JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL/ULC 2351:2023

STANDARD FOR SAFETY

Spray Nozzles for Fire-Protection Service

ANSI/UL 2351-2023

SCC FOREWORD

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UL Standard for Safety for Spray Nozzles for Fire-Protection Service, ANSI/CAN/UL/ULC 2351

Third Edition, Dated December 13, 2023

Summary of Topics

These new edition of ANSI/CAN/UL/ULC 2351 dated December 13, 2023 is to harmonize UL 2351 and ULC/ORD-C2351 and to reflect the latest ANSI and SCC approval dates and to incorporate the proposal dated May 26, 2023.

The requirements are substantially in accordance with Proposal(s) on this subject dated May 26, 2023.

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ANSI/CAN/UL/ULC 2351:2023

Standard for Spray Nozzles for Fire-Protection Service

First Edition – July, 2000
Second Edition – June, 2004

Third Edition

December 13, 2023

This ANSI/CAN/UL/ULC Safety Standard consists of the Third Edition.

The most recent designation of ANSI/UL 2351 as an American National Standard (ANSI) occurred on December 13, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This Standard has been designated as a National Standard of Canada (NSC) on December 13, 2023.

No Text on This Page

CONTENTS

Preface

This is the Third Edition of ANSI/CAN/UL/ULC 2351, Standard for Spray Nozzles for Fire-Protection Service.

ULSE is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO). ULC Standards is accredited by the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization.

This ANSI/CAN/UL/ULC 2351 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

Annexes A and B, identified as Informative, are for information purposes only.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

This joint American National Standard and National Standard of Canada is based on, and now supersedes, the Second Edition of UL 2351 and the First Edition of ULC/ORD-C2351-03.

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

This Edition of the Standard has been formally approved by the Technical Committee (TC) on Sprinkler Equipment For Fire Protection, TC 199.

This list represents the TC 199 membership when the final text in this Standard was balloted. Since that time, changes in the membership may have occurred.

TC 199 Membership

Name	Representing	Interest Category	Region
Joe Beagen	Flexhead Industries Inc.	Producer	USA
Kerry M. Bell	UL Solutions	Testing & Stds Org	USA
Art Black	Carmel Fire Protection Associates	AHJ	USA
Dale Bonn	Travelers Insurance	General Interest	USA
Chase Browning	Medford Fire Rescue	AHJ	USA

TC 199 Membership Continued on Next Page

TC 199 Membership Continued

Name	Representing	Interest Category	Region
Ken Bush	Maryland State Fire Marshal's Office	AHJ	USA
Ronnie Conklin	Fort Worth Fire Department	AHJ	USA
Diane J. Haithcock	UL Standards & Engagement	TC Chair	USA
Kevin Hall	American Fire Sprinkler Association	General Interest	USA
Mohamed Seyed Ibrahim	Sibca Electronic Equipment LLC	Supply Chain	United Arab Emirates
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This Standard is intended to be used for conformity assessment.

The intended primary application of this Standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE

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 Where values of measurement are specified in both SI and U.S. Customary units, it is the responsibility of the user of this Standard to determine the unit of measurement appropriate for the user's needs.

4 Referenced Publications

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.

4.2 The following publications are referenced in this Standard:

ASME B1.20.1, *Standard for Pipe Threads, General Purpose (Inch)*

ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

NFPA 13, *Standard for the Installation of Sprinkler Systems*

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*

UL 157, *Gaskets and Seals*

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

5.5 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 0.5 °C (1 °F) 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 24.

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).

6.2 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.

7 Inlet Threads

7.1 Nozzles shall be provided with not less than 10 mm (1/4 inch) external NPT pipe threads at the inlet that comply with 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.

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.

Table 8.1
Temperature Classification Ratings and Color Coding

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.

10 Pressure Rating – General

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

11 Strainer

11.1 A nozzle having a water passageway less than 5 mm (3/16 inch) 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.

12 Protective Covers

12.1 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.

12.2 Automatic nozzles required to be equipped with protective covers shall comply with Section 34, Impact Test for Protective Covers, and 51.2.

PERFORMANCE

13 General

13.1 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 15 – 47.

14 Samples

14.1 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.

15 Load on Heat Responsive Element

15.1 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 16.

15.2 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.

16 Strength of Heat Responsive Element Test

16.1 Fusible-alloy types

16.1.1 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 16.1.2 and 16.1.3.

16.1.2 Compliance with 16.1.1(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.

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

16.2 Glass-bulb types

16.2.1 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.

16.2.2 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 25 kg/s (55 pounds-force) load per second or at a rate that deflects the bulb 0.51 mm (0.02 inch) 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 Annex A – Tolerance Limit Calculation Method.

16.2.3 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.

17 Glass-Bulb Thermal Shock Test

17.1 An automatic nozzle having a glass bulb shall withstand the thermal shock of rapid temperature changes when tested as specified in 17.2 without breakage or fracture of the glass bulb.

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

18 Leakage Test

18.1 When tested as described in 18.2 and 18.3, an automatic nozzle shall not exhibit leakage at any pressure from 0 psig to the applicable leakage test pressure shown in Table 8.1.

Table 18.1
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)

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

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

19 Hydrostatic Strength Test

19.1 An automatic nozzle shall withstand, for 1 minute, without rupture, an internal hydrostatic pressure equal to the hydrostatic test pressure shown in Table 18.1.

19.2 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 bar (0 psig) to the hydrostatic test pressure shown in Table 18.1 at a rate not exceeding 20.7 bar (300 psig) 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.

20 30-Day Leakage Test

20.1 When tested as described in 20.2 and 20.3, an automatic nozzle shall:

a) Experience no leakage when subjected to the 30 day test pressure specified in Table 20.1 for 30 days;

b) Not leak when subjected to the leakage test pressure specified in Table 18.1 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 20.1
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)

20.2 Five samples are to be installed on a water-filled test line maintained under a constant test pressure as specified in Table 20.1 for 30 days. The samples are to be examined weekly during the test period for evidence of leakage of water at the closure cap.

20.3 Following completion of this 30-day test period, the samples are to be subjected to the leakage test specified in 18.1. The samples shall be examined for distortion or mechanical damage.

21 Water Hammer Test

21.1 When tested as described in 21.2 and 21.3, 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 21.1;

b) Not leak when subjected to the Leakage Test specified in Table 18.1 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.

Table 21.1
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)

21.2 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 21.1, 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.

21.3 Following completion of the pressure cycling, the samples are to be subjected to the leakage test as specified in 18.1. The samples are then to be examined for distortion or mechanical damage.

22 Operating Temperature (Bath) Test

22.1 The operating temperature of automatic nozzles, when tested as described in 22.2 – 22.7, shall be within a maximum temperature range as follows:

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

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

For the purpose of this determination for nozzles rated 204 °C (400 °F) 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 22.2.

22.2 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 23.

22.3 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 0.31 ±0.034 bar (4.5 ±0.5 psig).

22.4 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.

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

22.6 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.

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

23 Air Bath Test for Glass Bulb Nozzles

23.1 When a partial fracture of a glass bulb occurs during the Operating Temperature (Bath) Test, Section 22, nozzles with a glass bulb heat responsive element shall fully operate when subjected to the air bath test described in 23.2.

23.2 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 11 ±1.1 °C (20 ±2 °F) 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 0.5 ±0.3 °C (1 ±0.5 °F) 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.

24 Sensitivity Tests

24.1 General

24.1.1 An automatic nozzle shall comply with the following requirements:

a) 24.2.1 for quick response (QR) nozzles;

b) 24.2.2 for standard response nozzles.

24.1.2 A coating shall not remain on nozzle parts in a manner that impairs operation or distribution at the time of nozzle operation in 24.2 and 24.3.

24.2 Sensitivity – oven heat test

24.2.1 A QR nozzle shall have a maximum operating time specified in Table 24.1 for each sample when tested in the sensitivity test oven as specified in 24.2.3 – 24.2.5. If the nozzle temperature rating is not shown in Table 24.1, the maximum operating time for each sample shall be determined by using the formula specified in 24.2.6 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.

24.2.2 A standard response nozzle shall operate within the time range specified in Table 24.1 for each sample nozzle when tested in the oven heat test as specified in 24.2.3 – 24.2.5. If the nozzle temperature rating is not shown in Table 24.2, the minimum and maximum operating time range for each sample shall be determined by using the formula specified in 24.2.6, 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 630 $(ft \cdot s)^{1/2}$ [350 $(m \cdot s)^{1/2}$] for the maximum value, and the marked temperature rating of the nozzle.

Table 24.1
Operating Time for Nozzles in Sensitivity-Oven Heat Test

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 24.2.1.

Table 24.2
Sensitivity Oven Temperatures

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)

24.2.3 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 25.4 mm (1 inch) 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

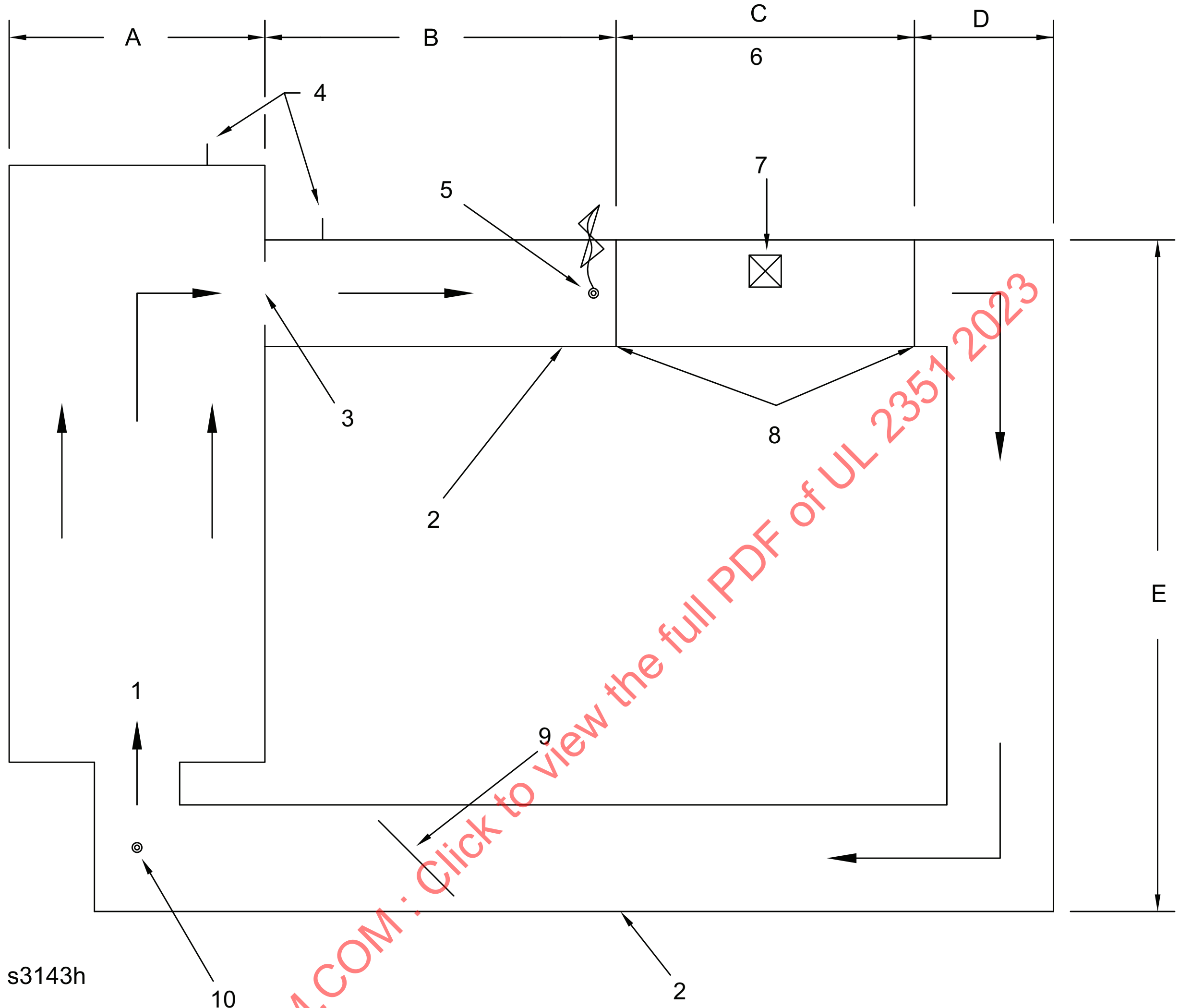
c) For nozzle designs incorporating frame arms with symmetrical heat responsive elements, ten samples are to be orientated in the pendent position with the frame arms in a plane perpendicular to the direction of air flow.

24.2.4 The samples are to be conditioned at 21 ±5 °C (70 ±9 °F) for at least 2 hours. The inlet end of each sample is to be connected to a source of air pressure at 28 ±7 kPa (4 ±1 psig) 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 24.2.1.

24.2.5 The sensitivity test oven is to consist of a square or rectangular stainless steel chamber. A typical chamber is illustrated in Figure 24.1. A constant air velocity of 2.54 ±0.01 m/s (8.33 ±0.05 feet per second) and an air temperature as specified in Table 24.2 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 0.05 mm^2 (30 AWG) thermocouple centered upstream from the sample as shown in Figure 24.1.

Figure 24.1

Typical Sensitivity Test Oven Configuration



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Key

1 – Heating Plenum

2 – 8 in x 8 in (203 mm x 203 mm) Square Duct

3 – Orifice

4 – Air Velocity Pressure Taps

5 – 30 AWG Thermocouple

6 – Test Section

7 – Sprinkler

8 – Fine Mesh Screens

9 – Air Velocity Damper

10 – Blower

A – 14 in (356 mm)

B – 50 in (1.27 mm)

C – 16 in (406 mm)

D – 12 in (295 mm)

E – 54 in (1.37 mm)

24.2.6 The required nozzle operating time values specified in 24.2.1 and 24.2.2 shall be calculated by using the following equation:

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

Where:

RTI is Response Time Index [(ft·s)$^{1/2}$; (m·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 [8.33 ft/s; 2.54 m/s]

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

T_g is nominal gas temperature in test section in Table 24.2 [°F; °C]

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

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

24.3.1 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 24.3.2 – 24.3.4.

24.3.2 Nozzles of each type are to be installed in a test room (see 24.3.4) 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.v

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 102 mm (4 inches) below the ceiling.

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

24.3.3 The nozzle is to be mounted as specified in 24.3.2 on a ceiling or a wall of 4.6 by 4.6 m (15 by 15 feet) closed room having an 2.4-m (8-foot) high ceiling. The nozzle inlet waterway is to be filled with water having a temperature of 21 ±1.6 °C (70 ±3 °F). The water is to be pressurized to 0.31 ±0.034 bar (4.5 ±0.5 psig), when required for nozzle operation.

24.3.4 The fire source is to consist of a 305 by 305 by 305 mm (1 by 1 by 1 foot) sand burner located in one corner of the room with a flow of natural gas of 14.2 m^3 (500 standard cubic feet) per hour for ordinary temperature rated nozzles and 17.0 m^3 (600 standard cubic feet) per hour for intermediate temperature rated nozzles. See Figure 24.2. 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 5.1 m (16 feet, 9 inches) from the corner of the room where the sand burner is located.

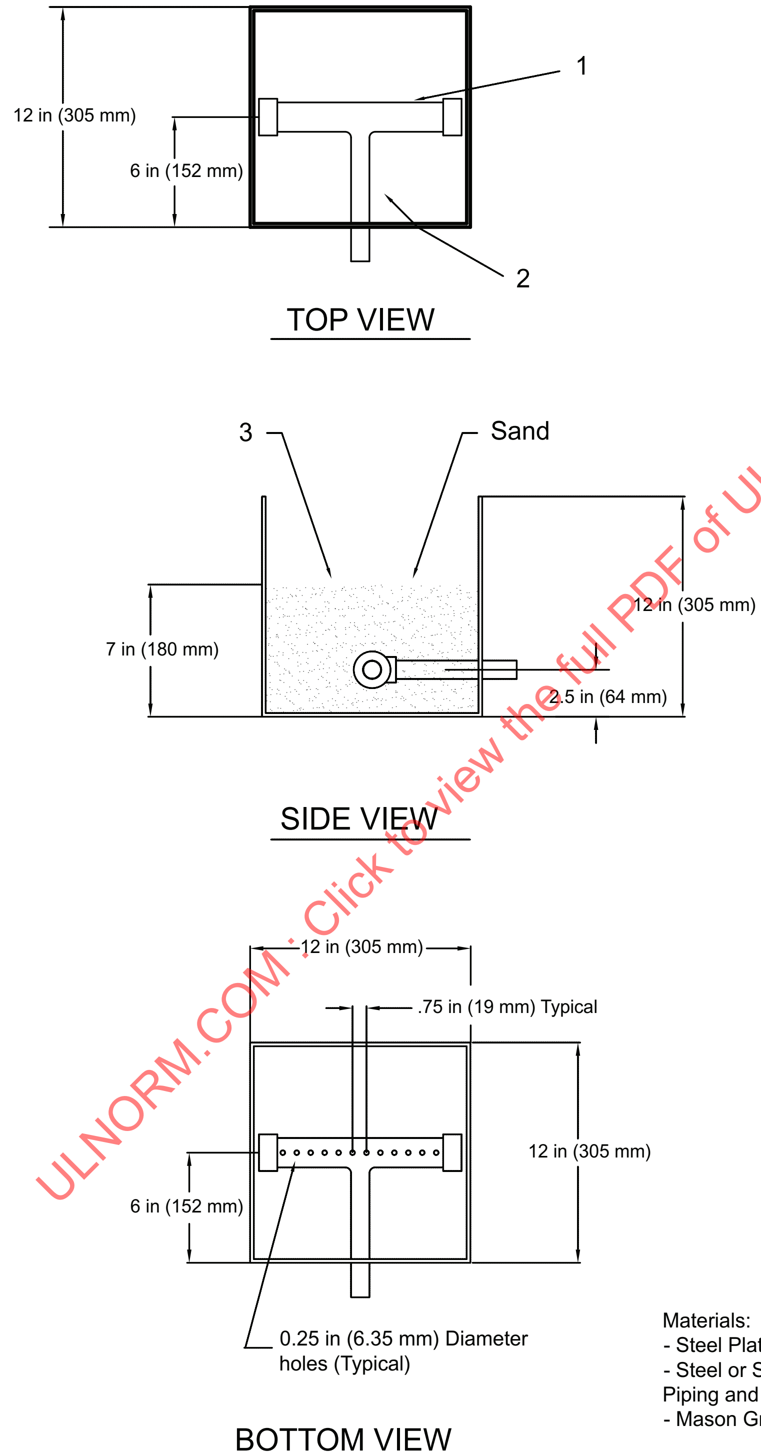
b) A pendent, upright, or ceiling type nozzle is to be installed in the intended position at a point where a diagonal line from the corner having the burner to the opposite corner intersects an arc having a radius equal to the distance from the corner having the burner to the midpoint of the opposite 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 31 ±1 °C (87 ±2 °F) for ordinary temperature rated nozzles and 49 ±1.1 °C (120 ±2 °F) for intermediate temperature rated nozzles, as measured in the center of the room 254-mm (10-inches) below the ceiling. The gas burner is to be ignited, and the operation time of the nozzle is to be recorded.

Figure 24.2

Example of sand burner apparatus



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

s5529a

25 Operation – Lodgement Test

25.1 An automatic nozzle shall operate at service pressures of 0.48 bar (7 psig) 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.

25.2 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 25.1. The test pressures and number of samples tested at each pressure using each water supply configuration is to be as specified in Table 25.1. 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.

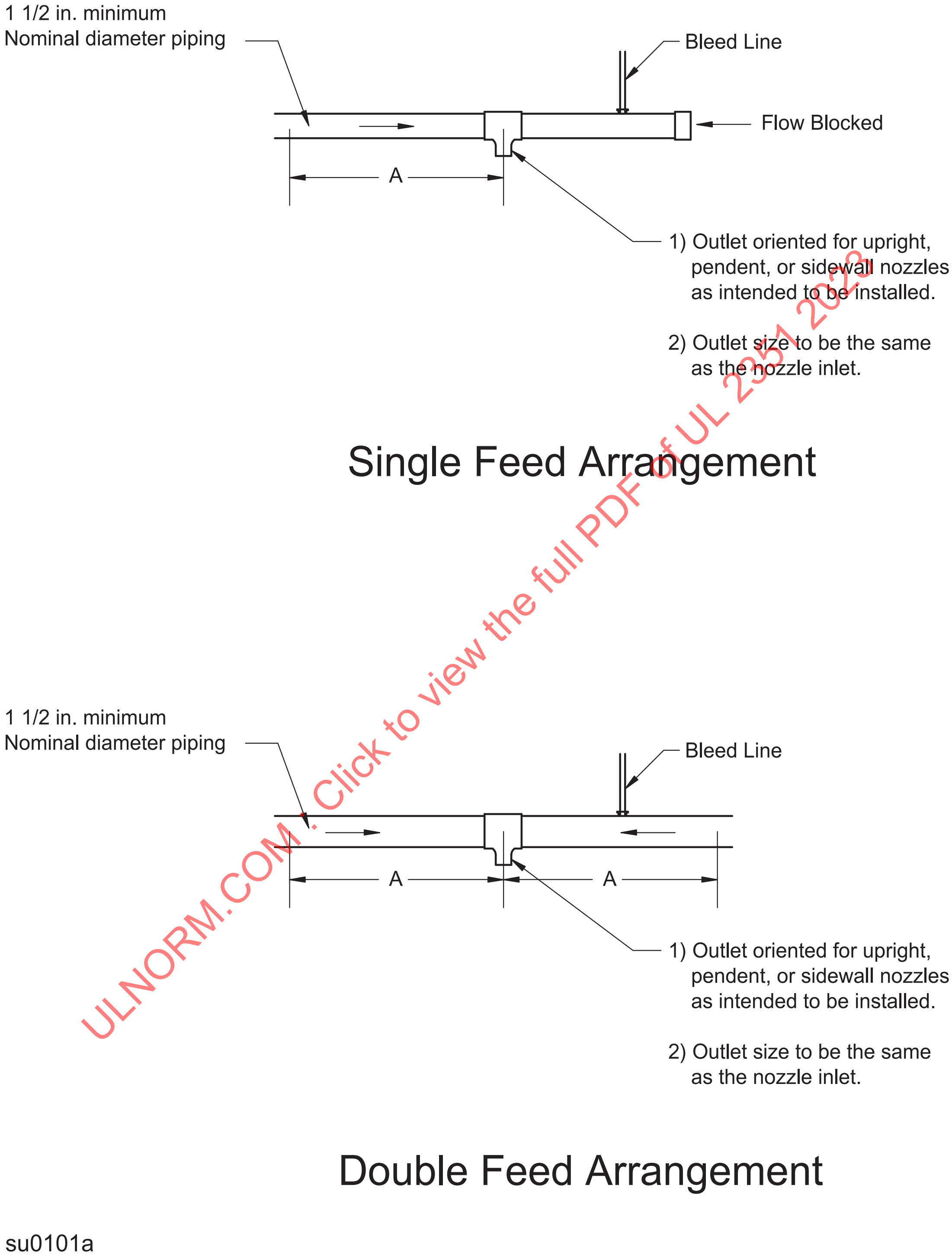
Table 25.1
Samples and Test Pressures for Operation-Lodgement Test

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 25.1

Operation – lodgement test arrangements



A – Minimum 10 times nominal diameter straight length

26 Flow Endurance Test

26.1 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 1.72 bar (25 psig).

26.2 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 26.1 for 30 minutes.

27 High Temperature Exposure Test (90 Day)

27.1 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 27.1, or 11 °C (20 °F) below the rated operating temperature of the samples (whichever is the lower temperature), and not less than 49 °C (120 °F). Following the exposure, each nozzle shall comply with the Leakage Test, Section 18. Nozzles are to then be subjected to 24.2, Sensitivity – Oven Heat Test. 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).

Table 27.1
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)

27.2 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.

28 High Temperature Exposure – Test for Wax Coated Nozzles

28.1 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 27.1, or 11 °C (20 °F) below the rated operating temperature of the samples (whichever is the lower temperature), and not less than 49 °C (120 °F). 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, 24.2

28.2 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.

29 Heat Resistance Test

29.1 A nozzle without operating parts shall withstand the exposure to heat and subsequent immersion in water as described in 29.2 without signs of significant deformation, blistering or fracture.

29.2 A sample nozzle, without operating parts, shall be placed in an oven or furnace on its inlet and heated to a temperature of 650 ±10 °C (1200 ±20 °F) 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 15 ±6 °C (60 ±10 °F).

30 Strength of Frame Test

30.1 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.

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

30.3 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.

30.4 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 0.51 mm (0.02 inch) 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.

30.5 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 30.1.

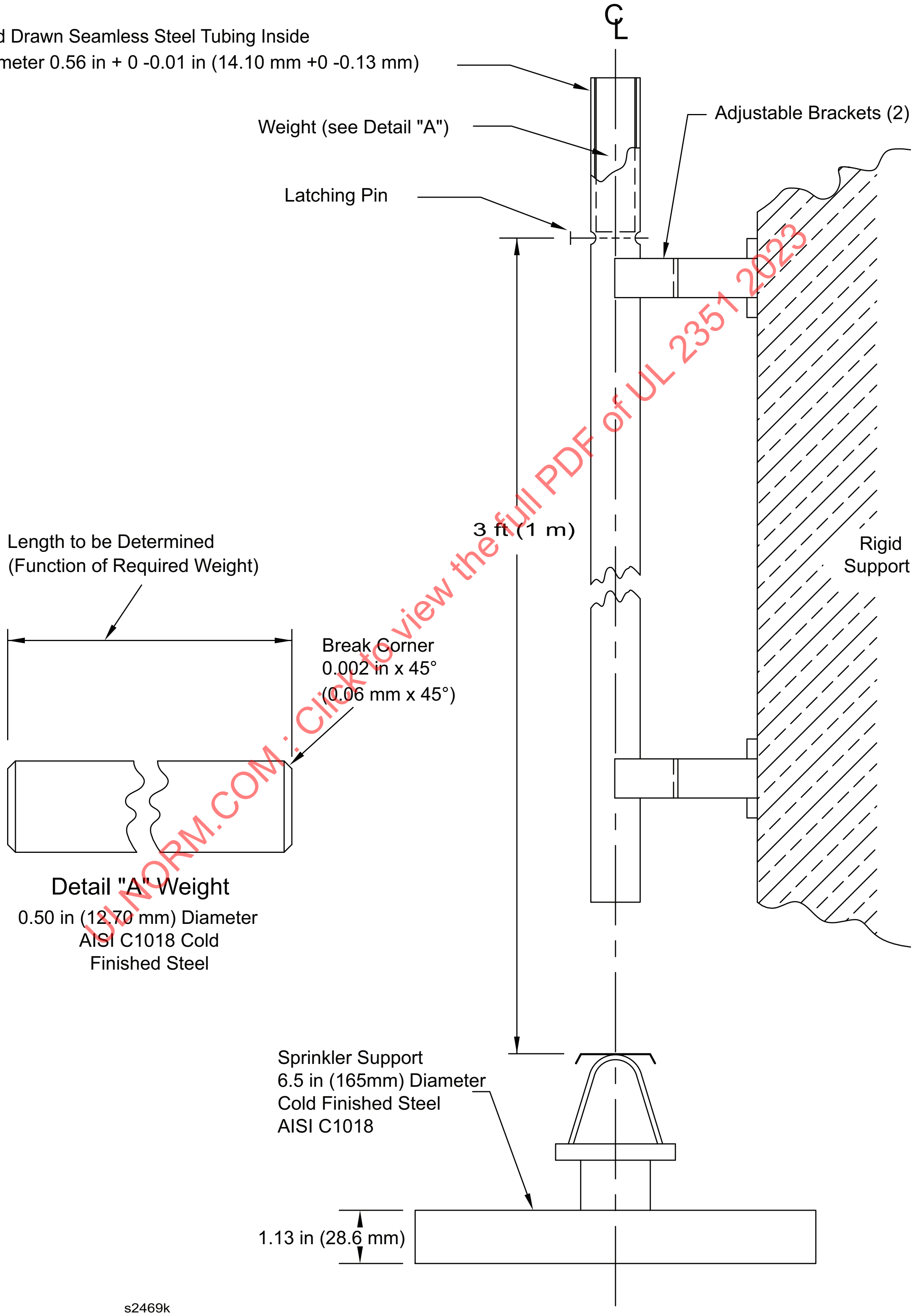
31 Impact Resistance Test

31.1 An automatic nozzle shall not be damaged or leak when tested as described in 31.2. See Figure 31.1.

31.2 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 18, followed by the Sensitivity – Oven Heat Test, 24.2.

Figure 31.1

Impact Test Apparatus



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32 Rough Usage Test

32.1 An automatic nozzle shall withstand the effects of rough usage without deterioration of its performance characteristics. Following three minutes of tumbling as described in 32.3, the nozzle shall comply with the Leakage Test, Section 18, and the Sensitivity Tests, Section 24.

32.2 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.

32.3 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 254 mm (10 inches). The distance between opposite sides is to be 305 mm (12 inches). For each test, one sample and five 38.1 mm (1.5 inch) 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 18, and to the Sensitivity Tests, Section 24.

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

33 Vibration Test

33.1 An automatic nozzle shall withstand the effects of vibration without deterioration of its performance characteristics. The nozzle is to be subjected to vibration of 1.0 mm (0.04 inch) 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 18. In addition, the nozzle shall operate as intended when subjected to the Sensitivity – Oven Heat Test, 24.2.

33.2 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.

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

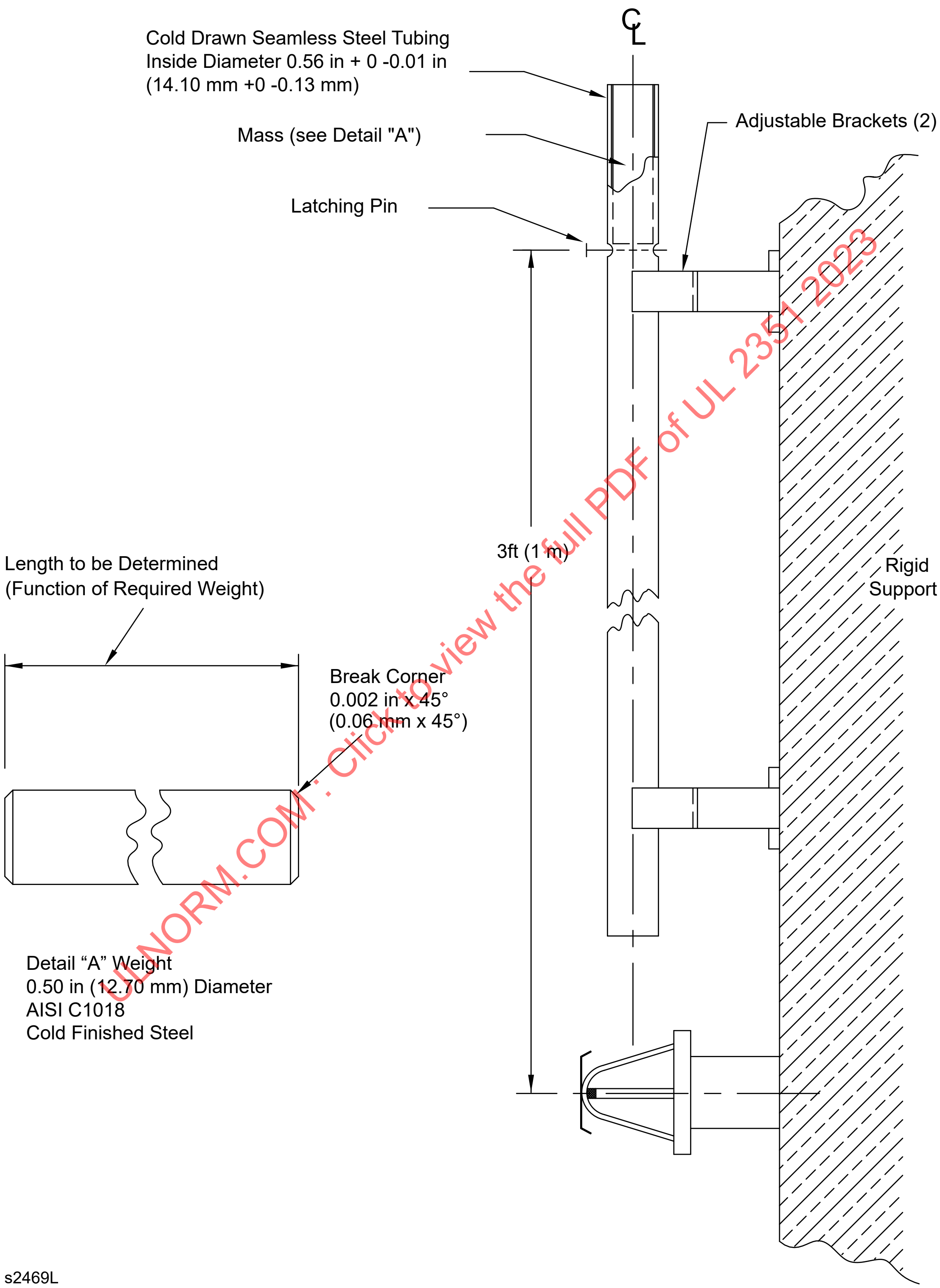
33.4 For this test, amplitude is defined as the maximum displacement of sinusoidal motion from position of rest to one-half of the total table displacement; resonance is defined as the maximum magnification of the applied vibration.

34 Impact Test for Protective Covers

34.1 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 34.2. See Figure 34.1.

Figure 34.1

Impact Test Apparatus for Protective Covers



34.2 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 18, followed by the Sensitivity – Oven Heat Test, 24.2.

35 Calibration Test

35.1 Each K-factor value shall be ±5% or ±0.2 units L/min/(bar)$^{1/2}$ [gpm/(psi)$^{1/2}$] of the K-factor marked on the nozzle, whichever is greater, when tested in accordance with 35.2 – 35.3.

35.2 The nozzle is to be installed on an outlet from a reservoir sized so that the velocity head effect ($2g/V^2$) 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 [15 mm, 20 mm, 25 mm (1/2, 3/4 or 1 inch NPT)], as described in ASME B1.20.1. For nozzles having a nominal "K" factor of 115 L/min/(bar)$^{1/2}$ [8 gpm/(psi)$^{1/2}$] 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 3.2-mm (1/8-inch) or more. See Figure 35.1 as an example of the apparatus. For nozzles having a nominal "K" factor greater than 115 L/min/(bar)$^{1/2}$ [8 gpm/(psi)$^{1/2}$], 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 35.2 for an example of this apparatus.

Figure 35.1

Calibration Test Equipment

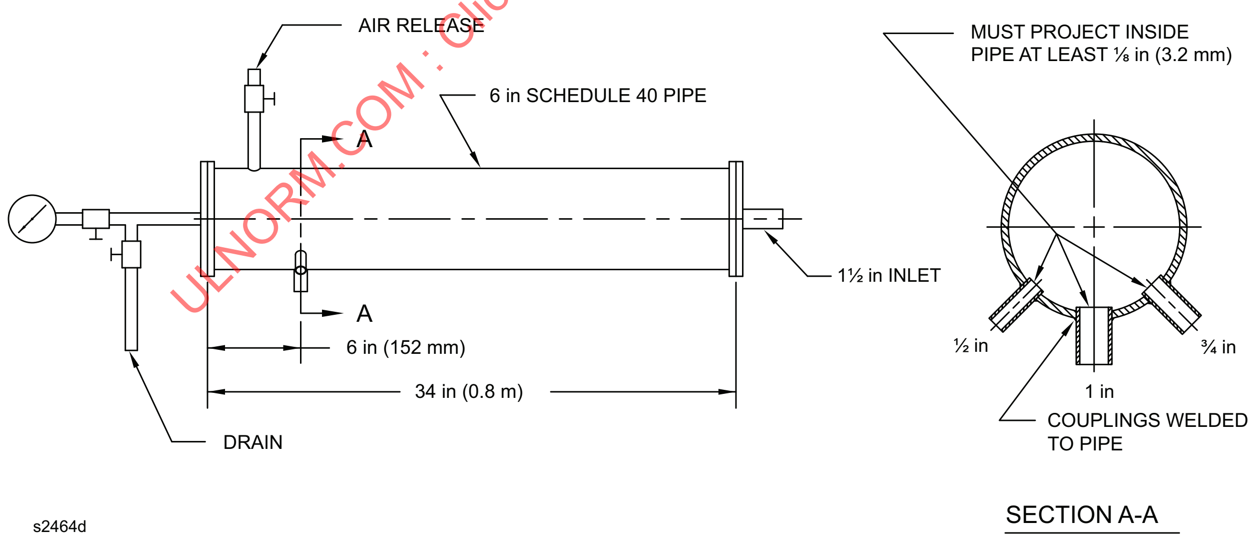
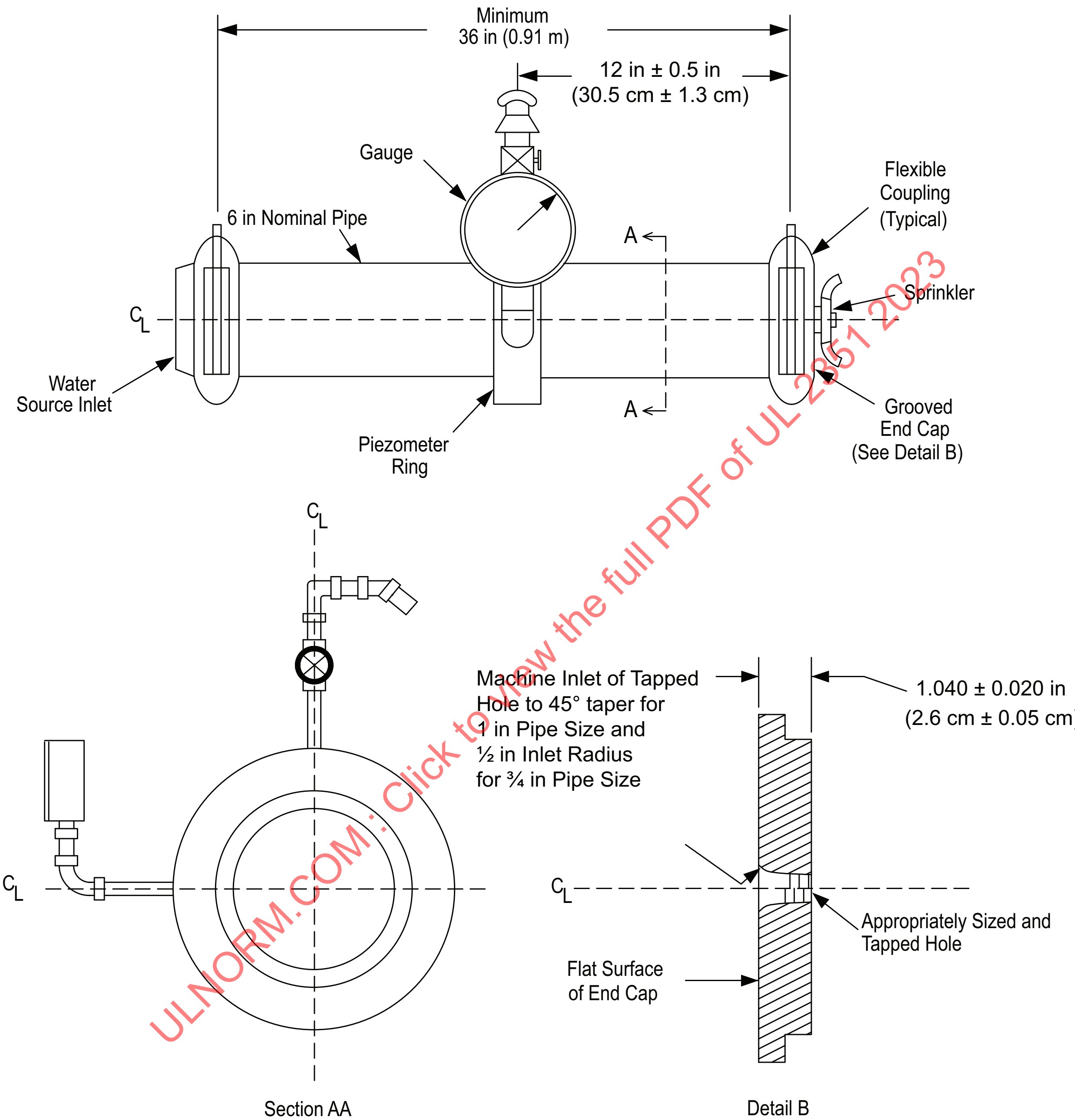


Figure 35.2

Calibration Test Equipment for Nozzles with "K" Factors Greater Than 8



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Note: All dimensions are nominal size except as noted

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

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

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

c) Decreased to 0.48 bar (7 psig).

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.

36 Distribution Test

36.1 General

36.1.1 A spray nozzle shall produce a spray angle within ±6° 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 ±305 mm (12 inches) when comparing the published characteristic spray pattern, when tested as described in 36.1.2 – 36.3.1. Other methods of determining nozzle discharge patterns are permitted to be used provided the same level of accuracy is maintained.

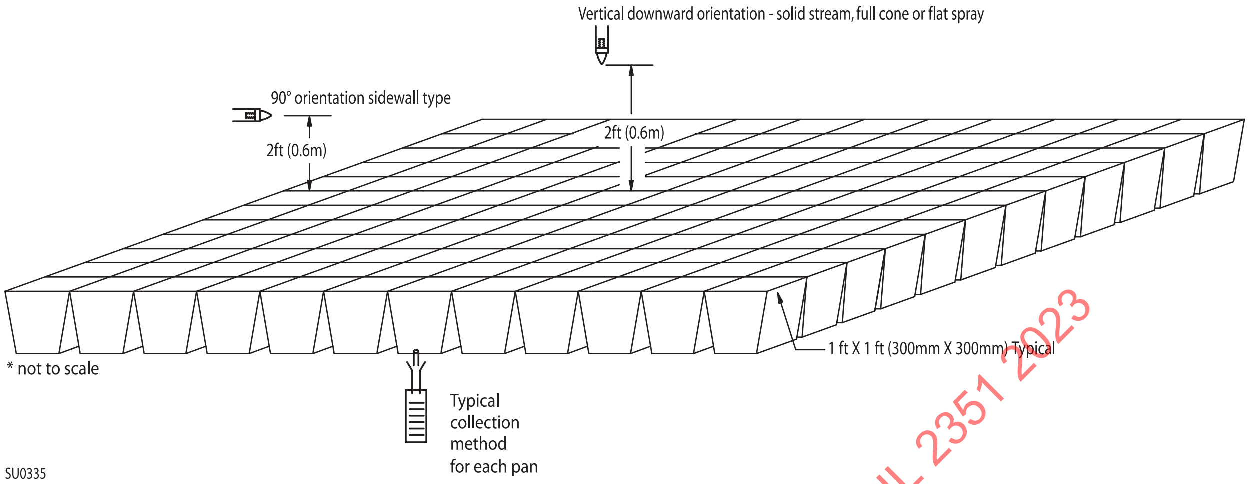
36.1.2 For a nozzle intended to be installed at various orientation positions, the nozzle shall be tested at 0° (vertically downward), using the test methods described in 36.2.1 and at orientation angles of 120, 135, 150, and 180° (vertically upward) using the test methods described in 36.3.1. A sidewall nozzle shall be tested at 90° using the test method described in 36.2.1.

36.2 Water collection

36.2.1 An open spray nozzle is to be supplied with water at the minimum and maximum discharge pressure, through a 25 mm (1 inch) size tee fitting. The outlet is to be the same size as the inlet threads of the nozzle for nozzles with inlet threads 25 mm (1 inch) and smaller. Tee fittings are to be the same size as the nozzle inlet threads for nozzles with inlet threads larger than 25 mm (1 inch). The nozzle is to be positioned at distances of 0.6 m (2 feet) and at a maximum installation height, "x", referenced in the manufacturer's installation instructions, above an array of 305 by 305 mm (1 by 1 foot) square collection pans as shown in Figure 36.1. 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° 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.

Figure 36.1

Collection Pan Array

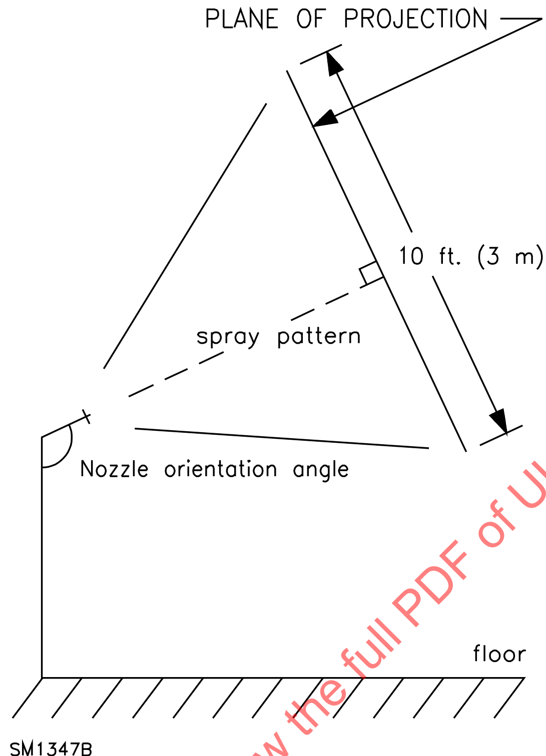


36.3 Spray angle determination

36.3.1 An open spray nozzle is to be supplied with water at the minimum and maximum discharge pressure, through a 25 mm (1 inch) size tee fitting. The outlet is to be the same size as the inlet threads of the nozzle for nozzles with inlet threads 25 mm (1 inch) and smaller. Tee fittings are to be the same size as the nozzle inlet threads for nozzles with inlet threads larger than 25 m (1 inch). The nozzle is to be positioned at distance of 0.6 m (2 feet) from a 3 by 3 m (10 by 10 foot) dry surface (plane of protection), with the plane of protection positioned perpendicular to the line between the nozzle and this plane. See Figure 36.2. 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 3 m (10 feet) 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.

Figure 36.2

Open spray nozzle, plane of protection



37 10-Day Corrosion Test

37.1 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 38.1.4 – 38.1 for 10 days each. Following the exposure, the Sensitivity – Oven Heat Test, 24.2, is to be conducted on the nozzles.

37.2 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.

38 30-Day Corrosion Test

38.1 General

38.1.1 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 38.1.2 – 38.4.1 for 30 days. Following the exposure, the Sensitivity – Oven Heat Test (see 24.2.1 – 24.2.5) 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.

38.1.2 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 24.2.1 – 24.2.5) for determination of its operating time.

38.1.3 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.

38.1.4 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.

38.2 Salt spray

38.2.1 The samples are to be supported vertically and exposed to salt spray (fog) as specified in ASTM B117, except that the salt solution is to consist of 20 percent by weight common salt (sodium chloride).

38.3 Moist hydrogen sulfide air mixture

38.3.1 The samples are to be supported vertically and exposed to a moist hydrogen sulfide air mixture in a closed glass chamber maintained at 24 ±3 °C (75 ±5 °F). 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 (0.34-oz/0.11 ft^3 of chamber volume)] shall be maintained at the bottom of the chamber for humidity.

38.4 Moist carbon dioxide-sulfur dioxide air mixture

38.4.1 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 24 ±3 °C (75 ±5 °F). 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 (0.34-oz/0.11 ft^3 of chamber volume)] is to be maintained at the bottom of the chamber for humidity.

39 90-Day Moist Air Test

39.1 An automatic nozzle shall withstand an exposure to high temperature-humidity in accordance with 39.2 for a period of 90 days. Following the exposure, each test sample shall operate at a service pressure not exceeding 0.48 bar (7 psig) within 5 seconds after operation of the heat responsive element.

39.2 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 95 ±1 °C (203 ±2 °F) 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.

39.3 After the exposure, each sample is to be installed on piping and supplied with water at a service pressure of 0.48 bar (7 psig). 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.

40 Stress-Corrosion Cracking Of Brass Nozzle Parts Test

40.1 After being subjected for 10 days to a moist ammonia exposure as described in 40.2 and 40.3, a nozzle having brass parts shall:

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

b) Perform as intended.

40.2 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.

40.3 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 38.1 plus 12.7 mm, minus 0 mm (1.5 plus 0.5, minus 0 inches) 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 34 ±1 °C (93 ±2 °F).

40.4 After the exposure period, the test samples are to be examined using a microscope having a magnification of 25X 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 40.2 and 40.3 shall withstand, without leakage, a hydrostatic test pressure of 12.1 bar (175 psig) or one equivalent to their maximum design pressure, whichever is greater, for 1 minute, and operate at 0.48 bar (7 psig) 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.

41 Stress-Corrosion Cracking of Stainless Spray Nozzle Parts Test

41.1 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 41.2 – 41.7.

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

41.3 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 12.7 mm (0.5 inches) 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 150 ±1 °C (302 ±2 °F). 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 41.1.

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

41.5 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 41.6 or 41.7, as applicable. Test samples not exhibiting degradation comply with the requirements and shall not be tested further.

41.6 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 41.3. 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 0.48 bar (7 psig) – see Operation – Lodgement Test, Section 25.

41.7 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 41.3. Following the exposure, the test samples shall withstand a flowing pressure of 12.1 bar (175 psig) for 30 minutes without separation of permanently attached parts.

42 Dezincification Test of Brass Parts

42.1 General

42.1.1 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).

42.2 Reagent

42.2.1 A test solution is to be prepared by dissolving 12.7 g (0.028 pound) of copper (II) chloride dihydrate ($CuCl_2 2H_2 0$) in distilled water and then making up the volume to 1000 ml (0.26 gallon). Fresh solution is to be used for each test.

42.3 Test Pieces

42.3.1 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).

42.3.2 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.

42.4 Method

42.4.1 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 0.59 inch (15 mm) 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 (plus 50 ml, minus 10 ml) [0.066 gallon (plus 0.013 gallon, minus 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.