UL 2351

STANDARD FOR SAFETY

Spray Nozzles for Fire-Protection Service

UL Standard for Safety for Spray Nozzles for Fire-Protection Service, UL 2351

Second Edition, Dated June 4, 2004

Summary of Topics

These revision to ANSI/UL 2351 is a reaffirmation and continuance of the Second Edition of the Standard for Spray Nozzles for Fire-Protection Service as an American National Standard.

Text that has been changed in any manner or impacted by UL's electronic publishing system 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 revised requirements are substantially in accordance with Proposal(s) on this subject dated August 10, 2018.

The following table lists the future effective dates with the corresponding reference.

Future Effective Dates	References
June 3, 2016	19.1, 25A.1, 25A.2, 27.2, and 31.1

Approved American National Standard
ANSI
ANSI/UL 2351-2014 (R2018)

UL 2351

Standard for Spray Nozzles for Fire-Protection Service

First Edition – July, 2000

Second Edition

June 4, 2004

This ANSI/UL Standard for Safety consists of the Second edition including revisions through October 2, 2018.

The most recent designation of ANSI/UL 2351 as a Reaffirmed American National Standard (ANS) occurred on October 2, 2018. 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 These requirements cover automatic and non-automatic (open) type water spray nozzles for installation in accordance with the Standard for Installation of Sprinkler Systems, NFPA 13, and the Standard for Water Spray Fixed Systems for Fire Protection, NFPA 15.

1.2 Nozzles are categorized by the discharge coefficient ″K″ of the orifice, water discharge angle or pattern, type of coating or plating, and other factors that have a bearing on their application. Automatic nozzles are also categorized by operating temperature rating.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component.

2.2 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.

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

2.4 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 Units of Measurement

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

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 AUTOMATIC NOZZLE – A nozzle intended to open automatically by operation of a heat-responsive element that maintains the discharge orifice closed by means such as the exertion of force on a cap (button or disc). A nozzle is installed on piping so that a spray of water is discharged in a specific pattern for suppression or control of fires, or protection from fire exposure.

5.3 COATED, PAINTED, OR PLATED NOZZLE – A nozzle that has factory applied coatings, paint, or platings for corrosion protection or decorative purposes.

5.4 DISCHARGE COEFFICIENT "K" – Coefficient of discharge in the formula:

$$K = \frac{Q}{\sqrt{p}}$$

in which:

Q is the flow in gallons per minute, and

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

In SI units:

Q is the flow in liters per minute; and

p is the pressure in bar

5.4 revised June 3, 2014

5.5 DISCHARGE PRESSURE RANGE – The pressure range corresponding to the specified minimum and maximum pressures at which the spray nozzle is intended to be discharged.

5.6 HEAT RESPONSIVE ELEMENT – That portion of an automatic nozzle that breaks, melts, or otherwise functions to initiate the automatic operation of the nozzle when exposed to sufficient heat.

5.7 MANUAL MEANS OF ACTUATION – A means of system actuation in which the system operator initiates system discharge.

5.8 NON-AUTOMATIC (OPEN) NOZZLE – A nozzle that discharges water immediately when water is supplied from the water control valve. A non-automatic nozzle may be an automatic nozzle with the heat responsive and activating elements removed. The discharge orifice is open.

5.9 OPERATING TEMPERATURE – The temperature at which the heat responsive element of a nozzle operates when subjected to a 1°F (0.5°C) per minute temperature rise while immersed in a liquid bath.

5.10 ORIFICE – The outlet that controls the amount of water discharged from a nozzle at a given pressure.

5.11 QUICK RESPONSE (QR) NOZZLE – A nozzle that complies with the applicable requirements for such nozzles in the Sensitivity Tests, Section 21.

CONSTRUCTION

6 General

6.1 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 as specified in this standard. The closure of the water seat shall not be achieved by the use of a 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).

6.1 revised February 24, 2009

6.2 Stampings shall show no cracking or splitting and shall be uniformly smooth and cleanly cut.

6.3 An automatic nozzle shall be chemically or mechanically staked to maintain the manufacturer's assembly load. The assembly load shall not be able to be changed by the use of common hand tools without causing visible damage to the nozzle.

6.4 Nozzle types or materials not anticipated by these requirements require additional evaluation, such as tests to investigate special metallic or nonmetallic materials.

6.5 Sample spray nozzles are to be constructed in accordance with the manufacturer's detailed drawings including materials, dimensions, and tolerances.

6.6 For 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.

6.6 added June 3, 2014

7 Inlet Threads

7.1 Nozzles shall be provided with not less than 1/4 inch external NPT pipe threads at the inlet that comply with the Standard for Pipe Threads, General Purpose (Inch), ASME B1.20.1.

Exception No. 1: Nozzles intended for use in installations where fittings incorporate other than NPT threads, shall be permitted with pipe threads complying with a national pipe thread standard compatible with those fittings.

Exception No. 2: Nozzle inlets intended for attachment to piping by means other than threads are able to be used when the nozzles are intended to be attached in a manner that does not involve welding and that permits nozzle removal from the piping without the use of special tools or torch cutting equipment.

Revised 7.1 effective February 24, 2011

Table 7.1
Discharge coefficient ″K″ and thread-type

Table 7.1 deleted effective February 24, 2011

7.2 Threads shall be cleanly cut and true and free from burrs, scoring, or chatter marks.

8 Temperature Ratings

8.1 The temperature ratings, temperature classifications, and color coding of automatic spray nozzles shall be as specified in Table 8.1. The frame arms of the automatic spray nozzles or glass bulb heat responsive element shall be colored according to the color code specified in Table 8.1.

8.1 revised February 24, 2009

Table 8.1
Temperature classification ratings and color coding

Table 8.1 revised June 3, 2014

Temperature classification	Temperature rating		Color coded		Maximum ambient temperature	
	°F	(°C)	Frame arms	glass bulb	°F	(°C)
Ordinary	135 – 170	(57 – 77)	Uncolored or Black	Orange -135°F (57°C) or Red -155°F (68°C)	100	(38)
Intermediate	175 – 225	(79 – 107)	White	Yellow -175°F (79°C) or Green -200°F (93°C)	150	(66)
High	250 – 300	(121 – 149)	Blue	Blue	225	(107)
Extra High	325 – 375	(163 – 191)	Red	Purple	300	(149)
Very Extra High	400 – 475	(204 – 246)	Green	Black	375	(191)
Ultra High	500 – 575	(260 – 302)	Orange	Black	475	(246)

9 Coatings and Platings

9.1 The operation and distribution characteristics of a nozzle shall not be impaired by the application of any factory-applied coating, paint, or plating when the nozzle is tested in accordance with these requirements.

9.2 A corrosion resistant coating or plating shall be uniformly applied.

9.3 A wax coating shall not be brittle when new nor become brittle with age.

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10 Pressure Rating

10.1 Nozzles shall have a rated pressure of 175 psig (12.1 bar), 250 psig (17.2 bar), or 300 psig (20.7 bar).

10A Strainer

10A.1 A nozzle having a water passageway less than 3/16 inch (5 mm) shall be provided with a strainer or filter constructed of a corrosion resistant material. The maximum dimension of an opening in the strainer or filter shall not exceed 80 percent of the smallest water passageway being protected.

Added 10A.1 effective February 24, 2011

11 Protective Covers

11.1 Automatic 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.

11.1 effective December 4, 2005

11.2 Automatic nozzles required to be equipped with protective covers shall comply with Section 30, Impact Test for Protective Covers, and 46.2.

11.2 effective December 4, 2005

PERFORMANCE

12 General

12.1 To determine compliance with these requirements, the various types and spray patterns of a nozzle shall be subjected to the performance tests described in Sections 14 – 42.

13 Samples

13.1 The number of samples required for investigation varies for different nozzle types. The number of samples required for examination and test are to be determined following a review of detailed drawings, examination of a preliminary sample, or both.

14 Load on Heat Responsive Element

14.1 For automatic nozzles, the average and maximum design loads exerted on the heat responsive element, and the overall load tolerance based on the design load for the assembly, are to be determined. When the application of the rated pressure to the inlet end of the nozzle increases the assembly load by more than 10 percent, the additional load is to be added to the measured load on the heat responsive element. The information developed is to be used for Strength of Heat Responsive Element Test, Section 15.

14.1 revised February 24, 2009

14.2 At least 25 nozzles are to be tested to determine the average load. An arrangement for measuring the load on the heat responsive element is to be developed for each specific design.

15 Strength of Heat Responsive Element Test

15.1 Fusible-alloy types

15.1.1 For automatic nozzles, a heat responsive element in the ordinary temperature rating, see Table 8.1, shall either:

a) Sustain a load of 15 times its maximum design load for a period of 100 hours; or

b) Demonstrate the ability to sustain the maximum design load when tested in accordance with 15.1.2 and 15.1.3.

15.1.2 Compliance with 15.1.1(b) is to be determined by subjecting sample heat-responsive elements to loads in excess of the maximum design load. A minimum of ten samples are to be loaded at various values as required up to 15 times the design load. At least one heat responsive element shall sustain a load for a time greater than 1000 hours. These load and time values are then to be used to derive a least-square, full logarithmic regression curve of time as a function of load, from which the loads at 1 hour and 1000 hours are to be determined. The design load shall comply with the following equation:

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

in which:

L_d *is the maximum design load;*

L_m *is the load at 1000 hours; and*

L_o *is the load at 1 hour.*

15.1.3 The test samples are to be loaded at a conditioned temperature of 70 ±5°F (21 ±3°C).

15.2 Glass-bulb types

15.2.1 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.

15.2.1 revised June 3, 2014

15.2.2 Deleted February 24, 2009

15.2.3 The bulb strength is to be measured by applying a steadily increasing load, utilizing a compression-testing machine, until the bulb breaks. This test is to be conducted with the bulb mounted in the seating parts, with the same dimensions used in the nozzle and a material hardness within the range of 38 - 50 Rockwell C. The rate of loading shall not exceed 55 pounds-force load per second (25 kg/s) or at a rate that deflects the bulb 0.02 inch (0.51 mm) per minute, whichever measurement is convenient for the test apparatus being used. Bulb seats are capable of being reinforced circumferentially so as not to interfere with the bulb breakage. A minimum of 15 samples of each temperature rating and each bulb type are to be tested. See Supplement SA – Tolerance Limit Calculation Method.

15.2.3 added June 3, 2014

15.2.4 Calculations are to be based on the Normal or Gaussian Distribution except where another distribution is shown to be more applicable due to manufacturing or design factors.

15.2.4 added June 3, 2014

15A Glass-Bulb Thermal Shock Test

15A.1 An automatic nozzle having a glass bulb shall withstand the thermal shock of rapid temperature changes when tested as specified in 15A.2 without breakage or fracture of the glass bulb.

15A.1 added February 24, 2009

15A.2 At least five sample nozzles are to be conditioned for 5 minutes in a liquid bath at 20°F (11°C) less than the marked temperature rating. The samples then are to be removed and immediately submerged in another liquid bath at 50°F (10°C). The bulb of each nozzle shall be visually observed for signs of breakage or fracture.

15A.2 added February 24, 2009

16 Leakage Test

16.1 When tested as described in 16.2 and 16.3, an automatic nozzle shall not exhibit leakage at any pressure from 0 psig to the applicable leakage test pressure shown in Table 16.1.

Table 16.1
Test pressures for the leakage and hydrostatic tests

Rated pressure		Leakage test pressure		Hydrostatic test pressure	
psig	(bar)	psig	(bar)	psig	(bar)
175	(12.1)	500	(34)	700	(48)
250	(17.2)	500	(34)	1000	(69)
300	(20.7)	600	(41)	1200	(83)

16.2 At least 20 samples are to be individually tested. The nozzle inlets are to be filled with water and vented of air.

16.3 The pressure is to be increased from 0 psig to the test pressure at a rate not exceeding 300 psig (20.7 bar) per minute and then held for 1 minute. There shall be no visible leakage in any sample.

17 Hydrostatic Strength Test

17.1 An automatic nozzle shall withstand, for 1 minute, without rupture, an internal hydrostatic pressure equal to the hydrostatic test pressure shown in Table 16.1.

17.2 At least 20 samples are to be individually tested. The nozzle inlets are to be filled with water and vented of air. The pressure is to be increased from 0 psig to the hydrostatic test pressure shown in Table 16.1 at a rate not exceeding 300 psig (20.7 bar) per minute. The pressure is to be maintained at the test pressure and held for 1 minute. The sample shall not rupture, operate, or release any of its operating parts during the pressure increase nor while being maintained at the test pressure for 1 minute.

18 30-Day Leakage Test

18.1 When tested as described in 18.2 and 18.3, an automatic nozzle shall:

a) Experience no leakage when subjected to the 30 day test pressure specified in Table 18.1 for 30 days;

b) Not leak when subjected to the leakage test pressure specified in Table 16.1 or less for 1 minute following the 30 days; and

c) Show no distortion or other mechanical damage following the leakage testing, specified in (b), as determined by visual examination.

Table 18.1
Test pressures for the 30-day leakage test

Rated pressure		30-day test pressure	
psig	**(bar)**	**psig**	**(bar)**
175	(12.1)	300	(20.7)
250	(17.2)	450	(31)
300	(20.7)	500	(34)

18.2 Five samples are to be installed on a water-filled test line maintained under a constant test pressure as specified in Table 18.1 for 30 days. The samples are to be examined weekly during the test period for evidence of leakage of water at the closure cap.

18.3 Following completion of this 30-day test period, the samples are to be subjected to the leakage test specified in 16.1. The samples shall be examined for distortion or mechanical damage.

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19 Water Hammer Test

19.1 When tested as described in 19.2 and 19.3, an automatic nozzle shall:

a) Experience no leakage when subjected to 100,000 applications of pressure surges having a test pressure range as specified in Table 19.1;

b) Not leak when subjected to the Leakage Test specified in Table 16.1 for 1 minute, following the 100,000 cycles of water hammer; and

c) Show no distortion or other physical damage following the water hammer testing, as determined by visual examination.

Revised 19.1 effective June 3, 2016

Table 19.1
Test pressure ranges for the water hammer test

Rated pressure		Test pressure	
psig	(bar)	psig	(bar)
175	(12.1)	50 – 500	(3.4 – 34)
250	(17.2)	50 – 500	(3.4 – 34)
300	(20.7)	150 – 600	(10 – 41)

19.2 Five samples are to be installed on a water-filled test line connected to a pump system that produces a rapid rise in discharge pressure, in accordance with Table 19.1, at the rate of not more than 60 cycles per minute. The test piping is to be filled so that there is water at the nozzle seat, and the pump is to be placed in operation and adjusted to produce the specified test-pressure cycle.

19.2 revised June 3, 2014

19.3 Following completion of the pressure cycling, the samples are to be subjected to the leakage test as specified in 16.1. The samples are then to be examined for distortion or mechanical damage.

20 Operating Temperature (Bath) Test

20.1 The operating temperature of automatic nozzles, when tested as described in 20.2 – 20.8, shall be within a maximum temperature range as follows:

a) ±3.5 percent of the marked temperature rating for nozzles rated less than 400°F (204°C), and

b) 107 percent of the marked temperature rating for nozzles rated 400°F (204°C) and higher.

For the purpose of this determination for nozzles rated 400°F (204°C) and higher, the marked temperature rating is to be the minimum value and included as one of the values within the range, making a total of eleven values in the range. Upon operation, all operating parts of the nozzle shall clear the waterway as intended, except as indicated in 20.2.

20.1 revised June 3, 2014

20.2 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, but additional nozzle samples shall be subjected to the Air Bath for Glass Bulb Nozzles Test, Section 20A.

20.2 revised June 3, 2014

20.3 At least ten samples of each type of nozzle produced, including plated, painted, coated, and uncoated types of each temperature rating, are to be subjected to this test. A nozzle that does not require pressure to operate is to be tested at zero gauge pressure. A nozzle that requires pressure to operate is to be tested while pressurized at 4.5 ±0.5 psig (0.31 ±0.034 bar).

20.4 The samples are to be placed in an upright position and completely immersed in the water or oil bath. The bath vessel is to be supplied with a source for heating the liquid at the prescribed rate and with means to agitate the liquid and measure the temperature of the liquid bath.

20.5 Water is to be used in bath tests of nozzles that have operating temperature ratings of 175°F (79°C) or lower. Samples having operating temperature ratings of 176 – 575°F (80 – 302°C) are to be bath-tested in oil having a flash point exceeding the test temperature.

20.6 *Deleted June 3, 2014*

20.7 A calibrated temperature measuring device is to be used to determine temperatures of the liquids in bath tests. The sensing element of the temperature measuring device is to be held level with the nozzle operating parts by a support member.

20.7 revised June 3, 2014

20.8 The temperature of the bath liquid is to be increased at a convenient rate until the liquid is within 20°F (11°C) of the temperature rating of the device [30°F (16°C) for 325°F (163°C) and higher temperature ratings]. The rate of temperature rise then is to be controlled at a rate not exceeding 1°F (0.5°C) per minute until operation of the nozzle or until a temperature 20°F (11°C) above the rated temperature is reached. The temperature of the liquid and the time of operation, as each nozzle operates, are to be recorded.

20A Air Bath Test for Glass Bulb Nozzles

20A.1 When a partial fracture of a glass bulb occurs during the Operating Temperature (Bath) Test, Section 20, nozzles with a glass bulb heat responsive element shall fully operate when subjected to the air bath test described in 20A.2.

20A.1 added June 3, 2014

20A.2 Fifty sample automatic nozzles with a glass bulb heat responsive element shall be placed on their inlet in a programmable circulating air oven. The temperature in the oven shall be gradually increased to 20 ±2°F (11 ±1.1°C) below the marked temperature rating of the nozzles. When this temperature is reached, the oven shall be maintained at a constant temperature for a period of 60 ±5 minutes. The temperature shall then be increased at a constant rate of 1 ±0.5°F (0.5 ±0.3°C) per minute until the temperature in the oven is 25 percent higher than the marked temperature rating of the nozzles or until all the nozzles operate, whichever occurs first. Each sample shall be examined for full operation.

20A.2 added June 3, 2014

21 Sensitivity Tests

21.1 General

21.1.1 An automatic nozzle shall comply with the following requirements:

a) 21.2.1 for quick response (QR) nozzles;

b) 21.2.2 for standard response nozzles.

21.1.2 A coating shall not remain on nozzle parts in a manner that impairs operation or distribution at the time of nozzle operation in 21.2 and 21.3.

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21.2 Sensitivity – oven heat test

21.2.1 A QR nozzle shall have a maximum operating time specified in Table 21.1 for each sample when tested in the sensitivity test oven as specified in 21.2.3 – 21.2.5. If the nozzle temperature rating is not shown in Table 21.1, the maximum operating time for each sample shall be determined by using the formula specified in 21.2.6 based on a Response Time Index (RTI) value of 50 $(m \cdot s)^{1/2}$ [90 $(ft \cdot s)^{1/2}$], and the marked temperature rating of the nozzle.

21.2.1 effective December 4, 2005

21.2.2 A standard response nozzle shall operate within the time range specified in Table 21.1 for each sample nozzle when tested in the oven heat test as specified in 21.2.3 – 21.2.5. If the nozzle temperature rating is not shown in Table 21.2, the minimum and maximum operating time range for each sample shall be determined by using the formula specified in 21.2.6, based on a RTI value of 80 $(m \cdot s)^{1/2}$ [145 $(ft \cdot s)^{1/2}$] for the minimum value and on a RTI value of 350 $(m \cdot s)^{1/2}$ [630 $(ft \cdot s)^{1/2}$] for the maximum value, and the marked temperature rating of the nozzle.

21.2.2 effective December 4, 2005

Table 21.1
Operating time for nozzles in sensitivity-oven heat test

Table 21.1 effective December 4, 2005

Temperature rating		Oven temperature		Quick responses type, seconds	Standard response type, seconds		Coated standard response type, seconds[a]
°F	(°C)	°F	(°C)	Max.	Min.	Max.	Max.
135	(57.2)	275	(135)	11.2	17.8	78.0	180
140	(60.0)	275	(135)	12.3	19.7	86.1	180
155	(68.3)	275	(135)	16.0	25.6	111.9	180
160	(71.1)	275	(135)	17.4	27.7	121.3	180
165	(73.9)	275	(135)	18.8	30.0	131.1	180
175	(79.4)	386	(197)	12.1	19.4	84.8	180
200	(93.3)	386	(197)	16.1	25.7	112.4	180
212	(100.0)	386	(197)	18.2	29.0	127.1	180
220	(104.4)	386	(197)	19.6	31.8	137.3	180
250	(121.1)	555	(291)	14.3	22.7	99.3	180
286	(141.1)	555	(291)	18.1	29.0	126.8	180
300	(148.9)	555	(291)	19.8	31.7	138.5	180
360	(182.2)	765	(407)	16.7	26.8	117.0	180
400	(204.4)	765	(407)	20.0	32.0	139.9	180
450	(232.2)	765	(407)	24.6	39.4	172.3	180
500	(260.0)	765	(407)	30.0	48.1	210.3	210.3

[a] Corrosion resistant nozzles with coated heat responsive elements including wax, lead, Teflon, wax over lead, and polyester coating. Coated quick response nozzles shall comply with 21.2.1.

Table 21.2
Sensitivity oven temperatures

Table 21.2 effective December 4, 2005

Temperature rating		Oven temperature	
°F	(°C)	°F ±2°F	(°C ±1°C)
135 – 170	(57 – 77)	275	(135)
175 – 225	(79 – 107)	386	(197)
250 – 300	(121 – 149)	555	(290)
325 – 375	(163 – 191)	765	(407)
400 – 475	(204 – 246)	765	(407)
500 – 575	(260 – 302)	765	(407)

21.2.3 Nozzles of each style are to be tested in the sensitivity test oven in the pendent position with the heat responsive element located at least 1 inch (25.4 mm) away from the inside surfaces of the oven as follows:

a) For nozzle designs without frame arms and incorporating symmetrical heat responsive elements and symmetrical nozzle bodies, ten samples are to be orientated in the pendent position;

b) For nozzle designs with or without frame arms and incorporating unsymmetrical heat responsive elements or unsymmetrical body designs, ten samples are to be orientated in the pendent position with the heat responsive element upstream of the axis of the body; and

c) For nozzle designs incorporating frame arms with symmetrical heat responsive elements, ten samples are to be orientated in the pendent position with the frame arms in a plane perpendicular to the direction of air flow.

21.2.3 effective December 1, 2005

21.2.4 The samples are to be conditioned at 70 ±9°F (21 ±5°C) for at least 2 hours. The inlet end of each sample is to be connected to a source of air pressure at 4 ±1 psig (28 ±7 kPa) and quickly plunged into the sensitivity test oven in a pendent position. The operating time is to be measured using a timer capable of measuring 0.01 seconds and accurate to within 0.01 ±0.01 seconds. Each sample is to be observed to determine if operation occurs as intended within the time specified in 21.2.1.

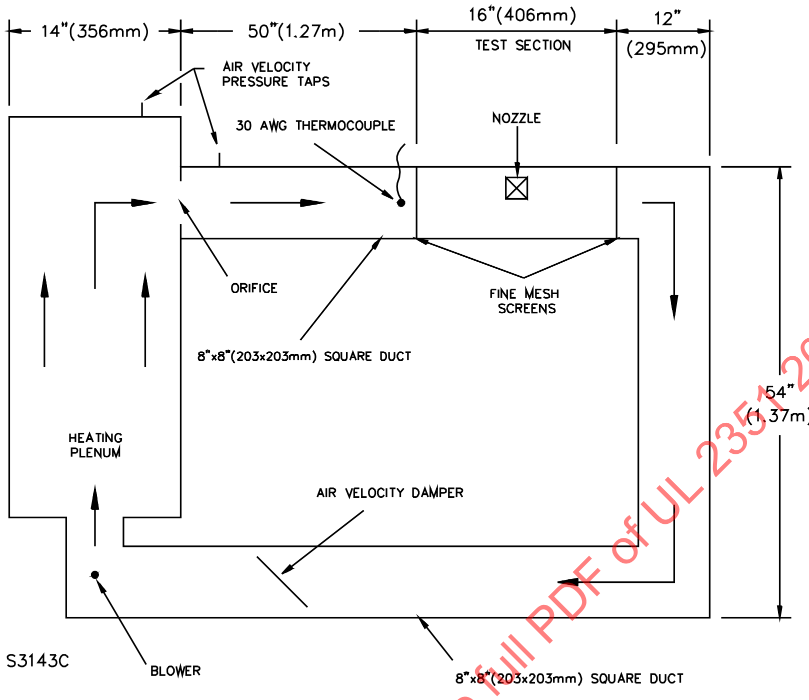
21.2.4 revised June 3, 2014

21.2.5 The sensitivity test oven is to consist of a square or rectangular stainless steel chamber. A typical chamber is illustrated in Figure 21.1. A constant air velocity of 8.33 ±0.05 feet per second (2.54 ±0.01 m/s) and an air temperature as specified in Table 21.2 for each temperature rating and style nozzle are to be established. Air velocity is to be measured using an orifice plate and a manometer or a bidirectional probe and a velometer. The air temperature is to be measured by use of a 30 AWG (0.05 mm^2) thermocouple centered upstream from the sample as shown in Figure 21.1.

21.2.5 revised June 3, 2014

Figure 21.1
Typical sensitivity test oven configuration

Figure 21.1 revised June 3, 2014



21.2.6 The required nozzle operating time values specified in 21.2.1 and 21.2.2 shall be calculated by using the following equation:

$$t_o = \frac{-RTI * \ln\left[1 - \left[\frac{(T_m - T_u)}{T_g - T_u}\right]\right]}{\sqrt{u}}$$

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Where:

RTI is Response Time Index [(m·s)$^{1/2}$; (ft·s)$^{1/2}$]

t_o is operating time of the nozzle [s]

u is nominal gas velocity in the test section of the wind tunnel [2.54 m/s; 8.33 ft/s]

T_m is marked temperature rating of the nozzle [°C; °F]

T_g is nominal gas temperature in test section in Table 21.2 [°C; °F]

T_u is nominal ambient air temperature [24°C; 75°F]

21.2.6 effective December 6, 2005

21.3 Sensitivity – room heat test for quick response (QR) nozzles

21.3.1 Ordinary or intermediate temperature rated QR nozzles shall have an operating time of 75 seconds or less for each nozzle when tested as specified in 21.3.2 – 21.3.4.

21.3.2 Nozzles of each type are to be installed in a test room (see 21.3.4) in the following position and orientation:

a) For nozzles intended to be installed in the pendent position and nozzle designs without frame arms and incorporating symmetrical heat responsive elements and symmetrical bodies, ten samples are to be installed in their intended pendent position at the ceiling.

b) For nozzles intended to be installed in the pendent position, with or without frame arms and incorporating unsymmetrical heat responsive elements, ten samples are to be orientated with the heat responsive element downstream of the axis of the nozzle body in relation to the direction of the fire source. The samples are to be in their intended pendent position.

c) For nozzles intended to be installed in the pendent position, incorporating frame arms with symmetrical heat responsive elements, ten samples are to be orientated with the frame arms in a plane parallel to the direction of the fire source. The samples are to be installed in their intended pendent position.

d) For nozzles intended to be installed in the upright position having configurations referenced in (a), (b), and (c), ten samples are to be installed in the intended pendent position.

e) For nozzles intended to be installed in the horizontal position, ten samples are to be installed in their intended position with the deflector or discharge outlet located 4 inches (102 mm) below the ceiling.

f) For nozzles that are intended for installation in multiple positions, they shall be tested in accordance with (e).

21.3.3 The nozzle is to be mounted as specified in 21.3.2 on a ceiling or a wall of 15 by 15 feet (4.6 by 4.6 m) closed room having an 8-foot (2.4-m) high ceiling. The nozzle inlet waterway is to be filled with water having a temperature of 70 ±3°F (21 ±1.6°C). The water is to be pressurized to 4.5 ±0.5 psig (0.31 ±0.034 bar), when required for nozzle operation.

21.3.4 The fire source is to consist of a 1 by 1 by 1 foot (305 by 305 by 305 mm) sand burner located in one corner of the room with a flow of natural gas of 500 standard cubic feet (14.2 m^3) per hour for ordinary temperature rated nozzles and 600 standard cubic feet (17.0 m^3) per hour for intermediate temperature rated nozzles. See Figure 21.2. Installation is to be as follows:

a) A pendent, upright, or ceiling type nozzle is to be installed along a diagonal line on the ceiling at a distance of 16 feet, 9 inches (5.1 m) from the corner of the room where the sand burner is located.

b) A pendent, upright, or ceiling type nozzle is to be installed in the intended position at a point where a diagonal line from the corner having the burner to the opposite corner intersects an arc having a radius equal to the distance from the corner having the burner to the midpoint of the opposite wall.

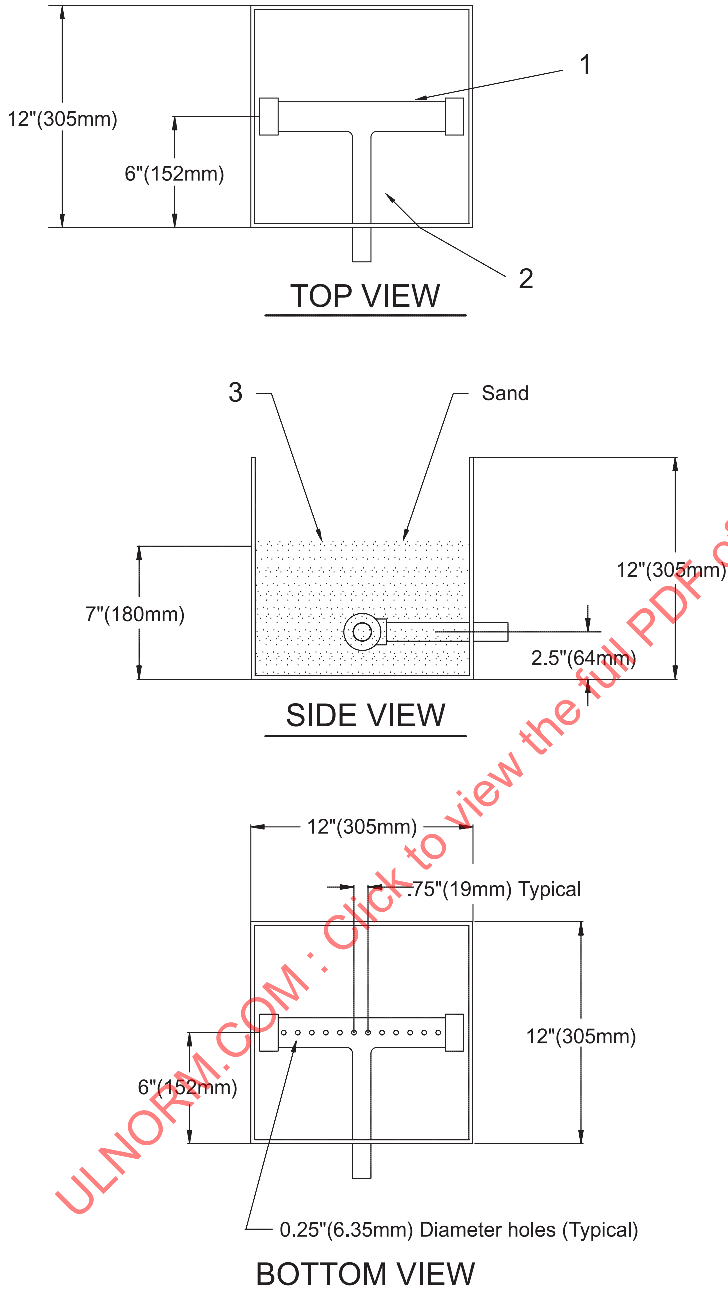
c) A sidewall type nozzle is to be installed on the midpoint of the wall furthest from the corner having the sand burner.

The test is to be started when the ambient temperature is 87 ±2°F (31 ±1°C) for ordinary temperature rated nozzles and 120 ±2°F (49 ±1.1°C) for intermediate temperature rated nozzles, as measured in the center of the room 10-inches (254-mm) below the ceiling. The gas burner is to be ignited, and the operation time of the nozzle is to be recorded.

21.3.4 revised February 24, 2009

Figure 21.2
Example of sand burner apparatus

Figure 21.2 added February 24, 2009



Materials:
- Steel Plate Box, Welded.
- Steel or Stainless Steel Piping and Fittings.
- Mason Grade Sand.

Key:
1 Nominal 1 Inch Piping.
2 Nominal 1-1/4 or 1-1/2 Inch Pipe
3 Sand Depth

S5529

22 Operation – Lodgement Test

22.1 An automatic nozzle shall operate at service pressures of 7 psig (0.48 bar) to the rated pressure. All operating parts shall release with sharp, positive action. Operating parts intended to be released from the nozzle assembly shall clear the nozzle frame and deflector to not impair the water distribution pattern.

Revised 22.1 effective February 24, 2011

22.2 Each sample is to be installed in its intended installation position on a rigid piping arrangement and supplied with flowing water. Tests are to be conducted using a single-feed and a double-feed water supply arrangement as described in Figure 22.1. The test pressures and number of samples tested at each pressure using each water supply configuration is to be as specified in Table 22.1. Each sample is then to be operated by exposing the heat responsive element to a uniform application of heat. A nozzle does not comply when a part interfering with correct water distribution maintains interference for more than 1 minute under the water flow service pressure. The service pressure and the action of the operating parts, when releasing are to be observed to determine compliance with these requirements.

Revised 22.2 effective February 24, 2011

Table 22.1
Samples and test pressures for operation-lodgement test

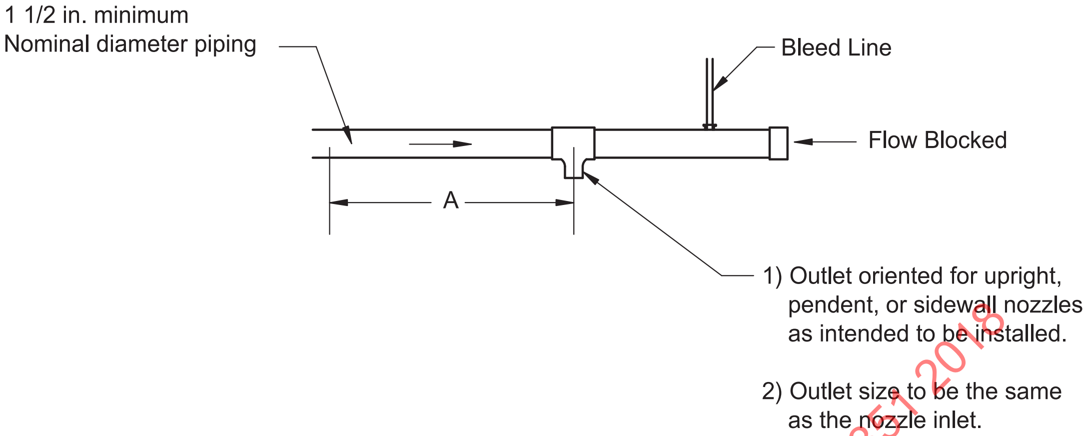
Added Table 22.1 effective February 24, 2011

Test pressure, psig (kPa)	Water supply arrangement	Number of test samples
7 (48)	Single Feed	5
7 (48)	Double Feed	5
25 (172)	Single Feed	5
25 (172)	Double Feed	5
50 (345)	Single Feed	5
50 (345)	Double Feed	5
75 (517)	Single Feed	5
75 (517)	Double Feed	5
100 (689)	Single Feed	5
100 (689)	Double Feed	5
125 (862)	Single Feed	5
125 (862)	Double Feed	5
150 (1034)	Single Feed	5
150 (1034)	Double Feed	5
175 (1206)	Single Feed	5
175 (1206)	Double Feed	5
Incremental 25[a]	Single Feed	5 at each pressure
Incremental 25[a]	Double Feed	5 at each pressure

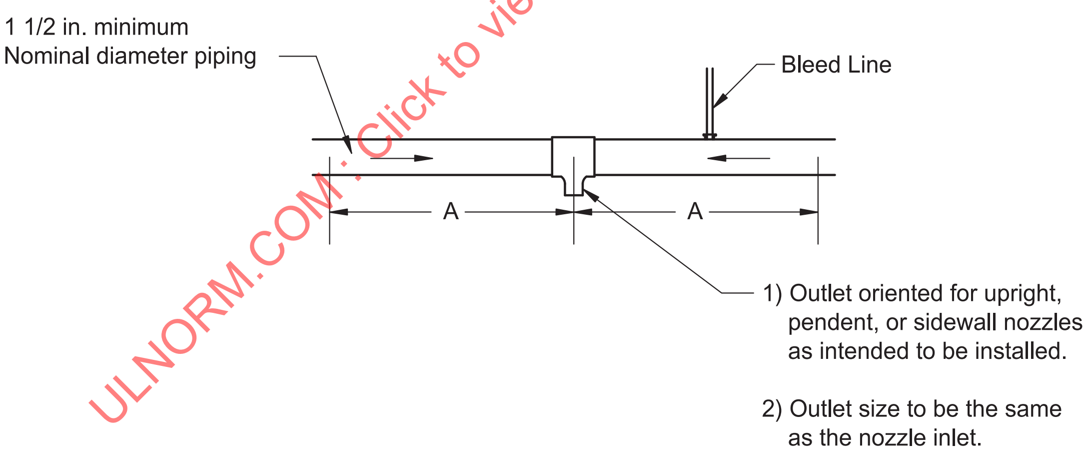
[a] If the nozzle is rated for a pressure of greater than 175 psig (1206 kPa), nozzles are to be tested in 25 psig (172 kPa) increments from 200 psig (1379 kPa) to the rated pressure.

Figure 22.1
Operation – lodgement test arrangements

Added Figure 22.1 effective February 24, 2011



Single Feed Arrangement



Double Feed Arrangement

su0101a

A – Minimum 10 times nominal diameter straight length

23 Flow Endurance Test

23.1 A nozzle shall withstand for 30 minutes, without evidence of cracking, deformation, or separation of any part, a water flow at a pressure equal to the rated pressure plus 25 psig (1.72 bar).

23.2 One sample nozzle is to be installed in its intended orientation on an elbow in a pressurized water system. For automatic nozzles, the heat responsive element is to be activated at the specified test pressure, and the water flow shall be adjusted to obtain the test pressure specified in 23.1 for 30 minutes.

23.2 revised June 3, 2014

24 High Temperature Exposure Test (90 Day)

24.1 An automatic nozzle, except for a wax coated nozzle, shall withstand for 90 days, without evidence of weakness or malfunction, an exposure to a high-ambient temperature in accordance with Table 24.1, or 20°F (11°C) below the rated operating temperature of the samples (whichever is the lower temperature), and not less than 120°F (49°C). Following the exposure, each nozzle shall comply with the Leakage Test, Section 16. Nozzles are to then be subjected to the Sensitivity – Oven Heat Test (see 21.2.1 – 21.2.5). Each sample shall be operable, and the average time of operation shall not increase more than a 1.3 multiple when compared to the average time of samples not subjected to the High Temperature Exposure Test (90 Day).

24.1 revised June 3, 2014

Table 24.1
High-temperature exposure test conditions

Spray nozzle temperature rating		High ambient test temperature	
°F	(°C)	°F	(°C)
135 – 140	(57 – 60)	120	(49)
145 – 170	(63 – 77)	125	(52)
175 – 225	(79 – 107)	175	(79)
250 – 300	(121 – 149)	250	(121)
325 – 375	(163 – 191)	300	(149)
400 – 475	(204 – 246)	375	(191)
500 – 575	(260 – 302)	475	(246)

24.2 An automatically-controlled, circulating-type, constant-temperature oven is to be used for this test. Five automatic nozzles of each operating temperature are to be placed in an oven at the specified test temperature.

25 High Temperature Exposure – Test for Wax Coated Nozzles

25.1 A wax coated automatic nozzle shall withstand for 90 days, without evidence of deterioration or malfunction, an exposure to a high-ambient temperature as specified in Table 24.1, or 20°F (11°C) below the rated operating temperature of the samples (whichever is the lower temperature), and not less than 120°F (49°C). Following the exposure, the coating shall not show evidence of deterioration such as cracking, flaking, or flowing. The nozzle then is to be subjected to the Sensitivity – Oven Heat Test (see 21.2.1 – 21.2.5).

25.1 revised February 24, 2009

25.2 An automatically-controlled, circulating-type, constant-temperature oven is to be used for this test. Five automatic nozzles with each type of coating are to be placed in the oven at the specified test temperatures.

25A Heat Resistance Test

25A.1 A nozzle without operating parts shall withstand the exposure to heat and subsequent immersion in water as described in 25A.2 without signs of significant deformation, blistering or fracture.

Added 25A.1 effective June 3, 2016

25A.2 A sample nozzle, without operating parts, shall be placed in an oven or furnace on its inlet and heated to a temperature of 1200 ± 20°F (650 ± 10°C) for a period of 15 minutes. Following the exposure, the nozzle shall be removed from the oven by holding the inlet portion of the nozzle, when possible, with tongs or a similar device and submersing the sample in a water bath having a temperature of 60 ±10°F (15 ±6°C).

Added 25A.2 effective June 3, 2016

26 Strength of Frame Test

26.1 An automatic nozzle frame shall not show permanent distortion in excess of 0.2 percent of the distance between its bearing points when subjected to a test loading of twice its assembly load at rated hydrostatic pressure.

26.2 The distance between load-bearing points is to be measured to the nearest 0.001 inch (0.03 mm) from the plane of the nozzle-orifice outlet at the center of the orifice to the center of the compression bearing surface.

26.3 At least ten nozzles are to be individually installed in a test apparatus that applies a load to the upper compression bearing surface. A measuring instrument is to be attached to indicate the amount of deflection at the deflector end of the nozzle frame.

26.4 The heat responsive element of the sample is to be carefully removed without damaging the frame. The negative deflection, due to release of the assembly load, is to be recorded. A load is then to be applied to redeflect the nozzle at a rate of 0.02 inch (0.51 mm) per minute until the deflection returns to zero. The load at zero deflection is to be recorded as the assembly load. An alternative means to measure the nozzle assembly load shall be permitted to be used when determined to provide equivalent or more accurate results.

26.4 revised June 3, 2014

26.5 A load of twice the assembly load at rated pressure is then to be applied to the individual sample. The deflection during the load application and the amount of permanent set after the load application are to be determined to verify compliance with the requirements in 26.1.

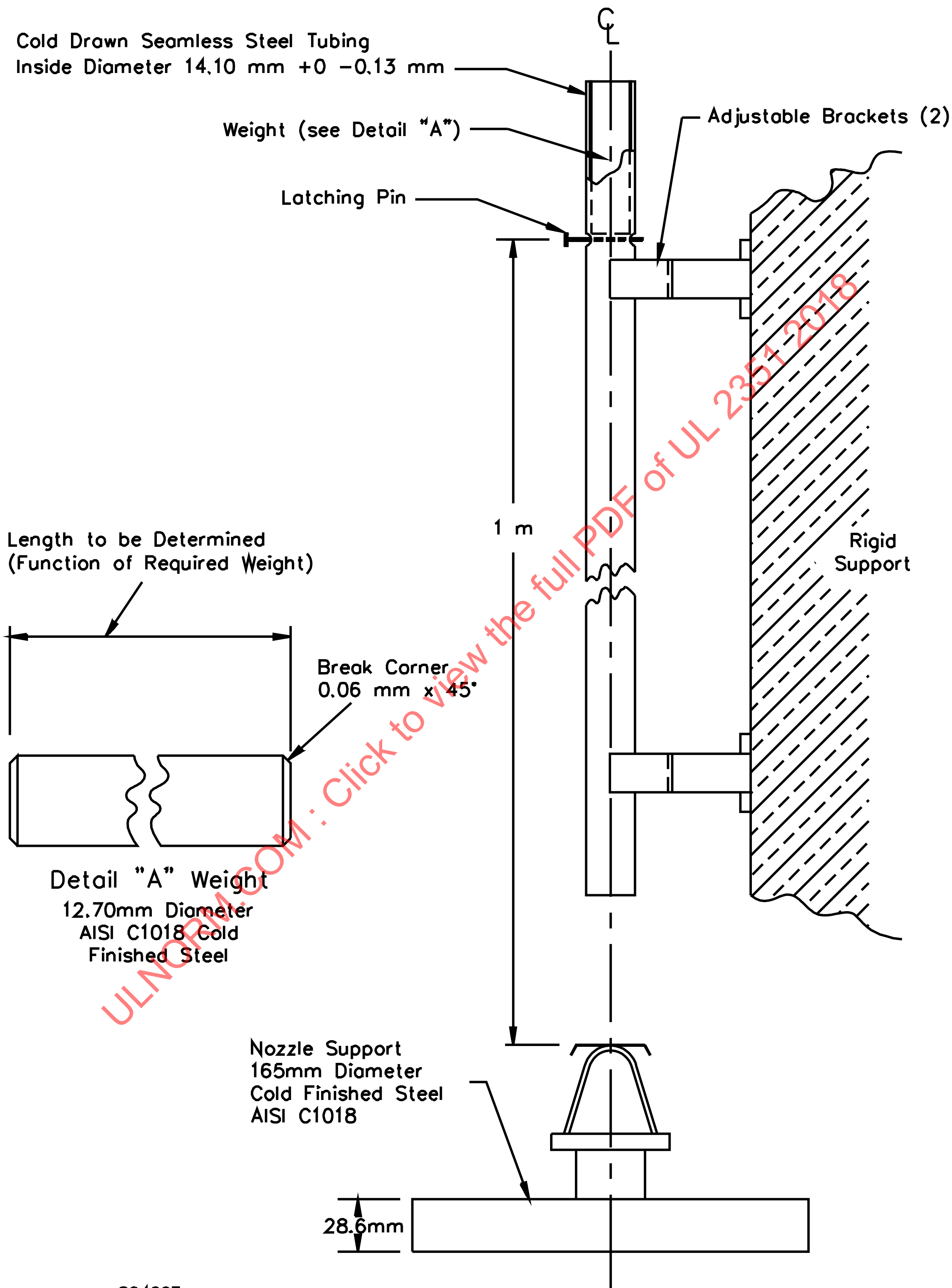
27 Impact Resistance Test

27.1 An automatic nozzle shall not be damaged or leak when tested as described in 27.2. See Figure 27.1.

27.2 Five sample nozzles are to be tested by dropping a cylindrical mass equivalent to the mass of the nozzle to the nearest 15-g increment from a height of one meter onto the geometric center of the deflector. The mass is to be prevented from impacting more than once upon each sample. Following the impact, each nozzle is to be visually examined and there shall be no evidence of cracks, breaks, or any other damage. Each sample nozzle shall be subjected to the Leakage Test, Section 16, followed by the Sensitivity – Oven Heat Test, see 21.1 – 21.2.5.

Revised 27.2 effective June 3, 2016

Figure 27.1
Impact test apparatus



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28 Rough Usage Test

28.1 An automatic nozzle shall withstand the effects of rough usage without deterioration of its performance characteristics. Following three minutes of tumbling as described in 28.3, the nozzle shall comply with the Leakage Test, Section 16, and the Sensitivity Tests, Section 21.

28.2 Five sample nozzles are to be tested. The nozzles are to be tested with shipping protector in place, when the protector is intended to be removed from the nozzle after the nozzle is installed and reference to this removal requirement is made in the installation instructions.

28.3 Five samples are to be individually placed in a vinyl-lined right hexagonal prism-shaped drum[a] designed to provide a tumbling action. The drum is to have an axis of rotation of 10 inches (254 mm). The distance between opposite sides is to be 12 inches (305 mm). For each test, one sample and five 1.5 inch (38.1 mm) hardwood cubes are to be placed in the drum. The drum is to be rotated at 1 revolution per second for 3 minutes. The sample is to be removed from the drum, examined for signs of damage, and then subjected to the Leakage Test, Section 16, and to the Sensitivity Tests, Section 21.

[a]A drum intended for use with this test is available from Kramer Industries, Inc., Copiague, NY 11726, Model K1401.

28.3 revised February 24, 2009

29 Vibration Test

29.1 An automatic nozzle shall withstand the effects of vibration without deterioration of its performance characteristics. The nozzle is to be subjected to vibration of 0.04 inch (1.0 mm) amplitude for 120 hours at a frequency that is continuously varied between 18 – 37 Hertz. However, when the nozzles exhibit resonance at a frequency within the range of 18 – 37 Hertz, the resonant frequency is to be used for the entire test period. Following the vibration test, the nozzle shall comply with the Leakage Test, Section 16. In addition, the nozzle shall operate as intended when subjected to the Sensitivity – Oven Heat Test (see 21.2.1 – 21.2.5).

29.2 Five nozzle samples are to be threaded into the pipe couplings on a steel mounting plate, and the plate is to be bolted to the table of a vibration machine so that the nozzles are mounted vertically. The test nozzles then are to be vibrated in the vertical direction.

29.3 This test is to be conducted with the test nozzles unpressurized.

29.4 For this test, amplitude is defined as the maximum displacement of sinusoidal motion from position of rest to one-half of the total table displacement; resonance is defined as the maximum magnification of the applied vibration.

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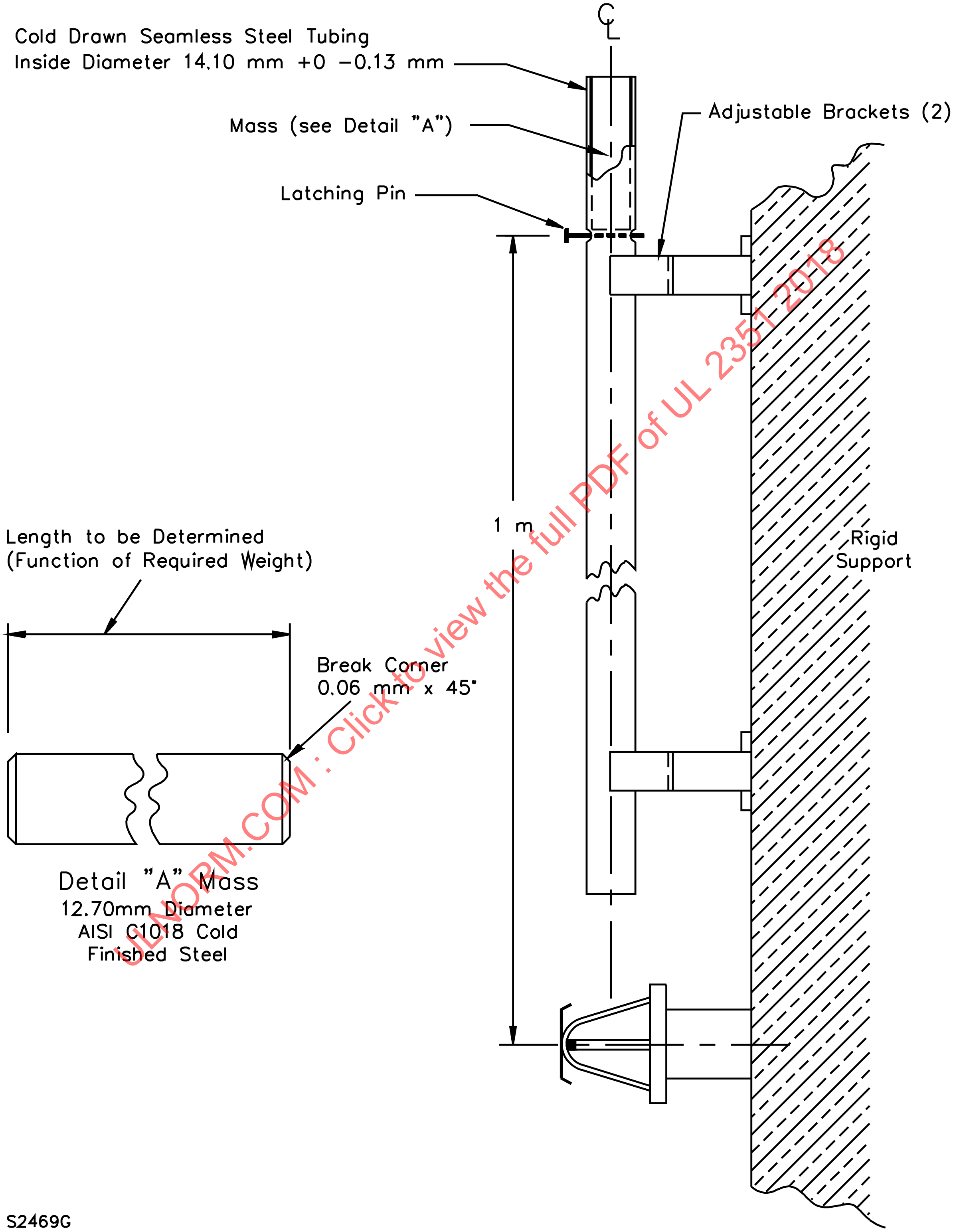
30 Impact Test for Protective Covers

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 as described in 30.2. See Figure 30.1.

30.1 effective December 4, 2005

Figure 30.1
Impact test apparatus for protective covers

Figure 30.1 effective December 4, 2005



30.2 Five sample automatic nozzles having glass bulb heat responsive elements with their protective covers are to be mounted in the horizontal position and impacted with a cylindrical mass equivalent to the mass of the nozzle to the nearest 15-gram increment from a height of one meter onto the geometric center of the glass bulb heat responsive element. Five additional samples are to be tested with the impact applied to the opposite side of the nozzle if the cover is designed to provide unsymmetrical protection. If the glass bulb extends beyond the perimeter of the nozzle deflector, an additional five samples are to be mounted in the vertical position and impacted with the same cylindrical mass from a height of one meter onto the geometric center of the glass bulb heat responsive element. The mass is to be prevented from impacting more than once upon each sample. Following the impact, each nozzle is to be visually examined and there shall be no evidence of cracks, breaks, or any other damage to the glass bulb. Each sample nozzle shall then be subjected to the Leakage Test, Section 16, followed by the Sensitivity – Oven Heat Test, see 21.2.

30.2 revised June 3, 2014

31 Calibration Test

31.1 Each K-factor value shall be ±5% or ±0.2 units (gpm/(psi)$^{1/2}$) of the K-factor marked on the nozzle, whichever is greater, when tested in accordance with 31.2 – 31.3.

Revised 31.1 effective June 3, 2016

31.2 The nozzle is to be installed on an outlet from a reservoir sized so that the velocity head effect ($V^2/2g$) is reduced to approach a velocity of zero. The outlet is to consist of a pipe coupling of a size corresponding with the size of the nozzle thread (1/2, 3/4 or 1 inch NPT), as described in the Standard for Pipe Threads, General Purpose (Inch), (Revision and Redesignation of ASME/ANSI B2.1) ASME B1.20.1. For nozzles having a nominal ″K″ factor of 8 or less, the coupling is to be installed in the reservoir by positioning the coupling in a hole so that the inlet to the coupling protrudes into the interior of the reservoir 1/8-inch (3.2-mm) or more. See Figure 31.1 as an example of the apparatus. For nozzles having a nominal ″K″ factor greater than 8, the outlet shall consist of a nominal six-inch blank flange drilled threaded to the appropriate thread size, and attached to a six-inch pipe. See Figure 31.2 for an example of this apparatus.

Figure 31.1
Calibration test equipment

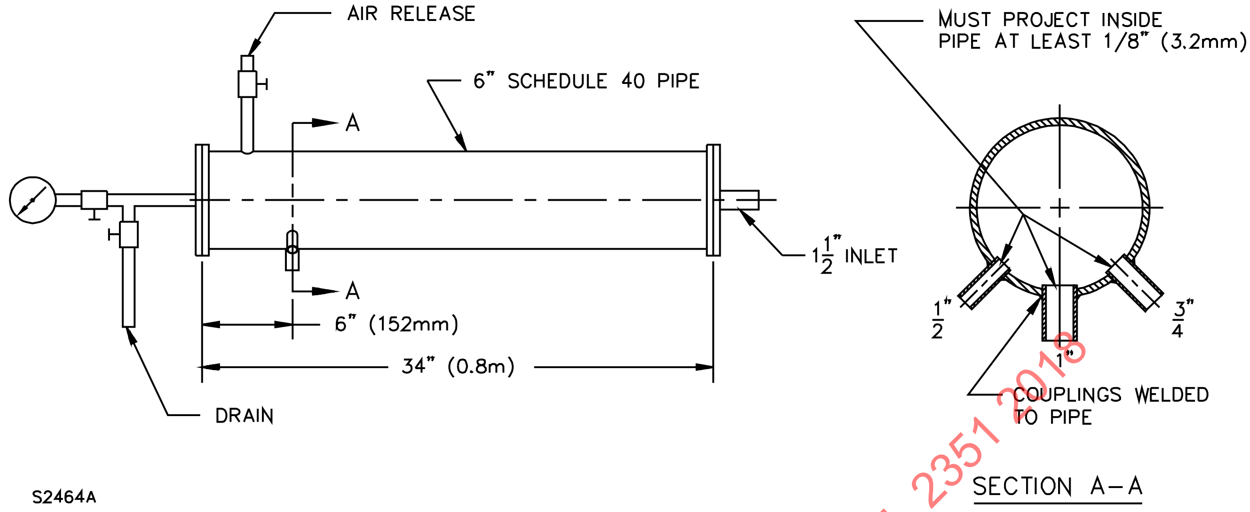
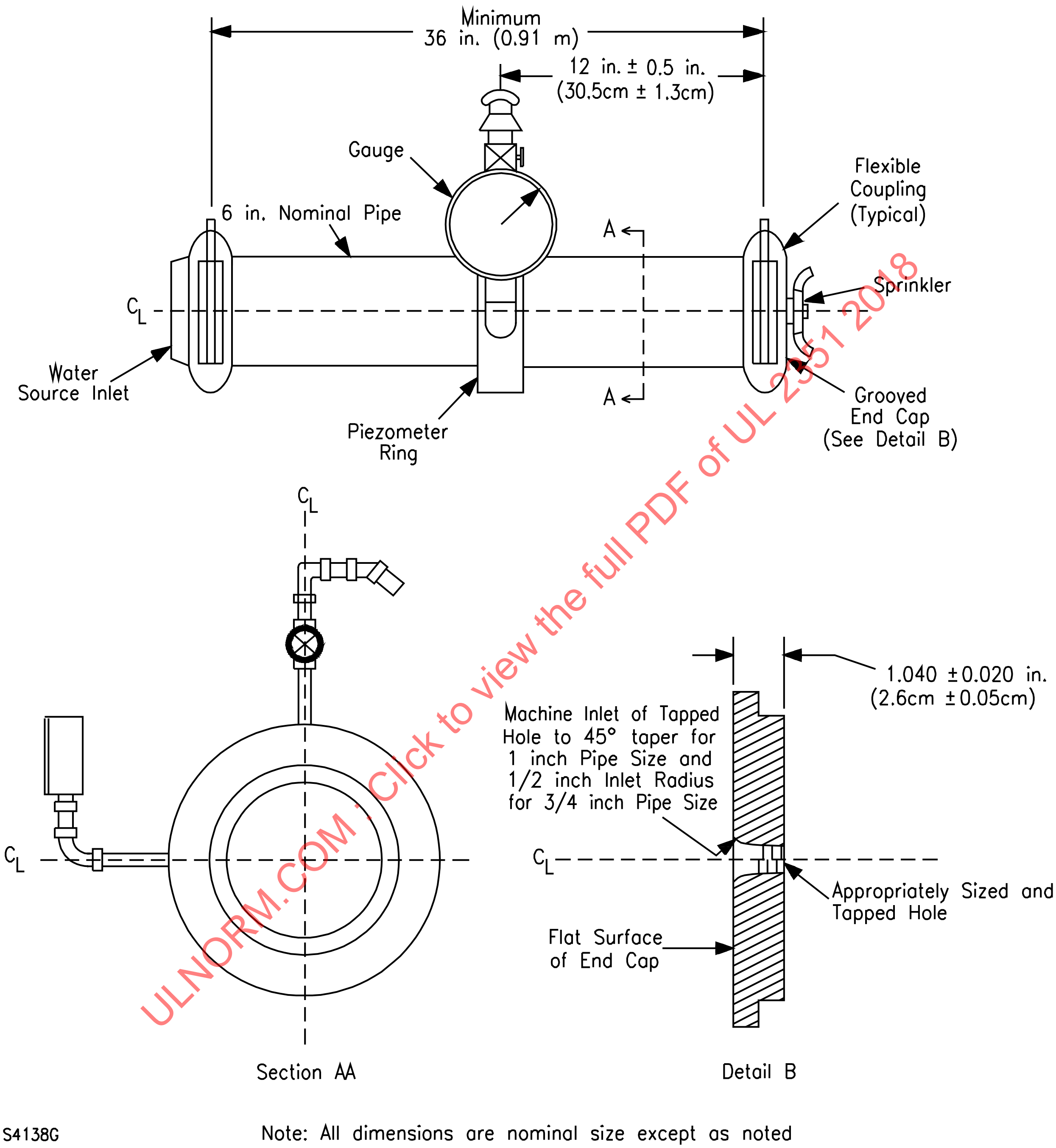


Figure 31.2

Calibration test equipment for nozzles with ″K″ factors greater than 8

Figure 31.2 revised February 24, 2009



Note: All dimensions are nominal size except as noted

31.3 The sample is to be flow tested first at a pressure of 7 psig (0.48 bar) and then at 10 psig (0.69 bar). Following this flow test, the pressure is to be:

a) Increased in 5 psig (0.34 bar) increments to 50 psig (3.45 bar), in 10 psig (0.69 bar) increments to 75 psig (5.17 bar) less than the rated pressure;

b) Decreased in 10 psig (0.69 bar) increments to 50 psig (3.45 bar), in 5 psig (0.34 bar) increments to 10 psig (0.69 bar); and then

c) Decreased to 7 psig (0.48 bar).

The flow at each increment of pressure is to be measured by a flow-measuring device having an accuracy of within 2 percent of the actual flow. The discharge coefficient ″K″ is to be calculated by dividing the flow in gallons per minute (L/S × 15.85) by the square root of the pressure in psig (bar × 14.5). Discharge coefficient ″K″ is then to be calculated.

32 Distribution Test

Section 32 revised and relocated as Section 32A

32A Distribution Test

32A.1 General

32A.1.1 A spray nozzle shall produce a spray angle within ± 6 degrees of the manufacturer's published water discharge angles and, when specified in the installation instructions, the average water collection density within the coverage area shall be within ±15 percent of the published water density and the discharge collection patterns shall be within ±12 inches (305 mm) when comparing the published characteristic spray pattern, when tested as described in 32A.1.2 – 32A.3.1. Other methods of determining nozzle discharge patterns are permitted to be used provided the same level of accuracy is maintained.

32A.1.1 added June 3, 2014

32A.1.2 For a nozzle intended to be installed at various orientation positions, the nozzle shall be tested at 0 degrees (vertically downward), using the test methods described in 32A.2.1 and at orientation angles of 120, 135, 150, and 180 degrees (vertically upward) using the test methods described in 32A.3.1. A sidewall nozzle shall be tested at 90 degrees using the test method described in 32A.2.1.

32A.1.2 added June 3, 2014

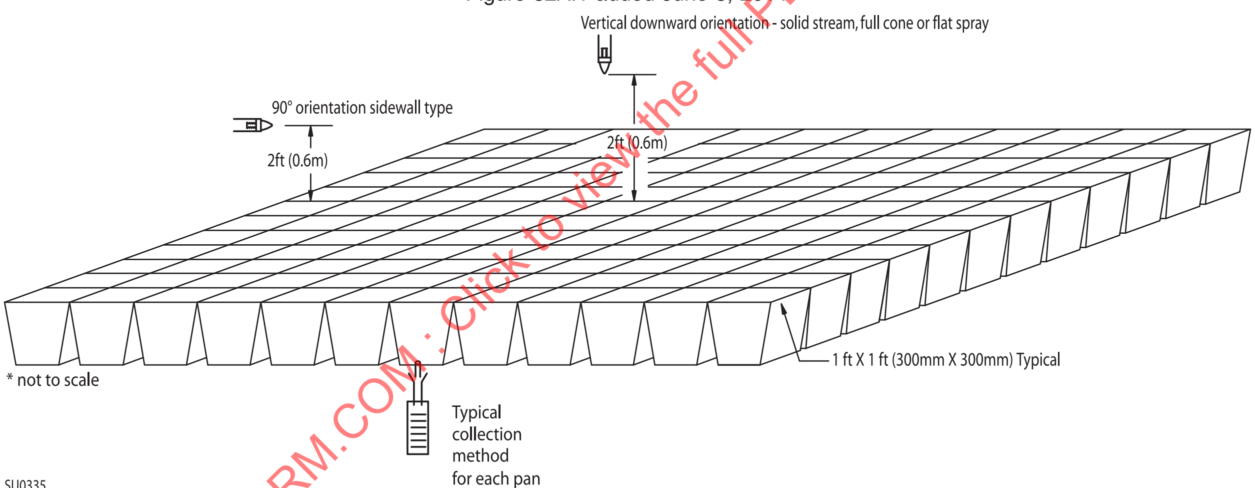
32A.2 Water Collection

32A.2.1 An open spray nozzle is to be supplied with water at the minimum and maximum discharge pressure, through a 1 inch (25.4 mm) size tee fitting. The outlet is to be the same size as the inlet threads of the nozzle for nozzles with inlet threads 1 inch (25.4 mm) and smaller. Tee fittings are to be the same size as the nozzle inlet threads for nozzles with inlet threads larger than 1 inch (25.4 mm). The nozzle is to be positioned at distances of 2 feet (0.6 m) and at a maximum installation height, ″x″, referenced in the manufacturer's installation instructions, above an array of 1 by 1 foot (305 by 305 mm) square collection pans as shown in Figure 32A.1. Water is to be collected in a large enough area such that at least one row of perimeter collection pans has no pans with more than a trace amount of water collected after the termination of the water discharged from the nozzle. The nozzle can optionally be positioned in a location other than the center of the collection pans to measure the discharge within the coverage area. After a ten-minute discharge, or less if any collection pan is filled to its capacity, the water collection is to be measured, the nozzle or collection pans shall be rotated 90 degrees for nozzles other than the sidewall type, and the test repeated. The water distribution is to be determined by measuring the water collected in each pan compared to the manufacturer's installation instructions.

32A.2.1 added June 3, 2014

Figure 32A.1
Collection pan array

Figure 32A.1 added June 3, 2014



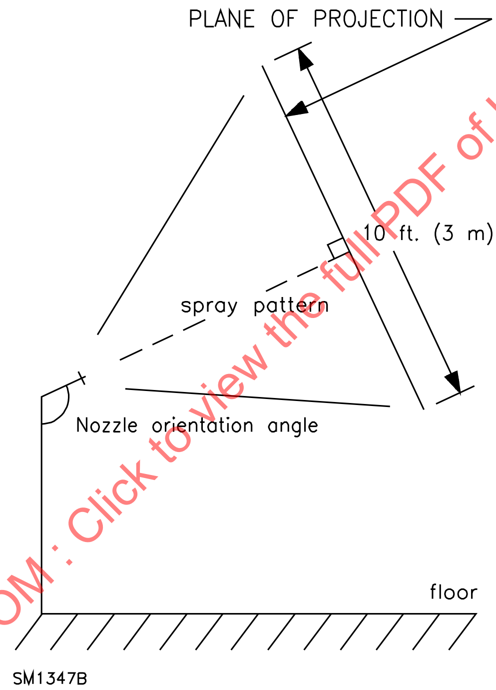
32A.3 Spray Angle Determination

32A.3.1 An open spray nozzle is to be supplied with water at the minimum and maximum discharge pressure, through a 1 inch (25.4 mm) size tee fitting. The outlet is to be the same size as the inlet threads of the nozzle for nozzles with inlet threads 1 inch (25.4 mm) and smaller. Tee fittings are to be the same size as the nozzle inlet threads for nozzles with inlet threads larger than 1 inch (25.4 m). The nozzle is to be positioned at distance of 2 feet (0.6 m) from a 10 by 10 foot (3 by 3 m) dry surface (plane of protection), with the plane of protection positioned perpendicular to the line between the nozzle and this plane. See Figure 32A.2. Water from the nozzle is to be discharged for at least 30 seconds or the time required to exhibit a characteristic spray pattern. The spray angle and pattern, as determined by visually observing the wetted surface of the plane, is to be compared to the manufacturer's installation instructions. The nozzle can optionally be positioned at a location other than the center of the plane of protection to measure the spray angle. The nozzle is then to be positioned 10 feet (3 m) or the maximum distance specified in the manufacturer's instructions, whichever is less, and observations made for impingement of water on the plane of protection.

32A.3.1 added June 3, 2014

Figure 32A.2
Open spray nozzle, plane of protection

Figure 32A.2 added June 3, 2014



33 10-Day Corrosion Test

33.1 The external parts of an automatic nozzles shall withstand an exposure to salt spray, hydrogen sulfide, and carbon dioxide-sulfur dioxide atmospheres when tested in accordance with 34.1.4 – 34.5.1 for 10 days each. Following the exposure, the Sensitivity – Oven Heat Test, 21.2, is to be conducted on the nozzles.

33.2 Each sample shall be operable, and the average time of operation shall not increase more than a 1.3 multiple when compared with the average time of operation of samples not subjected to the 10-Day Corrosion Test. During the corrosive exposure, the inlet thread orifice is to be sealed by a plastic cap after the nozzle has been filled with de-ionized water.

33.3 Deleted February 24, 2009

34 30-Day Corrosion Test

34.1 General

34.1.1 The external parts of an automatic nozzle having a corrosion-resistant coating or plating shall withstand an exposure to salt spray, hydrogen sulfide, and carbon dioxide-sulfur dioxide atmospheres when tested in accordance with 34.1.3 – 34.5.1 for 30 days. Following the exposure, the Sensitivity – Oven Heat Test (see 21.2.1 – 21.2.5) is to be conducted. Each sample shall be operable, and the average time of operation shall not increase more than a 1.3 multiple when compared to the average time of samples not subjected to the 30-Day Corrosion Test.

34.1.1 revised June 3, 2014

34.1.2 Deleted February 24, 2009

34.1.3 Not more than 5 days, nor less than 1 day, after the exposure period, each sample nozzle shall be subjected to the Sensitivity – Oven Heat Test (see 21.2.1 – 21.2.5) for determination of its operating time.

34.1.4 Three groups, each consisting of five sample nozzles, are to be assembled. One group is to be exposed to 20 percent salt spray, the second to hydrogen sulfide, and the third to sulfur dioxide-carbon dioxide. During the corrosive exposure, the inlet thread orifice is to be sealed by a plastic cap after the nozzle has been filled with de-ionized water.

34.1.4 revised June 3, 2014

34.1.5 CAUTION – Hydrogen sulfide and sulfur dioxide are both toxic gases. Hydrogen sulfide gas is also flammable. Therefore, such gases must be stored, transferred, and used only with gas-tight systems. Adequate ventilation must also be supplied to handle any accidental leakage. Presence of these gases is readily noticeable. Due to their unpleasant odor and irritant effect, they give warning of their presence.

34.2 Salt spray

34.2.1 The samples are to be supported vertically and exposed to salt spray (fog) as specified in Standard Practice for Operating Salt Spray (Fog) Testing Apparatus, ASTM B117, except that the salt solution is to consist of 20 percent by weight common salt (sodium chloride).

34.2.1 revised February 24, 2009

34.3 Samples for moist hydrogen sulfide air mixture test and moist carbon dioxide-sulfur dioxide air mixture test

34.3.1 Deleted February 24, 2009

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34.4 Moist hydrogen sulfide air mixture

34.4.1 The samples are to be supported vertically and exposed to a moist hydrogen sulfide air mixture in a closed glass chamber maintained at 75 ±5 °F (24 ±3 °C). 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 remaining gas-air mixture from the previous day 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 occur. 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 m^3 of chamber volume) shall be maintained at the bottom of the chamber for humidity.

34.4.1 revised February 24, 2009

34.5 Moist carbon dioxide-sulfur dioxide air mixture

34.5.1 The samples are to be supported vertically and exposed to a moist carbon dioxide-sulfur dioxide air mixture in a closed glass chamber maintained at 75 ±5 °F (24 ±3 °C). 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 out of every seven that this does not occur, the chamber is to remain closed and no purging or introduction of gas is to occur. A small amount of water (10-ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

34.5.1 revised February 24, 2009

35 90-Day Moist Air Test

35.1 An automatic nozzle shall withstand an exposure to high temperature-humidity in accordance with 35.2 for a period of 90 days. Following the exposure, each test sample shall operate at a service pressure not exceeding 7 psig (0.48 bar) within 5 seconds after operation of the heat responsive element.

35.2 Five samples are to be installed on a pipe manifold that contains water and the entire manifold is to be placed in a temperature-humidity chamber for 90 days. The temperature of the chamber is to be 203 ±2°F (95 ±1°C) and the humidity is to be 98 ±2 percent. The nozzle samples for the moist air test are to have heat responsive elements that have a temperature rating to withstand the elevated temperature.

35.2 revised February 24, 2009

35.3 After the exposure, each sample is to be installed on piping and supplied with water at a service pressure of 7 psig (0.48 bar). Each nozzle is then to be activated by exposing the heat responsive element to a uniform application of heat. The operating parts intended to be released from the nozzle assembly shall be thrown clear of the frame and deflector within 5 seconds after operation of the heat responsive element.

36 Stress-Corrosion Cracking Of Brass Nozzle Parts Test

36.1 After being subjected for 10 days to a moist ammonia exposure as described in 36.2 and 36.3, a nozzle having brass parts shall:

a) Show no evidence of cracking, delamination, or degradation; and

b) Perform as intended.

36.1 revised February 24, 2009

36.2 Five samples without any plating or coating are to be degreased and then exposed for 10 days to a moist ammonia-air mixture maintained in a glass chamber having a glass cover.

36.2 revised February 24, 2009

36.3 A sufficient amount of aqueous ammonia to cover the bottom of the chamber and having a specific gravity of 0.94 is to be maintained during the test. The lowest portion of the samples are to be positioned 1.5 +0.5, -0 inches (38.1 +12.7 mm, -0 mm) above the liquid surface and supported on an inert tray. The moist ammonia-air mixture in the chamber is to be maintained at atmospheric pressure with the temperature constant at 93 ±2°F (34 ±1°C).

36.3 revised June 3, 2014

36.4 After the exposure period, the test samples are to be examined using a microscope having a magnification of 25× for any cracking, delamination or other degradation as a result of the test exposure. Operating parts exhibiting degradation as a result of the test exposure described in 36.2 and 36.3 shall withstand, without leakage, a hydrostatic test pressure of 175 psig (12.1 bar) or one equivalent to their maximum design pressure, whichever is greater, for 1 minute, and operate at 7 psig (0.48 bar) when exposed to a uniform application of heat. When the samples have any cracking, delamination, or degradation of non-operating parts as a result of the test exposure, they shall withstand the forces of flowing water at the rated pressure for 30 minutes.

36.4 revised June 3, 2014

37 Stress-Corrosion Cracking of Stainless Spray Nozzle Parts Test

37.1 Austenitic stainless steel parts of a nozzle shall show no evidence of cracking, delamination, or degradation, or shall demonstrate intended performance, after being subjected to boiling magnesium chloride solution. The exposure to the solution is to be 150 hours for nozzles intended for normal use and 500 hours for nozzles having stainless steel parts not protected by a corrosion resistant coating when intended for use in corrosive atmospheres. See 37.2 – 37.7.

37.1 revised February 24, 2009

37.2 Five samples without any plating or coating are to be degreased prior to being exposed to the magnesium chloride solution.

37.2 revised February 24, 2009

37.3 Parts used in nozzles are to be placed in a sealed glass chamber that is fitted with a thermometer and a wet condenser. The flask is to be filled one-half full or to a level at least 0.5 inches (1.27 cm) above the test sample with a nominal 44 percent by weight magnesium chloride solution, placed on a thermostatically-controlled electrically heated mantel, and maintained at a boiling temperature of 302 ±2°F (150 ±1°C). The parts are to be unassembled, that is, not contained in a nozzle assembly. The exposure is to last for 150 or 500 hours, as specified in 37.1.

37.3 revised June 3, 2014

37.4 After the exposure period, the test samples are to be removed from the boiling magnesium chloride solution and rinsed in de-ionized water.

37.5 The test samples are then to be examined using a microscope having a magnification of 25× for any cracking, delamination, or other degradation as a result of the test exposure. Test samples exhibiting degradation are to be tested as described in 37.6 or 37.7, as applicable. Test samples not exhibiting degradation comply with the requirements and shall not be tested further.

37.6 Operating parts exhibiting degradation are to be reassembled into the nozzle or, if this is not possible, new parts tested as follows. 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 37.3. Following the exposure, the test samples shall withstand, without leakage, a hydrostatic test pressure at their rated pressure for 1 minute, and then operate at 7 psig (0.48 bar) – see Operation – Lodgement Test, Section 22.

37.6 revised June 3, 2014

37.7 Non-operating parts exhibiting degradation are to be reassembled into the nozzle or, if this is not possible, new parts tested as follows. 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 37.3. Following the exposure, the test samples shall withstand a flowing pressure of 175 psig (12.1 bar) for 30 minutes without separation of permanently attached parts.

37.7 revised February 24, 2009

38 Dezincification Test of Brass Parts

38.1 General

38.1.1 Automatic nozzle parts that are made of a copper alloy containing more than 15 percent zinc and normally exposed to system water are not to 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).

38.1 relocated as 38.1.1 February 24, 2009

38.2 Reagent

38.2.1 A test solution is to be prepared by dissolving 12.7 g (0.028 pound) of copper (II) chloride dihydrate ($CuCl_22H_20$) in distilled water and then making up the volume to 1000 ml (0.26 gallon). Fresh solution is to be used for each test.

38.2.1 added February 24, 2009

38.3 Test Pieces

38.3.1 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 of the test pieces to be exposed shall be approximately 100 mm^2(0.155 in^2).

38.3.1 added February 24, 2009

38.3.2 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.

38.3.2 added February 24, 2009

38.4 Method

38.4.1 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 mm^2(0.155 in^2) of exposed surface of the test piece.

38.4.1 added February 24, 2009

38.4.2 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.

38.4.2 added February 24, 2009

38.4.3 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 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.

38.4.3 added February 24, 2009

38.4.4 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 not 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.

38.4.4 added February 24, 2009