

UL 2167

ISBN 0-7629-0801-7

Water Mist Nozzles for Fire Protection Service

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

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

First Edition, Dated December 27, 2002

Revisions: This Standard contains revisions through and including February 20, 2004.

Summary of Topics

This revisions to ANSI/UL 2167 is being issued to add Glass Bulb Integrity Requirements and to clarify Open Area Fire Test Methods and Requirements.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The following table lists the future effective dates with the corresponding references:

Future Effective Dates	References
August 20, 2005	Paragraph 50.6, Sections 6A, 27A, and 48A
December 27, 2004	Entire Standard (except as noted above)

The new and revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated February 20, 2004. The bulletin(s) is now obsolete and may be discarded.

The revisions dated February 20, 2004 include a reprinted title page (page1) for this Standard.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

UL's Standards for Safety are copyrighted by UL. Neither a printed copy of a Standard, nor the distribution diskette for a Standard-on-Diskette and the file for the Standard on the distribution diskette should be altered in any way. All of UL's Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of UL.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of UL.

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

UL provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

UL will attempt to answer support requests concerning electronic versions of its Standards. However, this support service is offered on a reasonable efforts basis only, and UL may not be able to resolve every support request. UL supports the electronic versions of its Standards only if they are used under the conditions and operating systems for which it is intended. UL's support policies may change from time-to-time without notification.

UL reserves the right to change the format, presentation, file types and formats, delivery methods and formats, and the like of both its printed and electronic Standards without prior notice.

Purchasers of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgement (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

If a single-user version electronic Standard was purchased, one copy of this Standard may be stored on the hard disk of a single personal computer, or on a single LAN file-server or the permanent storage device of a multiple-user computer in such a manner that this Standard may only be accessed by one user at a time and for which there is no possibility of multiple concurrent access.

If a multiple-user version electronic Standard was purchased, one copy of the Standard may be stored on a single LAN file-server, or on the permanent storage device of a multiple-user computer, or on an Intranet server. The number of concurrent users shall not exceed the number of users authorized.

Electronic Standards are intended for on-line use, such as for viewing the requirements of a Standard, conducting a word search, and the like. Only one copy of the Standard may be printed from each single-user version of an electronic Standard. Only one copy of the Standard may be printed for each authorized user of a multiple-user version of an electronic Standard. Because of differences in the computer/software/printer setup used by UL and those of electronic Standards purchasers, the printed copy obtained by a purchaser may not look exactly like the on-line screen view or the printed Standard.

An employee of an organization purchasing a UL Standard can make a copy of the page or pages being viewed for their own fair and/or practical internal use.

The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

Copyright © 2004 Underwriters Laboratories Inc.

This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-6	February 20, 2004
7-10	December 27, 2002
11-12B	February 20, 2004
13-29	December 27, 2002
30-30B	February 20, 2004
31-36	December 27, 2002
37	February 20, 2004
38-83	December 27, 2002
84-87	February 20, 2004
88	December 27, 2002
89-90B	February 20, 2004
91-92	December 27, 2002
93-94B	February 20, 2004
95-96	December 27, 2002
97-98	February 20, 2004
SA1-SA2	February 20, 2004
SA3-SA4	December 27, 2002
SB1-SB2	December 27, 2002
SC1-SC2	December 27, 2002

No Text on This Page

DECEMBER 27, 2002
(Title Page Reprinted: February 20, 2004)



ANSI/UL 2167-2004

1

UL 2167

Standard for Water Mist Nozzles for Fire Protection Service

First Edition

December 27, 2002

The most recent designation of ANSI/UL 2167 as an American National Standard (ANSI) occurred on February 2, 2004.

This ANSI/UL Standard for Safety, which consists of the First edition with revisions through February 20, 2004, is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to UL-RTP Standards Department, 12 Laboratory Dr., Research Triangle Park, NC 27709.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

ISBN 0-7629-801-7

COPYRIGHT © 2002, 2004 UNDERWRITERS LABORATORIES INC.

No Text on This Page

CONTENTS

FOREWORD	6
----------------	---

INTRODUCTION

1 Scope	7
2 Units of Measurement	7
3 Components	7
4 Undated References	8
5 Glossary	8

CONSTRUCTION

6 General	11
6A Protective Covers	12
7 Strainer and Filter	12

PERFORMANCE

8 General	12
9 Water Mist Nozzle Requirements	12A
10 Exposure Tests On Nozzles Incorporating Polymeric Gaskets	13
10.1 Nozzles with polymeric seals	13
10.2 Corrosive exposures	13
10.3 Temperature cycling exposure	14
10.4 Hydrocarbon exposure followed by moist air exposure	14
10.5 Hydrocarbon exposure followed by water immersion exposure	14
10.6 Exposure to antifreeze solutions	15
11 Nominal Operating Temperatures	15
12 Operating Temperature Test	16
13 Water Flow Test	16
14 Water Distribution Test	17
15 Water Droplet Size and Velocity	18
16 Function Test	19
17 Deflector/Orifice Assembly Test	20
18 Body Strength Test	20
19 Strength of Glass Bulb Elements	21
20 Strength of Fusible Elements	21
21 Leak Resistance	22
22 Hydrostatic Strength	22
23 Heat Exposure	23
23.1 Glass bulb nozzles	23
23.2 Uncoated automatic nozzles	23
23.3 Coated automatic nozzles	24
24 Thermal Shock	25
25 Corrosion Tests	25
25.1 Stress corrosion test for brass nozzles and parts	25
25.2 Stress-corrosion cracking of stainless steel nozzles and parts	26
25.3 Sulfur dioxide corrosion	27
25.4 Salt spray corrosion	28
25.5 Moist air exposure	29

26	Integrity of Nozzle Coatings	29
26.1	Evaporation of wax and bitumen used for atmospheric protection of nozzles	29
26.2	Resistance to low temperatures	30
26.3	Resistance to high temperature	30
27	Water Hammer	30
27A	Impact Test for Protective Covers	30
28	Dynamic Heating	30B
29	Plunge Test	31
30	Prolonged Plunge Test	32
31	Heat Resistance	35
32	Vibration	35
33	Rough Usage Test	36
34	Impact Test	36
35	Lateral Discharge	38
36	Thirty-Day Leakage Resistance	38
37	Vacuum Resistance	39
38	Clogging Test	39
39	Freezing Test	41
40	Shipboard Machinery Space Fire Tests	42
40.1	General	42
40.2	Test apparatus	43
40.3	Test enclosure	47
40.4	Fire tests	47
40.5	Extinguishing system	49
40.6	Test procedure	49
40.7	Test observations	50
41	Shipboard Passenger Cabin Fire Tests	51
41.1	General	51
41.2	Fire tests	51
41.3	Test arrangement	52
41.4	Test procedure	60
41.5	Test observations	60
42	Shipboard Passenger Cabins Greater than 12 m ²	61
42.1	General	61
42.2	Test arrangement	61
42.3	Fire source	63
42.4	Nozzle installation	65
42.5	Test procedure	66
43	Shipboard Public Space Fire Tests	66
43.1	General	66
43.2	Shipboard light hazard areas	67
43.3	Shipboard ordinary hazard areas	73
44	Residential Area Fire Tests	75
44.1	General	75
44.2	Test arrangement	76
44.3	Fire source	79
44.4	Test method	80
45	Light Hazard Area Fire Tests	80
46	Ordinary Hazard Group 1 Fire Tests	84
46.1	General	84
46.2	Open area fire tests	84
46.3	Test arrangement	84
46.4	Fire source	85

46.5 Test procedure	85
46.6 Corner fire tests	86
46.7 Test arrangement	86
46.8 Fire source	86A
46.9 Test procedure	88
47 Ordinary Hazard Group 2 Fire Tests	88
47.1 General	88
47.2 Open area fire tests	88
47.3 Test arrangement	89
47.4 Fire source	89
47.5 Test procedure	90
47.6 Corner fire tests	90
47.7 Test arrangement	90
47.8 Fire source	91
47.9 Test procedure	93

MANUFACTURING AND PRODUCTION TESTS

48 Production Leakage Test	93
48A Glass Bulb Integrity Test	93

INSTRUCTIONS

49 Design and Installation Instructions	94
---	----

MARKING

50 Water Mist Nozzle Marking	94A
------------------------------------	-----

SUPPLEMENT SA - TOLERANCE LIMIT CALCULATION METHOD

SA1 General	SA1
SA2 Calculation of Standard Deviation	SA1
SA3 Determination of K Factor	SA1
SA4 Comparison of Tolerance Limits	SA2

SUPPLEMENT SB - NOTES ON THE STRENGTH TEST FOR NOZZLE RELEASE ELEMENTS (Informative)

SUPPLEMENT SC - NOZZLE DROPLET SIZE DISTRIBUTION SUMMATION METHOD

SC1 General	SC1
SC2 Calculation for Single Location and Bin Size	SC1
SC3 Calculation for Summation of All Measurement Locations	SC1

FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

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.

1.1 effective December 27, 2004

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

1.2 effective December 27, 2004

2 Units of Measurement

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

2.1 effective December 27, 2004

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.

3.1 effective December 27, 2004

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.

3.2 effective December 27, 2004

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

3.3 effective December 27, 2004

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.

3.4 effective December 27, 2004

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.

4.1 effective December 27, 2004

5 Glossary

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

5.1 effective December 27, 2004

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

5.2 effective December 27, 2004

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

5.3 effective December 27, 2004

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.

5.4 effective December 27, 2004

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

5.5 effective December 27, 2004

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.

5.6 effective December 27, 2004

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

5.7 effective December 27, 2004

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

5.8 effective December 27, 2004

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.

5.9 effective December 27, 2004

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.

5.10 effective December 27, 2004

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

5.11 effective December 27, 2004

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.

5.12 effective December 27, 2004

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.

5.13 effective December 27, 2004

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.
- 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.

5.14 effective December 27, 2004

5.15 OPERATING PRESSURE – The pressure at which a nozzle is intended to operate.

5.15 effective December 27, 2004

5.16 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 effective December 27, 2004

5.17 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 effective December 27, 2004

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

5.18 effective December 27, 2004

5.19 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 effective December 27, 2004

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

5.20 effective December 27, 2004

5.21 RATED PRESSURE – Maximum service pressure at which a nozzle is intended to operate, and not less than 1.2 MPa (175 psi).

5.21 effective December 27, 2004

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

5.22 effective December 27, 2004

5.23 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 effective December 27, 2004

5.24 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 effective December 27, 2004

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

5.25 effective December 27, 2004

5.26 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 effective December 27, 2004

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

5.27 effective December 27, 2004

5.28 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.

5.28 effective December 27, 2004

5.29 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.

5.29 effective December 27, 2004

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.

6.1 effective December 27, 2004

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.

6.2 effective December 27, 2004

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.

6.3 effective December 27, 2004

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.)

6.4 effective December 27, 2004

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 operating 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).

6.5 effective December 27, 2004

6A Protective Covers

6A.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.

Added 6A.1 effective August 20, 2005

7 Strainer and Filter

7.1 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.

7.1 effective December 27, 2004

PERFORMANCE

8 General

8.1 Water mist nozzles shall be tested for compliance with one or more of the Fire Tests described in Sections 40 – 47.

8.1 effective December 27, 2004

8.2 Unless other temperatures are indicated, tests are to be conducted at an ambient temperature of $20 \pm 5^{\circ}\text{C}$ ($68 \pm 9^{\circ}\text{F}$). Fire tests are to be conducted at an ambient temperature of $20 \pm 10^{\circ}\text{C}$ ($68 \pm 18^{\circ}\text{F}$). Fuel temperatures are to be $20 \pm 10^{\circ}\text{C}$ ($68 \pm 18^{\circ}\text{F}$).

8.2 effective December 27, 2004

8.3 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 standby pressure, if applicable, as specified in the Manufacturer's Design and Installation Manual.

8.3 effective December 27, 2004

8.4 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.

8.4 effective December 27, 2004

9 Water Mist Nozzle Requirements

9.1 The tests in Sections 10 – 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.

9.1 effective December 27, 2004

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

9.2 effective December 27, 2004

9.3 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.

9.3 effective December 27, 2004

No Text on This Page

12B

10 Exposure Tests On Nozzles Incorporating Polymeric Gaskets

10.1 Nozzles with polymeric seals

10.1.1 A nozzle that incorporates a polymeric material to effect the closure of the orifice shall not leak when exposed to the pressures specified in 10.2 – 10.6, and shall operate at its minimum operating or standby pressure after being exposed, in separate groups of samples, to the exposures specified in 10.2 – 10.6.

10.1.1 effective December 27, 2004

10.2 Corrosive exposures

10.2.1 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 25.4.2, the second to hydrogen sulfide as specified in 10.2.2 and 10.2.3, and the third to carbon dioxide-sulfur dioxide as specified in 10.2.4. Each exposure period is to be 30 days.

10.2.1 effective December 27, 2004

10.2.2 The specimens intended for tests specified in 10.2.3 and 10.2.4 are to be supported vertically in a glass chamber provided with a glass cover having openings for gas inlet and outlet. The size of the glass chamber is not critical and may be varied to accommodate the number and size of the samples to be tested.

10.2.2 effective December 27, 2004

10.2.3 The samples are to be exposed to a moist hydrogen sulfide air mixture in a closed glass 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 chamber from a commercial gas cylinder; the volume required being measured with a flow meter and timer. Prior to each introduction of gas, the gas-air mixture from the previous charging is to be thoroughly purged from the chamber. On the two days out 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 upper middle portion of the chamber. A small amount of water (10 ml/0.003 m³ of the chamber volume) is to be maintained at the bottom of the chamber for humidity.

10.2.3 effective December 27, 2004

10.2.4 The samples are to be exposed to a moist carbon dioxide-sulfur dioxide air mixture in a closed glass chamber. 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 gas-air mixture from the previous charging is to be thoroughly purged from the chamber. On the two days out 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 ml/0.003 m³ of the chamber volume) is to be maintained at the bottom of the chamber for humidity.

10.2.4 effective December 27, 2004

10.2.5 Following the exposure, the operating parts in contact with the polymeric material of each test sample shall operate within 5 seconds after being exposed to the minimum operating or standby pressure.

10.2.5 effective December 27, 2004

10.3 Temperature cycling exposure

10.3.1 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 23.1, whichever is lower.

10.3.1 effective December 27, 2004

10.3.2 Following the exposures, each nozzle is to be supplied with water at its minimum operating or standby 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.

10.3.2 effective December 27, 2004

10.4 Hydrocarbon exposure followed by moist air exposure

10.4.1 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 $21 \pm 5.6^\circ\text{C}$ ($70 \pm 10^\circ\text{F}$) 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 25.5, with the nozzles installed in the pendent position and the hydrocarbon mixtures left in the inlet.

10.4.1 effective December 27, 2004

10.4.2 After these test exposures, each sample is to be pressurized to its minimum operating or standby 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.

10.4.2 effective December 27, 2004

10.5 Hydrocarbon exposure followed by water immersion exposure

10.5.1 Two groups, each consisting of five samples, are to be assembled and subjected to the hydrocarbon exposures described in 10.4. 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 or standby pressure and immersed for 90 days in tap water maintained at a temperature of $87 \pm 2^\circ\text{C}$ ($189 \pm 3.6^\circ\text{F}$). 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 related or standby pressure.

10.5.1 effective December 27, 2004

10.5.2 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.

10.5.2 effective December 27, 2004

10.6 Exposure to antifreeze solutions

10.6.1 Four groups, each consisting of five samples, are to be assembled. The samples are to be installed onto a manifold. The manifold is to be partially filled, such that the inlet of each sample is exposed to the following antifreeze solutions (by volume) for 90 days at a temperature of $87 \pm 2^{\circ}\text{C}$ ($189 \pm 3.6^{\circ}\text{F}$):

- a) One group exposed to a 60 percent diethylene glycol/40 percent tap water mixture;
- b) One group exposed to a 53 percent ethylene glycol/47 percent tap water mixture;
- c) One group exposed to a 60 percent propylene glycol/40 percent tap water mixture; and
- d) One group exposed to a 70 percent glycerine/30 percent tap water mixture.

10.6.1 effective December 27, 2004

10.6.2 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.

10.6.2 effective December 27, 2004

11 Nominal Operating Temperatures

11.1 The nominal operating temperatures of automatic nozzles shall be as indicated in Table 11.1.

11.1 effective December 27, 2004

Table 11.1
Nominal operating temperature values

Table 11.1 effective December 27, 2004

Glass bulb nozzles			Fusible element nozzles		
Nominal operating temp.		Liquid color code	Nominal operating temp.		Frame color code
$^{\circ}\text{C}$	$(^{\circ}\text{F})$		$^{\circ}\text{C}$	$(^{\circ}\text{F})$	
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			

11.2 The nominal operating temperatures of automatic nozzles shall be specified in advance by the manufacturer and verified in accordance with 12.1.

11.2 effective December 27, 2004

11.3 The nominal operating temperature marked on the nozzle shall be that determined when the nozzle is tested in accordance with 12.2 and 12.4, taking into account the specifications of 12.1.

11.3 effective December 27, 2004

12 Operating Temperature Test

12.1 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.

12.1 effective December 27, 2004

12.2 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.

12.2 effective December 27, 2004

12.3 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.

12.3 effective December 27, 2004

12.4 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.

12.4 effective December 27, 2004

13 Water Flow Test

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

$$K = Q/P^{0.5}$$

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).

13.1 effective December 27, 2004

13.2 The value of K published in the manufacturer's design and installation instructions shall be verified using the test method specified in 13.3. The average flow constant K shall be within 5 percent of the manufacturer's published value.

13.2 effective December 27, 2004

13.3 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. The flow constant, K, is to be averaged from each series of readings, meaning increasing pressure and decreasing pressure, and each average value shall be within 10 percent of the manufacturer's published value. During the test, pressures are to be corrected for differences in height between the gauge and the outlet orifice of the nozzle.

13.3 effective December 27, 2004

14 Water Distribution Test

14.1 The discharge characteristics of the nozzle shall be determined in accordance with 14.2 – 14.7.

14.1 effective December 27, 2004

14.2 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.

14.2 effective December 27, 2004

14.3 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.

14.3 effective December 27, 2004

14.4 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.

14.4 effective December 27, 2004

14.5 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).

14.5 effective December 27, 2004

14.6 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.

14.6 effective December 27, 2004

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

14.7 effective December 27, 2004

14.8 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.

14.8 effective December 27, 2004

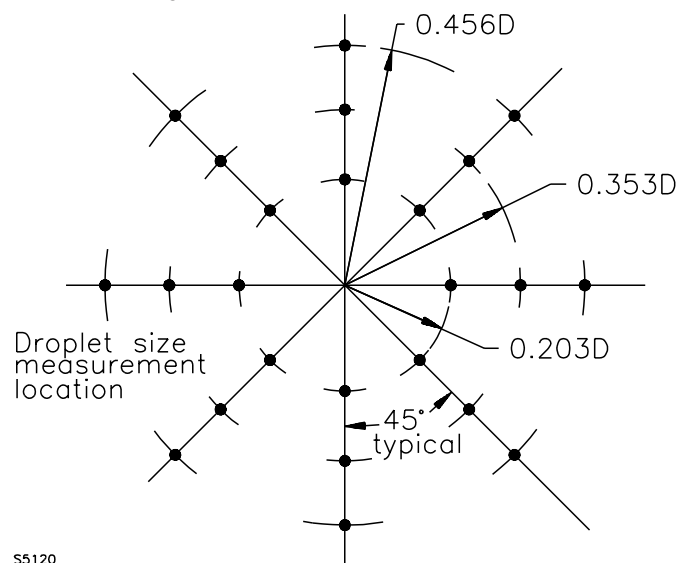
15 Water Droplet Size and Velocity

15.1 The cumulative volumetric distribution of water droplets is to be determined in accordance with 15.2 – 15.5 and recorded as the flow rate per unit area weighted distribution of water droplets measured at the 24 locations shown in Figure 15.1.

15.1 effective December 27, 2004

Figure 15.1
Droplet size measurement locations

Figure 15.1 effective December 27, 2004



D is the diameter of the discharge pattern as determined in 14.6.

15.2 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 14.6 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 15.1. 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 15.1.

15.2 effective December 27, 2004

15.3 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.

15.3 effective December 27, 2004

15.4 Standard Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis, ASTM E 799, 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.

15.4 effective December 27, 2004

15.5 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.

15.5 effective December 27, 2004

16 Function Test

16.1 When tested in accordance with 16.3 – 16.4:

- 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 lodgement of released parts are to be cleared within this 5 second period.

16.1 effective December 27, 2004

16.2 Automatic nozzles are to be heated in air. While being heated, they are to be subjected to each of the water pressures specified in 16.3 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 16.3 applied to their inlet.

16.2 effective December 27, 2004

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

16.3 effective December 27, 2004

16.4 Lodgement 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.

16.4 effective December 27, 2004

17 Deflector/Orifice Assembly Test

17.1 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.

17.1 effective December 27, 2004

18 Body Strength Test

18.1 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 18.2 – 18.5.

18.1 effective December 27, 2004

18.2 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.

18.2 effective December 27, 2004

18.3 An indicator capable of reading deflection to an accuracy of 0.01 mm (0.0004 inch) is to be used to measure any change in length of the nozzle between its load bearing points. Movement of the nozzle shank thread in the threaded bushing of the test machine is to be avoided or taken into account.

18.3 effective December 27, 2004

18.4 The load is to then be released and the heat responsive element is to be removed. When the nozzle reaches room temperature, a second measurement is to be made using the indicator.

18.4 effective December 27, 2004

18.5 An increasing mechanical load is to then be applied to the nozzle at a rate not exceeding 500 N/min (110 lb/min) until the indicator reading at the load bearing point returns to the initial value achieved under hydrostatic load. The mechanical load required to achieve this is to be recorded as the service load.

18.5 effective December 27, 2004

18.6 The applied load is to then be progressively increased at a rate not exceeding 500 N/min (110 lb/min) on each of the five specimens until twice the measured service load has been applied. This load is to be maintained for 15 ±5 seconds.

18.6 effective December 27, 2004

18.7 The load is to then be removed and any permanent elongation is to be recorded.

18.7 effective December 27, 2004

19 Strength of Glass Bulb Elements

19.1 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.

19.1 effective December 27, 2004

19.2 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.

19.2 effective December 27, 2004

19.3 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.

19.3 effective December 27, 2004

20 Strength of Fusible Elements

20.1 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 20.2.

20.1 effective December 27, 2004

20.2 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.

20.2 effective December 27, 2004

20.3 These tests are to be conducted at an ambient temperature of $20 \pm 3^\circ\text{C}$ ($68 \pm 5.4^\circ\text{F}$).

20.3 effective December 27, 2004

21 Leak Resistance

21.1 An automatic nozzle shall not show any sign of leakage when tested as specified in 21.2.

21.1 effective December 27, 2004

21.2 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.

21.2 effective December 27, 2004

22 Hydrostatic Strength

22.1 A nozzle shall not rupture, operate, or release any parts when tested as specified in 22.2.

22.1 effective December 27, 2004

22.2 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. The pressure is to be increased from 0 bar (0 psi) to four times the rated 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.

22.2 effective December 27, 2004

23 Heat Exposure

23.1 Glass bulb nozzles

23.1.1 There shall be no damage to the glass bulb element when a glass bulb nozzle is tested by the method specified in 23.1.2 – 23.1.3.

23.1.1 effective December 27, 2004

23.1.2 Glass bulb nozzles are to be heated in a liquid bath from a temperature of $20 \pm 5^{\circ}\text{C}$ ($68 \pm 9^{\circ}\text{F}$) to $20 \pm 2^{\circ}\text{C}$ ($36 \pm 3.6^{\circ}\text{F}$) 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.

23.1.2 effective December 27, 2004

23.1.3 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.

23.1.3 effective December 27, 2004

23.2 Uncoated automatic nozzles

23.2.1 Uncoated automatic nozzles are to withstand exposure to increased ambient temperature, without evidence of weakness or failure, when tested as specified in 23.2.2.

23.2.1 effective December 27, 2004

23.2.2 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 23.1, 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 or standby pressure, but not less than 12 bar (175 psi). After exposure:

- a) Four nozzles are to be subjected to the tests specified in 21.2;
- b) Four nozzles are to be subjected to the test of 16.1 (two nozzles at the minimum operating or standby pressure and two nozzles at the rated pressure); and
- c) Four nozzles shall comply with the requirements of 12.1.

23.2.2 effective December 27, 2004

Table 23.1
Test temperatures for coated and uncoated automatic nozzles

Table 23.1 effective December 27, 2004

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)

23.3 Coated automatic nozzles

23.3.1 In addition to meeting the requirement of 23.2 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 23.3.2 and 23.3.3.

23.3.1 effective December 27, 2004

23.3.2 In addition to the test exposure of 23.2.2 in an uncoated version, twelve coated nozzles shall be exposed to the test of 23.2.2 using the temperatures shown in Table 23.1.

23.3.2 effective December 27, 2004

23.3.3 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 21.2;
- b) Four nozzles are to be subjected to the test of 16.1 (two nozzles at the minimum operating or standby pressure and two nozzles at the rated pressure); and
- c) Four nozzles shall comply with the requirements of 12.1.

23.3.3 effective December 27, 2004

24 Thermal Shock

24.1 Glass bulb nozzles shall not be damaged when tested by the method specified in 24.2 and 24.3. Proper operation shall not be identified as damage.

24.1 effective December 27, 2004

24.2 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.

24.2 effective December 27, 2004

24.3 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 16.1.

24.3 effective December 27, 2004

25 Corrosion Tests

25.1 Stress corrosion test for brass nozzles and parts

25.1.1 When tested in accordance with 25.1.3 – 25.1.7, brass nozzles and parts shall not show fractures which affect their ability to function as intended.

25.1.1 effective December 27, 2004

25.1.2 Five sample nozzles and parts are to be subjected to the aqueous ammonia test described in 25.1.3 – 25.1.7.

25.1.2 effective December 27, 2004

25.1.3 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).

25.1.3 effective December 27, 2004

25.1.4 An 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, 40 mm (1.6 inches) below the bottom of the samples. 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.

25.1.4 effective December 27, 2004

25.1.5 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.

25.1.5 effective December 27, 2004

25.1.6 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 21.2 at the rated pressure for 1 minute, and also subjected to the tests described in 16.3 and 16.4 at the minimum flowing or standby pressure. Open nozzles are to be subjected to the test described in 22.2 at twice the rated pressure for 1 minute.

25.1.6 effective December 27, 2004

25.1.7 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.

25.1.7 effective December 27, 2004

25.2 Stress-corrosion cracking of stainless steel nozzles and parts

25.2.1 When tested in accordance with 25.2.3 – 25.2.7, stainless steel water mist nozzles or parts shall show no fractures or breakage which affects their ability to function as intended.

25.2.1 effective December 27, 2004

25.2.2 Five samples are to be degreased prior to being exposed to the magnesium chloride solution described in 25.2.3 – 25.2.7.

25.2.2 effective December 27, 2004

25.2.3 The samples are to be placed in a 500 ml flask that is fitted with a thermometer and a wet condenser 760 mm (30 inches) long. The flask is to be filled one-half full with a 42 percent by weight magnesium chloride solution, placed on a thermostatically-controlled electrically heated mantel, and maintained at a boiling temperature of $150 \pm 1^\circ\text{C}$ ($302 \pm 1.8^\circ\text{F}$) and exposed for 500 hours.

25.2.3 effective December 27, 2004

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

25.2.4 effective December 27, 2004

25.2.5 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 25.2.6 or 25.2.7, as applicable. Test samples not exhibiting degradation are determined to meet the intent of the requirement without further test.

25.2.5 effective December 27, 2004

25.2.6 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 25.2.3. 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 16.1 at the minimum flowing or standby pressure.

25.2.6 effective December 27, 2004

25.2.7 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.

25.2.7 effective December 27, 2004

25.3 Sulfur dioxide corrosion

25.3.1 Nozzles shall be resistant to sulfur dioxide saturated with water vapor when conditioned in accordance with 25.3.2 – 25.3.5. After exposure, the water flow rate of the 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 operating or standby pressure as described in 16.1 – 16.4. The remaining five samples shall comply with the requirements of 28.2.

25.3.1 effective December 27, 2004

25.3.2 Ten nozzles are to be subjected to the following sulfur dioxide corrosion test. The test equipment is to consist of a 5 L (1.3 gallon) vessel made of heat-resistant glass with a corrosion-resistant lid of such a shape as to prevent condensate dripping on the nozzles. The vessel is to be heated through the base and provided with a cooling coil around the side walls. A temperature sensor placed centrally 160 ±20 mm (6.5 ±0.8 inches) above the bottom of the vessel is to regulate the heating so that the temperature inside the glass vessel is 45 ±3°C (113 ±5.4°F). During the test, water is to flow through the cooling coil at a rate which keeps the temperature of the discharge water below 30°C (86°F). This combination of heating and cooling is to encourage condensation on the surfaces of the nozzles. The nozzles are to be shielded from condensate drippage. 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.

Exception: Other volumes up to 15 L (3.9 gal) can be used provided the quantities of chemicals are proportionately increased.

25.3.2 effective December 27, 2004

25.3.3 The nozzles to be tested are to be suspended in their normal mounting position under the lid inside the vessel and subjected to a corrosive sulfur dioxide atmosphere for 8 days. The corrosive atmosphere is to be obtained by introducing a solution made up by dissolving 20 g (0.15 oz) of sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3\text{H}_2\text{O}$) crystals in 500 ml (17 fl oz) of water.

25.3.3 effective December 27, 2004

25.3.4 For at least 6 days of the 8 day period, 20 ml (0.68 fl oz) of dilute sulfuric acid consisting of 156 ml (5.25 fl oz) of normal H_2SO_4 (0.5 mol/L) diluted with 844 ml (28.5 fl oz) of water are to be added at a constant rate. After 8 days, the nozzles are to be removed from the vessel, and the vessel emptied and cleaned.

25.3.4 effective December 27, 2004

25.3.5 The nozzles are to be removed from the container and dried for 4 to 7 days at a temperature not exceeding 35°C (95°F) with a relative humidity not greater than 70 percent.

25.3.5 effective December 27, 2004

25.4 Salt spray corrosion

25.4.1 Coated and uncoated nozzles shall be resistant to salt spray when conditioned in accordance with 25.4.2 – 25.4.4. Following exposure, the water flow rate of the open nozzles at their minimum operating or standby 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 operating or standby pressure as described in 16.1 – 16.4. The remaining five samples shall comply with the requirements of 28.2.

25.4.1 effective December 27, 2004

25.4.2 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.

25.4.2 effective December 27, 2004

25.4.3 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.

25.4.3 effective December 27, 2004

25.4.4 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 flowing 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 16.1 and five nozzles are to be tested in accordance with 28.2.

25.4.4 effective December 27, 2004

25.4.5 For nozzles intended for corrosive atmospheres, the nozzles are to be subjected to the tests specified in 25.4.1 – 25.4.4 except that the duration of the salt spray exposure shall be 30 days.

25.4.5 effective December 27, 2004

25.5 Moist air exposure

25.5.1 Nozzles shall be resistant to moist air exposure after being tested in accordance with 25.5.2. Following exposure, the water flow rate of open nozzles at their minimum operating or standby 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 operating or standby pressure as described in 16.3 and 16.4. The remaining five samples shall comply with the requirements of 28.2.

25.5.1 effective December 27, 2004

25.5.2 Ten nozzles are to be exposed to a high temperature-humidity atmosphere consisting of a relative humidity of 98 ± 2 percent and a temperature of $95 \pm 4^\circ\text{C}$ ($203 \pm 7^\circ\text{F}$). 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 $25 \pm 5^\circ\text{C}$ ($77 \pm 9^\circ\text{F}$) 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 5 percent of the value specified in the manufacturer's design and installation instructions. For the automatic nozzle samples, five nozzles are to be functionally tested at their minimum operating or standby pressure in accordance with 16.1 and five nozzles are to be subjected to the dynamic heating test in accordance with 28.2.

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.

25.5.2 effective December 27, 2004

26 Integrity of Nozzle Coatings

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

26.1.1 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 26.1.2.

26.1.1 effective December 27, 2004

26.1.2 A 50 cm^3 (3 in^3) 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 26.1.1.

26.1.2 effective December 27, 2004