high temperature of 11 °C (20 °F) below its marked operating temperature or the test temperature in [Table 24.1](#), whichever is lower.

11.3.2 Following the exposures, each nozzle is to be supplied with water at its minimum functional pressure. Each nozzle is then to be operated by exposing the heat responsive element to a uniform application of heat. The operating parts in contact with polymeric material of each test sample shall operate as intended within 5 seconds.

11.4 Hydrocarbon exposure followed by moist air exposure

11.4.1 Two groups consisting of five samples are to be assembled. One group is to have the nozzle inlet exposed to a liquid mixture of saturated hydrocarbon chains ranging from C12 to C17, mixed in equal parts by weight. The second group is to have the nozzle inlet exposed to a solid mixture of saturated hydrocarbon chains ranging from C18 to C25, mixed in equal parts by weight. Sufficient hydrocarbon material is to be placed in the inlet to completely cover the polymeric seal. Both groups of nozzles are then to be conditioned at 21 ± 5.6 °C (70 ± 10 °F) for a minimum of 72 hours. After these exposures, the samples are then to be subjected to the 90-day moist air test specified in [26.7](#), with the nozzles installed in the pendent position and the hydrocarbon mixtures left in the inlet.

11.4.2 After these test exposures, each sample is to be pressurized to its minimum functional pressure and examined for leakage for a period of 1 minute, and then operated by exposing the heat responsive element to a uniform application of heat.

11.5 Hydrocarbon exposure followed by water immersion exposure

11.5.1 Two groups, each consisting of five samples, are to be assembled and subjected to the hydrocarbon exposures described in [11.4](#). After the minimum 72 hour hydrocarbon exposure, the samples are to be hydrostatically pressurized to a pressure value of 1.7 bar (25 psig) less than the rated pressure for water mist nozzles having a rated pressure of less than 34.5 bar (500 psi) or the maximum standby pressure for nozzles having a rated pressure of 34.5 bar (500 psi) or greater and immersed for 90 days in tap water maintained at a temperature of 87 ± 2 °C (189 ± 3.6 °F). After 30 and 60 days, the hydrostatic pressure is to be released and then repressurized to a pressure value of 1.7 bar (25 psig) less than the rated pressure for water mist nozzles having a rated pressure of less than 34.5 bar (500 psi) or the maximum standby pressure for nozzles having a rated pressure of 34.5 bar (500 psi) or greater.

11.5.2 After these test exposures, each sample is to be pressurized to the minimum operating or standby pressure, examined for leakage for a period of 1 minute, and then operated by exposing the heat responsive element to a uniform application of heat.

12 Nominal Operating Temperatures

12.1 The nominal operating temperatures of automatic nozzles shall be as indicated in [Table 12.1](#).

Table 12.1
Nominal Operating Temperature Values

Glass bulb nozzles			Fusible element nozzles		
Nominal operating temp.		Liquid color code	Nominal operating temp.		Frame color code
°C	(°F)		°C	(°F)	
57	(135)	orange	57 – 77	(135 – 171)	uncolored
68	(155)	red	80 – 107	(176 – 225)	white
79	(175)	yellow	121 – 149	(250 – 300)	blue
93 – 107	(199 – 225)	green	163 – 191	(325 – 376)	red
121 – 141	(250 – 286)	blue			
163 – 182	(325 – 360)	mauve			

12.2 The nominal operating temperatures of automatic nozzles shall be specified in advance by the manufacturer and verified in accordance with [13.1](#).

12.3 The nominal operating temperature marked on the nozzle shall be that determined when the nozzle is tested in accordance with [13.2](#) and [13.4](#), taking into account the specifications of [13.1](#).

13 Operating Temperature Test

13.1 Automatic nozzles shall open within a temperature range of:

$$X \pm (0.035X + 0.62)^\circ \text{C}$$

$$[X \pm (0.035X)^\circ \text{F}]$$

in which:

X is the nominal operating temperature.

13.2 Ten nozzles are to be heated from ambient temperature to a test temperature 20 – 22 °C (36 – 40 °F) below their nominal operating temperature. The rate of increase of temperature is to not exceed 20 °C per minute (36 °F per minute) and the temperature is to be maintained for 10 minutes. The temperature is to then be increased at a rate between 0.4 – 0.7 °C (0.7 – 1.2 °F) per minute until the nozzle operates using equipment having an accuracy of 0.35 percent of the nominal rating or ±0.25 °C (±0.5 °F), whichever is greater.

13.3 Automatic nozzle operation for this test includes the intended functioning of eutectic elements or any rupture of a glass bulb heat responsive element. If partial fracture of the glass bulb in the liquid environment occurs which does not result in nozzle operation, the temperature at which bulb-fracture occurred shall be considered the operating temperature.

13.4 The test is to be conducted in a water bath for nozzles having nominal operating temperatures less than or equal to 80 °C (176 °F). An oil having a flash point exceeding the test temperature is to be used for higher-rated operating elements. The liquid bath is to be constructed in such a way that the temperature deviation within the test zone does not exceed 0.5 percent, or 0.5 °C (0.9 °F), whichever is greater.

14 Discharge Coefficient Test

14.1 The flow constant K for nozzles is given by the formula:

$$K = \frac{Q}{P^{0.5}}$$

in which:

K is the nozzle flow constant;

Q is the flow rate in liters per minute (gallons per minute); and

P is the pressure in bar (pounds per square inch).

14.2 The value of K published in the manufacturer's design and installation instructions shall be verified using the test method specified in [14.3](#). The average flow constant K shall be within 10 percent of the manufacturer's published value.

14.3 The nozzle and a pressure gauge are to be mounted on a supply pipe. The pipe shall be sized so that the velocity head effect ($V^2/2g$) is reduced to approach a velocity of zero. The water flow is to be measured using a calibrated flow meter at pressures ranging from the minimum operating or standby pressure to the rated pressure at intervals of 10 percent of the operating range. In one series of tests, the pressure is to be increased from zero to each value and, in the next series, the pressure is to be decreased from the rated pressure to each value. During the test, pressures are to be corrected for differences in height between the gauge and the outlet orifice of the nozzle.

15 Water Distribution Test

15.1 The discharge characteristics of the nozzle shall be determined in accordance with [15.2](#) – [15.7](#).

15.2 Tests are to be conducted in a test chamber with minimum dimensions of 7 by 7 m (23 by 23 ft), or 300 percent of the maximum coverage area being tested, whichever is greater. A single open nozzle and four open nozzles arranged in a square at their maximum spacings are to be installed as specified in the manufacturer's design and installation instructions.

15.3 The distance between the ceiling and the distribution plate is to be 50 mm (2 inches) for upright nozzles and 275 mm (11 inches) for exposed pendent style nozzles or as specified in the manufacturer's design and installation instructions. For nozzles without distribution plates, the distances are to be measured from the ceiling to the outlet of the nozzle.

15.4 Recessed, flush, and concealed type nozzles are to be mounted in a false ceiling of dimensions not less than 6 by 6 m (20 by 20 ft) and arranged symmetrically in the test chamber. Nozzles are to be installed in the ceiling as specified in the manufacturer's design and installation instructions.

15.5 Arrange a sufficient number of 305 by 305 mm (1 by 1 ft) water collection pans on the floor in a square pattern to collect the water being discharged in one quadrant of the protection area referenced in the manufacturer's design and installation manual. Install a single nozzle in the vertical down position so that the distance between the top of the water collection pans and the horizontal plane of the nozzle outlet is 1 m (39.4 inches).

15.6 Discharge water at a flow rate corresponding to the minimum discharge pressure specified in the manufacturer's design and installation manual for at least 10 minutes and record the amount of water

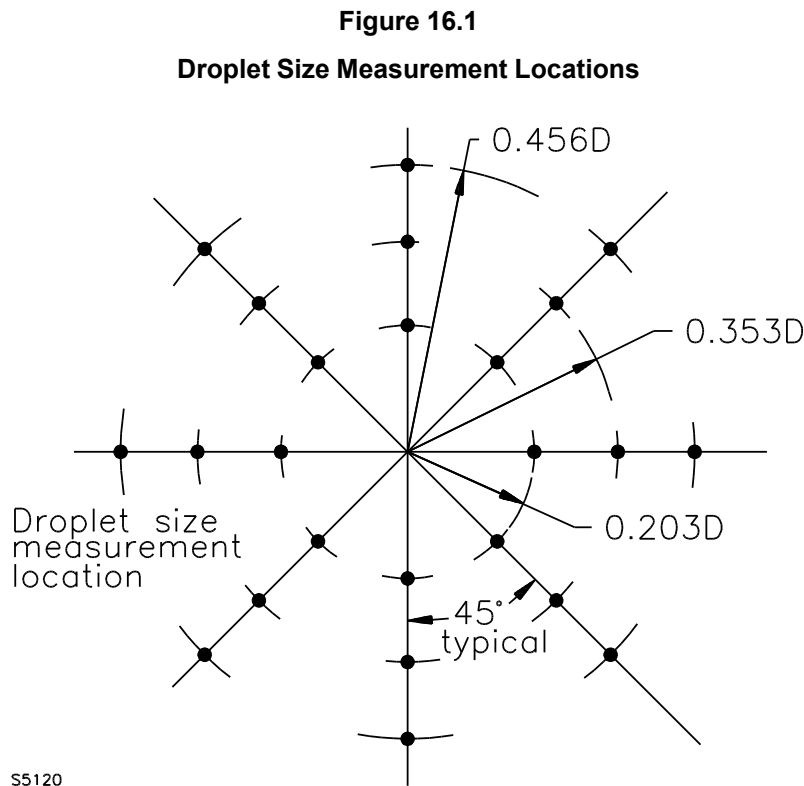
collected in each pan. Determine the smallest square pattern of water collection pans that contain at least 22.5 percent of the total water discharged. Twice the number of pans along a side of this square pattern is assumed to be the diameter, D , of the discharge pattern.

15.7 Repeat the same test procedure at a water flow rate corresponding to the maximum discharge pressure.

15.8 The results of the water distribution test are to be used to determine when additional fire tests are required as a result of changes in the discharge pattern over the operating pressure range.

16 Water Droplet Size and Velocity

16.1 The cumulative volumetric distribution of water droplets is to be determined in accordance with [16.2](#) – [16.5](#) and recorded as the flow rate per unit area weighted distribution of water droplets measured at the 24 locations shown in [Figure 16.1](#).



D is the diameter of the discharge pattern as determined in [15.6](#).

16.2 The radial array of measurement locations is to be positioned symmetrically about the central axis of the water mist nozzle. The nozzle spray patterns diameter D , utilized for calculating the radial distances to the measurement locations as determined in [15.6](#) at 1.0 m (39.4 inch) below the tip of the nozzle. Water discharge distribution measurements in a plane oriented perpendicular to the central axis of the nozzle and 1.0 m (39.4 inch) below the tip, are to be conducted using 0.305-m by 0.305-m (1-ft by 1-ft) collection pans centered on the radial measurement locations and oriented as shown in [Figure 16.1](#). In the case of spray pattern diameters less than 3.05 m (10 ft), 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 1.0 m (39.4 inch) below the tip, are to be conducted at each of the 24 measurement locations shown in [Figure 16.1](#).

16.3 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 shall be calculated and presented using the guidance in Supplement [SC](#).

16.4 Standard Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis, ASTM E799, 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.

16.5 The results of the water droplet size and velocity measurements are to be used to determine when additional fire tests are required due to changes in the water droplet size over the operating pressure range. The water mist discharge is to be scanned over a range of at least 50 – 2000 microns to assist in characterizing the water droplets.

17 Function Test

17.1 When tested in accordance with [17.3](#) – [17.4](#):

- a) An open nozzle fitted with a protective device for the outlet shall operate within 5 seconds after the application of pressure; and
- b) Within 5 seconds after the operation of the heat responsive element an automatic nozzle shall operate as intended.

Any lodgment of released parts are to be cleared within this 5 second period.

17.2 Automatic nozzles are to be heated in air. While being heated, they are to be subjected to each of the water pressures specified in [17.3](#) applied to their inlet. The temperature of the air is to result in the operation of the nozzle within 1 minute. Open nozzles fitted with a protective device for the outlet are to be subjected to each of the water pressures specified in [17.3](#) applied to their inlet.

17.3 Eight nozzles are to be tested in each normal mounting position and at each of the following pressures equivalent to the minimum functional pressure, rated pressure, and at the mid-point pressure between the minimum operating and rated pressure. The flowing pressure shall be at least 75 percent of the initial operating pressure.

17.4 Lodgment is determined to have occurred when one or more of the operating parts lodge in the discharge assembly in such a way that the water distribution is altered for longer than 5 seconds.

18 Deflector/Orifice Assembly Test

18.1 Three nozzles are to be individually tested in their intended mounting position with water flowing at 125 percent of the rated pressure for a period of at least 15 minutes. Following the 15 minutes of water flow, the deflector/orifice assembly shall not be damaged or deformed and shall remain intact.

19 Body Strength Test

19.1 The nozzle body of an automatic nozzle shall not show permanent elongation of more than 0.2 percent between its load-bearing points after being subjected to twice the measured service load as determined using the method described in [19.2](#) – [19.5](#).

19.2 The service load is to be measured on 10 automatic nozzles by securely installing each nozzle in a tension/compression test machine and applying a force equivalent to the application of the rated pressure.

19.3 The distance between load-bearing points is to be measured to the nearest 0.03 mm (0.001 inch) from the plane of the nozzle orifice outlet at the center of the orifice to the center of the compression bearing surface. Movement of the nozzle shank thread in the threaded bushing of the test machine is to be avoided or taken into account.

19.4 A measuring instrument is to be attached to indicate the amount of deflection at the deflector end of the nozzle frame.

19.5 With the threaded inlet restrained from movement, a measuring instrument is to be positioned to indicate the amount of deflection at the deflector end of the nozzle frame. The heat responsive element of the sample is then to be carefully removed so as not to damage the frame. The negative axial deflection, due to release of the assembly load, is to be recorded. A force is then to be applied to re-deflect the nozzle at a rate of 0.51 mm (0.02 inch) per minute until the deflection returns to zero. The force at zero deflection is to be recorded as the assembly load. An alternate means of determining assembly load shall be permitted to be utilized when determined to provide equivalent or more accurate results.

19.6 A force equal to twice the sum of the force recorded in [19.5](#) plus the force applied to the nozzle frame at rated pressure is then to be applied to each sample and held for not more than 5 seconds. The deflection during the application of this load and the amount of permanent set after the load has been released are to be determined. The percentage of permanent deformation (elongation) shall be calculated using the measured permanent deflection and the minimum distance measured between load bearing points to verify compliance with the requirements in [19.1](#).

20 Strength of Glass Bulb Elements

20.1 The lower tolerance limit for bulb strength, based on calculations with a degree of confidence of 0.99 for 99 percent of samples, shall exceed two times the upper tolerance limit for nozzle assembly load based on calculations with the same degree of precision as for bulb strength. Calculations shall be based on the Normal or Gaussian Distribution except where another distribution is shown to be more applicable due to manufacturing or design factors.

20.2 The bulb strength is to be measured by utilizing a compression testing machine to apply a steadily increasing load until the bulb fractures. This test is to be conducted with the bulb mounted in the seating parts used in the nozzle, and at a rate of loading not exceeding 245 N/s (55 lb/s), or at a rate that deflects the bulb 0.50 mm (0.02 inch) per minute, whichever measurement is convenient for the test apparatus being used.

20.3 At least 15 sample bulbs in the lowest temperature rating of each bulb type are to be positioned in their normal mounting device and are to be subjected to a uniformly increasing force at a rate not exceeding 245 N/s (55 lb/s) in the test machine. The crush force is to be recorded for each bulb, and the average crush force is to be calculated. Bulb seatings shall be permitted to be reinforced circumferentially but shall not interfere with the bulb breakage. For sample calculations, see Supplement [SA](#).

21 Strength of Fusible Elements

21.1 For each design, fusible heat-responsive elements in the lowest temperature rating shall demonstrate their ability to sustain the design load when tested in accordance with [21.2](#).

21.2 Fusible heat-responsive elements are to be subjected to loads in excess of the maximum design load L_d , which produce failure within and after 1000 hours. At least 10 samples are to be subjected to different loads up to 15 times the maximum design load. Abnormal failures which are not related to

evaluation of the fusible material are to be rejected. A full logarithmic regression analysis using the method of least squares is to be performed. From the analysis, the load at 1 hour, L_o , and the load at 1000 hours, L_m , is to be calculated where:

$$L_d \leq \frac{1.02 L_m^2}{L_o}$$

For sample calculations, see Supplement [SB](#).

21.3 These tests are to be conducted at an ambient temperature of 20 ± 3 °C (68 ± 5.4 °F).

22 Leak Resistance

22.1 An automatic nozzle shall not show any sign of leakage when tested as specified in [22.2](#).

22.2 Twenty nozzles are to be subjected to a water pressure of twice their rated pressure. The pressure is to be increased from 0 bar to twice the rated pressure, maintained for a period of 3 minutes, and then decreased to 0 bar. After the pressure has returned to 0 bar, it is to then be increased to the minimum operating or standby pressure specified by the manufacturer in not more than 5 seconds. This pressure is to be maintained for 15 seconds and then increased to the rated pressure and maintained for 15 seconds.

23 Hydrostatic Strength

23.1 A nozzle shall not rupture, operate, or release any parts when tested as specified in [23.2](#).

23.2 In preparation for this test, open nozzles are to be fitted with a ball or similar device to seal each orifice. Twenty nozzles are to be subjected to an internal hydrostatic pressure of four times the rated pressure for nozzles having a rated pressure of less than 34.5 bar (500 psi) and two times the rated pressure for nozzles having a rated pressure of 34.5 bar (500 psi) or greater. The pressure to the inlet of the nozzle is to be increased from 0 bar (0 psi) to the required test pressure and held there for a period of 1 minute. The nozzle under test shall not rupture, operate, or release any of its parts during the pressure increase nor while being maintained at four times the rated pressure for 1 minute.

24 Heat Exposure

24.1 Glass bulb nozzles

24.1.1 There shall be no damage to the glass bulb element when a glass bulb nozzle is tested by the method specified in [24.1.2](#) – [24.1.3](#).

24.1.2 Glass bulb nozzles are to be heated in a liquid bath from a temperature of 20 ± 5 °C (68 ± 9 °F) to 20 ± 2 °C (36 ± 3.6 °F) below their nominal operating temperature. The rate of increase of temperature shall not exceed 20 °C (36 °F) per minute. Water is to be used for nozzles having a temperature rating not greater than 80 °C (176 °F). An oil having a flash point exceeding the test temperature is to be used for higher temperature rated nozzles.

24.1.3 This temperature is to then be increased at a rate of 1 °C (1.8 °F) per minute to the temperature at which the gas bubble dissolves, or to a temperature 5 °C (9 °F) less than the lower limit of the operating temperature range, whichever is lower. The nozzle is to be removed from the liquid bath and cooled in air until the gas bubble forms again. During the cooling period, the pointed end of the glass bulb (seal end) is to be pointing downwards. This test is to be performed four times on each of four nozzles.

24.2 Uncoated automatic nozzles

24.2.1 Uncoated automatic nozzles are to withstand exposure to increased ambient temperature, without evidence of weakness or failure, when tested as specified in [24.2.2](#).

24.2.2 Twelve nozzles are to be exposed for a period of 90 days to a high ambient temperature that is 11 °C (20 °F) below the nominal rating or at the temperature shown in [Table 24.1](#), whichever is lower, and not less than 49 °C (120 °F). When the service load is dependent on the service pressure, nozzles are to be tested under an applied load equal to the rated pressure, but not less than 12 bar (175 psi). After exposure:

- a) Four nozzles are to be subjected to the tests specified in [22.2](#);
- b) Four nozzles are to be subjected to the test of [17.1](#) (two nozzles at the minimum functional pressure and two nozzles at the rated pressure); and
- c) Four nozzles shall comply with the requirements of [13.1](#).

Table 24.1
Test Temperatures for Coated and Uncoated Automatic Nozzles

Nominal operating temperature		Uncoated nozzle test temperature		Coated nozzle test temperature	
°C	(°F)	°C	(°F)	°C	(°F)
57 – 60	(135 – 140)	49	(120)	49	(120)
61 – 77	(141 – 171)	52	(125)	49	(120)
78 – 107	(172 – 225)	79	(175)	66	(150)
108 – 149	(226 – 300)	121	(250)	107	(225)
150 – 191	(302 – 376)	149	(300)	149	(300)

24.3 Coated automatic nozzles

24.3.1 In addition to meeting the requirement of [24.2](#) in an uncoated version, coated automatic nozzles shall withstand exposure to ambient temperatures without evidence of weakness or failure of the coating when tested as specified in [24.3.2](#) and [24.3.3](#).

24.3.2 In addition to the test exposure of [24.2.2](#) in an uncoated version, twelve coated nozzles shall be exposed to the test of [24.2.2](#) using the temperatures shown in [Table 24.1](#).

24.3.3 The test is to be conducted for 90 days. During this period, each sample is to be removed from the oven at intervals of 7 days and cooled for a minimum of 2 hours and a maximum of 4 hours. During this cooling period, each sample shall be examined for failure or weakness of the coating. After exposure:

- a) Four nozzles are to be subjected to the tests specified in [22.2](#);
- b) Four nozzles are to be subjected to the test of [17.1](#) (two nozzles at the minimum functional pressure and two nozzles at the rated pressure); and
- c) Four nozzles shall comply with the requirements of [13.1](#).

25 Thermal Shock

25.1 Glass bulb nozzles shall not be damaged when tested by the method specified in [25.3](#) and [25.3](#). Proper operation shall not be identified as damage.

25.2 Before starting the test, a minimum of 24 nozzles are to be conditioned at a temperature of 20 – 25 °C (68 – 77 °F) for at least 30 minutes.

25.3 The nozzles are to be immersed in a bath of liquid 10 ± 2 °C (18 ± 3.6 °F) below the marked operating temperature of the nozzles. After 5 minutes, the nozzles are to be removed from the bath and immersed immediately, with the bulb seal downwards, in another bath of liquid at 10 ± 1 °C (50 ± 1.8 °F). Following 5 cycles of conditioning in the baths, the samples shall then be tested in accordance with [17.1](#).

26 Corrosion Tests

26.1 Stress corrosion test for brass nozzles and parts

26.1.1 When tested in accordance with [26.1.3](#) – [26.1.7](#), brass nozzles and parts shall not show fractures which affect their ability to function as intended.

26.1.2 Five sample nozzles and parts are to be subjected to the aqueous ammonia test described in [26.1.3](#) – [26.1.7](#).

26.1.3 The samples are to be degreased and exposed for 10 days to a moist ammonia-air mixture in a glass container of volume 0.02 ± 0.01 m³ (0.7 ± 0.1 ft³).

26.1.4 A sufficient amount of aqueous ammonia solution, having a density of 0.94 g/cm³ (0.034 lb/in³), is to be maintained in the bottom of the container. The lowest portion of the samples are to be positioned 38.1 mm (1.5 inches, -0 mm) [1-1/2 (+1/2, -0) inches] above the liquid surface and supported by an inert tray. A volume of aqueous ammonia solution corresponding to 0.01 ml per cubic centimeter of the volume of the container produces the following atmospheric concentrations: 35 percent ammonia, 5 percent water vapor, and 60 percent air.

26.1.5 The moist ammonia-air mixture is to be maintained as closely as possible at atmospheric pressure with the temperature maintained at 34 ± 2 °C (93 ± 3.6 °F). Provision is to be made for venting the chamber via a capillary tube to avoid the build-up of pressure. Specimens are to be shielded from condensate drip.

26.1.6 After exposure, each nozzle is to be rinsed with water and dried. The samples are to then be examined using a microscope having a magnification of 25 times for any cracking or other degradation. When a crack, or failure of any part is observed, the automatic nozzle is to be subjected to the test described in [22.2](#) at the rated pressure for 1 minute, and also subjected to the tests described in [17.3](#) and [17.4](#) at the minimum functional pressure. Open nozzles are to be subjected to the test described in [23.2](#) at twice the rated pressure for 1 minute.

26.1.7 Nozzles showing cracking, or failure of any part shall not show evidence of separation or breakage when subjected to flowing water at rated pressure for 30 minutes.

26.2 Stress-corrosion cracking of stainless steel nozzles and parts

26.2.1 When tested in accordance with [26.2.3](#) – [26.2.7](#), austenitic stainless steel water mist nozzles or parts shall show no fractures or breakage which affects their ability to function as intended. The standard exposure period is to be 150 hours; however, the exposure period is to be 500 hours for water mist nozzles incorporating exposed stainless steel parts intended for use in corrosive atmospheres.

26.2.2 Five samples are to be degreased prior to being exposed to the magnesium chloride solution described in [26.2.3](#) – [26.2.7](#).

26.2.3 The samples are to be placed in a sealed glass container that is fitted with a thermometer and a wet condenser. The container is to be filled approximately one-half full – or to a level at least 1.27 cm (0.5 inches) above the test sample – with a 44 percent by weight magnesium chloride solution, placed on a thermostatically-controlled electrically heated mantle, and maintained at a boiling temperature of $150 \pm 1^\circ\text{C}$ ($302 \pm 1.8^\circ\text{F}$). The exposure period is to be 150 or 500 hours, as specified in [26.2.1](#).

26.2.4 After exposure, the test samples are to be removed from the boiling magnesium chloride solution and rinsed in deionized water.

26.2.5 The test samples are to then be examined using a microscope having a magnification of 25 times for any cracking or other degradation. Test samples exhibiting degradation are to be tested as described in [26.2.6](#) or [26.2.7](#), as applicable. Test samples not exhibiting degradation are determined to meet the intent of the requirement without further test.

26.2.6 For operating parts of automatic nozzles exhibiting degradation, five new sets of parts are to be assembled in nozzle frames made of materials that do not alter the corrosive effects of the magnesium chloride solution on the stainless steel parts. These test samples are to be degreased and subjected to the magnesium chloride solution exposure specified in [26.2.3](#). Following the exposure, the test samples are to withstand, without leakage, a hydrostatic test pressure equal to the rated pressure for 1 minute and subjected to [17.1](#) at the minimum functional pressure.

26.2.7 For non-operating parts exhibiting degradation, the test samples are to withstand a flowing pressure at the rated pressure for 30 minutes without separation or breakage.

26.3 Sulfur dioxide/carbon dioxide corrosion

26.3.1 Nozzles shall be resistant to a sulfur dioxide/carbon dioxide air mixture when conditioned in accordance with [26.3.2](#) – [26.3.5](#). After exposure, the water flow rate of the open nozzles at their minimum operating pressure shall be within 10 percent of the value specified in the manufacturer's design and installation instructions. For automatic nozzles, five nozzles shall operate when tested at their minimum functional pressure as described in [17.1](#) – [17.4](#). The remaining five samples shall comply with the requirements of [31.2](#).

26.3.2 Ten nozzles are to be subjected to the following sulfur dioxide/carbon dioxide corrosion test. The test equipment is to consist of a vessel made of a closed glass chamber with a corrosion-resistant lid of such a shape as to prevent condensate dripping on the nozzles. The vessel is to be heated so that the temperature inside the glass vessel is $25 \pm 3^\circ\text{C}$ ($75 \pm 5^\circ\text{F}$). The inlet of each sample is to be sealed with a nonreactive cap, such as plastic. The outlet of open nozzles is to be sealed as specified in the manufacturer's installation and maintenance instructions.

26.3.3 The nozzles to be tested are to be suspended in their normal mounting position inside the vessel. On five days out of every seven, an amount of carbon dioxide equivalent to 1.0 percent of the volume of the chamber, plus an amount of sulfur dioxide equivalent to 1.0 percent of the volume of the chamber, are to be introduced. Prior to each introduction of gas, the remaining gas-air mixture from the previous day is to be thoroughly purged from the chamber. On the two days of every seven that this does not occur, the chamber is to remain closed and no purging or introduction of gas is to be provided. A small amount of water ($10\text{ ml}/0.003\text{ m}^3$ of chamber volume) is to be maintained at the bottom of the chamber for humidity.

26.3.4 The test is to be conducted for 10 days. After 10 days, the nozzles are to be removed from the vessel, and the vessel emptied and cleaned.

26.3.5 After removal, the nozzles are to be dried for 4 to 7 days at a temperature not exceeding 35°C (95°F) with a relative humidity not greater than 70 percent. After drying, the samples are to be tested in accordance with [26.3.1](#).

26.4 Hydrogen sulfide corrosion

26.4.1 Nozzles shall be resistant to a hydrogen sulfide air mixture when conditioned in accordance with [26.4.2](#) – [26.4.5](#). After exposure, the water flow rate of the open nozzles at their minimum operating pressure shall be within 10 percent of the value specified in the manufacturer's design and installation instructions. For automatic nozzles, five nozzles shall operate when tested at their minimum functional pressure as described in [17.1](#) – [17.4](#). The remaining five samples shall comply with the requirements of [31.2](#).

26.4.2 Ten nozzles are to be subjected to the following hydrogen sulfide corrosion test. The test equipment is to consist of a vessel made of a closed glass chamber with a corrosion-resistant lid of such a shape as to prevent condensate dripping on the nozzles. The vessel is to be heated so that the temperature inside the glass vessel is 25 ± 3 °C (75 ± 5 °F). The inlet of each sample is to be sealed with a nonreactive cap, such as plastic. The outlet of open nozzles is to be sealed as specified in the manufacturer's installation and maintenance instructions.

26.4.3 The nozzles to be tested are to be suspended in their normal mounting position inside the test chamber. On five days out of every seven, an amount of hydrogen sulfide equivalent to 1.0 percent of the volume of the chamber is to be introduced into the test chamber from a commercial gas cylinder. Prior to each introduction of gas, the remaining gas-air mixture from the previous day is to be thoroughly purged from the chamber. On the two days of every seven that this does not occur, the chamber is to remain closed and no purging or introduction of gas is to be provided. During the exposure, the gas-air mixture is to be gently stirred by means of a small fan located in the chamber. A small amount of water (10 ml/0.003 m³ of chamber volume) is to be maintained at the bottom of the chamber for humidity.

26.4.4 The test is to be conducted for 10 days. After 10 days, the nozzles are to be removed from the vessel, and the vessel emptied and cleaned.

26.4.5 After removal, the nozzles are to be dried for 4 to 7 days at a temperature not exceeding 35 °C (95 °F) with a relative humidity not greater than 70 percent. After drying, the samples are to be tested in accordance with [26.4.1](#).

26.5 Salt spray corrosion

26.5.1 Coated and uncoated nozzles shall be resistant to salt spray when conditioned in accordance with [26.5.2](#) – [26.5.4](#). Following exposure, the water flow rate of the open nozzles at their minimum functional pressure shall be within 10 percent of the value specified in the manufacturer's design and installation instructions. For automatic nozzles, five nozzles shall operate when tested at their minimum functional pressure as described in [17.1](#) – [17.4](#). The remaining five samples shall comply with the requirements of [31.2](#).

26.5.2 Ten nozzles are to be exposed to a salt spray within a fog chamber. During the corrosive exposure, the outlet of open nozzles is to be sealed as specified in the manufacturer's design and installation instructions and the inlet is to be sealed by a plastic cap after the nozzles have been filled with deionized water. The salt solution is to be a 20 percent by mass sodium chloride solution in distilled water. The pH is to be between 6.5 and 7.2 and the density between 1.126 g/ml and 1.157 g/ml when atomized at 35 °C (95 °F). A means of controlling the atmosphere in the chamber is to be provided. The specimens are to be supported in their normal operating position and exposed to the salt spray (fog) in a chamber having a volume of at least 0.43 m³ (15 ft³) in which the exposure zone is to be maintained at a temperature of 35 ± 2 °C (95 ± 3.6 °F). The temperature is to be recorded at least once per day and at least 7 hours apart except weekends and holidays when the chamber is not normally opened. Salt solution is to be supplied from a recirculating reservoir through air-aspirating nozzles, at a pressure between 0.7 bar (10 psi) and 1.7 bar (24.6 psi). Salt solution runoff from exposed samples is to be collected and is to not return to the reservoir for recirculation.

26.5.3 Fog is to be collected from at least two points in the exposure zone to determine the rate of application and salt concentration. The fog is to be such that for each 80 cm² (12 in²) of collection area, 1 – 2 ml (0.03 – 0.07 fl oz) of solution is to be collected per hour over a 16 hour period. The salt concentration is to be 20 ±1 percent by mass.

26.5.4 The nozzles are to withstand exposure to the salt spray for a period of 10 days. After this period, the nozzles are to be removed from the fog chamber and dried for 4 to 7 days at a temperature of 20 – 25 °C (68 – 77 °F) in an atmosphere having a relative humidity not greater than 70 percent. Following the drying period, the water flow rate of the open nozzles at their minimum operating pressure is to be within 5 percent of the value specified in the manufacturer's design and installation instructions. For the automatic nozzle samples, five nozzles are to be tested at the minimum flowing or standby pressure in accordance with [17.1](#) and five nozzles are to be tested in accordance with [31.2](#).

26.6 Nozzles intended for corrosive atmospheres

26.6.1 For nozzles intended for corrosive atmospheres, the nozzles are to be subjected to the tests specified in [26.3](#), [26.4](#) and [26.5](#) except that the duration of the exposures shall be 30 days.

26.7 Moist air exposure

26.7.1 Nozzles shall be resistant to moist air exposure after being tested in accordance with [26.7.2](#). Following exposure, the water flow rate of open nozzles at their minimum operating pressure shall be within 5 percent of the value specified in the manufacturer's design and installation instructions. For automatic nozzles, five nozzles shall operate when tested at their minimum functional pressure as described in [17.3](#) and [17.4](#). The remaining five samples shall comply with the requirements of [31.2](#).

26.7.2 Five nozzles are to be exposed to a high temperature-humidity atmosphere consisting of a relative humidity of 98 ±2 percent and a temperature of 95 ±4 °C (203 ±7 °F). The outlet of open nozzles is to be sealed as specified in the manufacturer's design and installation instructions. The nozzles are to be installed on a pipe manifold containing deionized water. The manifold used with open nozzles is to be vented to prevent dislodgement of the outlet closure. The entire manifold is to be placed in the high temperature humidity enclosure for 90 days. After this period, the nozzles are to be removed from the temperature-humidity enclosure dried for 4 – 7 days at a temperature of 25 ±5 °C (77 ±9 °F) in an atmosphere having a relative humidity of not greater than 70 percent. Following the drying period, the water flow rate of the open nozzles at their minimum flowing pressure is to be within 10 percent of the value specified in the manufacturer's design and installation instructions. For the automatic nozzle samples, nozzles are to be functionally tested at their minimum functional pressure in accordance with [17.1](#).

Exception: At the manufacturer's option, additional samples are not prohibited from being furnished for this test to provide early evidence of failure. The additional samples shall be removed from the test chamber at 30 day intervals for testing.

27 Dezincification Test of Brass Parts

27.1 General

27.1.1 Closed nozzle parts that are made of a copper alloy containing more than 15 percent zinc and normally exposed to system water shall not exhibit the following after exposure to a copper chloride solution for 144 hours:

- a) An average dezincification depth exceeding 100 µm (0.0039 inch); and
- b) An individual reading of dezincification depth exceeding 200 µm (0.0079 inch).

27.2 Reagent

27.2.1 A test solution is to be prepared by dissolving 12.7 g (0.028 pound) of copper (II) chloride dihydrate ($\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$) in distilled water and then making up the volume to 1000 ml (0.26 gallon). Fresh solution is to be used for each test.

27.3 Test pieces

27.3.1 Three test pieces are to be taken from the nozzle part. These pieces are to be cut in such a way, for example by sawing and grinding with light pressure, that the properties of the materials are unaffected. The area of each test piece to be exposed shall be approximately 100 mm² (0.155 square inch).

27.3.2 Each test piece is to be embedded in a thermoset resin having minimal shrinkage characteristics and the test surface ground using wet abrasive paper, finishing with 500 grade or finer. The test surfaces are to be cleaned with ethanol prior to testing.

27.4 Method

27.4.1 Each test piece is to be placed in the middle of the beaker containing the copper (II) chloride solution so that the test surface is vertical and at least 15 mm (0.59 inch) above the bottom of a glass beaker covered with suitable plastic foil, for example polyethylene, secured with elastic thread or another method of sealing using non-metallic compound. A total of 250 ml (+50 ml, -10 ml) [0.066 gallon (+0.013 gallon, -0.0026 gallon)] of the copper (II) chloride solution is required per 100 mm² (0.155 square inch) of exposed surface of the test piece.

27.4.2 The beaker containing the test piece is to be placed in the thermostatically controlled oven or oil bath with the temperature maintained at 75 ±2 °C (167 ±3 °F). The test piece is to be exposed continuously for 144 hours. At the end of this period, they are to be removed from the beaker, washed in water, rinsed in the ethanol, and allowed to dry.

27.4.3 Microscopic examination of the test piece is to be conducted as soon as possible after the exposure. If the test pieces are stored before microscopic examination, they are to be kept in a desiccator. Each test piece is to be sectioned at right angles to the exposed test surface, and the remaining thermoset resin attached to the section that is to be removed. The cross-sectioned piece is then to be re-embedded in a thermoset resin having minimal shrinkage, and the area to be viewed is to be ground and polished for microscopic examination. The total length of section through the exposed surface is not to be less than 5 mm (0.2 inch). If the dimensions of the test piece make this impossible, the section is to be taken to provide the maximum possible total length.

27.4.4 The dezincification depth measurements are to be made at five evenly spaced locations and the average calculated. The dezincification depth is to be measured from the post exposed test surface and is not to include the sample edge. The maximum dezincification is to be recorded and the average depth calculated. Magnification is to be used to provide the greatest accuracy of measurement.

28 Integrity of Nozzle Coatings

28.1 Evaporation of wax and bitumen used for atmospheric protection of nozzles

28.1.1 Waxes and bitumens used for coating nozzles shall not contain volatile matter in such quantities as to result in shrinkage, hardening, cracking, or flaking of the applied coating. The loss in mass shall not exceed 5 percent of that of the original sample when tested in accordance with [28.1.2](#).

28.1.2 A 50 cm³ (3 in³) sample of wax or bitumen is to be placed in a metal or glass cylindrical container having a flat bottom, an internal diameter of 55 mm (2.2 inches), and an internal height of 35 mm

(1.4 inches). The container without the lid is to be placed in an automatically controlled constant ambient temperature oven with air circulation. The temperature in the oven is to be controlled at 16 °C (29 °F) below the nominal operating temperature of the nozzle, and not less than 50 °C (122 °F). The sample is to be weighed before and after 90 days exposure to determine any loss of volatile matter. The sample shall comply with the requirements of [28.1.1](#).

28.2 Resistance to low temperatures

28.2.1 All coatings used for nozzles shall not crack or flake when subjected to low temperatures by the method in [28.2.2](#).

28.2.2 Five nozzles coated by normal production methods (such as with wax, bitumen, or a metallic coating) are to be subjected to minus 10 ±2 °C (14 ±3.6 °F) for 24 hours. On removal from the low-temperature cabinet, the nozzles are to be exposed to normal ambient temperature 30 minutes prior to examination of the coating to the requirements of [28.2.1](#).

28.3 Resistance to high temperature

28.3.1 Coated nozzles shall comply with the requirements of [24.3](#).

29 Water Hammer

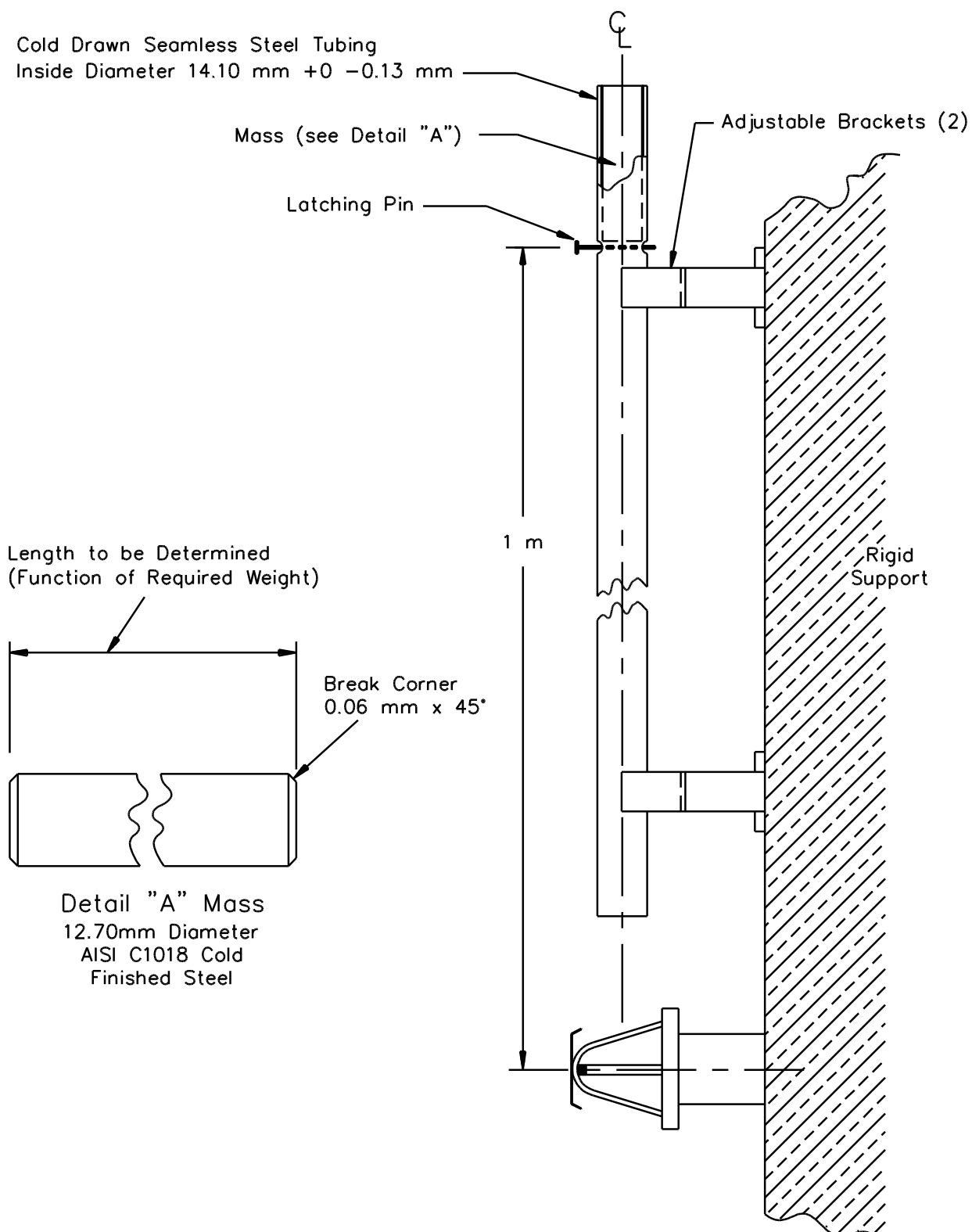
29.1 Automatic nozzles shall not leak when subjected to pressure surges from 4 bar (58 psi) to two times the rated pressure. They shall show no signs of mechanical damage when tested in accordance with [29.2](#) and shall operate within the parameters of [17.3](#) at their minimum functional pressure.

29.2 Five nozzles are to be connected in their normal operating position to the test equipment. After purging the air from the nozzles and the test equipment, 3000 cycles of pressure varying from 4 ±2 bar (58 ±29 psi) to the test pressure are to be generated. The pressure is to be raised from 4 bar to the test pressure at a rate not exceeding 30 cycles of pressure per minute. The pressure is to be measured with an electrical pressure transducer or other equivalent device.

30 Impact Test for Protective Covers

30.1 A glass bulb type automatic nozzle, with the protective cover installed, shall not be damaged or leak and the cover shall remain in place when tested. See [Figure 30.1](#).

Figure 30.1
Impact Test Apparatus for Protective Covers



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