ULC Standards
Normes ULC

JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL/ULC 199:2025A

STANDARD FOR SAFETY

Automatic Sprinklers for Fire-Protection Service

Approved American National Standard
ANSI

ANSI/UL 199-2025

scc ccn

SCC FOREWORD

National Standard of Canada

A National Standard of Canada is a standard developed by a Standards Council of Canada (SCC) accredited Standards Development Organization, in compliance with requirements and guidance set out by SCC. More information on National Standards of Canada can be found at www.scc.ca.

SCC is a Crown corporation within the portfolio of Innovation, Science and Economic Development (ISED) Canada. With the goal of enhancing Canada's economic competitiveness and social well-being, SCC leads and facilitates the development and use of national and international standards. SCC also coordinates Canadian participation in standards development, and identifies strategies to advance Canadian standardization efforts.

Accreditation services are provided by SCC to various customers, including product certifiers, testing laboratories, and standards development organizations. A list of SCC programs and accredited bodies is publicly available at www.scc.ca.

UL Standard for Safety for Automatic Sprinklers for Fire-Protection Service, ANSI/CAN/UL/ULC 199

Thirteenth Edition, Dated February 25, 2022

Summary of Topics

This revision of ANSI/CAN/UL/ULC 199 dated June 27, 2025 includes a correction to the L_m variable definition located in paragraph 17.1.2. This was correct in the ballot dated February 5, 2021.

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The corrected requirement is substantially in accordance with Proposal(s) on this subject dated February 5, 2021.

No Text on This Page

ANSI/UL 199-2025

FEBRUARY 25, 2022
(Title Page Reprinted: June 27, 2025)

ANSI/CAN/UL/ULC 199:2025A

Standard for Automatic Sprinklers for Fire-Protection Service

Fourth Edition – October, 1969
Fifth Edition – May, 1974
Sixth Edition – September, 1977
Seventh Edition – July, 1982
Eighth Edition – February, 1990
Ninth Edition – December, 1995
Tenth Edition – April, 1997
Eleventh Edition – November, 2005
Twelfth Edition – April, 2020

Thirteenth Edition

February 25, 2022

This ANSI/CAN/UL/ULC Safety Standard consists of the Thirteenth Edition including revisions through June 27, 2025.

The most recent designation of ANSI/UL 199 as an American National Standard (ANSI) occurred on February 4, 2025. ANSI approval for this 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 February 4, 2025.

No Text on This Page

CONTENTS

EXPOSURE AND CORROSION TESTS

WATER FLOW AND DISTRIBUTION TESTS

No Text on This Page

Preface

This is the Thirteenth Edition of ANSI/CAN/UL/ULC 199, Standard for Automatic Sprinklers 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 199 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 Thirteenth Edition Joint American National Standard and National Standard of Canada is based on, and now supersedes, the Twelfth Edition of UL 199 and the Second Edition of ULC/ORD-C199.

Requests for interpretation of this Standard should be sent to ULC Standards. The requests should be worded in such a manner as to permit a “yes” or “no” answer based on the literal text of the requirement concerned.

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
Kerry M. Bell	UL Solutions	Testing & Stds Org	USA
Art Black	Carmel Fire Protection Associates	Authorities Having Jurisdiction / Regulator	USA
Dale Bonn	Travelers Insurance	General Interest	USA
Chase Browning	National Fire Sprinkler Association	General Interest	USA
Ken Bush	Maryland State Fire Marshal's Office	Authorities Having Jurisdiction	USA
Kevin Hall	American Fire Sprinkler Association	General Interest	USA
Felipe Luz	UL Standards & Engagement	TC Chair	Canada
Rick McCullough	Standards Individuals	General Interest	Canada
Sean Pearce	National Fire Equipment Ltd.	Supply Chain	Canada
Milosh Puchovsky	Worcester Polytechnic Institute	General Interest	USA
Scott Pugsley	Seneca College	General Interest	Canada
Richard Ray	Cybor Fire Protection Co.	Supply Chain	USA
Mohamed Salaheldin	Lichfield Fire & Safety Equipment FZE	Producer	United Arab Emirates
Paul Sasser	Reliable Automatic Sprinkler Co Inc.	Producer	USA
Michael Savage	Marion Country, FL	Authorities Having Jurisdiction	USA
Piya Sawangpanich	P. S GRAND GROUP CO., LTD.	Testing & Stds Org	Thailand
Kevin Scott	KH Scott & Associates	Authorities Having Jurisdiction	USA
David Sheppard	US Bureau of Alcohol Tobacco Firearms & Explosives	Government	USA
Manuel Silva	Johnson Controls Inc.	Producer	USA
Juergen Teschner	Job GMBH	Producer	USA
David Tiller	Office of the Fire Marshal & Emergency Management	Authorities Having Jurisdiction	Ontario
Tom Wancho	Victualic Co.	Producer	USA
Nicolette Weeks	UL Standards & Engagement	TC Project Manager	USA
Jingchuan Zheng	Shenzen Urban Public Safety and Technology Institute	Testing & Stds Org	China
Jeffrey Zwirn	IDS Research Development Inc.	Producer	USA

International Classification for Standards (ICS): 13.220.01, 13.220.10, 13.220.20

For information on ULSE Standards, visit http://www.shopulstandards.com, call toll free 1-888-853-3503 or email us at ClientService@shopULStandards.com.

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

No Text on This Page

INTRODUCTION

1 Scope

1.1 These requirements cover automatic sprinklers including conventional, spray, sidewall, extended coverage, residential, certain specific application sprinklers and storage sprinklers including early suppression fast response (ESFR) intended for installation on sprinkler systems for fire-protection service. Requirements for the installation and use of sprinklers are included in the National Building Code of Canada, Standards for the Installation of Sprinkler Systems, NFPA 13; Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes, NFPA 13D; and Installation of Sprinkler Systems in Low-Rise Residential Occupancies, NFPA 13R; as well as other applicable NFPA Standards.

1.2 The requirements in this standard are not intended to restrict the application of representative fire and other tests for special sprinklers, as referenced in Standard for the Installation of Sprinkler Systems, NFPA 13, that are intended to provide protection for specific fire hazards.

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 Measurements

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 Normative References

4.1 The following standards are referenced in this standard, and portions of these referenced standards may be essential for compliance.

American Society of Mechanical Engineers (ASME) Standards

ANSI/ASME B1.20.1, *Standard on Pipe Threads, General Purpose, Inch*

American Society for Testing and Materials (ASTM) Standards

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

ASTM E11, *Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves*

ASTM E1354, *Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*

National Fire Protection Association (NFPA) Codes and Standards

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

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*

NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*

National Research Council Canada

National Building Code of Canada

UL Standards

UL 9, *Standard for Fire Tests of Window Assemblies*

UL 157, *Standard for Gaskets and Seals*

UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*

UL 746C, *Standard for Polymeric Materials – Use in Electrical Equipment Evaluations*

ULC Standards

CAN/ULC-S102, *Method of Test for Surface Burning Characteristics of Building Materials and Assemblies*

CAN/ULC-S136, *Standard Method of Fire Test of Sprinkler Protected Window Systems*

5 Glossary

5.1 For the purpose of this standard the following definitions apply:

5.2 ACTUAL DELIVERED DENSITY (ADD) – The rate at which water, discharged from a sprinkler, is actually deposited onto the top of the protected horizontal surface under a fire condition.

5.3 ASSEMBLY LOAD – The extension force applied to the sprinkler frame by the assembly of its operating mechanism.

5.4 AUTOMATIC SPRINKLER – A sprinkler intended to open automatically by operation of a heat-responsive element that maintains the discharge orifice closed by means such as the exertion of pressure on a cap (button or disc). A sprinkler is installed on piping so that a spray of water is discharged in a specific pattern for suppression or control of fires.

5.5 CEILING SPRINKLER – See Concealed Ceiling Sprinkler (5.7), Flush Ceiling Sprinkler (5.18) and Recessed Ceiling Sprinkler (5.28).

5.6 COATED, PAINTED, OR PLATED SPRINKLER – A sprinkler that has factory applied coatings, paint, or platings for corrosion protection or decorative purposes.

5.7 CONCEALED CEILING SPRINKLER – A sprinkler assembly having a cover plate.

5.8 CONTROL MODE DENSITY AREA (CMDA) STORAGE SPRINKLER FOR STANDARD COVERAGE AREAS – A sprinkler intended to be installed using standard coverage areas and density/area criteria referenced in NFPA 13.

5.9 CONTROL MODE SPECIFIC APPLICATION (CMSA) STORAGE SPRINKLER – A sprinkler intended for the protection of stored commodities as referenced in NFPA 13 or the end use limitations specified for the product.

5.10 CONVENTIONAL (OLD STYLE) SPRINKLER – A sprinkler intended for installation in the upright or pendent position, that directs from 40 to 60 % of the total water initially discharged in the downward direction.

5.11 DISCHARGE COEFFICIENT "K" – Coefficient of discharge in the formula,

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

in which:

Q is the flow in gpm, and

p is the pressure in lbf/in^2 gauge (psig).

In SI units:

Q is the flow in l/min; and

p is the pressure in bar.

5.12 DRY-TYPE SPRINKLER – A sprinkler secured in an extension nipple that has a seal at the inlet end to prevent water from entering the nipple until the sprinkler operates. These sprinklers consist of an upright, pendent, sidewall, flush, or other types.

Note: Dry-type ESFR sprinklers are intended for use on wet systems only since ESFR sprinklers are not intended for use in dry systems as referenced in NFPA 13.

5.13 EARLY-SUPPRESSION FAST-RESPONSE (ESFR) SPRINKLER – A quick responding sprinkler that automatically discharges water over a specified area to provide early suppression of a fire.

5.14 EXTENDED COVERAGE SPRINKLER INTENDED FOR LIGHT HAZARD OCCUPANCIES (ECLH) – A sprinkler having a specified area of coverage which is larger than the standard sprinkler coverage areas and is intended for use in light hazard occupancies described in NFPA 13.

5.15 EXTENDED COVERAGE SPRINKLER INTENDED FOR ORDINARY HAZARD OCCUPANCIES (ECOH) – A sprinkler having a specified area of coverage which is larger than the standard sprinkler coverage areas and is intended for use in ordinary hazard occupancies described in NFPA 13.

5.16 EXTENDED COVERAGE CONTROL MODE DENSITY AREA (CMDA) STORAGE SPRINKLER – A sprinkler intended to be installed using the extended coverage area and density/area criteria referenced in NFPA 13.

5.17 FLOW CONTROL (FC) SPRINKLER – A sprinkler that is intended to control water flow by automatically cycling open and closed within a specified temperature range.

5.18 FLUSH CEILING SPRINKLER – A sprinkler in which all or part of the body is mounted above the lower plane of the ceiling (or beyond a wall for sidewall sprinklers), but all of the heat responsive collector is below the lower plane of the ceiling (or beyond a wall for sidewall sprinklers).

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

5.20 HEPTANE – Commercial grade heptane having the following characteristics:

a) Minimum Initial Boiling Point of 190 °F (88 °C);

b) Maximum Dry Point of 212 °F (100 °C); and

c) Specific Gravity (60 °F/60 °F) (15.6 °C/15.6 °C) of 0.68 – 0.73.

5.21 OPEN SPRINKLER – An automatic sprinkler with the heat responsive and activating elements removed. The discharge orifice is open.

5.22 OPERATING TEMPERATURE – The temperature at which the heat responsive element of a sprinkler operates when immersed in a liquid bath under controlled rate of rise conditions.

5.23 ORIFICE – The opening that controls the amount of water discharged from a sprinkler at a given pressure.

5.24 PENDENT SPRINKLER – A sprinkler intended to be installed so that its deflector is located below the orifice and the water flows downward against the deflector.

5.25 QUICK RESPONSE-EXTENDED COVERAGE LIGHT HAZARD OCCUPANCY SPRINKLER – A sprinkler that complies with the applicable requirements for such sprinklers in the Sensitivity Tests, Section 33, when tested and installed in a test room at greater than standard spacings as stated in the installation instructions and complies with the requirements for extended coverage light hazard occupancy sprinklers.

5.26 QUICK RESPONSE-EXTENDED COVERAGE ORDINARY HAZARD OCCUPANCY SPRINKLER – A sprinkler that complies with the applicable requirements for such sprinklers in the Sensitivity Tests, Section 33, when tested and installed in a test room at greater than standard spacings as stated in the installation instructions and complies with the requirements for extended coverage ordinary hazard occupancy sprinklers.

5.27 QUICK RESPONSE (QR) SPRINKLER – A sprinkler that complies with the applicable requirements for such sprinklers in the Sensitivity Tests, Section 33, and that is intended to be installed at standard spacings.

5.28 RECESSED CEILING SPRINKLER – A sprinkler assembly in which all or part of the sprinkler body or frame, other than the inlet thread, is mounted within a recessed housing.

5.29 RESIDENTIAL SPRINKLER – A sprinkler intended to be installed in residential occupancies.

5.30 RESPONSE TIME INDEX (RTI) – A measure of the thermal sensitivity of the sprinkler's heat responsive element.

5.31 SIDEWALL SPRAY SPRINKLER – A sprinkler intended for installation on or near the wall and near the ceiling, and designed to discharge most of the water away from the nearby wall with a small portion of the discharge directed at the wall behind the sprinkler.

5.32 SPECIFIC APPLICATION SPRINKLERS – A sprinkler intended for a limited end use such as for protecting windows, combustible concealed spaces or attics.

5.33 SPRAY SPRINKLER (STANDARD) – A sprinkler intended for installation in either the upright or pendent position respectively, designed to distribute water downward in an umbrella-shaped pattern. The discharge from a spray sprinkler having a nominal 5.6 (80) “K” factor covers a circle 16 ft (4.88 m) in diameter, 4 ft (1.22 m) below the sprinkler, when the sprinkler is discharging water at the rate of 15 gpm (57 l/min). See 10 Pan Distribution Test, 54.3.

5.34 STANDARD FIRE TEST COMMODITY – CARTONED GROUP A PLASTICS (UNEXPANDED) – Single wall corrugated cardboard cartons measuring a nominal 21 by 21 by 20.5 in high (530 by 530 by 520 mm) containing 125 crystalline polystyrene cups in separate compartments within the carton. Single wall corrugated cardboard sheets are used to separate the five layers of cups and interlocking single wall corrugated cardboard vertical dividers are used to separate the 25 cups in each layer. Eight of the cartons are arranged in a 2 x 2 x 2 array with the open end of the cups facing down and placed on a nominal 42 by 42 by 5 in high (1070 by 1070 by 127 mm) two-way hardwood pallet.

5.35 STANDARD FIRE TEST COMMODITY – CLASS II Double tri-wall corrugated cardboard cartons with five-sided steel (open bottom) stiffeners inserted for stability. The cartons are to comply with the requirements for Class 2, Style E, “AAA” fluting as specified in the Federal Specification for Boxes, Fiberboard, Corrugated, Tri-Wall, PPP-B-640D. The two cartons have a combined nominal thickness of 1 in (25 mm). The a nominal measurements for the outside carton are 42 by 42 by 42 in (1070 by 1070 by 1070 mm) and the nominal measurements for the inside carton are 41 by 41 by 41 in (1040 by 1040 by 1040 mm). The cartons are to be placed on a nominal 42 by 42 by 5 in high (1070 by 1070 by 127 mm) two-way hardwood pallet.

5.36 STORAGE SPRINKLER – See Control Mode Density Area (CMDA) Storage Sprinkler for Standard Coverage Areas (See 5.8), Control Mode Specific Application (CMSA) Storage Sprinkler (5.9), Early-Suppression Fast-Response (ESFR) Sprinkler (5.13) and Extended Coverage Control Mode Density Area (CMDA) Storage Sprinkler (5.16).

5.37 UPRIGHT SPRINKLER – A sprinkler intended to be installed so that its deflector is located above the orifice and the water flows upward against the deflector.

6 Terminology

6.1 Where these requirements reference “automatic sprinkler”, the requirements apply to any type of sprinkler unless otherwise specified.

6.2 Where these requirements reference "extended coverage sprinklers", the requirements apply to any type of extended coverage sprinkler unless otherwise specified.

CONSTRUCTION

7 General

7.1 An automatic sprinkler 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).

7.2 For dry-type pendent and sidewall sprinklers, the connection of the extension nipple to the seal assembly at the inlet shall be airtight. See Dry Sprinkler Air Tightness Test, Section 27.

7.3 Stampings shall show no cracking or splitting and shall be uniformly smooth and clean cut.

7.4 An automatic sprinkler 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 sprinkler.

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

7.6 An escutcheon for sprinklers other the polymeric residential sprinklers shall be constructed of a metallic material.

7.7 When installed with the intended fittings specified in the installation instructions, see Manufacturer's Installation Instructions, Section 60, dry sprinklers installed in dry systems shall be constructed to minimize the potential to accumulate water, scale, and sediment on the sprinkler inlet and shall provide an unobstructed flow path upon operation.

7.8 For sprinklers 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. For the purposes of applying this requirement, a bulb tip within the waterway of a dry type sprinkler shall be considered enclosed.

7.9 Sprinklers 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 sprinkler system is placed in service.

Exception: Certain sprinkler designs, such as sprinklers with guards, concealed, intermediate level, wax coated and dry type sprinklers, may not be required to have protective covers.

7.10 Sprinklers required to be equipped with sprinkler covers shall comply with Impact Test for Protective Covers, Section 21 and 59.12.

7.11 In addition to the applicable requirements described herein, flexible dry-type sprinklers or sprinklers constructed with an integral flexible hose connection shall be evaluated in accordance with the applicable requirements described in UL 2443, Standard for Flexible Sprinkler Hose with Fittings for Fire Protection Service. Sprinklers with an integral flexible hose connection shall be constructed to avoid the potential of altering the K-factor of the assembly when the sprinkler needs to be replaced, such as having an inlet configuration that is not typical for the K-Factor of the assembly.

8 Inlet Threads

8.1 Sprinklers shall be provided with external pipe threads at the inlet end as specified in Table 11.1. Inlet-end pipe threads shall comply with the Standard on Pipe Threads, General Purpose, Inch, ANSI/ASME B1.20.1.

Exception No. 1: Dry-type sprinklers shall be permitted to be provided with larger external NPT pipe threads.

Exception No. 1A: External taper pipe threads (NPT) of 1-in size shall be permitted to be used for 5.6 and 8.0 nominal "K" factor sprinklers in lieu of those specified in Table 11.1.

Exception No. 2: Internal taper pipe threads (NPT) of 3/4- or 1-in size shall be permitted to be used for an 8.0 nominal "K" factor, ceiling, and dry type sprinklers in lieu of those specified in Table 11.1.

Exception No. 3: Sprinklers intended for use in installations where sprinkler fittings incorporate pipe threads other than NPT type threads shall be permitted to be provided with pipe threads complying with a national pipe thread standard compatible with those fittings.

Exception No. 4: Sprinkler inlets intended for attachment to piping by means other than threads are able to be used when the sprinklers:

a) Have a nominal "K" factor corresponding to the discharge coefficient as specified in Table 11.1;

b) Are provided with nominal "K" factor markings as specified in 59.2; and

c) Are intended to be attached in a manner that does not involve welding and that permits sprinkler removal from sprinkler piping without the use of special tools or torch cutting equipment.

8.2 Threads shall be clean cut and true and free from burrs, scoring, or chatter marks.

9 Temperature Ratings

9.1 The temperature ratings, temperature classifications, and color codings of automatic sprinklers shall be as specified in Table 9.1. See 59.6.

Table 9.1
Temperature Ratings, Classifications, and Color Codings

Temperature classification	Temperature rating		Color code		Maximum ceiling temperature	
	°F	(°C)	Sprinkler	Glass bulb	°F	(°C)
Ordinary	135 – 170	(57 – 77)	Uncolored or Black	Orange – 135 °F (57 °C) Red – 155 °F (68 °C)	100	(38)
Intermediate	175 – 225	(79 – 107)	White	Yellow – 175 °F (79 °C) 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)

9.2 Residential and ESFR sprinklers shall have a temperature rating that falls within the range of the ordinary or intermediate classification.

10 Pressure Rating

10.1 Sprinklers other than storage and ESFR sprinklers shall have a rated pressure of 175 psig (1.2 Mpa), 250 psig (1.7 Mpa), or 300 psig (2.1 Mpa). Storage and ESFR sprinklers shall have a rated pressure of 175 psig (1.2 Mpa).

10.2 The discharge pressure associated with a rated flow for any sprinkler shall not be less than 7 psig (48 kPa).

11 Nominal "K" Factor

11.1 Sprinklers other than residential sprinklers and dry sprinklers in lengths longer than the minimum, shall have a discharge coefficient complying with one of the nominal "K" factor ranges specified in Table 11.1. The nominal "K" factor is to be determined from the discharge coefficient "K", as specified by the Discharge Coefficient Test, Section 53.

Table 11.1
Nominal "K" factor and thread size

Nominal K-factor, gpm/(psi)$^{1/2}$(L/min/(bar)$^{1/2}$)	Discharge coefficient "K"		External thread-type
	gpm/(psi)$^{1/2}$	(L/min/(bar)$^{1/2}$)	in NPT
1.4 (20)	1.3 – 1.5	(19 – 22)	1/2
1.9 (27)	1.8 – 2.0	(26 – 29)	1/2
2.8 (40)	2.6 – 2.9	(38 – 42)	1/2
4.2 (60)	4.0 – 4.4	(57 – 63)	1/2
5.6 (80)	5.3 – 5.8	(76 – 84)	1/2
8.0 (115)	7.4 – 8.2	(107 – 118)	3/4 or 1/2[+]
11.2 (160)	10.7 – 11.7	(159 – 166)	3/4 or 1/2[+]
14.0 (200)	13.5 – 14.5	(195 – 209)	3/4
16.8 (240)	16.0 – 17.6	(231 – 254)	3/4
19.6 (280)	18.6 – 20.6	(272 – 301)	1
22.4 (320)	21.3 – 23.5	(311 – 343)	1
25.2 (360)	23.9 – 26.5	(349 – 387)	1
28.0 (400)	26.6 – 29.4	(389 – 430)	1

[+] The 1/2 in NPT inlet thread for these sprinklers are for use in existing facilities (retrofit) only as referenced in NFPA 13.

11.2 The diameter of a discharge orifice or any internal passage of a sprinkler shall be at least 0.21 in (5.3 mm).

11.3 Sprinklers intended for use in dry or pre-action systems shall have a "K" factor greater than 4.0.

12 Coatings And Platings

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

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

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

13 Polymeric Residential Sprinklers

13.1 Residential sprinklers having pressure retaining and other load bearing components made of polymeric materials shall be constructed to comply with the following:

a) Requirements described within this standard that are applicable to residential sprinklers.

b) Sprinklers that have polymeric gaskets and no additional pressure retaining or load bearing polymeric components are not limited to the use restrictions described in 13.2 and 13.3.

13.2 Polymeric materials used to construct pressure retaining and load bearing components shall be constructed in such a manner that the polymeric materials do not extend into the area being protected by the sprinkler unless covered with a metallic material such as brass, bronze or stainless steel.

13.3 The manufacturer's installation instructions shall indicate that the polymeric sprinklers are to be attached to plastic sprinkler pipe and fittings only. See Section 60.

PERFORMANCE

GENERAL

14 Details

14.1 To determine compliance with these requirements, the various types and patterns of a sprinkler shall be subjected to the applicable performance tests described herein.

14.2 When a recessed or concealed sprinkler is tested with an escutcheon and cover plate (as applicable) during the performance tests, the sprinkler is to be recessed to the maximum depth allowed by the sprinkler/escutcheon combination.

15 Samples

15.1 The number of samples required for investigation varies for different sprinkler 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.

PHYSICAL STRENGTH AND LEAKAGE TESTS

16 Load on Heat Responsive Element Test

16.1 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 working pressure to the inlet end of the sprinkler increases the assembly load by more than

10 %, 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 17.

16.2 At least 25 sprinklers 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.

17 Strength Of Heat Responsive Element Test

17.1 Fusible-alloy types

17.1.1 A heat responsive element in the ordinary temperature rating shall either:

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

b) Demonstrate the ability to sustain the maximum design load when tested in accordance with 17.1.2 and 17.1.3.

17.1.2 Compliance with 17.1.1(a) is to be determined by subjecting at least ten sample heat responsive elements to a load of 15 times the maximum design load for at least 100 h. Compliance with 17.1.1(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 h. These load and time values shall then be used to derive a least-square, full logarithmic regression curve of load as a function of time, from which the loads at 1 h and 1000 h are to be determined. The design load shall comply with the following equation:

$$L_d \leq 1.02 L^2_m / L_o$$

in which:

L_d is the maximum design load;

L_m is the load at 1000 h; and

L_o is the load at 1 h.

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

17.2 Glass-bulb types

17.2.1 The lower tolerance limit for bulb strength, based on calculations with a degree of confidence of 0.99 for 99 % of samples, shall exceed two times the upper tolerance limit for sprinkler assembly load based on calculations with the same degree of precision as for bulb strength.

17.2.2 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 sprinkler and a material hardness within the range of 38 – 50 Rockwell C. The rate of loading shall not exceed 55 lbf load per s (25 kg/s), or at a rate that deflects the bulb 0.02 in (0.51 mm) per min, whichever measurement is convenient for the test apparatus being used. Bulb seats shall be permitted to be reinforced circumferentially to not 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.

17.2.3 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.

18 Glass-bulb Thermal Shock Test

18.1 A sprinkler having a glass bulb shall withstand the thermal shock of rapid temperature changes without breakage or fracture of the glass bulb when tested as specified in 18.2.

18.2 At least five samples of the sprinkler are to be conditioned for 5 min 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 sprinkler shall be visually observed for signs of breakage or fracture.

19 Strength Of Frame Test

19.1 An automatic sprinkler frame shall not show permanent deformation in excess of 0.2 % of the distance between its bearing points when subjected to a test loading of twice its assembly load at rated hydrostatic pressure.

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

19.3 At least ten sprinkler samples 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 sprinkler frame.

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

19.5 A force equal to twice the sum of the force recorded in 19.4 plus the force applied to the sprinkler frame at rated pressure is then to be applied to each sample and held for not more than 5 s. The deflection during the application of this load and the amount of permanent set after the load has been released are to be determined. The percentage of permanent deformation (elongation) shall be calculated using the measured permanent deflection and the minimum distance measured between load bearing points to verify compliance with the requirements in 19.1.

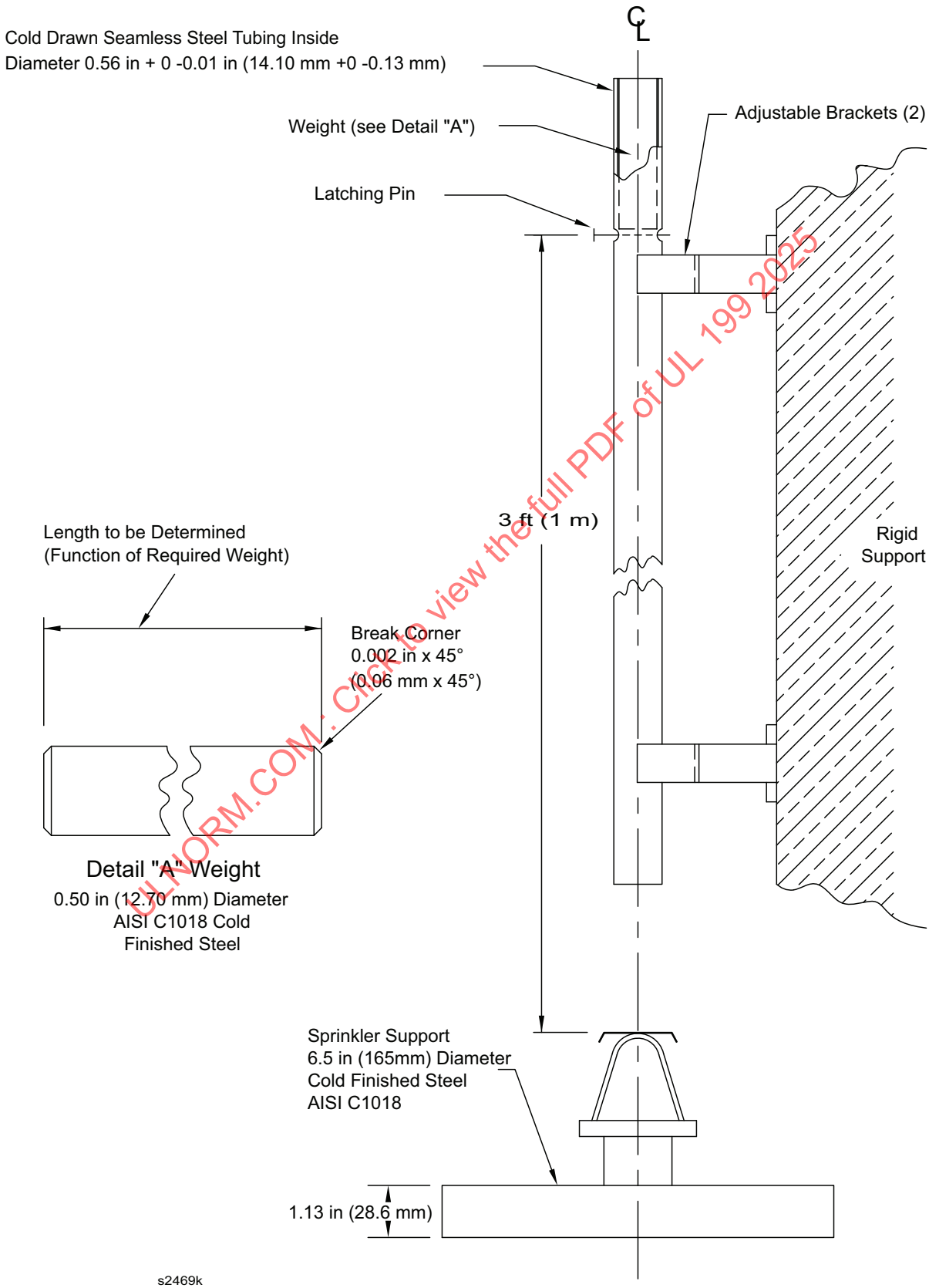
20 Impact Resistance Test

20.1 An automatic sprinkler, except for dry type sprinklers, shall not be damaged or leak when tested as described in 20.2. See Figure 20.1.

20.2 Five sample sprinklers are to be tested by dropping a cylindrical mass equivalent to the mass of the sprinkler to the nearest 15 g increment from a height of one meter onto the geometric center of the deflector, or when this is not practicable such as with a concealed or flush type sprinkler, onto the butt end of the sprinkler. The mass is to be prevented from impacting more than once upon each sample. Following the impact, each sprinkler is to be visually examined and there shall be no evidence of cracks, breaks, or any other damage. Each sample sprinkler shall then be subjected to the Leakage Test, Section 25, followed by the applicable testing in Sensitivity Tests, Section 33 based upon sprinkler type.

Figure 20.1

Impact test apparatus

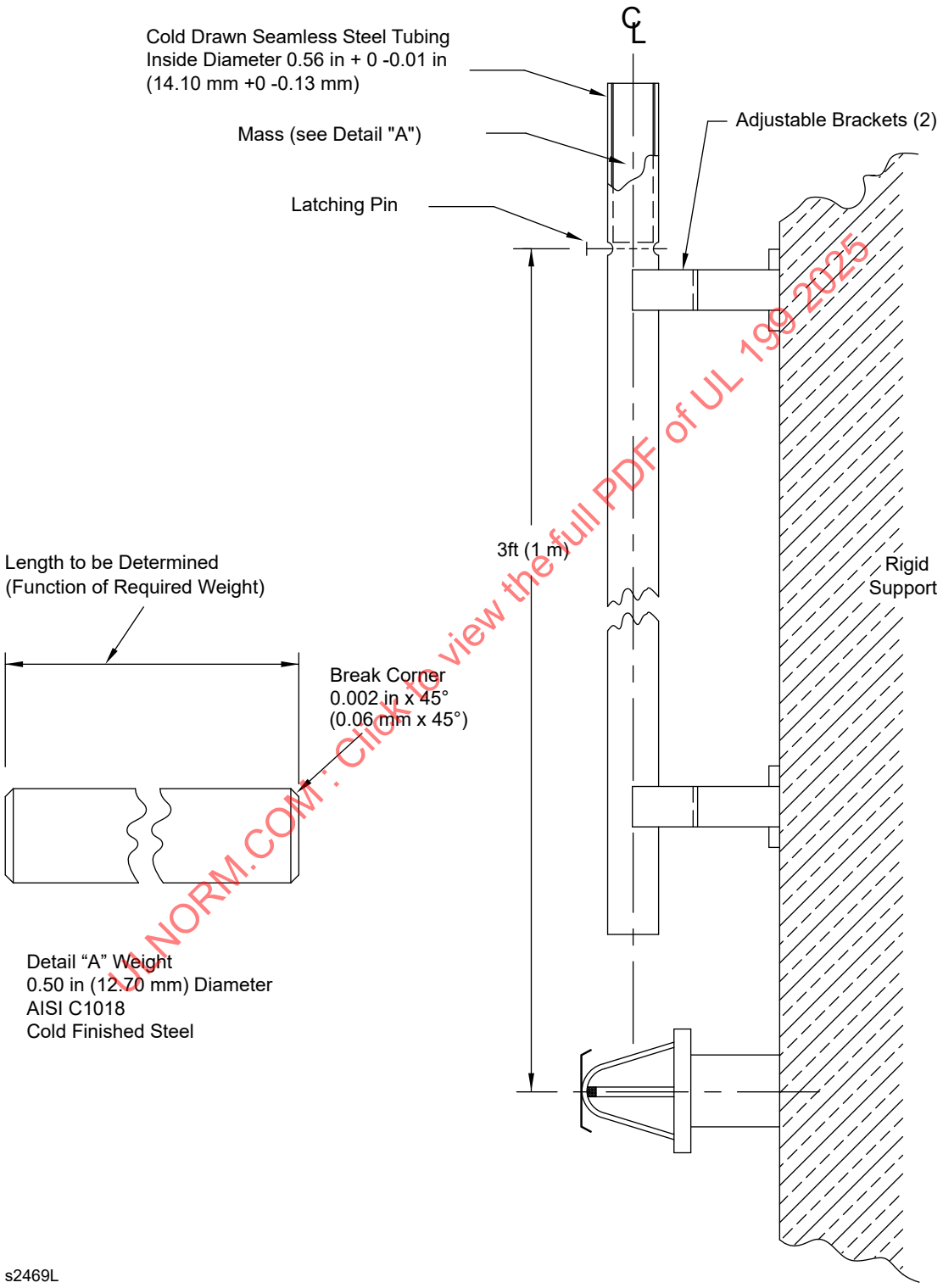


21 Impact Test for Protective Covers

21.1 A glass bulb type sprinkler, with the protective cover installed, shall not be damaged or leak and the cover shall remain in place when tested as described in 21.2. See Figure 21.1.

Figure 21.1

Impact test apparatus for protective covers



21.2 Five sample glass bulb sprinklers with their protective covers are to be mounted in the horizontal position and impacted with a cylindrical mass equivalent to the mass of the sprinkler to the nearest 15 g increment from a height of one meter onto the geometric center of the glass heat responsive element. Five additional samples are to be tested with the impact applied to the opposite side of the sprinkler if the cover is designed to provide unsymmetrical protection. If the glass bulb extends beyond the perimeter of the sprinkler deflector, an additional five sample sprinklers 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 heat responsive element. The mass is to be prevented from impacting more than once upon each sample. Following the impact, each sprinkler is to be visually examined and there shall be no evidence of cracks, breaks, or any other damage to the glass bulb. Each sample sprinkler shall then be subjected to the Leakage Test, Section 25. In addition, each sample shall then be subjected to the applicable testing in Sensitivity Tests, Section 33 based upon sprinkler type.

22 Impact Test for Guards

22.1 Sprinkler and guard assemblies subjected to the tests described in 22.2 – 22.5, shall:

a) Show no evidence of visual damage to the sprinkler; and

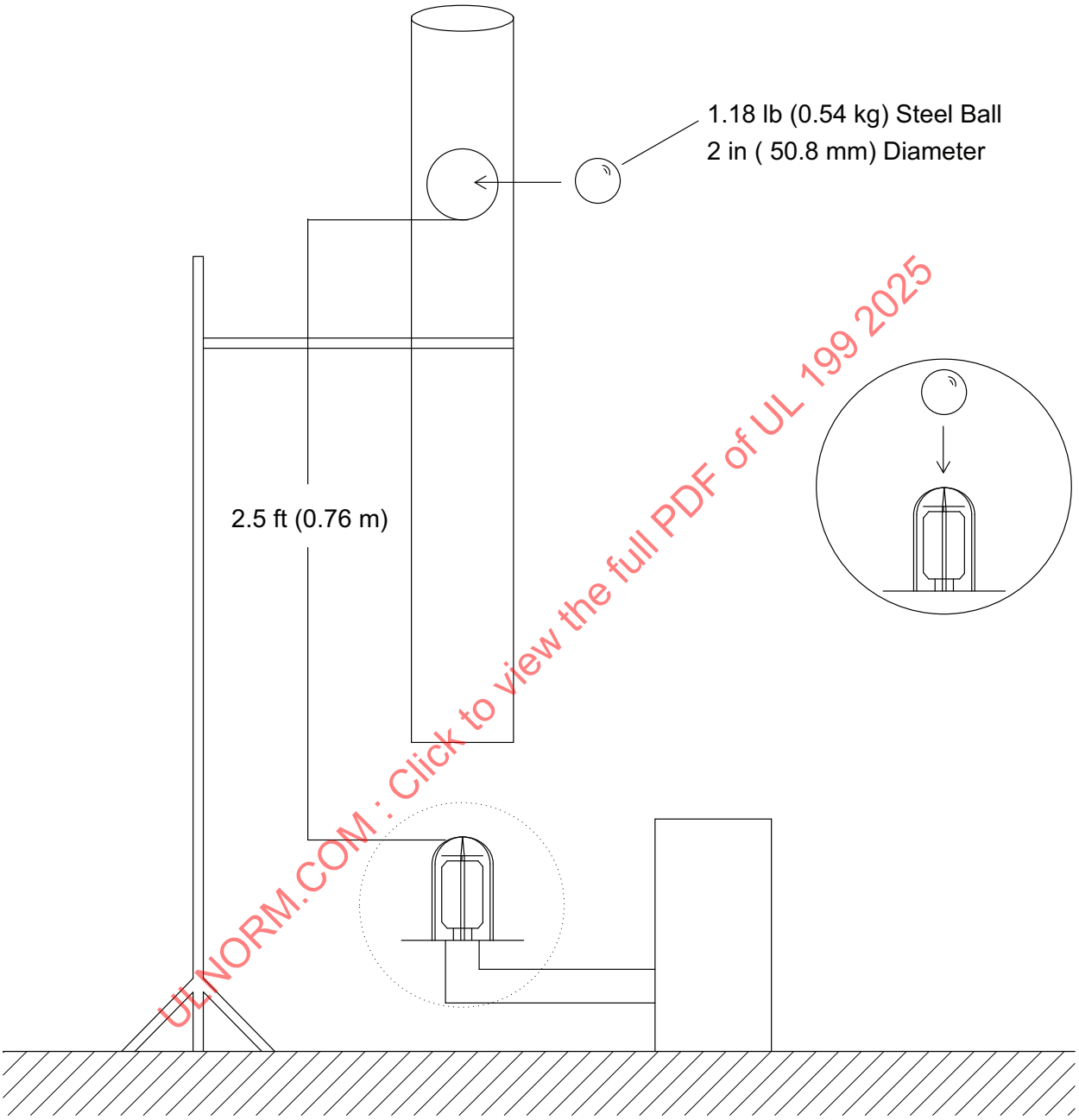
b) Comply with the Operation – Lodgement Test, Section 34.

22.2 Twelve sample sprinklers are to be assembled with their intended guard in accordance with the manufacturers installation instructions and divided into two groups of six assemblies in each group.

22.3 Samples from the first group are to be tested individually by dropping a 1.18 lb (0.54 kg), 2 in (50.8 mm) in diameter stainless steel ball (Series 440) from a height of 2.5 ft (0.76 m) onto the end of the assembly as shown in Figure 22.1. Samples from the second group are to be tested individually by dropping the ball onto the side, near the top of the guard as shown in Figure 22.2.

Figure 22.1

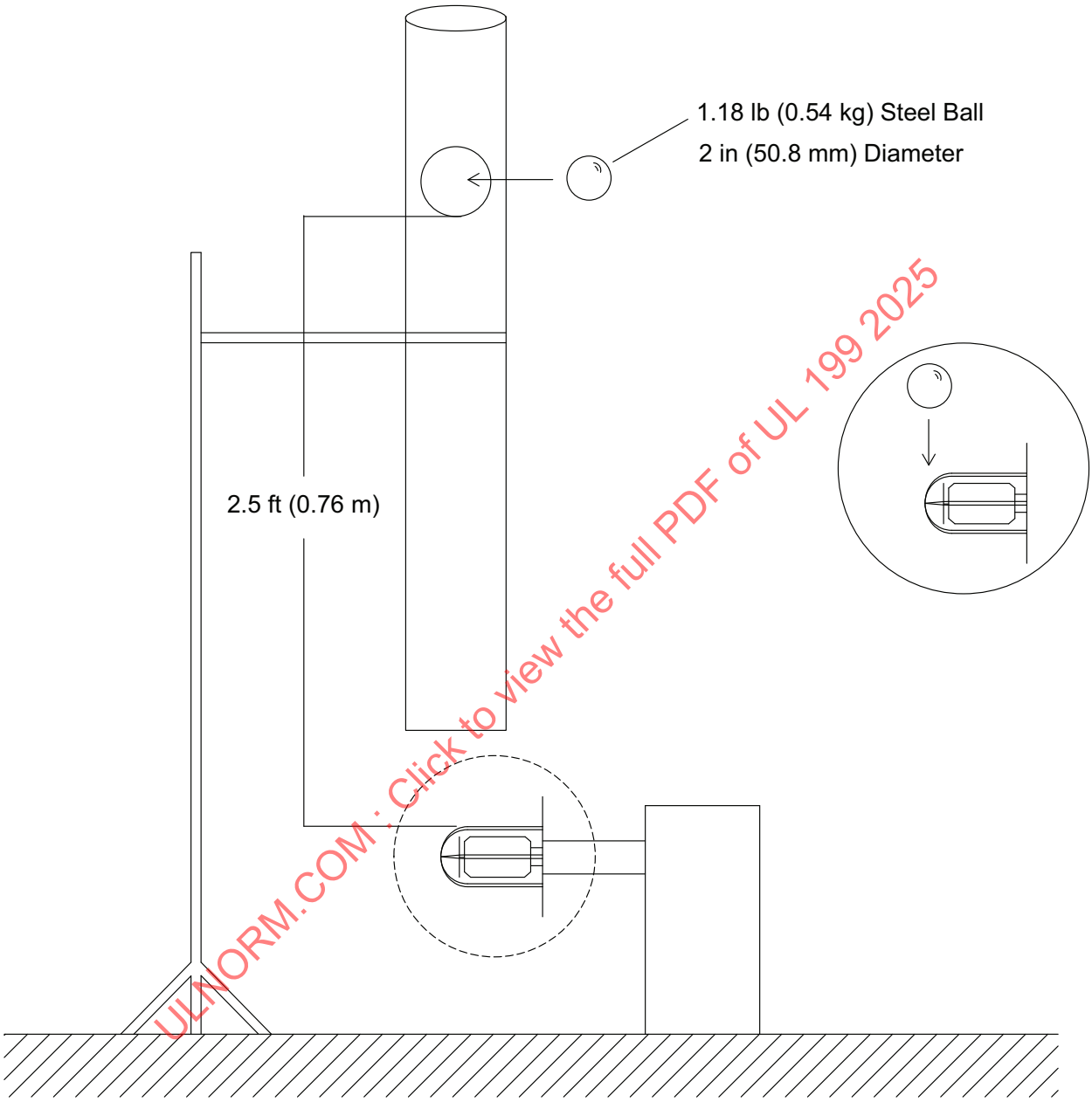
Impact test on first group of samples



sm1184b

Figure 22.2

Impact test on second group of samples



sm1185b

22.4 Impact due to falling steel ball in both cases shall be located between support members of the guard.

22.5 After impact, the sprinkler samples shall be visually examined for damage. The samples are then subjected to the Operation – Lodgement Test, Section 34 except that one sample from each group is to be tested using the double feed arrangement at each of following inlet six pressures: 25 (172), 50 (345), 75 (517), 100 (689), 125 (862) and 150 (1206) psig (kPa).

23 Rough Usage Test

23.1 An automatic sprinkler, except for dry-type sprinklers, shall withstand the effects of rough usage without deterioration of its performance characteristics. Following 3 min of tumbling as described in 23.3, the sprinkler shall comply with the Leakage Test, Section 25, and the Sensitivity Tests, Section 33 based upon the sprinkler type.

23.2 Five sample sprinklers are to be tested. The sprinklers are to be tested with a shipping protector in place when the protector is intended to be removed from the sprinkler after the sprinkler is installed and reference to this removal requirement is made in the installation instructions.

23.3 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 in (254 mm). The distance between opposite sides is to be 12 in (305 mm). For each test, one sample and five 1-1/2-in (38.1-mm) hardwood cubes are to be placed in the drum. The drum is to be rotated at 1 revolution per s for 3 min. The sample is to be removed from the drum, examined for signs of damage, and then subjected to the Leakage Test, Section 25, and to the Sensitivity Tests, Section 33.

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

24 Flow Endurance Test

24.1 An automatic sprinkler shall withstand for 30 min, without evidence of cracking, deformation, or separation of any part, a waterflow at a pressure equal to the rated pressure plus 25 psig (172 kPa).

24.2 One sample of an automatic sprinkler is to be installed in its intended installation orientation on an elbow or tee for dry type sprinklers in a pressurized water system having a supply pipe with a minimum nominal diameter of 1-1/2 in (40 mm). For concealed type sprinklers, the deflector support pins shall be orientated parallel to the supply pipe. The heat responsive element of the sprinkler is to be activated at the specified test pressure, and the water flow shall be adjusted to obtain the specified test pressure for 30 min.

25 Leakage Test

25.1 When tested as described in 25.2 and 25.3, an automatic sprinkler shall not exhibit leakage at any pressure from 0 to the applicable leakage test pressure shown in Table 25.1.

Table 25.1
Test Pressures for the Leakage and Hydrostatic Tests

Rated pressure		Leakage test pressure		Hydrostatic test pressure	
psig	(MPa)	psig	(MPa)	psig	(MPa)
175	(1.2)	500	(3.4)	700	(4.8)
250	(1.7)	500	(3.4)	1000	(6.9)
300	(2.1)	600	(4.1)	1200	(8.3)

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

25.3 The pressure is to be increased from 0 to the test pressure at a rate not exceeding 300 psig (2.07 MPa) per min and then held for 1 min at the pressure specified in Table 25.1. There shall be no visible leakage in any sample.

26 Hydrostatic Strength Test

26.1 An automatic sprinkler shall withstand, for 1 min, without rupture, an internal hydrostatic pressure equal to the hydrostatic test pressure shown in Table 25.1.

26.2 The samples from the Leakage Test, Section 25, are to be used for this test.

26.3 The sprinkler inlets are to be filled with water and vented of air. The pressure is to be increased from 0 to the hydrostatic test pressure shown in Table 25.1 at a rate not exceeding 300 psig (2.07 MPa) per min. The pressure is to be maintained at the test pressure and held for 1 min. 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 min.

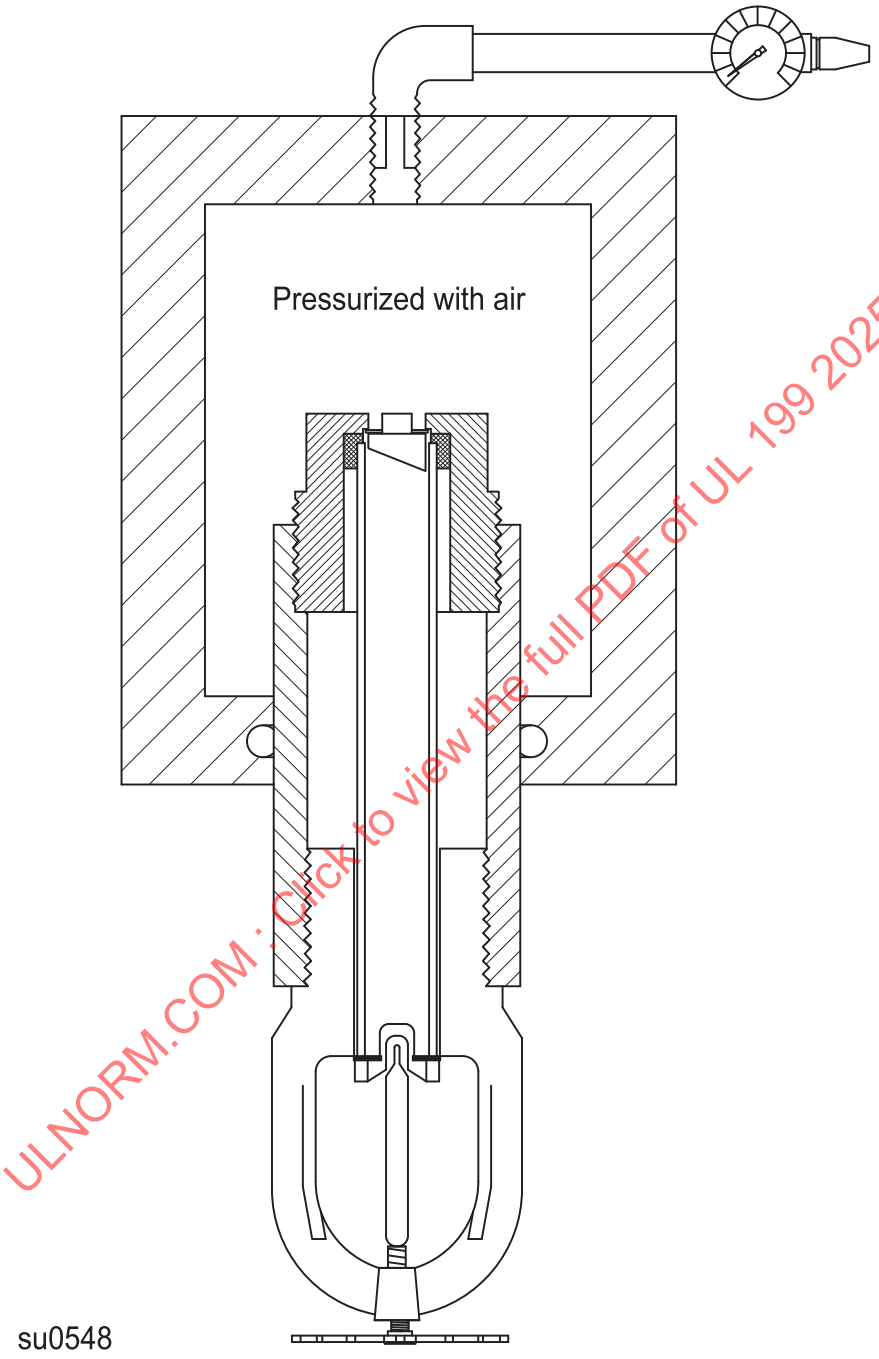
27 Dry Sprinkler Air Tightness Test

27.1 When tested as described in 27.2 and 27.3, the connection of the extension nipple to the inlet seal assembly for a dry-type pendent or sidewall sprinkler shall not exhibit leakage at any air pressure from 0 to 15 psig (0 to 103 kPa) when the pressure is applied externally to this connection.

27.2 At least five samples of the minimum length are to be individually tested. The assembly is to be installed in an air leakage test fixture in such a manner that the extension nipple connection to the inlet seal assembly can be fully pressurized with air. See Figure 27.1.

Figure 27.1

Dry sprinkler air tightness test apparatus (typical)



27.3 The assembly is to be immersed in water and orientated so that air bubbles indicating leakage past the extension nipple and inlet seal assembly connection point are allowed to freely escape from internal waterway of the dry sprinkler assembly. The air pressure applied to the connection point is then to be increased from 0 to 15 psig (0 to 103 kPa) within 30 s and then held for 30 s. Observations shall be made for leakage as evidenced by any air bubbles escaping from the internal portion of the dry sprinkler assembly.

28 30-Day Leakage Test

28.1 When tested as described in 28.2 – 28.4, an automatic sprinkler shall:

a) Experience no leakage when subjected to the 30 day test pressure specified in Table 28.1 for 30 days;

b) Not leak when subjected to the leakage test pressure specified in Table 25.1 or less for 1 min following the 30 days; and

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

Table 28.1
Test Pressures for the 30-Day Leakage Test

Rated pressure		30-day test pressure	
psig	(MPa)	psig	(MPa)
175	(1.2)	300	(2.1)
250	(1.7)	450	(3.1)
300	(2.1)	500	(3.4)

28.2 Five samples are to be installed on a water-filled test line maintained under a constant test pressure as specified in Table 28.1 for 30 days. The samples are to be examined during and at the end of the test period for evidence of leakage of water at the closure cap.

28.3 Following completion of this 30-day test period, the samples are to be tested to verify that they do not leak at the leakage test pressure specified in Table 25.1 or at any lower pressure. The pressure is to be increased from 0 to the required test pressure a rate not exceeding 300 psig (2.07 MPa) per min. The pressure is to be maintained at the leakage test pressure specified in Table 25.1 for 1 min, and is then to be decreased to 0 psig at a rate not exceeding 300 psig (2.07 MPa) per min.

28.4 The samples then are to be visually examined to verify there is no evidence of distortion or other mechanical damage.

29 Water Hammer Test

29.1 When tested as described in 29.2 – 29.5, an automatic sprinkler shall:

a) Experience no leakage when subjected to 100,000 applications of pressure surges having a test pressure range as specified in Table 29.1;

b) Not leak when subjected to the leakage test pressure specified in Table 25.1 for 1 min, 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 29.1
Test Pressure Ranges for the Water Hammer Test

Rated pressure		Test pressure range	
psig	(MPa)	psig	(MPa)
175	(1.2)	50 – 500	(0.34 – 3.4)
250	(1.7)	50 – 500	(0.34 – 3.4)
300	(2.1)	150 – 600	(1 – 4.1)

29.2 Five samples are to be installed on a water-filled test line connected to a pump system that produces a rapid rise in pressure in accordance with Table 29.1 at the rate of not more than 60 cycles per min. The test piping is to be filled so that there is water at the sprinkler seat, and the pump is to be placed in operation and adjusted to produce the specified test-pressure cycle.

29.3 During the pressure cycling, observations are to be made for evidence of leakage.

29.4 Following completion of the pressure cycling, the samples are to be tested to verify that they do not leak at the leakage test pressure specified in Table 25.1 or at any lower pressure. The pressure is to be increased from 0 to the required test pressure at a rate not exceeding 300 psig (2.07 MPa) per min. The pressure is to be maintained at the leakage test pressure specified in Table 25.1 for 1 min, and is then to be decreased to 0 psig at a rate not exceeding 300 psig (2.07 MPa) per min.

29.5 The samples then are to be visually examined to verify there is no evidence of distortion or other mechanical damage.

30 Vacuum Test

30.1 An automatic sprinkler shall not be damaged and shall comply with the Leakage Test, Section 25, following exposure to a vacuum as specified in 30.2.

30.2 Five samples are to be installed on a manifold and subjected to a vacuum of minus 8.84 psi (18 in of mercury) (minus 61 kPa) for 1 min. The samples are then to be removed from the manifold, visually examined for damage, and then subjected to the Leakage Test, Section 25.

OPERATION TESTS

31 Operating Temperature (Bath) Test

31.1 The operating temperature of automatic sprinklers and cover plates, when tested as described in 31.1 – 31.7, shall be within a temperature range as follows:

a) ±3.5 % of the marked temperature rating for sprinklers rated less than 400 °F (204 °C); and

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

For the purpose of this determination for sprinklers 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 sprinkler shall clear the waterway as intended except as indicated in 31.2.

31.2 Sprinkler 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 sprinkler operation, the temperature at which bulb-fracture occurred shall

be considered the operating temperature, but additional sprinkler samples shall be subjected to the Air Bath for Glass Bulb Sprinkler Test, Section 32.

31.3 At least ten samples of each type of sprinkler produced of each temperature rating are to be subjected to this test. A sprinkler that does not require pressure to operate is to be tested at zero gauge pressure. A sprinkler that requires pressure to operate is to be tested while pressurized at 4-1/2 ±1/2 psig (31 ±3.4 kPa).

31.4 Water is to be used in bath tests of sprinklers 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 an oil having a flash point exceeding the test temperature.

31.5 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 provided 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.

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

31.7 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 constant rate of 1 ±0.2 °F (0.5 ±0.1 °C) per min until operation of the sprinkler 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 sprinkler operates, are to be recorded.

32 Air Bath for Glass Bulb Sprinkler Test

32.1 When a partial fracture of a glass bulb occurs during the Operating Temperature (Bath) Test, Section 31, sprinklers with a glass bulb heat responsive element shall fully operate when subjected to the air bath test described in 32.2.

32.2 Fifty sample sprinklers 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 sprinklers. When this temperature is reached, the oven shall be maintained at a constant temperature for a period of 60 ±5 min. The temperature shall then be increased at a constant rate of 1 ±0.5 °F (0.5 ±0.3 °C) per min until the temperature in the oven is 25 % higher than the marked temperature rating of the sprinklers or until all the sprinklers operate, whichever occurs first. Each sample shall be examined for full operation.

33 Sensitivity Tests

33.1 General

33.1.1 An automatic sprinkler shall comply with the requirements as referenced in Table 33.1 based upon the sprinkler type:

Table 33.1
Sensitivity Requirements by Sprinkler Type

Sprinkler type	Requirements
Standard Response (all except flush, recessed and concealed; and extended coverage)	33.2.1
Standard Response Flush, Recessed and Concealed, and Standard Response Extended Coverage	33.2.1 and 33.3.1
Quick Response(all)	33.2.2 and 33.3.2
Residential	33.2.2 and 33.3.2
ESFR	33.2.3

33.1.2 A coating shall not remain on sprinkler parts in a manner that impairs operation or distribution at the time of sprinkler operation in 33.2 and 33.3.

33.2 Oven heat test

33.2.1 A standard response sprinkler shall operate within the time range specified in Table 33.2 for each sample sprinkler when tested in the Oven Heat Test as specified in 33.2.4 – 33.2.6. If the sprinkler temperature is not shown in Table 33.2, the minimum and maximum operating time range for each sample sprinkler shall be determined by using the formula specified in 33.2.7, 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 sprinkler.

Exception: The minimum operating time for the Oven Heat Test does not apply to standard response extended coverage and ceiling sprinklers complying with 33.3.1.

33.2.2 QR, QR extended coverage and residential sprinklers shall have the following operating time characteristics when tested in the sensitivity test oven as specified in 33.2.4 – 33.2.6:

a) A maximum operating time specified in Table 33.2 for each sample sprinkler in the as-received condition. If the sprinkler temperature rating is not shown in Table 33.2, the maximum operating time for each sample sprinkler shall be determined by using the formula specified in 33.2.7 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 sprinkler.

b) Mean operating time after being subjected to the exposure tests specified in Sections 36, 44, and 45 shall be equal to or less than a 1.30 multiple of the mean operating time of the sprinkler tested in the as-received condition.

Table 33.2
Operating Time in Oven Heat Test for Quick Response, Residential and Standard Response Sprinklers

Sprinkler temperature rating		Oven temperature		Quick response and residential[b] type, s	Standard response type, s		Coated standard response type, s[a]
°F	(°C)	°F	(°C)	Max.	Min.	Max.	Max.
135	(57.2)	275	(135)	11.2	17.8	78.3	180
140	(60.0)	275	(135)	12.3	19.7	86.3	180
155	(68.3)	275	(135)	16.0	25.6	112.2	180
160	(71.1)	275	(135)	17.3	27.7	121.5	180
165	(73.9)	275	(135)	18.7	30.0	131.3	180
175	(79.4)	386	(197)	12.1	19.4	85.2	180
200	(93.3)	386	(197)	16.1	25.7	112.9	180
212	(100.0)	386	(197)	18.2	29.0	127.5	180
220	(104.4)	386	(197)	19.7	31.8	137.9	180
250	(121.1)	555	(291)	14.2	22.7	99.6	180
286	(141.1)	555	(291)	18.1	29.0	127.2	180
300	(148.9)	555	(291)	19.8	31.7	138.9	180
360	(182.2)	765	(407)	16.7	26.8	117.0	180
400	(204.4)	765	(407)	20.0	32.0	139.8	180
450	(232.2)	765	(407)	24.6	39.4	172.2	180
500	(260.0)	765	(407)	30.0	48.1	210.2	210.3

[a] Corrosion resistant sprinklers with coated heat responsive elements including wax, lead, Teflon, wax over lead, and polyester coating. Coated quick response sprinklers shall comply with 33.2.2.

[b] Residential sprinklers shall have a temperature rating within the ordinary and intermediate classifications.

33.2.3 An ESFR sprinkler shall have the following sensitivity characteristics when tested in the sensitivity test oven as specified in 33.2.4 – 33.2.8.

a) An RTI not exceeding 36 $(m \cdot s)^{1/2}$ [65 $(ft \cdot s)^{1/2}$] in the as-received condition, and

b) Mean operating time after being subjected to the exposure tests specified in Sections 36, 44, and 45 shall be equal to or less than a 1.30 multiple of the mean operating time of the sprinklers tested in the as-received condition when tested in the most favorable orientation.

Exception: An ESFR sprinkler shall be permitted to have an RTI greater than 36 $(m \cdot s)^{1/2}$ [65 $(ft \cdot s)^{1/2}$] but not exceeding 50 $(m \cdot s)^{1/2}$ [90 $(ft \cdot s)^{1/2}$] when fire suppression can be demonstrated during large scale fire tests representing the installation conditions, protected storage configurations, and protected commodity specified for the sprinkler utilizing a higher RTI heat responsive element. See Section 55 for examples of large scale fire tests

Table 33.3
Sensitivity Oven Temperatures

Sprinkler 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 – 575	(163 – 302)	765	(407)

33.2.4 Sprinklers 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 in (25.4 mm) away from the inside surfaces of the oven as follows:

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

b) For sprinkler designs (other than ESFR) 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 sprinkler body.

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

d) For ceiling sprinkler designs incorporating removable cups, escutcheons, and removable closure assemblies, ten samples are to be orientated in the pendent position with the closure assemblies removed.

e) For flush sprinklers with an air gap between the heat responsive element and the sprinkler body, ten samples shall be orientated in the pendent position.

f) For ceiling sprinkler designs incorporating an integral closure assembly and flush style sprinklers without an air gap between the heat responsive element and sprinkler body, ten samples are to be orientated with the heat responsive element exposed to the air flow. Recessed or concealed style sprinkler designs where the heat responsive elements are not exposed, and that incorporate integral escutcheons or closures that are not practically removable, are not to be subjected to the Oven Heat Test.

g) For ESFR sprinklers, twenty samples are to be tested. Five samples are to be tested in each of the following orientations:

1) In the pendent position with the frame arms in a plane perpendicular to the direction of the air flow and the heat responsive element upstream of the axis of the sprinkler body. This orientation is generally most favorable with respect to response time.

2) In the pendent position with the sprinkler rotated 90° from the first orientation.

3) In the pendent position with the sprinkler rotated 135° from the first orientation.

4) In the pendent position with the sprinkler rotated 180° from the first orientation.

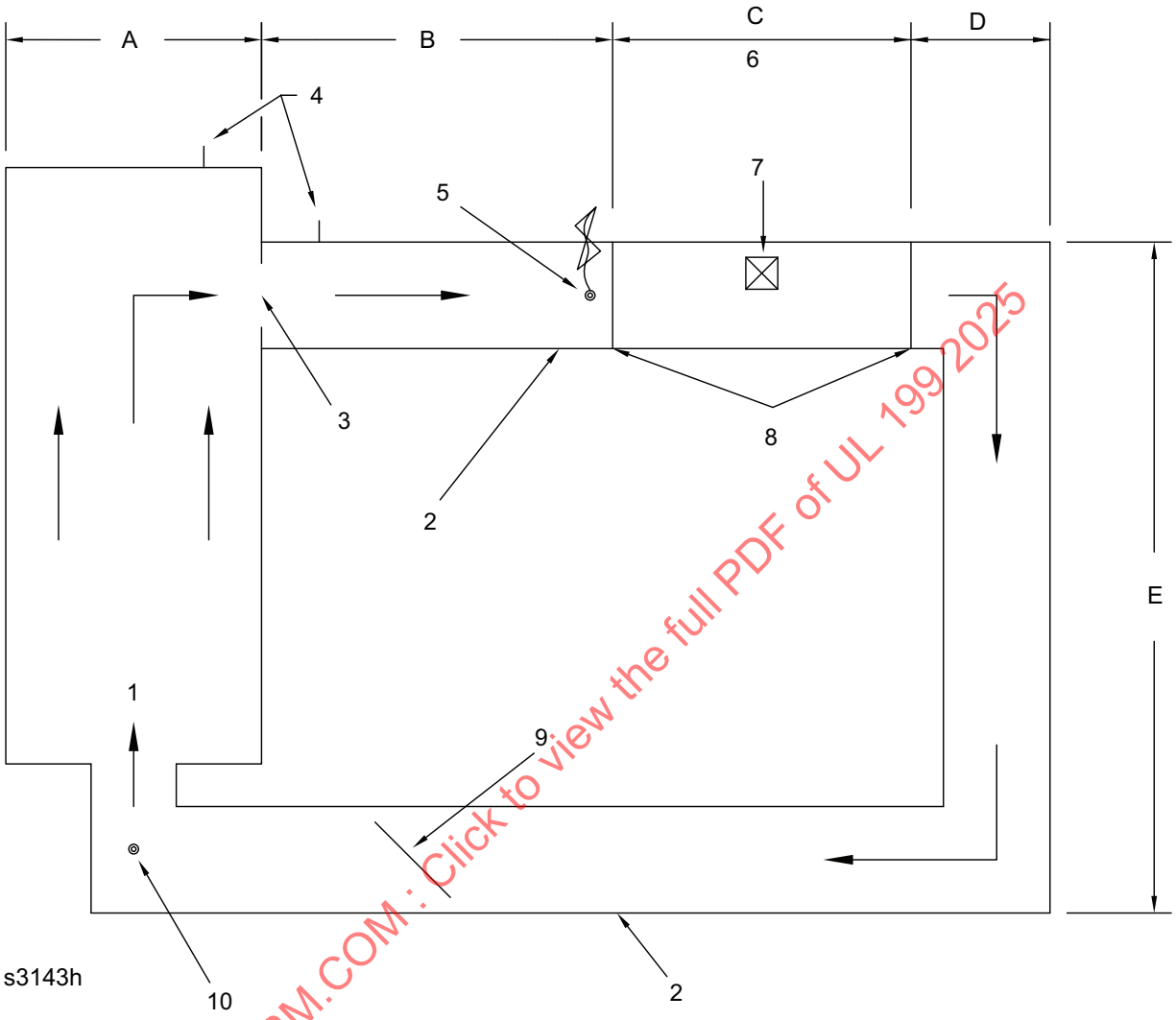
33.2.5 At least ten samples are to be conditioned at 75 ±2 °F (24 ±1 °C) for at least 2 h. The ambient temperature of the room with the plunge oven shall be 75 ±9 °F (24 ±5 °C). The inlet end of each sprinkler

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 s and accurate to within 0.01 ±0.01 s.

33.2.6 The sensitivity test oven is to consist of a square or rectangular stainless steel chamber. A typical chamber is illustrated in Figure 33.1. A constant air velocity of 8.33 ±0.05 ft/s (2.54 ±0.01 m/s) and an air temperature as specified in Table 33.2 for each temperature rating and style sprinkler 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 sprinkler as shown in Figure 33.1.

Figure 33.1

Typical Sensitivity Test Oven Configuration



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)

33.2.7 The required sprinkler operating time values specified in 33.2.1 and 33.2.2 shall be calculated by using the following equation:

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

Where:

RTI: Response Time Index [$(ft \cdot s)^{1/2}$; $(m \cdot s)^{1/2}$]

t_o: Operating time of the sprinkler [s]

u: Nominal gas velocity in the test section of the oven [8.33 ft/s; 2.54 m/s]

T_m: Marked temperature rating of the sprinkler [°F; °C]

T_g : Nominal gas temperature in test section in Table 33.2 [°F; °C]

T_u : Nominal sprinkler conditioning temperature [75 °F; 24 °C]

33.2.8 For ESFR sprinklers, the RTI for each sample is to be computed as follows:

$$RTI = Tu^{1/2}$$

in which:

$$T = -t_o / In\left[1 - \left(\frac{T_m}{T_g}\right)\right]$$

and:

t_o: Operating time of the sprinkler [s] T_m: Marked temperature rating of the sprinkler, [°F; °C]

T_g: Nominal gas temperature in the test section of the oven minus the nominal sprinkler conditioning temperature, [°F; °C]; and

U: Nominal gas velocity in the test section of the oven [8.33 ft/s; 2.54 m/s]

33.3 Room heat tests

33.3.1 When tested in accordance with 33.3.3 and 33.3.4 standard response flush, recessed and concealed standard coverage sprinklers, and standard response extended coverage sprinklers shall operate such that the mean response time and unbiased standard deviation provide computed statistical tolerance limits (see Annex A) with 95 % confidence that 99 % of the sprinklers tested do not exceed the applicable time limit described in Table 33.4.

33.3.2 When tested in accordance with 33.3.3 and 33.3.5, QR standard coverage, QR extended coverage and residential sprinklers shall operate within the applicable time limit described in Table 33.4.

Table 33.4
Room Heat Sensitivity Requirements by Sprinkler Response

Sprinkler type	Sprinkler temperature rating of 170 °F (77 °C) or less	Sprinkler temperature rating of 175 °F (79 °C) to 225 °F (107 °C)
Standard Response	231 sec	189 sec
Standard Response ECLH	231 sec	189 sec
Standard Response ECOH	150 sec	120 sec
QR and Residential	75 sec	75 sec
QR ECLH	75 sec	75 sec
QR ECOH	55 sec	55 sec
ESFR	Test Not Applicable	Test Not Applicable

33.3.3 Sprinklers of each type are to be installed in a test room in the following position and orientation:

a) For pendent and ceiling sprinkler designs without frame arms and incorporating symmetrical heat responsive elements and symmetrical sprinkler bodies, 10 samples are to be installed in their intended position at the ceiling.

b) For pendent and ceiling sprinkler designs with or without frame arms and incorporating unsymmetrical heat responsive elements, 10 samples are to be orientated with the heat responsive element downstream of the axis of the sprinkler body in relation to the direction of the fire source. The samples are to be in their intended position at the ceiling.

c) For pendent and ceiling sprinkler designs incorporating frame arms with symmetrical heat responsive elements, 10 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 position at the ceiling.

d) For pendent and sidewall sprinklers intended to be installed as a recessed sprinkler, 10 samples shall be tested in the recessed position in the ceiling or wall, as applicable, in lieu of the non-recessed position.

e) For flush, recessed and concealed sprinklers having a vented escutcheon, 10 samples are to be installed in the most recessed position in a manner that does not inhibit air flow through the escutcheon.

f) For extended coverage upright sprinklers and pendent sprinklers not intended to be installed as a recessed sprinkler, 10 samples shall be tested with the deflector 10 in (25.4 cm) below the ceiling.

g) For residential pendent sprinklers also intended to be installed as a recessed sprinkler, 10 samples shall be tested in the most recessed position in lieu of the maximum distance below the ceiling when the intended installation distance below the ceiling is 4 in (102 mm) or less.

h) For sidewall sprinklers, 10 samples are to be installed in their intended position with the deflector located 4 in (102 mm) below the ceiling and the maximum distance below the ceiling if intended for distances greater than 6 in (152 mm).

33.3.4 Sprinkler samples used for tests with a starting ambient temperature of 87 ±2 °F (31 ±1 °C) shall be conditioned at 87 ±2 °F (31 ±1 °C) for 2 h prior to being installed. Sprinkler samples having a starting ambient temperature of 120 ±3 °F (49 ±2 °C) shall be conditioned at 120 ±3 °F (49 ±2 °C) for 2 h prior to being installed.

33.3.5 At least ten samples shall be tested in groups of five in a nominal 8 ft (2,4 m) high closed room and subjected to the heat from a 12 in (305 mm) by 12 in (305 mm) by 12 in (305 mm) sand burner (see Figure 33.2) located on the floor in one corner of the room. The sprinklers shall be located 6 in (15 cm)

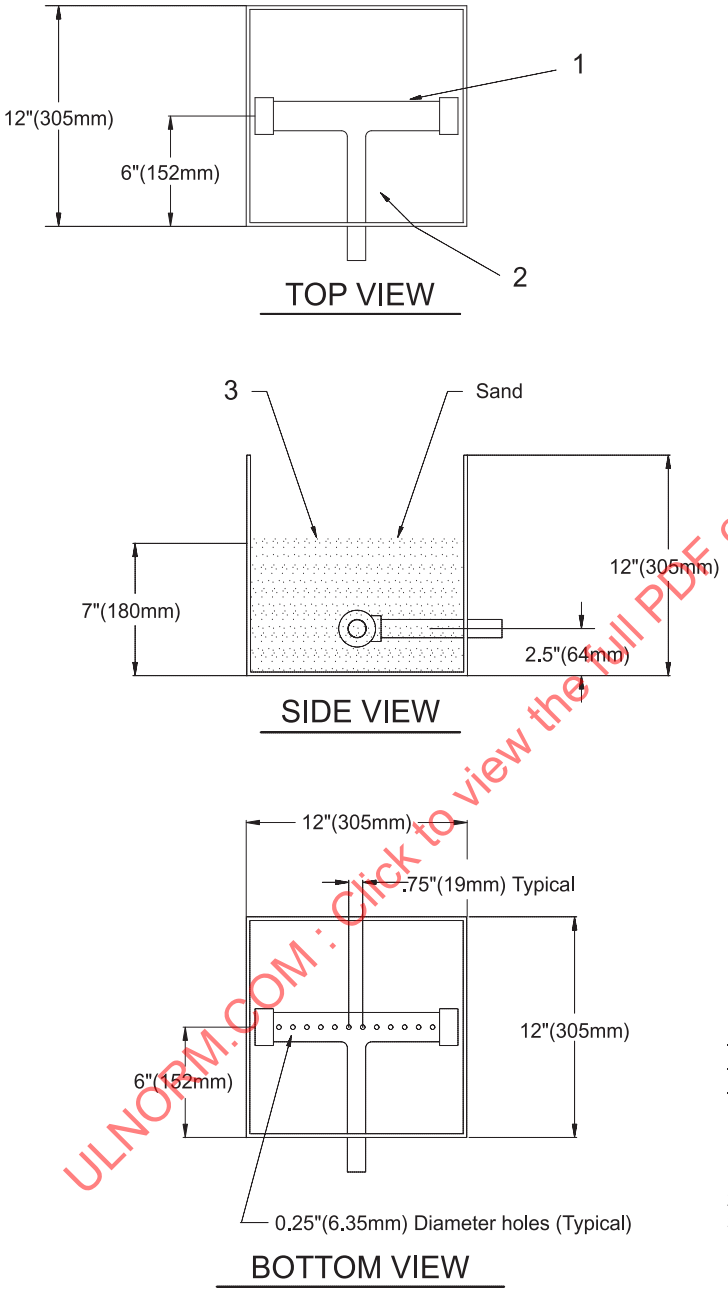
apart as described in Figure 33.3, Figure 33.4, Figure 33.5 or Figure 33.6 for the applicable type of sprinkler referenced in each figure and in Table 33.1 and Table 33.4. The test parameters for each type of sprinkler shall be as specified in Table 33.5. Each sprinkler shall be filled with water at (20 ±5) °C either with no pressure or with the inlet connected to a source of pressure at 0,05 MPa (0,5 bar). During or after the installation of a sprinkler in the room, the sprinklers shall not be exposed to a temperature greater than 15 °F(8 °C) above the starting ambient test temperature.

Table 33.5
Room Heat Sensitivity Test Parameters

Sprinkler type	Test room configuration	Gas flow for sprinkler temperature rating of 170 °F (77 °C) or less, ft^3/h (m^3/h)	Gas flow for sprinkler temperature rating of 175 °F (79 °C) to 225 °F (107 °C), ft^3/h (m^3/h)	Starting ambient temperature for sprinkler temperature rating of 170 °F (77 °C) or less, °F (°C)	Starting ambient temperature for sprinkler temperature rating of 175 °F (79 °C) to 225 °F (107 °C), °F (°C)
Standard-Response	Figure 33.3	340 (9.6)	915 (25.9)	87 ±2 (31 ±1)	120 ±3 (49 ±2)
Standard-Response Extended Coverage	Figure 33.4	340 (9.6)	915 (25.9)	87 ±2 (31 ±1)	120 ±3 (49 ±2)
Quick Response	Figure 33.5	500 (14.2)	600 (17.0)	87 ±2 (31 ±1)	120 ±3 (49 ±2)
Residential	Figure 33.5	500 (14.2)	500 (14.2)	87 ±2 (31 ±1)	87 ±2 (31 ±1)
Quick Response Extended Coverage	Figure 33.6	500 (14.2)	600 (17.0)	87 ±2 (31 ±1)	120 ±3 (49 ±2)

Figure 33.2

Example of Sand Burner Apparatus



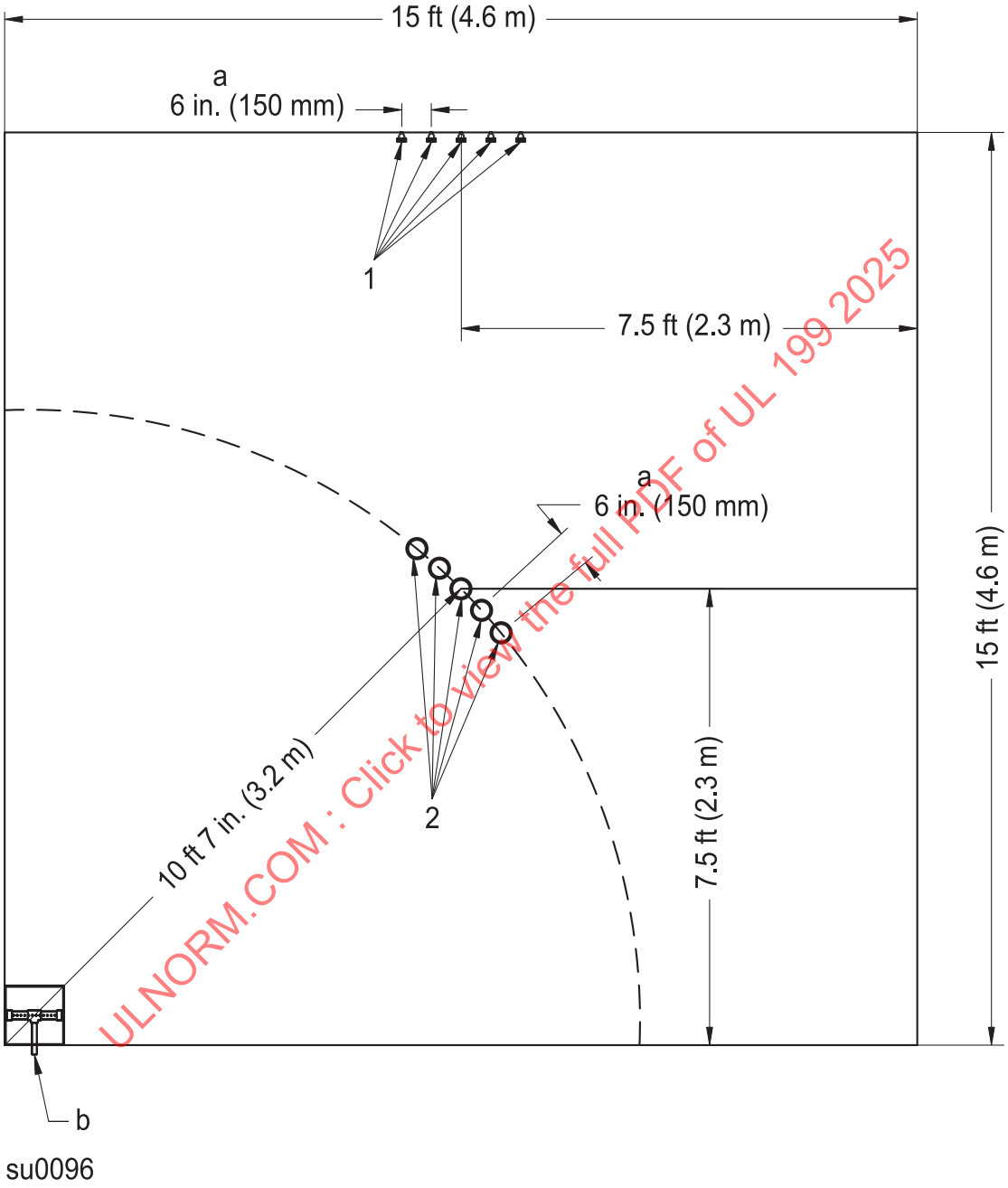
Materials:
- Steel Plate Box, Welded.
- Steel or Stainless Steel Piping and Fittings.
- Mason Grade Sand.

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

S5529

Figure 33.3

Plan View of Room Heat Test for Standard Response Flush, Recessed and Concealed Sprinklers having a Standard Coverage Area



Key

1 – sidewall sprinkler locations

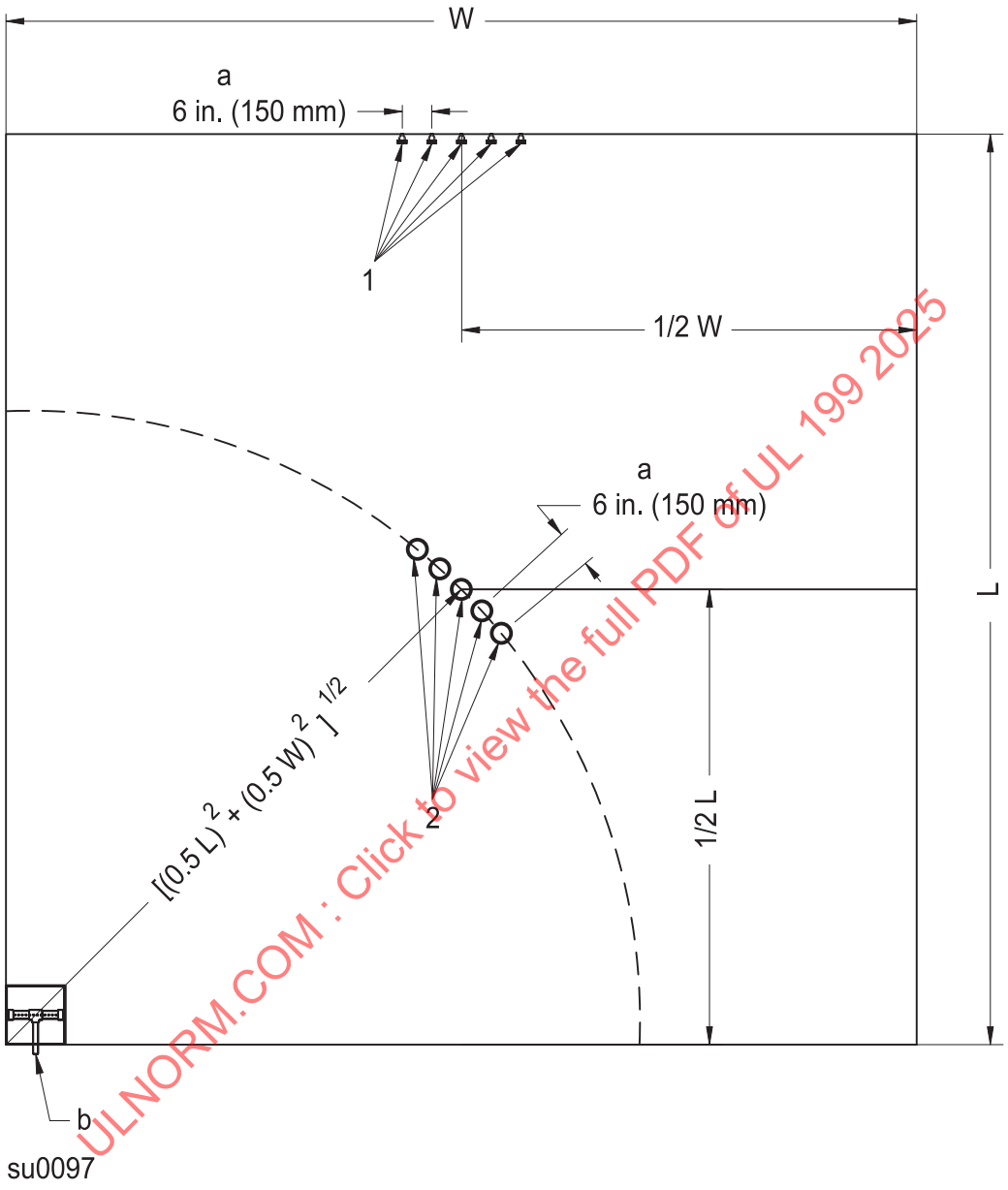
2 – pendent sprinkler locations

a – typical dimension

b – sand burner

Figure 33.4

Plan View of Room Heat Test for Standard Response Extended Coverage Sprinklers



Key

1 – sidewall sprinkler locations

2 – pendent sprinkler locations

L – coverage length

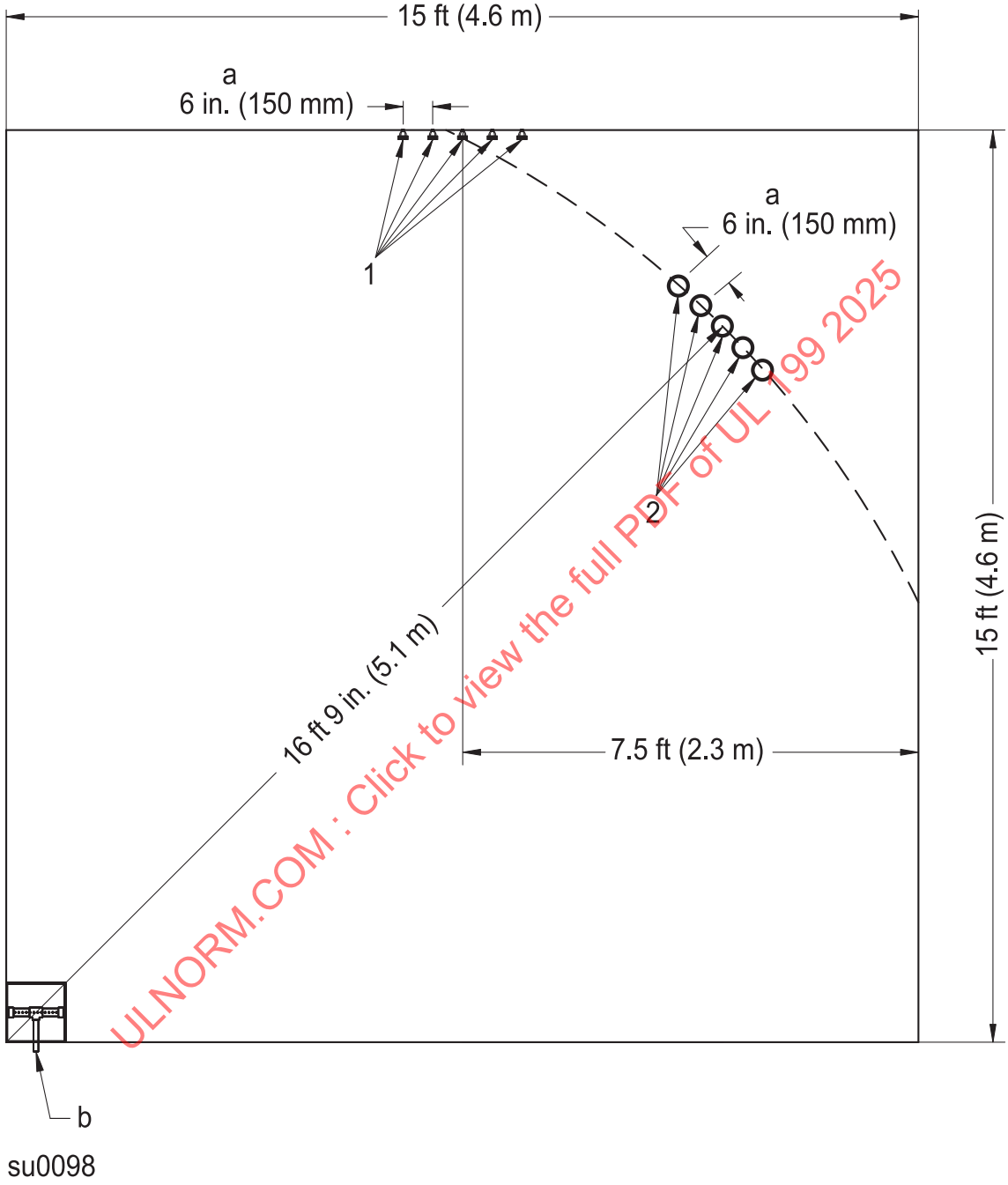
W – coverage width

a – typical dimension

b – sand burner

Figure 33.5

Plan View of Room Heat Test for QR and Residential Sprinklers



Key

1 – sidewall sprinkler locations

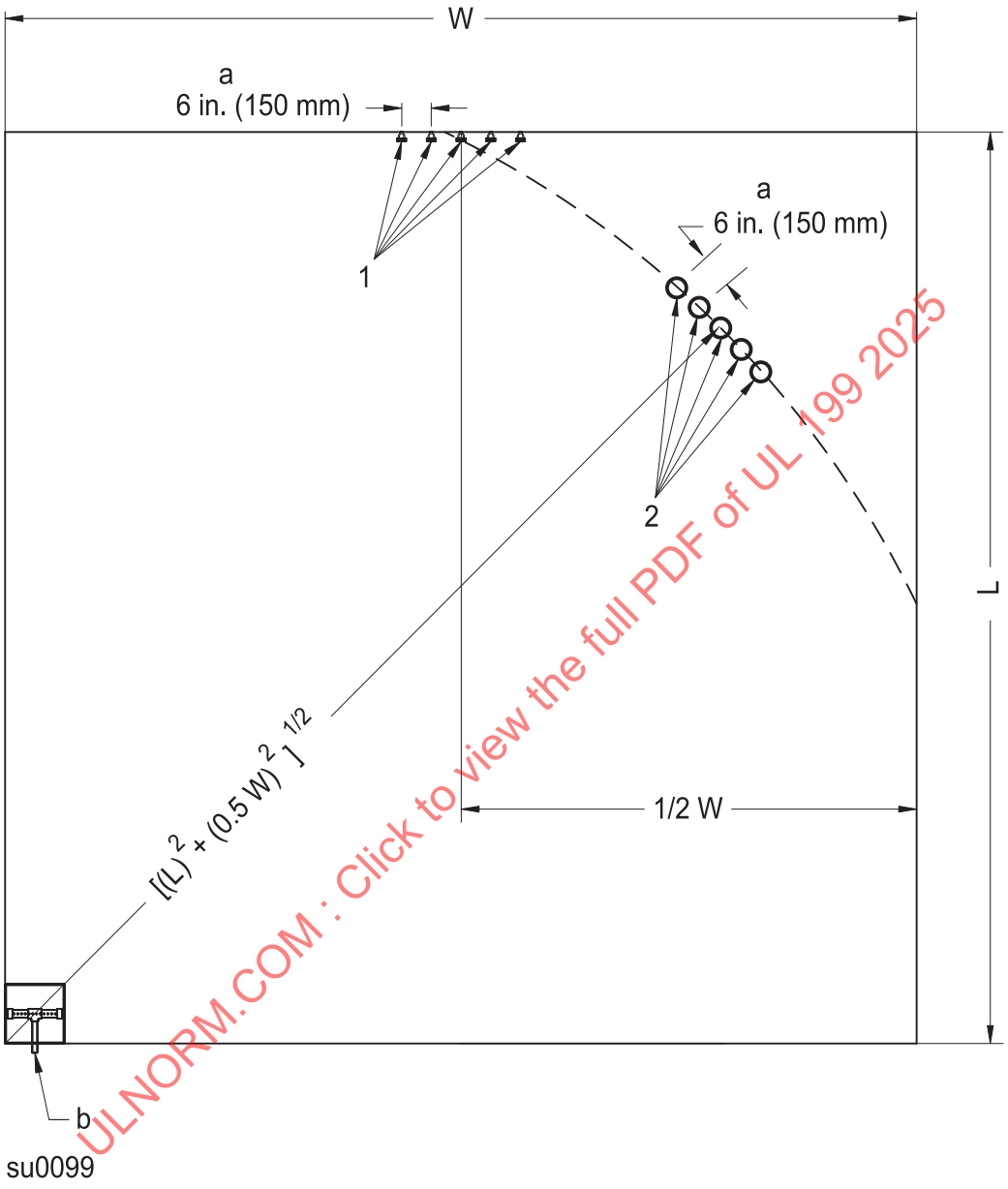
2 – pendent sprinkler locations

a – typical dimension

b – sand burner

Figure 33.6

Plan View of Room Heat Test for QR Extended Coverage Sprinklers



Key

1 – sidewall sprinkler locations

2 – pendent sprinkler locations

L – coverage length

W – coverage width

a – typical dimension

b – sand burner

34 Operation – Lodgement Test

34.1 An automatic sprinkler shall operate at service pressures of 7 psig (48 kPa) to the rated pressure. Upright dry-type sprinklers shall be permitted to operate at a minimum pressure in accordance with 34.3.

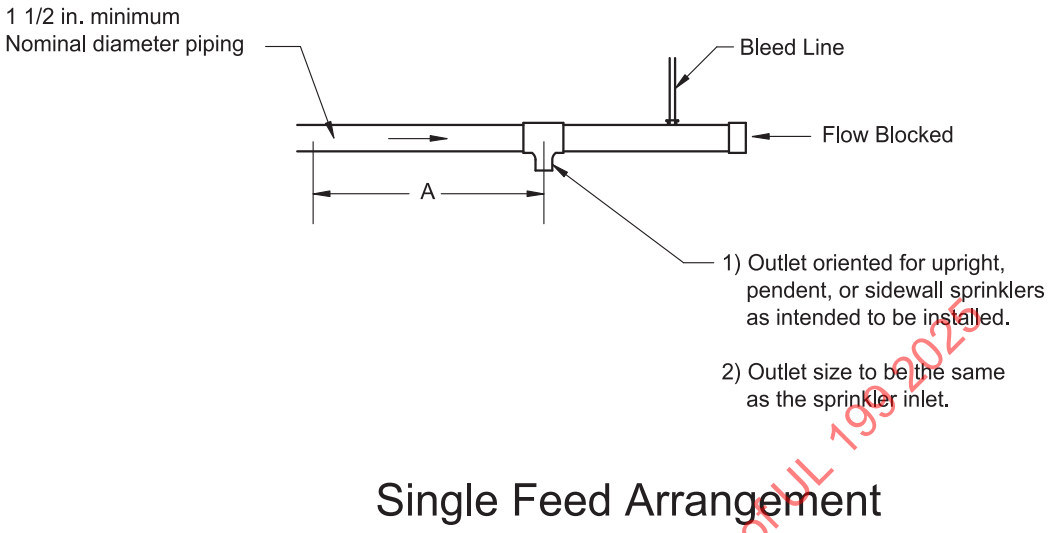
34.2 All operating parts shall release with sharp, positive action. Operating parts intended to be released from the sprinkler assembly shall clear the sprinkler frame and deflector to not impair the water distribution pattern and internal parts of dry sprinklers shall operate to not restrict water flow below its intended rate.

34.3 An upright dry-type sprinkler of the maximum length shall operate and clear the operating parts at a pressure of 12.5 psig (86 kPa) or less. When the minimum pressure required to clear operating parts exceeds 5 psig (34 kPa), the minimum operating pressure of the sprinkler as referenced in the Manufacturer's Installation Instructions, Section 60, shall be designated as two times the minimum pressure required to clear the operating parts.

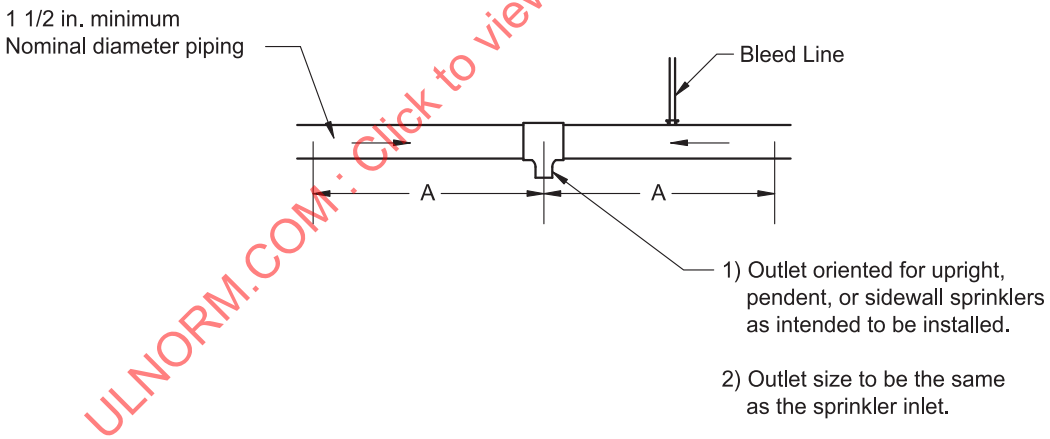
34.4 Automatic sprinklers or dry-type automatic sprinklers in the shortest length are to be individually tested except as specified in 34.3. Each sample is to be installed in its intended installation position on a rigid piping arrangement and supplied with flowing water. Tests are to be conducted using a single-feed and a double-feed water supply arrangement as described in Figure 34.1. The test pressures and number of samples tested at each pressure using each water supply configuration is to be as specified in Table 34.1. Each sample is to be operated by exposing the heat responsive element to a uniform application of heat. A sprinkler does not comply when a part interfering with correct water distribution or water flow maintains interference for more than 10 s 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.

Figure 34.1

Operation – Lodgement Test Arrangements



Single Feed Arrangement



Double Feed Arrangement

su0101

A – Minimum 10 times nominal diameter straight length

Table 34.1
Samples and Test Pressures for Operation-Lodgement Test

Test pressure, psig (kPa)	Water supply arrangement	Number of test samples
7 (48)[a]	Single Feed	5
7 (48)[a]	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[b]	Single Feed	5 at each pressure
Incremental 25[b]	Double Feed	5 at each pressure

[a] For dry upright sprinklers, the starting test pressure is 12.5 psig (86 kPa).

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

34.5 To determine the minimum operating pressure for upright dry-type sprinklers, five samples of maximum length are to be individually tested. Samples are to be installed on piping connected to a water supply intended for the purpose. With the supply pressure at 0 psig (0 kPa), the heat responsive element of each sample is to be operated. The service pressure is then to be increased at a rate not greater than 1 psig (7 kPa) in 15 s. The pressure at which internal parts clear the waterway is to be noted.

34.6 To determine that the internal parts of a dry sprinkler do not restrict the intended flow rate, a flow meter is to be connected to the water supply piping. Prior to operation of the test samples in 34.4, an operated sample that has demonstrated acceptable K-factor results in the Discharge Coefficient Test, Section 53, fixture shall be installed in the operational test fixture. Water is to be flowed at each of the pressures noted in 34.4 and the K-factor at each pressure is to be recorded. Dry-type sprinkler samples are to be tested as described in 34.4. After sprinkler operation, the flow at each pressure specified in 34.4 is to be recorded. The discharge coefficient K-factor is then to be calculated as specified in 53.4. The K-factor value shall be within 5 percent of previously tested K-factor samples.

35 Cycling Tests For Flow Control (FC) Sprinklers

35.1 Operational cycling test

35.1.1 An FC sprinkler shall operate as intended for 10,000 cycles when tested as described in 35.1.2. Following the 10,000 cycles of operation the sprinkler shall comply with the requirement in 25.1, except that slight weeping defined as leakage not exceeding 20 mL/min shall be permitted.

35.1.2 The sprinkler is to be installed in a test fixture and supplied with water at a pressure of 40 ±5 psig (276 ±49 kPa). Heat is to be applied to the sprinkler until it operates and attains the fully open position. The heat application then is to be discontinued and the heat sensing element permitted to cool until the sprinkler closes. This procedure is to be repeated until the specified number of test cycles is completed. The interval between each closing of the sample and reapplication of the heat is not to be greater than 60 s.

35.2 Cycling after water exposure test

35.2.1 An FC sprinkler shall operate as intended for 1000 cycles when tested as described in 35.1.2, after being immersed for 14 days in distilled water at a temperature between 203 – 212 °F (95 – 100 °C).

35.3 Contaminated-water cycling test

35.3.1 An FC sprinkler shall show no evidence of clogging when subjected to 1000 cycles as described in 35.1.2 using water that has been contaminated in accordance with 35.3.2. Following the 1000 cycles, the sprinkler shall comply with the requirements in 25.1, except that slight weeping defined as leakage not exceeding 20 mL/min shall be permitted.

35.3.2 The water used during the cycling specified in 35.3.1 is to consist of 15 gallons (0.06 m^3) of tap water into which has been mixed 3.5 lbs (1.584 kg) of contaminants which sieve as described in Table 35.1. The solution is to be continuously agitated during the test.

Table 35.1
Contaminant for Contaminated-Water Cycling Test

Sieve designation[a]	Nominal sieve opening		Grams of contaminant (±5 %)		
	in	(mm)	Pipe scale	Top soil	Sand
No. 25	0.0278	(0.706)	–	456	200
No. 50	0.0117	(0.297)	82	82	327
No. 100	0.0059	(0.150)	84	6	89
No. 200	0.0029	(0.074)	81	–	21
No. 325	0.0017	(0.043)	153	–	3
Total			400	544	640

[a] Sieve designations correspond with those specified in the Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves, ASTM E11. Cenco-Meinzer sieve sizes 25 mesh, 50 mesh, 100 mesh, 200 mesh, and 325 mesh, corresponding with the number designation in the table, have been found to comply with ASTM E11.

EXPOSURE AND CORROSION TESTS

36 High Temperature Exposure Test (90 Day)

36.1 An automatic sprinkler, except for wax coated sprinklers, shall withstand for 90 days, without evidence of weakness or malfunction, an exposure to a high-ambient temperature in accordance with Table 36.1, 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). To evaluate weakness and malfunction following the exposure, each sprinkler shall comply with the Leakage Test, Section 25. Also, following the leakage test, each sprinkler shall be operable and comply with the following sensitivity requirements based upon the type of sprinkler:

a) Sprinklers other than recessed and concealed types are to be subjected to the Oven Heat Test, see 33.2.1 – 33.2.8. The mean time of operation shall not increase more than a 1.30 multiple when

compared to the mean operating time of samples not subjected to the High Temperature Exposure Test (90 Day), Section 36. In addition, the operating time for each standard response sprinkler sample shall be within the limits described in 33.2.1.

b) Recessed and concealed sprinklers are to be subjected to the Room Heat Test, see 33.3. The mean time of operation shall not increase more than a 1.30 multiple when compared to the mean operating time of samples not subjected to the High Temperature Exposure Test (90 Day), Section 36.

Table 36.1
High-Temperature Exposure Test Conditions

Sprinkler 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)

36.2 An automatically-controlled, circulating-type, constant-temperature oven is to be used for this test. Five automatic sprinklers of each operating temperature are to be placed in an oven at the specified test temperature. For dry-type sprinklers, the minimum length to be produced shall be tested.

37 High Temperature Exposure Test for Wax Coated Sprinklers

37.1 A wax coated automatic sprinkler shall withstand for 90 days without evidence of deterioration or malfunction an exposure to a high-ambient temperature as specified in Table 9.1, 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. To evaluate malfunction following the exposure, sprinklers are to be subjected to the Oven Heat Test, see 33.2.1 – 33.2.8.

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

38 High Temperature Exposure Test For Flow Control (FC) Sprinklers

38.1 After being conditioned as described in 38.2, the change in the average discharge coefficient "K" of an FC sprinkler shall not exceed 10 % when compared with sprinklers that have not been conditioned.

38.2 Five sprinklers are to be conditioned for 1 h in a preheated circulating air oven maintained at 1000 °F (537 °C). The sprinklers then are to be removed from the oven and allowed to cool for at least 3 h at room temperature.

38.3 After cooling, the sprinklers are to be subjected to the Discharge Coefficient Test, Section 53, to determine compliance with the requirements in 38.1.

38.4 The sprinklers are to be maintained in their intended installation position at all times during the exposure and while being subjected to the Discharge Coefficient Test, Section 53.

39 Heat Resistance Test

39.1 A sprinkler, other than a polymeric residential sprinklers (see Section 52), without operating parts shall withstand the exposure to heat and subsequent immersion in water as described in 39.2 without signs of significant deformation, blistering or fracture.

39.2 A sample sprinkler, 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 min. Following the exposure, the sprinkler shall be removed from the oven by holding the inlet portion of the sprinkler, 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).

40 Elastomeric Parts Test

40.1 An elastomeric part used to provide a seal shall have the following properties when tested as specified in the Standard for Gaskets and Seals, UL 157:

a) For silicone rubber (having poly-organo-siloxane as its constituent characteristic), a minimum tensile strength of 500 psi (3.4 MPa) and a minimum ultimate elongation of 100 %.

b) For natural rubber and synthetic rubber other than silicone rubber, a minimum tensile strength of 1500 psi (10.3 MPa) and minimum ultimate elongation of 150 %; or a minimum tensile strength of 2200 psi (15.2 MPa) and a minimum ultimate elongation of 100 %.

c) Those properties relating to maximum tensile set; minimum tensile strength and elongation after oven aging; and hardness after oven aging, all as specified in Standard for Gaskets and Seals, UL 157. Also, the maximum compression set shall be 25 %. The maximum service temperature used to determine the oven time and temperature for oven aging is 60 °C (140 °F), unless the product is designated for use at a higher temperature.

40.2 The Standard for Gaskets and Seals, UL 157, provides for the testing of either finished elastomeric parts or sheet or slab material. Sheet or slab material is to be tested when the elastomeric parts are O-rings having diameters of less than 1 in (25.4 mm). The material tested is to be the same as that used in the product, regardless of whether finished elastomeric parts or sheet or slab material is tested.

41 Vibration Test

41.1 An automatic sprinkler shall withstand the effects of vibration without deterioration of its performance characteristics when subjected to vibration at the frequency, duration, and amplitude described in 41.2 and 41.3. Following the vibration, the sprinkler shall comply with the requirements in the Leakage Test, Section 25. After being subjected to the Leakage Test, the sprinkler shall then be subjected to the Sensitivity Tests, Section 33, based upon the type of sprinkler.

41.2 Five samples are to be attached to a steel mounting plate in any convenient fashion and the plate is to be bolted to the table of a vibration machine so that the samples are mounted vertically. The samples are to be vibrated in the vertical direction while unpressurized as indicated in Table 41.1. If the sprinklers exhibit resonance at any frequency within the tested ranges, the resonant frequency (frequencies) is to be used for the entire test period. For dry-type sprinklers, samples of the maximum length produced are to be tested.

Table 41.1
Vibration Test

Amplitude		Displacement		Frequency, hz	Duration, h
in	(mm)	in	(mm)		
0.04	(1.02)	0.08	(2.03)	18 to 37	120

41.3 For these tests, 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.

42 Freezing Test

42.1 Following exposure to the freezing conditions described in 42.2, an automatic sprinkler shall either operate, leak at low pressure, or not sustain any damage when water pressure is applied and shall comply with the requirements in Leakage Test, Section 25, and in Sensitivity Tests, Section 33.

42.2 Five sample sprinklers are to be individually connected to one end of a 4 in (101 mm) long, nominal 1 in or larger steel pipe. Each pipe is to be completely filled with water and exposed to an atmosphere of minus 20 ±10 °F (minus 29 ±5 °C) for 24 h. Following the exposure, the samples are to be visually examined. When no damage or evidence of operation is noted, the samples are then to be checked to determine whether they leak at a pressure of 7 psig (48 kPa). When they do not leak at a pressure of 7 psig (48 kPa), the samples shall then comply with the requirements in Leakage Test, Section 25, and Sensitivity Tests, Section 33. The test is to be repeated when the test apparatus, other than a sprinkler, fractures due to the freezing.

43 Evaporation Test for Wax Coatings

43.1 When tested as specified in 43.3, a protective coating for a sprinkler containing volatiles such as wax or similar material shall not shrink, harden, crack, or flake.

43.2 When tested as specified in 43.3, the loss of volatiles in a wax coating shall not exceed 5 % of the weight of the original sample.

43.3 A 50 mL sample of the protective coating is to be placed in a metal or glass cylindrical container having a flat bottom, an inside diameter of 55 mL, and an inside height of 35 mL. The container, without any lid, is to be placed in an automatically controlled, circulating-air, constant-ambient-temperature oven. The oven temperature is to be controlled as described in High Temperature – Test for Wax Coated Sprinklers, Section 37. The test is to be conducted for 90 days. During the test, the sample is to be removed from the oven at 7 day intervals and allowed to cool for not less than 2 nor more than 4 h. During this cooling time, the sample is to be examined for evidence of shrinking, hardening, cracking, or flaking. The sample is to be weighed before and after the 90 day exposure to determine loss of volatiles.

44 10-Day Corrosion Test

44.1 General

44.1.1 The external parts of an automatic sprinkler shall withstand an exposure to salt spray, hydrogen sulfide, and carbon dioxide-sulfur dioxide atmospheres when tested in separate groups of samples in accordance with 44.1.2 – 44.1.4 for a period of 10 days. Following the exposure, each sprinkler shall be operable and comply with the following sensitivity requirements based upon the type of sprinkler:

a) Sprinklers other than recessed and concealed types are to be subjected to the Oven Heat Test, see 33.2.1 – 33.2.8. The mean time of operation shall not increase more than a 1.30 multiple when compared to the mean operating time of samples not subjected to the 10-Day Corrosion Test, Section 44. In addition, the operating time for each standard response sprinkler sample shall be within the limits described in 33.2.1.

b) Recessed and concealed sprinklers are to be subjected to the Room Heat Test, see 33.3. The mean time of operation shall not increase more than a 1.30 multiple when compared to the mean operating time of samples not subjected to the 10-Day Corrosion Test, Section 44.

44.1.2 During the corrosive exposure, the sprinkler inlet is to be sealed by a plastic cap after the sprinkler has been filled with deionized water and provisions taken to prevent condensation from falling directly onto the test samples.

44.1.3 Within 1 to 5 days following the exposure period, each sample is to be subjected to the Sensitivity Test, Section 33, in the most favorable position with respect to operating time.

44.1.4 For all sprinklers except the ESFR type, three groups, each consisting of five sample sprinklers, are to be assembled. One group is to be exposed to 20 % salt spray, the second to hydrogen sulfide, and the third to sulfur dioxide-carbon dioxide. For ESFR sprinklers, four groups, each consisting of five sample sprinklers, are to be assembled. Two groups are to be exposed to 20 % salt spray, the third to hydrogen sulfide, and the fourth to sulfur dioxide-carbon dioxide.

44.1.5 CAUTION – Hydrogen sulfide and sulfur dioxide are both toxic gases. Hydrogen sulfide gas is also flammable. Because of this, such gases must be stored, transferred, and used only with gastight systems. Adequate ventilation must also be provided 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.

44.2 Salt spray exposure

44.2.1 The samples are to be supported vertically and exposed to salt spray (fog) as specified in Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117, except that the salt solution is to consist of 20 % by weight of common salt (sodium chloride). For all sprinklers except ESFR, one group of five samples is to be supported with the inlet in the vertical down position. For ESFR sprinklers, one group is to be supported with the inlet in the vertical down position and one group supported with the inlet in the vertical up position.

44.3 Moist hydrogen sulfide air mixture

44.3.1 The samples are to be supported with the inlet in the vertical down position and exposed to a moist hydrogen sulfide air mixture in a closed glass chamber maintained at an ambient temperature of 75 ±5 °F (24 ±3 °C). On 5 days out of every 7, an amount of hydrogen sulfide equivalent to 1.0 % 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 flowmeter 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 2 days out of every 7 that this does not occur, the chamber is to remain closed and no purging or introduction of gas is to be provided. During the exposure, the gas-air mixture is to be gently stirred by means of a small fan located in the upper middle portion of the chamber. A small amount of water (10 mL/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

44.4 Moist carbon dioxide-sulfur dioxide air mixture

44.4.1 The samples are to be supported with the inlet in the vertical down position and exposed to a moist carbon dioxide-sulfur dioxide air mixture in a closed glass chamber maintained at an ambient temperature of 75 ±5 °F (24 ±3 °C). On 5 days out of every 7, an amount of carbon dioxide equivalent to 1.0 % of the volume of the chamber, plus an amount of sulfur dioxide equivalent to 1.0 % of the volume of the chamber, is 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 2 days out of every 7 that this does not occur, the chamber is to remain closed and no purging or introduction of gas is to be provided. A small amount of water (10 mL/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

45 30-Day Corrosion Test

45.1 The external parts of an automatic sprinkler 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 separate groups of samples in accordance with 44.1.2 – 44.1.4 for a period of 30 days. Following the exposure, each sprinkler shall be operable and comply with the following sensitivity requirements based upon the type of sprinkler:

a) Sprinklers other than recessed and concealed types are to be subjected to the Oven Heat Test, see 33.2.1 – 33.2.8. The mean time of operation shall not increase more than a 1.30 multiple when compared to the mean operating time of samples not subjected to the 30-Day Corrosion Test, Section 45. In addition, the operating time for each standard response sprinkler sample shall be within the limits described in 33.2.1.

b) Recessed and concealed sprinklers are to be subjected to the Room Heat Test, see 33.3. The mean time of operation shall not increase more than a 1.30 multiple when compared to the mean operating time of samples not subjected to the 30-Day Corrosion Test, Section 45.

45.2 Each sample is to be subjected to the Sensitivity Test, Section 33, within 1 to 5 days following the exposure period.

46 90-Day Moist Air Test

46.1 An automatic sprinkler shall withstand an exposure to high temperature-humidity in accordance with 46.2 for a period of 90 days. Following the exposure, each test sample shall operate at a service pressure not exceeding 7 psig (48 kPa) within 5 s after operation of the heat responsive element.

46.2 Five samples are to be installed on a pipe manifold which 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 %. The sprinkler samples for the moist air test are to have heat responsive elements that have a temperature rating to withstand the elevated temperature.

46.3 After the exposure, each sample is to be installed on piping and supplied with water at a service pressure of 7 psig (48 kPa). Each sprinkler 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 sprinkler assembly shall be thrown clear of the frame and deflector within 5 s after operation of the heat responsive element.

47 Exposure Tests on Sprinklers Incorporating Polymeric Gaskets

47.1 General

47.1.1 An automatic sprinkler that incorporates a polymeric material to effect the closure of the orifice shall not leak, where specified, and shall operate at a service pressure not exceeding 7 psig (48 kPa) after being exposed, in separate groups of samples, to the exposures specified in 47.2 – 47.6.

47.2 Corrosive exposures

47.2.1 Three groups, each consisting of five samples, are to be assembled. One group is to be exposed to 20 % salt spray as specified in 44.2.1, the second to hydrogen sulfide as specified in 44.3.1 and the third to carbon dioxide-sulfur dioxide as specified in 44.4.1. Each exposure period is to be 30 days.

47.2.2 Following the exposure, the operating parts in contact with the polymeric material of each test sample shall operate within 5 s after being exposed to a service pressure not exceeding 7 psig (48 kPa).

47.3 Temperature cycling exposure

47.3.1 Five samples are to be exposed to ten temperature cycles, each comprised of a 24 h exposure to a low temperature of minus 40 °F (minus 40 °C) and a 24 h exposure to a high temperature as specified in Table 36.1.

47.3.2 Following the exposures, each sprinkler is to be installed on piping and supplied with water at a service pressure of 7 psig (48 kPa). Each sprinkler is then to be operated by exposing the heat responsive element to a uniform application of heat. The operating parts in contact with the polymeric material of each test sample shall operate as intended within 5 s.

47.4 Hydrocarbon exposure followed by moist air exposure

47.4.1 Two groups, each consisting of five samples, are to be assembled. One group is to have the sprinkler inlet exposed to a liquid mixture of saturated hydrocarbon chains ranging from C12 to C17, mixed in equal parts by weight. The second group is to have the sprinkler inlet exposed to a solid wax mixture of saturated hydrocarbon chains ranging from C18 to C25, mixed in equal parts by weight. The wax mixture has a melting point of 129 ±2 °F (54 ±1 °C). A hydrocarbon material equal to or greater than that required to completely cover the water seal area or 0.025 ml (approximately 0.1 g) is to be placed in the sprinkler inlet in a manner to expose the polymeric seal assembly to the hydrocarbon. The samples using the wax mixture shall be warmed to 140 ±5 °F (60 ±3 °C) to liquefy the material for even distribution over the seal area. Both groups of sprinklers are then to be conditioned at 70 ±10 °F (21 ±5.6 °C) for a minimum of 72 h. After these exposures, the samples are then to be subjected to the 90 day moist air test specified in 90-Day Moist Air Test, Section 46, with the sprinkler installed in the pendent position and the hydrocarbon mixtures left in the inlet.

47.4.2 After these test exposures, each sample is to be hydrostatically pressurized at 7 psig (48 kPa) and examined for leakage for a period of 1 min, and then operated by exposing the heat responsive element to a uniform application of heat.

47.5 Hydrocarbon exposure followed by water immersion exposure

47.5.1 Two groups, each consisting of five samples, are to be assembled and subjected to the hydrocarbon exposures described in 47.4. After the minimum 72 h hydrocarbon exposure, the samples are to be installed on a manifold and hydrostatically pressurized to a pressure value of 25 psig (172 (kPa) less than the rated pressure and immersed for 90 days in tap water maintained at a temperature of 189

±3.6 °F (87 ±2 °C). After 30 and 60 days, the hydrostatic pressure is to be released and then repressurized to a pressure value of 25 psig (172 (kPa) less than the rated pressure.

47.5.2 After these exposures, each sample is to be hydrostatically pressurized and operated at 7 psig (48 kPa) and examined for leakage for a period of 1 min, and then operated by exposing the heat responsive element to a uniform application of heat.

47.6 Exposure to antifreeze solutions

47.6.1 Two groups, each consisting of five samples, are to be assembled. The samples are to be installed onto a manifold. The manifold is to be partially filled, such that the inlet of each sample is exposed to the following antifreeze solutions (by volume) for 90 days at a temperature of 189 ±3.6 °F (87 ±2 °C):

a) One group exposed to a 40 % propylene glycol/60 % tap water mixture; and

b) One group exposed to a 50 % glycerine/50 % tap water mixture.

47.6.2 After these exposures, each sample is to be hydrostatically pressurized at 7 psig (48 kPa) and examined for leakage for a period of 1 min, and then operated by exposing the element to a uniform application of heat.

48 Dry-Type Sprinkler Deposit Loading Test

48.1 After exposure to a carbon dioxide-sulfur dioxide atmosphere in accordance with 48.2 – 48.6 for 30 days, the water seal assembly and internal components of a dry-type sprinkler shall function as intended within 5 s after 7 psig (48 kPa) air pressure is applied to the sprinkler inlet.

48.2 After the carbon dioxide-sulfur dioxide exposure, the samples are to be dried at 120 ±5 °F (49 ±2 °C) in an automatically-controlled, circulating-type, constant temperature oven for not less than 24 h or more than 72 h prior to being operated at 7 psig (48 kPa) with air.

48.3 Two groups, each consisting of five sample sprinklers in the ordinary temperature rating and the minimum length to be produced, are to be assembled. If lubricant is required to facilitate sprinkler assembly, the minimum amount required to assemble the test samples shall be used. One group is to be exposed with the sprinkler in the vertical position with the inlet up and the second group with the sprinkler inlet down.

48.4 The samples are to be exposed to a moist carbon dioxide-sulfur dioxide air mixture in a closed chamber maintained at 95 ±3 °F (35 ±1.7 °C). The samples are to be supported in a manner to permit the internal and external sprinkler parts to be exposed to the gases, such as by placing test samples on polymeric light diffuser trays with nominal 0.5 by 0.5 in (12.7 by 12.7 mm) openings. All test samples shall be supported at only one elevation level within the chamber. On five days out of every seven, an amount of carbon dioxide equivalent to 1.0 % of the volume of the chamber, plus an amount of sulfur dioxide equivalent to 1.0 % of the volume 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 be provided. 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. This water is to be replaced weekly.

48.5 After exposure to the carbon dioxide-sulfur dioxide air mixture, each sample is to be dried as specified in 48.2. Each sample is then to be stored at 70 ±5 °F (21 ±3 °C) prior to installation onto piping in the pendent position and supplied with air at a service pressure of 7 psig (48 kPa). Each sprinkler is then to be activated by exposing the heat responsive element to a uniform application of heat or by removing

the heat responsive element if it is degraded by the moist carbon dioxide-sulfur dioxide exposure. The water seal assembly and other internal parts shall clear the waterway as intended.

48.6 CAUTION – Sulfur dioxide is a toxic gas. This gas must be stored, transferred, and used only with gastight systems. Adequate ventilation must also be provided to handle leakage. Presence of this gas is readily noticeable. Due to its unpleasant odor and irritant effect, it gives warning of its presence.

49 Dezincification Test of Brass Parts

49.1 General

49.1.1 Sprinkler parts that are made of a copper alloy containing more than 15 % zinc and normally exposed to system water shall not exhibit the following after exposure to a copper chloride solution for 144 h:

a) An average dezincification depth exceeding 0.0039 in (100 µm); and

b) An individual reading of dezincification depth exceeding 0.0079 in (200 µm).

49.2 Reagent

49.2.1 A test solution is to be prepared by dissolving 0.028 lb (12.7 g) of copper (II) chloride dihydrate ($CuCl_2 \cdot 2H_20$) in distilled water and then making up the volume to 0.26 gallon (1000 ml). Fresh solution is to be used for each test.

49.3 Test pieces

49.3.1 Three test pieces are to be taken from the sprinkler part. These pieces are to be cut in such a way, for example by sawing and grinding with light pressure, that the properties of the materials are unaffected. The area of each test piece to be exposed shall be approximately 0.155 in^2 (100 mm^2).

49.3.2 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.

49.4 Method

49.4.1 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 in (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 0.066 gallon (+0.013 gallon, -0.0026 gallon) [250 ml (+50 ml, -10 ml)] of the copper (II) chloride solution is required per 0.155 square in (100 mm^2) of exposed surface of the test piece.

49.4.2 The beaker containing the test piece is to be placed in the thermostatically controlled oven or oil bath with the temperature maintained at 167 ±3 °F (75 ±2 °C). The test piece is to be exposed continuously for 144 h. 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.

49.4.3 Microscopic examination of the test piece is to be conducted as soon as possible after the exposure. If the test pieces are stored before microscopic examination, they are to be kept in a desiccator. Each test piece is to be sectioned at right angles to the exposed test surface, and the remaining thermoset resin attached to the section that is to be removed. The cross-sectioned piece is then to be re-embedded in a thermoset resin having minimal shrinkage, and the area to be viewed is to be ground and polished for

microscopic examination. The total length of section through the exposed surface is not to be less than 0.2 in (5 mm). If the dimensions of the test piece make this impossible, the section is to be taken to provide the maximum possible total length.

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

50 Stress-Corrosion Cracking of Brass Sprinkler Parts Test

50.1 After being subjected for 10 days to a moist ammonia exposure as described in 50.2 and 50.3, a sprinkler having brass parts shall:

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

b) Perform as intended.

50.2 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 chamber having a cover constructed of glass or suitable polymeric material.

50.3 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 1-1/2 (+1/2, -0) in [(38.1 mm) (12.7 mm, -0 mm)] above the liquid surface and supported by an inert tray. The moist ammonia-air mixture in the chamber is to be maintained at essentially atmospheric pressure with the temperature constant at 93 ±2 °F (34 ±1 °C).

50.4 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. The deposits on some samples shall be permitted to be removed using a cleaning solution to assist in the examination for cracks or degradation. Operating parts exhibiting degradation as a result of the test exposure described in 50.2 and 50.3 shall withstand, without leakage, a hydrostatic test pressure of 175 psig (1.21 MPa) or one equivalent to their maximum design pressure, whichever is greater, for 1 min, and operate at 7 psig (48 kPa) when exposed to a uniform application of heat. When the samples have any cracking, delamination, or degradation of nonoperating parts as a result of the test exposure, they shall withstand flowing water at their rated pressure for 30 min.

51 Stress-Corrosion Cracking Of Stainless Steel Sprinkler Parts Test

51.1 Austenitic stainless steel parts of a sprinkler 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 h for sprinklers intended for normal use, and 500 h for sprinklers having stainless steel parts not protected by a corrosion resistant coating when intended for use in corrosive atmospheres. See 51.2 – 51.7.

51.2 Five samples without any coating or plating are to be degreased prior to being exposed to the magnesium chloride solution. Samples of sprinklers for normal use are permitted to tested with the coating or plating intact if subjected to the 500 h exposure rather than the 150 h exposure.

51.3 Parts used in sprinklers are to be placed in a sealed glass chamber that is fitted with a thermometer and a wet condenser. The chamber is to be filled approximately one-half full or to a level at least 0.5 in (1.27 cm) above the test sample with a nominal 44 % 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 sprinkler assembly. The exposure is to last for 150 or 500 h, as specified in 51.1.

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

51.5 The test samples are then 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. Test samples exhibiting degradation are to be tested as described in 51.6 or 51.7, as applicable. Test samples not exhibiting degradation comply with the requirements and shall not be tested further.

51.6 Operating parts exhibiting degradation are to be reassembled into the sprinkler or, if this is not possible, new parts tested as follows. Five new sets of parts are to be assembled in sprinkler 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 51.3. Following the exposure, the test samples shall withstand, without leakage, a hydrostatic test pressure at their rated pressure for 1 min, and then operate at 7 psig (48 kPa) – see Operation – Lodgement Test, Section 34.

51.7 Nonoperating parts exhibiting degradation are to be reassembled into the sprinkler or, if this is not possible, new parts tested as follows. Five new sets of parts are to be assembled in sprinkler 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 51.3. Following the exposure, the test samples shall withstand a flowing pressure of 175 psig (1.21 MPa) for 30 min without separation of permanently attached parts.

52 Polymeric Residential Sprinkler Tests

52.1 General

52.1.1 After being subjected to the test exposures specified in 52.1.2, polymeric sprinkler assemblies shall show no visible cracks and comply with the Leakage Test (Section 25), Hydrostatic Strength Test (Section 26), and Flow Endurance Test (Section 24).

52.1.2 The sprinkler sample assemblies are to be subjected to the following exposures:

a) Water immersion specified in 52.1.3 for 180 days;

b) Air-oven aging specified in 52.1.4 for 180 days; and

c) Accelerated light and water specified in 52.1.5.

52.1.2 Test samples and post exposure testing

52.1.2.1 Eight sprinkler sample assemblies are to be subjected to each exposure described in 52.1.3 – 52.1.5. For sprinkler inlets with pipe threads constructed of a polymeric material, the inlet is to be threaded into a fitting with metallic threads that allow the sprinkler inlet to be open to the exposure environment during the tests described in 52.1.3 and 52.1.4. The inlet of four sprinkler samples shall be tightened into a fitting using the maximum torque value specified in the manufacturer's instructions and the remaining four samples shall be tightened to 120 % of the maximum torque value specified in the manufacturer's installation instructions prior to placing the samples into the exposures described in 52.1.3 and 52.1.4. After the exposure described in 52.1.5, the inlet of four sprinkler samples shall be tightened into a fitting with metallic threads using the maximum torque value specified in the manufacturer's instructions and the remaining four samples shall be tightened to 120 % of the maximum torque value specified in the manufacturer's installation instructions prior to the physical testing described in 52.1.2.2.

Exception: For sprinklers with polymeric inlet pipe threads that are constructed to prevent over-torqueing during installation, eight samples are tightened into a fitting using only the maximum torque value specified in the manufacturer's instructions.

52.1.2.2 Following the exposures described in 52.1.3 – 52.1.5, three samples with the maximum torque value and three samples with 120 % of the maximum torque value from each exposure are to be subjected to the Leakage Test (Section 25) and Hydrostatic Strength Test (Section 26). Leakage unrelated to the polymeric body shall not be considered a noncompliant result. When subjected to the Leakage Test (Section 25), no visible leakage past a polymeric threaded inlet connection shall be observed when the pipe threads are sealed as specified by the manufacturer and no visible cracks in the inlet threads shall be observed after removal of the sprinkler from the fitting. The remaining samples from each exposure are to be subjected to the Flow Endurance Test (Section 24).

52.1.2.3 At the manufacturer's option, additional samples shall be permitted to be subjected to these exposures and removed for physical testing after shorter exposure durations to obtain interim results for informational purposes.

52.1.3 Water immersion exposure

52.1.3.1 The test samples specified in 52.1.2 are to be immersed in a bath containing tap water and maintained at a temperature of 189 ±4 °F (87 ±2 °C) for a period of 180 days. After the exposure, the samples are to be conditioned for not less than 24 h at 70 ±5 °F (21 ±3 °C) prior to the physical testing described in 52.1.2.2.

52.1.4 Air oven aging exposure

52.1.4.1 The test samples specified in 52.1.2 are to be subjected to 242 ±5 °F (117 ±3 °C) for 180 days. After the exposure, the samples are to be conditioned for not less than 24 h at 70 ±5 °F (21 ±3 °C) prior to the physical testing described in 52.1.2.2.

Exception: An air oven aging test at a lower temperature for a longer period of time may be applied. The duration of exposure is to be calculated from the following formula:

$$D = (184049)e^{-6.93\left(\frac{t_1}{t_2}\right)}$$

where:

D = test duration in days;

t_1 = lower test temperature for longer duration, °C; and

t_2= test temperature for D = 180 days, °C.

52.1.5 Light and water exposure

52.1.5.1 The test samples specified in 52.1.2 are to be exposed to ultraviolet light exposure in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. For polymeric sprinklers intended for indoor installations only, the exposure period shall be 360 h for carbon-arc or 500 h for xenon-arc conditioning. For polymeric sprinklers intended for outdoor installations only, the exposure period shall be 720 h for carbon-arc or 1000 h for xenon-arc conditioning. After the exposure, the samples are to be conditioned for not less than 24 h at 70 ±5 °F (21 ±3 °C) prior to the physical testing described in 52.1.2.2.

52.2 Long-term hydrostatic pressure test

52.2.1 When tested as described in 52.2.2 and 52.2.3, polymeric sprinkler assemblies shall withstand 2.5 times the rated working pressure for a period of 90 days without rupture, leakage, or operation with the assemblies conditioned to 150 °F and then comply with the Leakage (Section 25) and Sensitivity Oven Heat (33.2) Tests.

52.2.2 Ten sprinkler sample assemblies are to be subjected to this test. For sprinkler inlets with pipe threads constructed of a polymeric material, the inlet of five sprinkler samples shall be tightened into a fitting with metallic threads using the maximum torque value specified in the manufacturer's instructions and the remaining five samples shall be tightened to 120 % of the maximum torque value specified in the manufacturer's installation instructions prior to applying the test pressure.

Exception: For sprinklers with polymeric inlet pipe threads that are constructed to prevent over-torqueing during installation, ten samples are tightened into a fitting using only the maximum torque value specified in the manufacturer's instructions.

52.2.3 The test samples shall be connected to water filled supply piping, vented of entrapped air, and subjected to a constant pressure of 2.5 times the rated working pressure. The test samples are to be conditioned in an automatically controlled air bath or oven that is capable of maintaining a constant temperature of 150 ±4 °F (66 ±2 °C) for 90 days. After the exposure, the samples are to be conditioned for not less than 24 h at 70 ±5 °F (21 ±3 °C) prior to further testing. Each sample shall be then be subjected to the Leakage Test (Section 25) followed by the Sensitivity Oven Heat Test (33.2).

52.3 Temperature cycling test

52.3.1 When subjected to the temperature cycling exposure described in 52.3.2 and 52.3.3, polymeric sprinkler assemblies shall not crack, rupture, leak, or operate and then comply with the Leakage Test (Section 25), Sensitivity Oven Heat Test (33.2), and Flow Endurance Test (Section 24).

52.3.2 Ten sprinkler sample assemblies are to be subjected to this test. For sprinkler inlets with pipe threads constructed of a polymeric material, the inlet of five sprinkler samples shall be tightened into a fitting with metallic threads using the maximum torque value specified in the manufacturer's instructions and the remaining five samples shall be tightened to 120 % of the maximum torque value specified in the manufacturer's installation instructions prior to applying the test pressure.

Exception: For sprinklers with polymeric inlet pipe threads that are constructed to prevent over-torqueing during installation, ten samples are tightened into a fitting using only the maximum torque value specified in the manufacturer's instructions.

52.3.3 The test samples are to be exposed to ten temperature cycles while pressurized with air to 40 psig (276 Kpa) with each cycle comprised of a 24 h exposure to a low temperature of minus 40 ±4 °F (minus 40 ±2 °C) and a 24 h exposure to 150 ±4 °F (66 ±2 °C). After the exposure, the samples are to be conditioned for not less than 24 h at 70 ±5 °F (21 ±3 °C) prior to further testing. Each sample shall be then be subjected to the Leakage Test (Section 25) followed by the Sensitivity Oven Heat Test (33.2). After removal of the sprinkler from the fitting, no visible cracks in the inlet threads shall be observed. One of the samples shall then be subjected to the Flow Endurance Test (Section 24).

52.4 Impact test

52.4.1 A polymeric sprinkler assembly, except for dry-type sprinklers, shall not be damaged or leak when tested as described in 52.4.2 and then comply with the Leakage Test (Section 25), Sensitivity Oven Heat Test (33.2), and Flow Endurance Test (Section 24).

52.4.2 With each sample conditioned for not less than 24 h at the minimum installation temperature referenced in the manufacturer's instructions or 0 ±4 °F (minus 18 ±2 °C), whichever is lower, five sprinkler sample assemblies are to be subjected to an impact by dropping a cylindrical mass equivalent to the mass of the sprinkler to the nearest 15 g increment from a height of one meter onto the geometric center of the deflector or, when this is not practicable, onto the butt end of the sprinkler. The mass is to be prevented from impacting more than once upon each sample. See Figure 20.1 for a description of the test arrangement. Following the impact, each sprinkler is to be visually examined and there shall be no evidence of cracks, breaks, or any other damage. Each sample shall then be subjected to the Leakage Test (Section 25) followed by the Sensitivity Oven Heat Test (33.2). One of the samples shall then be subjected to the Flow Endurance Test (Section 24).

WATER FLOW AND DISTRIBUTION TESTS

53 Discharge Coefficient Test

53.1 When tested in accordance with 53.2 – 53.4, a sprinkler shall have individual “K” factor values at each pressure that are within ±5 % of the calculated mean discharge coefficient for the range of pressures tested and, except for residential sprinklers, shall have a mean discharge coefficient that is within one of the ranges specified in Table 11.1. For residential sprinklers, the mean discharge coefficient shall be within ±5 % of the nominal K-factor referenced in the manufacturer’s instructions. See 60.2(a).

Exception: A residential sprinkler with an mean “K” factor of less than 4.0 shall be permitted to have individual “K” factor values that are not within ±5 % of the mean "K" factor if the single "K" factor value is within ±0.2 units of the mean "K" factor value.

53.2 The sprinkler is to be installed on an outlet from a reservoir sized so that the velocity head effect ($V^2/2$ g) 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 sprinkler thread (1/2, 3/4 or, 1 in NPT), as described in the Standard on Pipe Threads, General Purpose, Inch, ANSI/ASME B1.20.1. For sprinklers 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 in (3.2 mm) or more. See Figure 53.1 as an example of the apparatus. For sprinklers having a nominal “K” factor greater than 8, the outlet shall consist of a nominal 6 in blank flange drilled and threaded to the appropriate thread size, and attached to a 6 in pipe. See Figure 53.2 for an example of this apparatus.

Figure 53.1

Discharge Coefficient Test Equipment for Sprinklers with Nominal K-factors of 8.0 (115) or Less

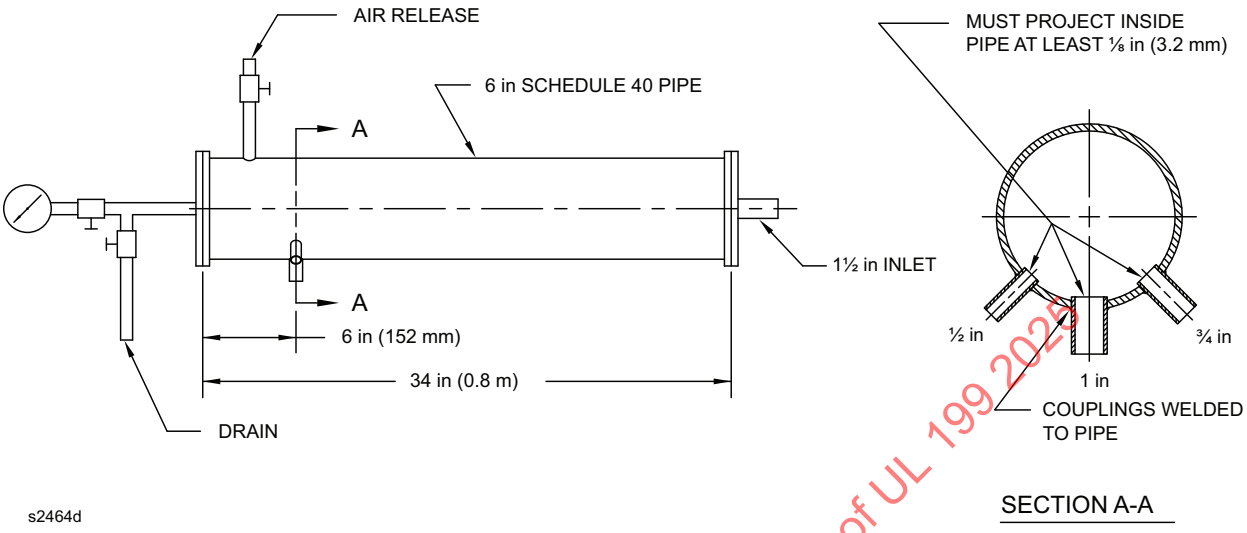
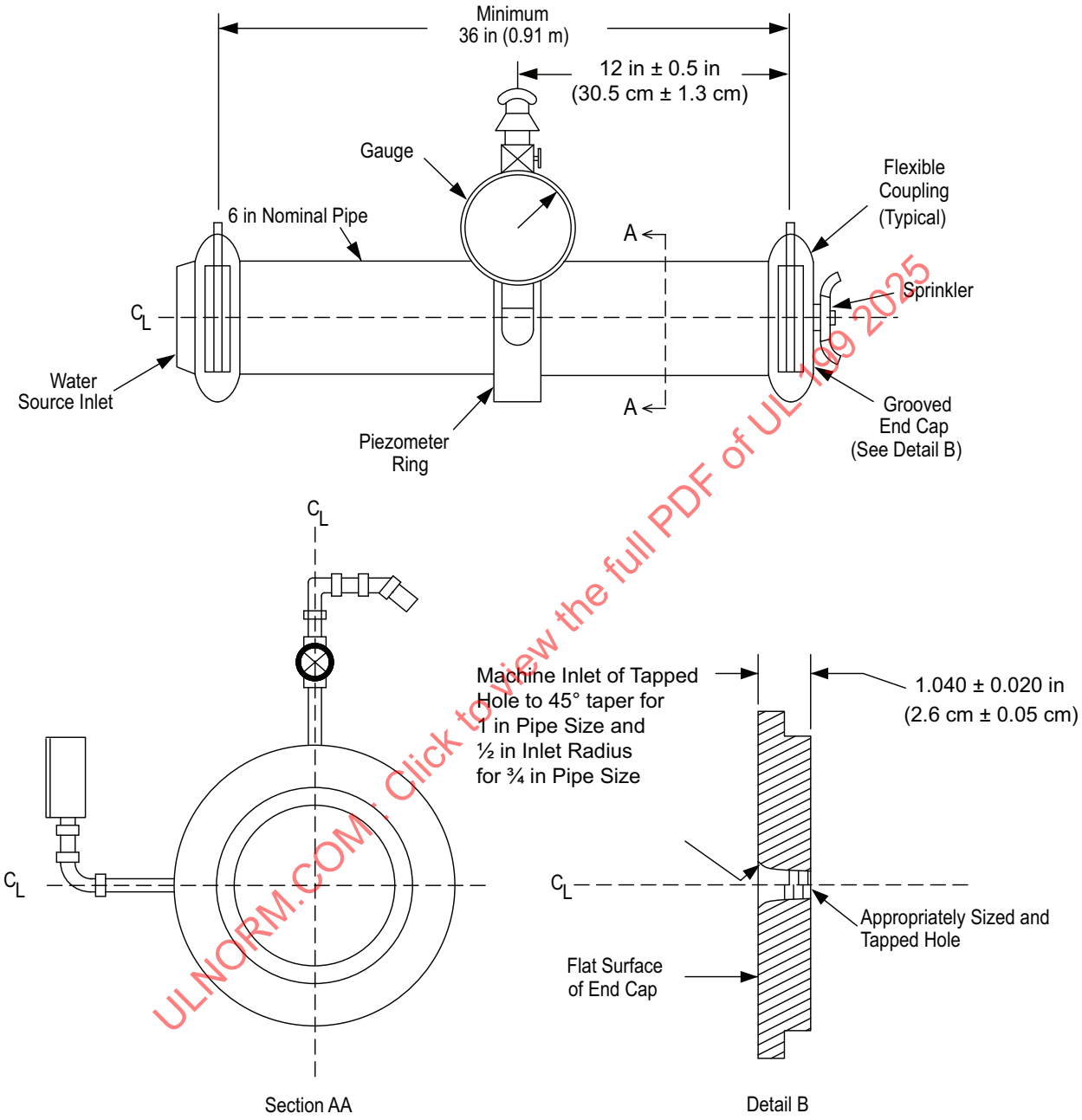


Figure 53.2

Discharge Coefficient Test Equipment for Sprinklers with Nominal K-factors Greater Than 8.0 (115)



s4138i

Note: All dimensions are nominal size except as noted

53.3 When dry-type sprinklers are tested, the range of lengths tested is to include the maximum and minimum lengths to be produced. The minimum length is to be used to determine compliance with the requirements specified in 11.2. Also see 60.1.

53.4 Two samples with the frame and deflector removed are to be tested. Each sprinkler sample is to be flow tested at nominal pressure increments. For all sprinklers, except ESFR, testing is initially conducted at a pressure of 7 psig (48 kPa) and then at 10 psig (69 kPa). For ESFR sprinklers, testing is to be started at 15 psig (103 kPa). Following this, the pressure is to be increased in 5 psig (34 kPa) increments up to 50 psig (345 kPa), in 10 psig (69 kPa) increments up to and including 75 psig (517 kPa) less than the rated pressure, decreased in 10 psig (69 kPa) increments down to 50 psig (345 kPa), in 5 psig (34 kPa) increments down to 10 psig (60 kPa), and then decreased to 7 psig (48 kPa). The flow at each increment of pressure is to be measured by a flow-measuring device having an accuracy of within 2 % of the actual flow. The discharge coefficient "K" is to be calculated by dividing the flow in gpm (L/min) by the square root of the pressure in psig (bar). The mean discharge coefficient "K" is then to be calculated.

54 Water Distribution Tests

54.1 General

54.1.1 An automatic sprinkler shall comply with the requirements as referenced in Table 54.1 based upon the sprinkler type.

Table 54.1
Water Distribution Requirements by Sprinkler Type

Sprinkler type	Requirements
Conventional (Old Style) sprinklers	54.2 Water Distribution Test – Conventional (Old Style) Sprinklers
All pendent and upright standard coverage sprinklers, including flush, recessed and concealed that have a nominal K-factor not exceeding 8.0 gpm/(psi)$^{1/2}$ [115 L/min/(bar)$^{1/2}$].	54.3 10 Pan Distribution Test 54.4 16 Pan Distribution Test
Sidewall standard coverage sprinklers, including flush, recessed and concealed that have a nominal K-factor not exceeding 8.0 gpm/(psi)$^{1/2}$ [115 L/min/(bar)$^{1/2}$]. Also, sprinkler guards.	54.5 100 Pan Distribution Test – Sidewall Sprinklers (Standard Coverage)
Pendent, upright and sidewall ECLH sprinklers including flush, recessed and concealed types	54.6 Wall Wetting Test for ECLH and ECOH Sprinklers
Pendent and upright ECOH sprinklers including flush, recessed and concealed types	54.7 Distribution Tests for ECOH Sprinklers
Residential pendent, upright and sidewall including flush, recessed and concealed types	54.8 Residential Sprinkler Water Distribution Test – Horizontal Surface 54.9 Residential Sprinkler Water Distribution Test Vertical Surface
ESFR having a nominal K-factor of 14.0 gpm/(psi)$^{1/2}$ [200 L/min/(bar)$^{1/2}$] and 16.8 gpm/(psi)$^{1/2}$ [240 L/min/(bar)$^{1/2}$]	54.10 Distribution Tests for Pendent ESFR Sprinklers Having a Nominal K-factor of 14.0 or 16.8 54.11 Thrust Force Test for Pendent ESFR Sprinklers Having a Nominal K-factor of 14.0 or 16.8
All sprinkler types except conventional	54.12 Lateral Discharge Tests

54.1.2 Additional water distribution tests shall be permitted to be conducted to characterize the distribution characteristics of sprinklers not addressed in Table 54.1.

54.2 Water distribution test – Conventional (old style) sprinklers

54.2.1 When a conventional (old style) sprinkler is flowing water at the rate specified in Table 54.2 for various sprinkler “K” factors, the number of containers in which the quantity of water is less than 50 % of the water coverage specified in column 2 of Table 54.2 shall not exceed the value specified in column 6 of Table 54.2.

Table 54.2
Water Coverage Values for Conventional Sprinklers

Nominal "K" Factor gpm/(psi)$^{1/2}$ (L/min/(bar)$^{1/2}$)	Water coverage		Flow rate per sprinkler		Protected area		Sprinkler spacing		Number of containers with a lower content of water
	gpm/ft^2	(mm/min)	gpm	(l/min)	ft^2	(m^2)	ft	(m)	
4.2 (57)	0.06	(2.5)	13.4	(50.6)	217.8	(20.25)	14.76	(4.5)	8
5.6 (80)	0.12	(5.0)	16.2	(61.3)	131.8	(12.25)	11.48	(3.5)	5
5.6 (80)	0.36	(15.0)	35.7	(135.0)	96.8	(9)	9.84	(3)	4
8.0 (115)	0.24	(10.0)	23.8	(90.0)	96.8	(9)	9.84	(3)	4
8.0 (115)	0.72	(30.0)	49.5	(187.5)	67.2	(6.25)	8.2	(2.5)	3

54.2.2 Four sprinklers of the same type shall be installed in a test chamber having minimum dimensions of 23 by 23 ft (7 by 7 m). The sprinklers shall be arranged in a square, on piping prepared for this purpose. The arrangement of the piping and collection pans is shown in Figure 54.1 – Table 54.4. The sprinklers are to be installed 2 in (50 mm) below the ceiling in the upright position and 11 in (275 mm) in the pendent position. The frame arms of the sprinklers shall be positioned parallel to the supply pipes.

Figure 54.1

Layout of Water Distribution Collection Room for Conventional Sprinklers

[Measured area 217.9 ft^2 (20.25 m^2)]

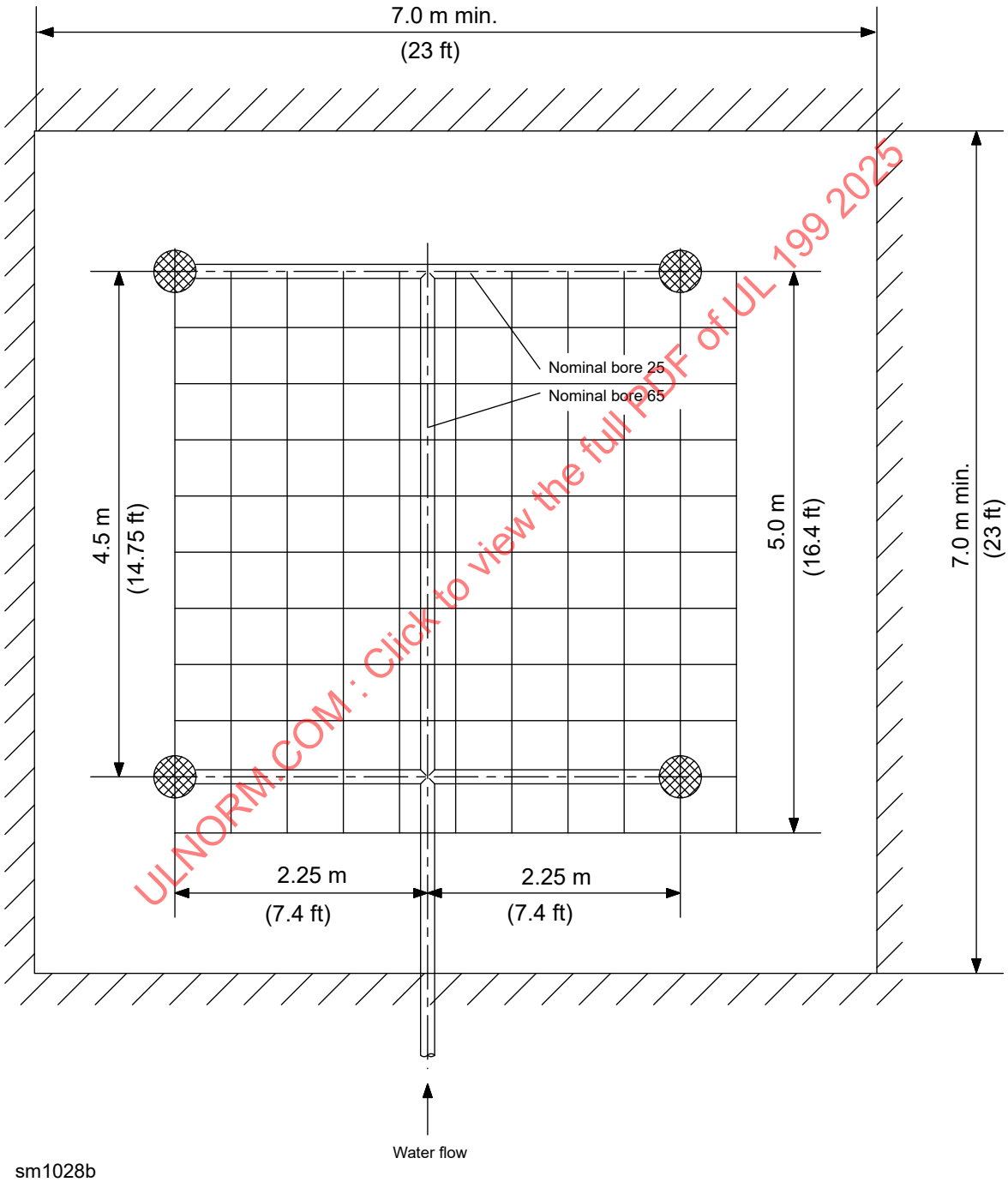


Figure 54.2

Layout of Water Distribution Collection Room for Conventional Sprinklers

[Measured area 131.8 ft^2 (12.25 m^2)]

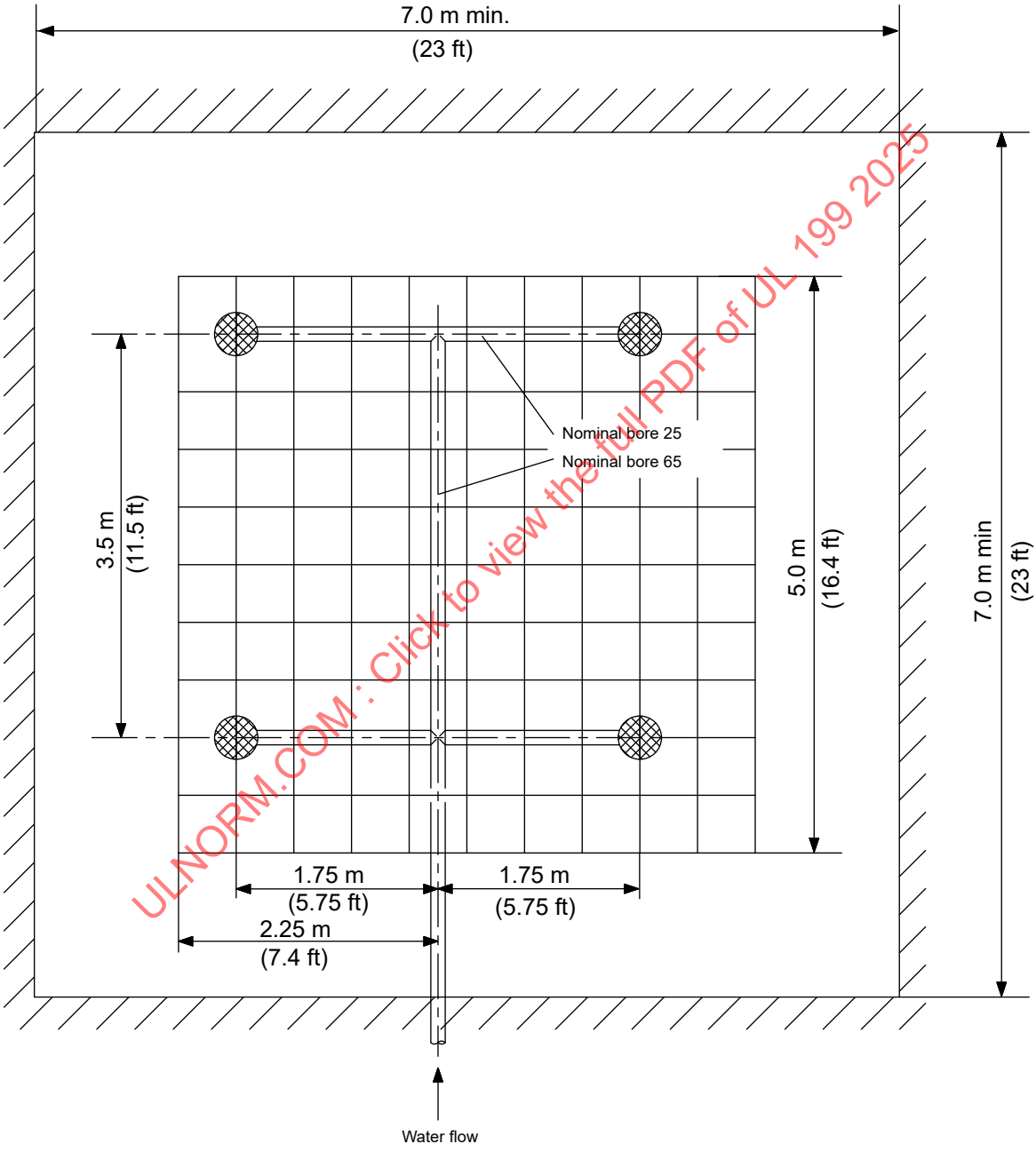


Figure 54.3

Layout of Water Distribution Collection Room for Conventional Sprinklers

[Measured area 96.8 ft^2 (9 m^2)]

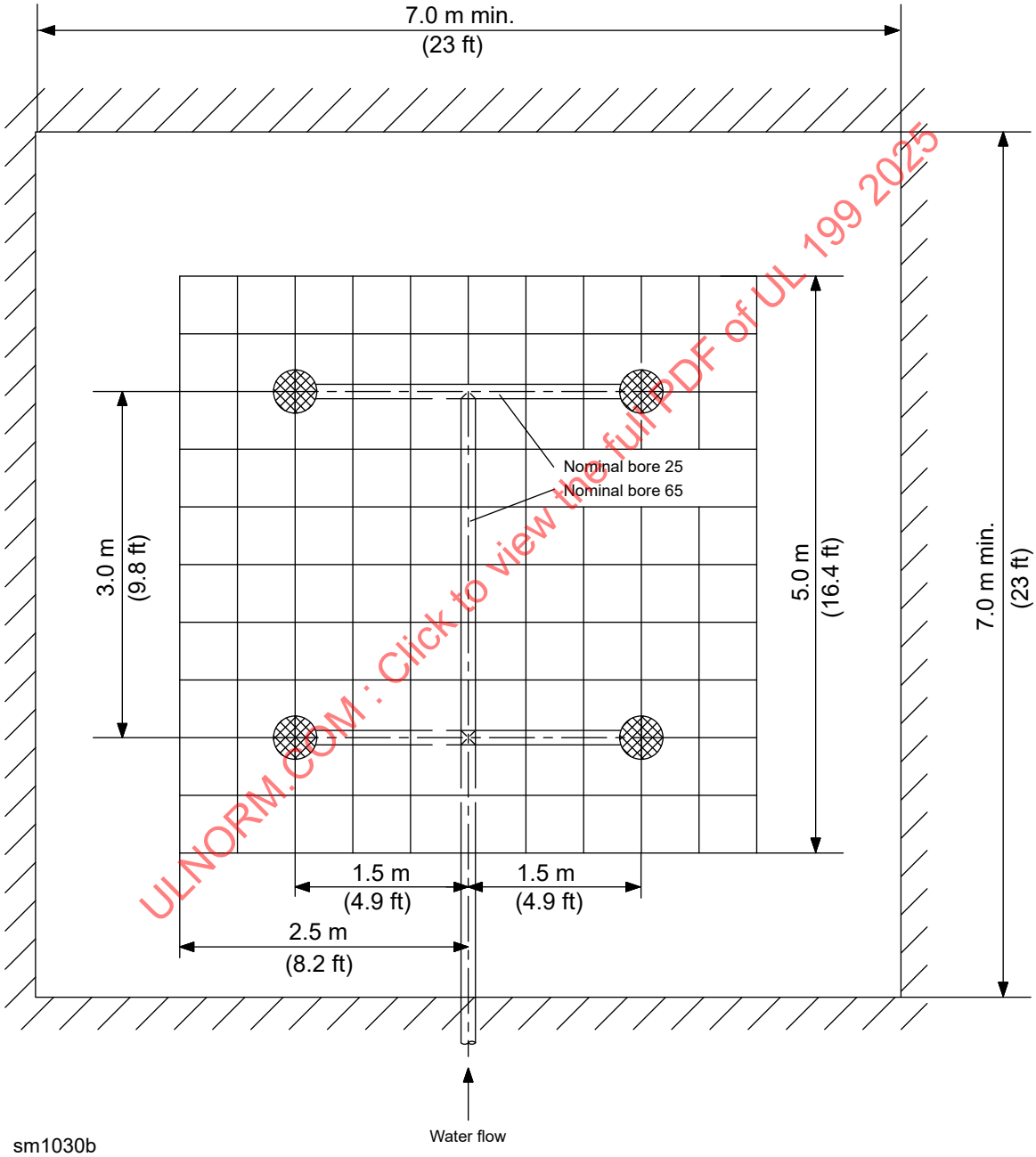
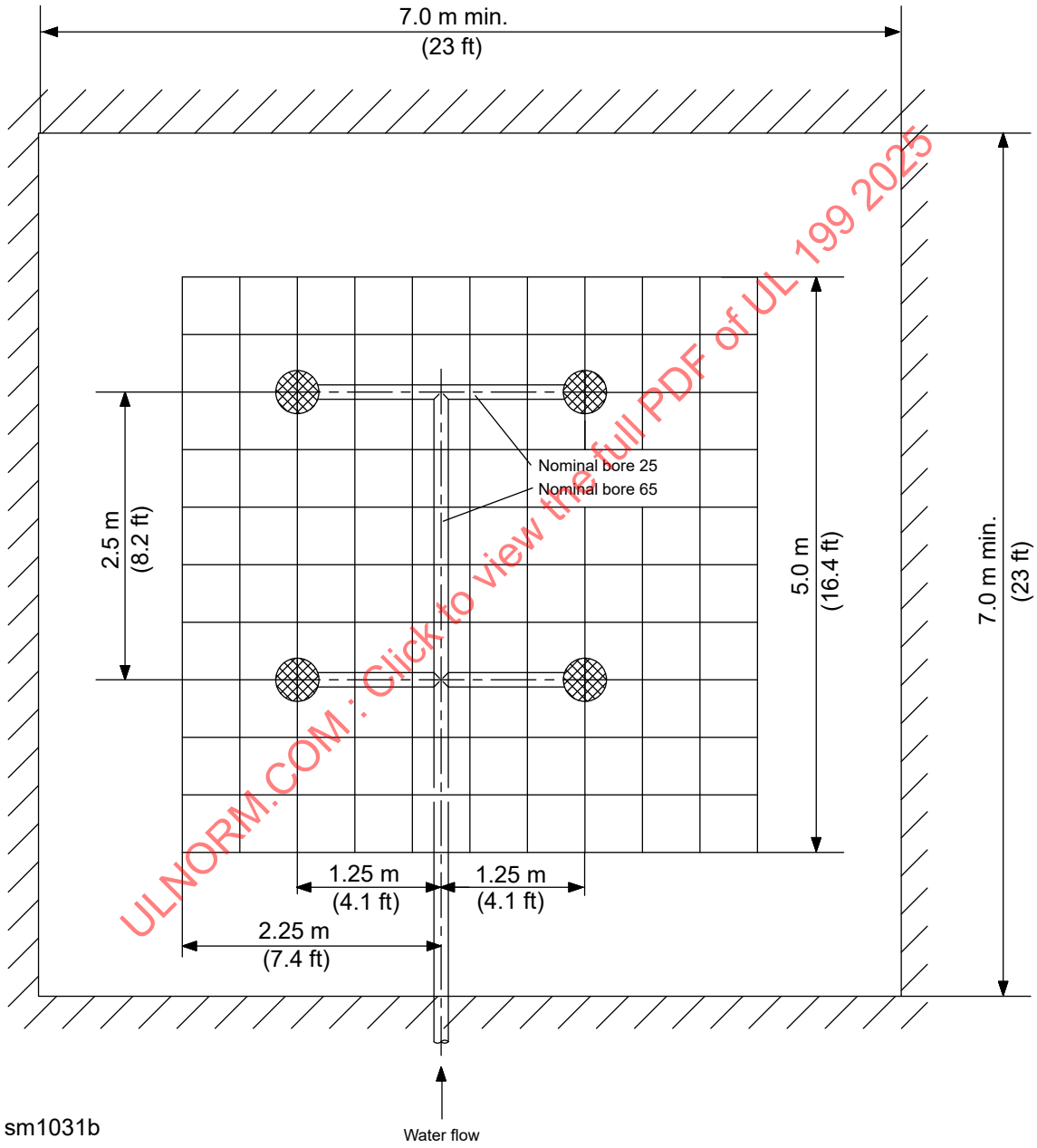


Figure 54.4

Layout of Water Distribution Collection Room for Conventional Sprinklers

[Measured area 67.24 ft^2 (6.25 m^2)]



54.2.3 Water is to be discharged for a minimum of 10 min, and the amount collected in each pan is to be measured and recorded to determine the amount and uniformity of discharge.

54.2.4 Flush or recessed type sprinklers shall be mounted in a false ceiling of dimensions not less than 20 by 20 ft (6 by 6 m), arranged symmetrically in the test chamber. The sprinklers shall be fitted directly into the horizontal pipework by means of tee or elbow fittings.

54.2.5 The area covered and the water density of coverage for the three nominal “K” factors are given in Table 54.2.

54.2.6 The water distribution in the area between the four sprinklers shall be measured by means of square collection pans of size 19.7 in (500 mm). The distance between the ceiling and the upper edge of the collection pans shall be 8.9 ft (2.7 m). The pans shall be positioned centrally in the room, beneath the four sprinklers. The water shall be collected for at least 3 min.

54.2.7 The water discharge of sprinklers downward from the deflectors is to be 40 to 60 %. The sprinklers are to be installed horizontally in a testing apparatus as shown in Figure 54.5. The deflector is to be positioned within the apparatus so that a theoretical dividing line between the two collecting volumes intersects a point on the axis of the sprinkler where the water spray is traveling substantially parallel to the plane of the partition. The sprinklers are to be tested at the flow conditions specified in Table 54.3.

Figure 54.5

Water Distribution Above and Below the Deflectors for Conventional Sprinklers

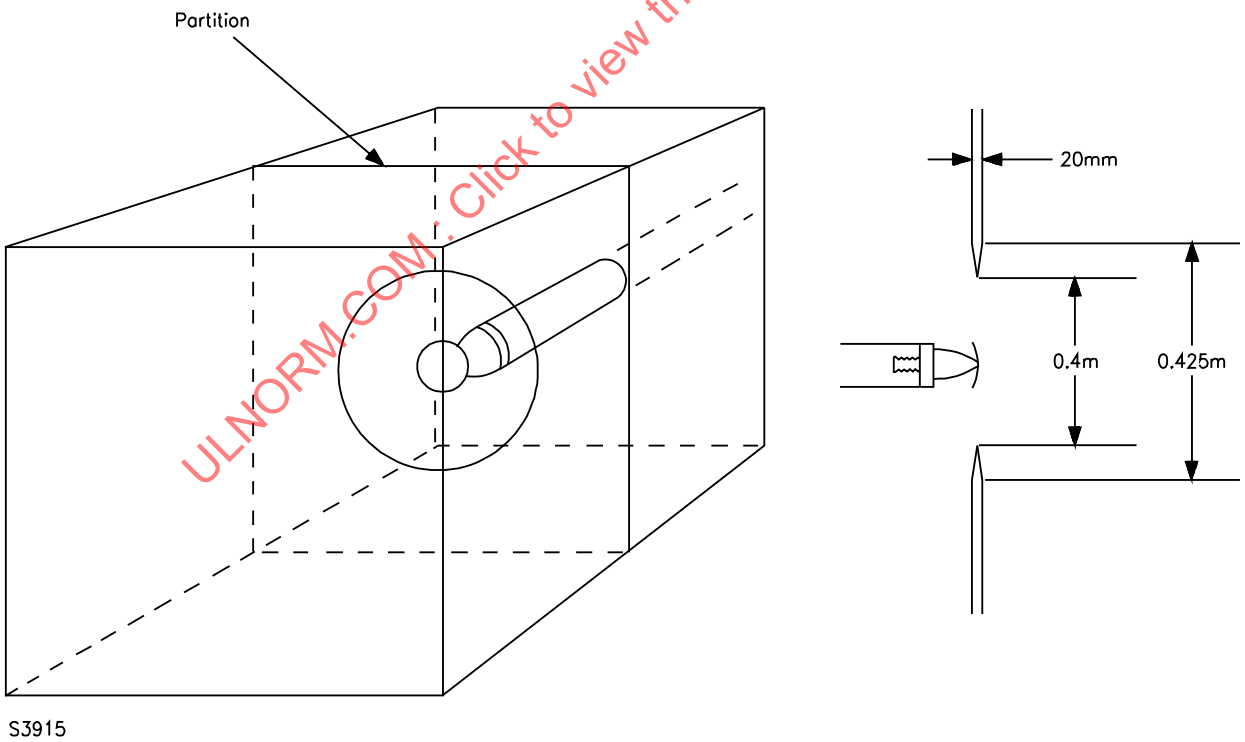


Table 54.3
Flow Conditions for Conventional Sprinklers

Nominal "K" Factor gpm/(psi)$^{1/2}$(L/min/(bar)$^{1/2}$)	Water flow rate	
	gal/min	(l/min)
4.2 (57)	13.4	(50.6)
5.6 (80)	16.2	(61.3)
8.0 (115)	23.8	(90)

54.3 10 Pan distribution test

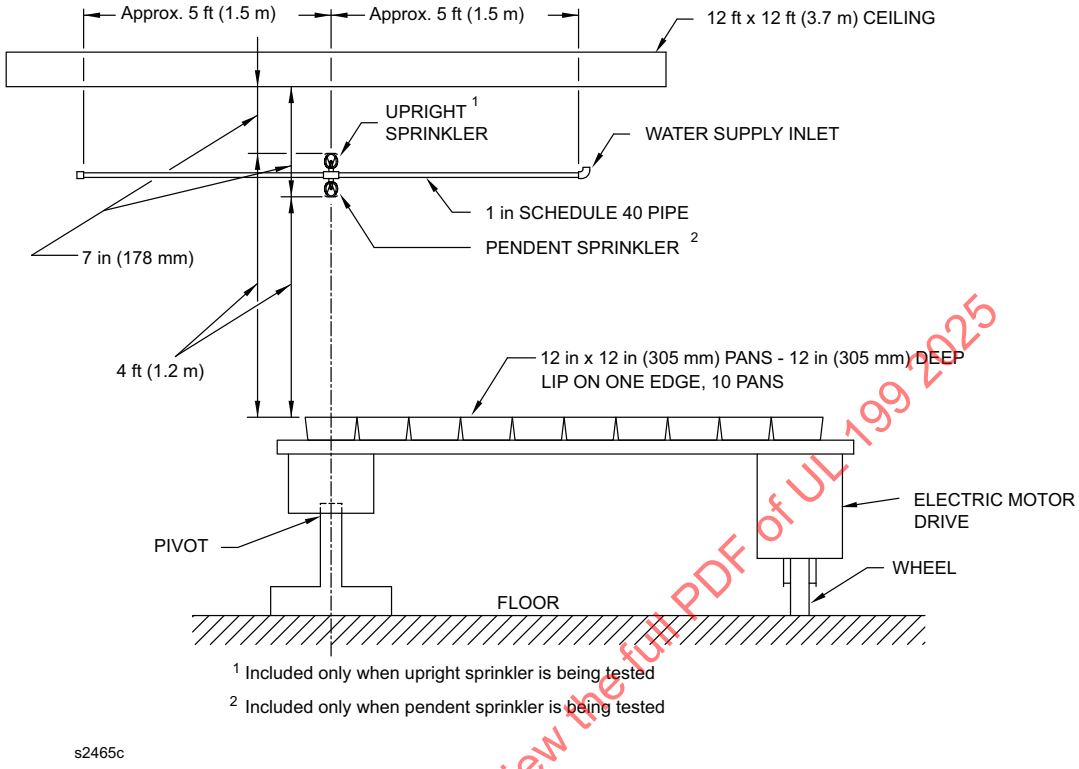
54.3.1 When tested as described in 54.3.3 and 54.3.4, the water-distribution pattern from a sprinkler, except as noted in 54.3.2, shall not exceed a 16 ft (4.88 m) diameter circular area located in a horizontal plane 4 ft (1.22 m) below the sprinkler deflector. When guards are used with a sprinkler, testing shall be conducted with and without the guard.

54.3.2 Water shall not accumulate in areas outside the 16 ft (4.88 m) diameter circle unless the accumulations do not exceed 0.03 gpm/ft^2 (1.2 mm/min).

54.3.3 An open sprinkler is to be installed in its intended position (upright or pendent) in a tee fitting 1 in by 1 in with an inlet the size of the sprinkler, supplied with water by 1 in piping flowing from one direction. The sprinkler deflector is to be located 7 in (178 mm) below a minimum 12 by 12 ft (3.65 by 3.65 m) smooth, flat, horizontal ceiling. The frame arms are to be parallel to the piping on which installed. For dry type sprinklers, the minimum length to be produced is to be tested. A ceiling or recessed type sprinkler is to be mounted in the ceiling in the intended installation position. The deflector is to be 4 ft (1.22 m) above a row of ten 1 ft^2 (305 mm^2) collection pans directly below the center of the sprinkler sample. The center of the first pan is to be directly below the center of the sprinkler. See Figure 54.6 for a rotating table arrangement. The test is to be repeated on a second sprinkler sample.

Figure 54.6

10 Pan Sprinkler Distribution Test Arrangement (Rotating Table Arrangement)



54.3.4 With the table and pans or sprinkler rotating at 1 revolution per min (rpm), water is to be discharged from the sprinkler for a minimum of 10 min or until a pan is filled with water, whichever occurs first and at a rate of 15 gpm (57 L/min) for 1.4 (20), 1.9 (27), 2.8 (40), 4.2 (57), and 5.6 (80) nominal "K" factor sprinklers and at a rate of 21 gpm (80 L/min) for 8.0 (115) nominal "K" factor sprinklers. The water collected is to be measured and the density in gpm/ft^2 (mm/min) calculated.

54.4 16 Pan distribution test

54.4.1 Four sprinklers, flowing at the rates indicated in Table 54.4 and tested as specified in 54.4.2 – 54.4.9, shall discharge water at an average density of:

a) Not less than the average shown in Table 54.4 for the 16 pans (see 54.4.8); and

b) Not less than 75 % of the specified average for any individual pan.

Table 54.4
16 Pan Sprinkler Distribution Tests

Nominal "K" Factor gpm/(psi)$^{1/2}$ (L/min/(bar)$^{1/2}$)	Waterflow per sprinkler		Minimum average collection	
	gpm	(L/min)	gpm/ft^2	(mm/min)
1.4 (20)	3.75	(14.2)	0.0375	(1.6)
1.9 (27)	5.25	(19.8)	0.0525	(2.2)
2.8 (40)	7.50	(28.4)	0.0750	(3.2)
4.2 (57)	11.25	(45.5)	0.1125	(4.8)
5.6 (80)	15.00	(56.7)	0.1500	(6.4)
8.0 (115)	21.00	(79.4)	0.2100	(8.9)

54.4.2 Dry-type sprinklers are to be tested using the shortest available length.

54.4.3 Sprinklers fitted with guards shall not reduce the average collection by more than 20 % compared to the sprinkler tested without guard, but shall also comply with the minimum average collection and individual pan requirements described in 54.4.1.

54.4.4 Sprinklers rated at a pressure greater than 175 psig (1.2 MPa), shall be tested at a flow rate corresponding to a pressure of 75 psig (517 kPa) less than the rated pressure and comply with the requirements of 54.4.1 (a) and (b) for the "K" factor specified.

54.4.5 Two distribution tests are to be conducted. After completion of the first test, two of the four sprinklers in opposite corners are to be transposed prior to conducting the second test. The results of each test shall be in accordance with 54.4.1.

54.4.6 Four open sprinklers, except the dry type, are to be installed in their intended position (upright or pendent) in 90° elbows having a 1 in (25.4 mm) inlet and an outlet the same size as the sprinkler inlet. Dry type sprinklers are to be installed in a 1 in (25.4 mm) tee having an outlet the same size as the sprinkler inlet. Each sprinkler is to be supplied with water through 1 in piping, with sprinkler deflectors located 7 in (178 mm) below a minimum 12- by 12 ft (3.66- by 3.66-m) smooth, flat, horizontal ceiling. The frame arms are to be parallel to the piping on which installed.

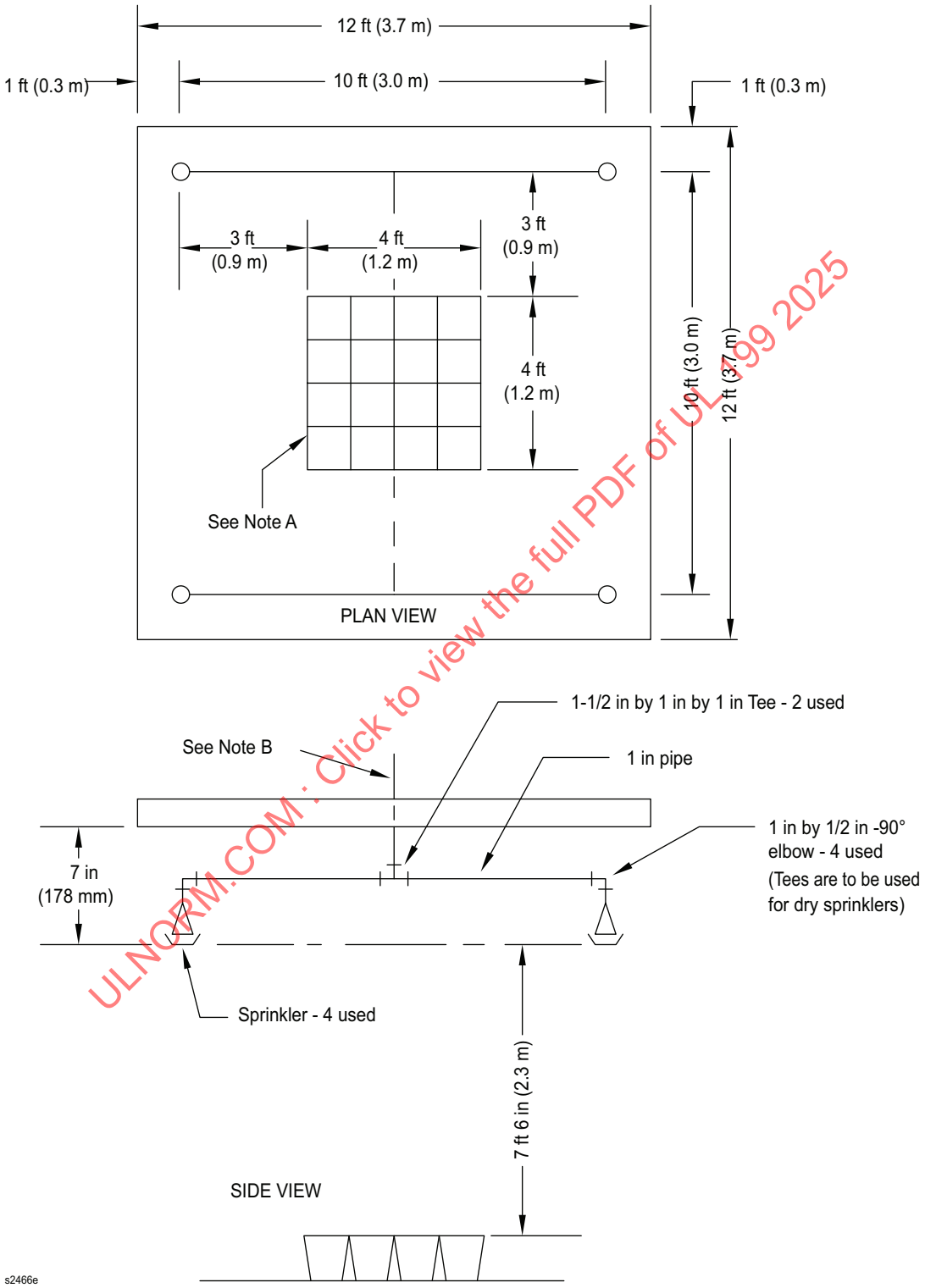
54.4.7 Each ceiling or recessed type sprinkler is to be mounted in the center of a minimum 2- by 2-ft (0.61- by 0.61-m) square "ceiling" in the intended installation position. Dry-type sprinklers are tested using the shortest available length.

54.4.8 The four sprinklers are to be installed on 10- by 10-ft (3.05- by 3.05-m) spacings. Sixteen 1 ft^2 (305-mm^2) pans, located 7 ft, 6 in (2.29 m) below the sprinkler deflectors and centered between the sprinklers, are to be used to collect the sprinkler discharge. See Figure 54.7.

54.4.9 Water is to be discharged for a minimum of 10 min. The amount collected in each pan is to be measured, and the density in gpm/ft^2 (mm/min^2) calculated.

Figure 54.7

16 Pan Sprinkler Distribution Test Arrangement



A – 16 pans, 12 by 12 by 12 in (0.3 by 0.3 by 0.3 m) deep.

B – Piping above ceiling and connecting piping to sprinkler branch piping all 1-1/2 in.

54.5 100 Pan distribution test – Sidewall sprinklers (standard coverage)

54.5.1 When tested as described in 54.5.3 – 54.5.5, the water distribution from two sidewall sprinklers over a 100 ft^2 (9.3 m^2) floor area covered by 100 collection pans (see Figure 54.8) shall be as follows:

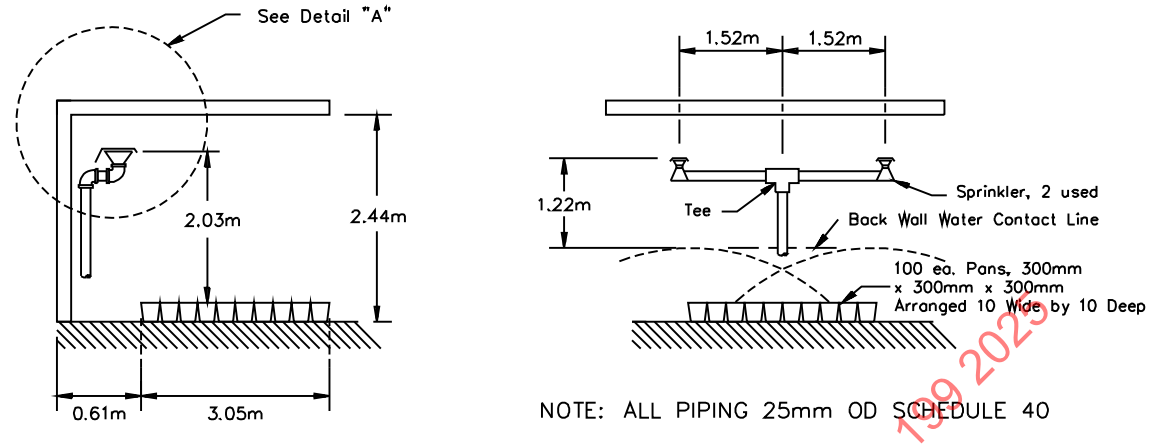
a) For 1.4 (20), 1.9 (27), 2.8 (40), 4.2 (57), and 5.6 (80) nominal "K" factor sprinklers, a minimum average water collection in the pans of 0.050 gpm/ft^2 (2.0 mm/min), and a minimum water collection of 0.030 gpm/ft^2 (1.2 mm/min) for any individual pan.

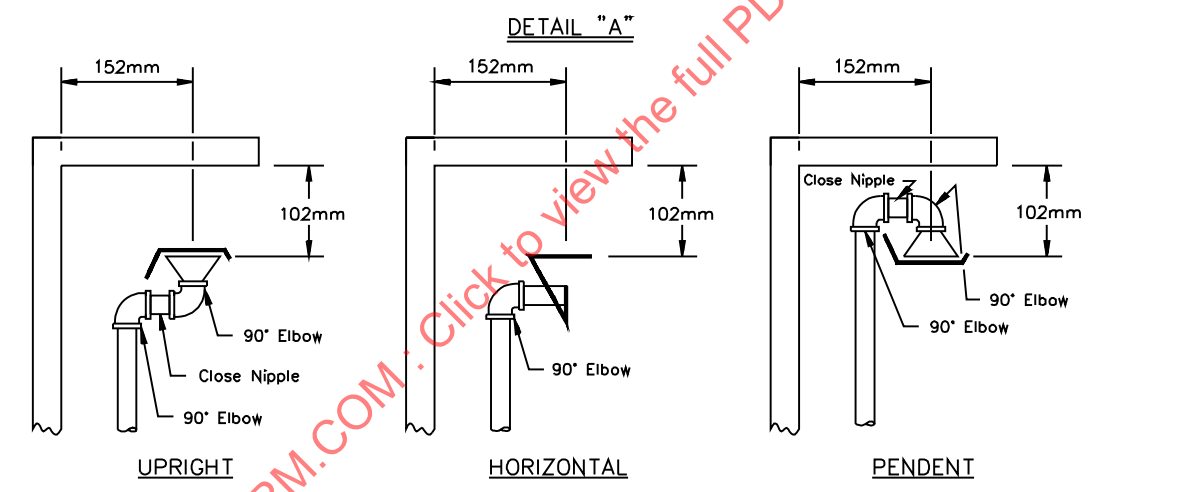
b) For 8.0 (115) nominal "K" factor sprinklers, a minimum average water collection in the pans of 0.070 gpm/ft^2 (2.9 mm/min), and a minimum water collection of 0.030 gpm/ft^2 (1.2 mm/min) for any individual pan.

c) Sprinklers fitted with guards shall not reduce the average collection by more than 20 % compared to the sprinkler tested without guard, but shall also comply with the minimum average and individual pan requirements described 54.5.1 (a) and (b).

Figure 54.8

Sidewall Sprinkler Distribution Test





S2468C

54.5.2 When tested as described in 54.5.3 – 54.5.5, each sidewall sprinkler shall wet an area of a smooth wall located behind the sprinkler to within 4 ft (1.22 m) below the level of the sprinkler deflector. Such wetting shall account for a minimum of 3.5 % of the total discharge at the minimum pressure specified in 54.5.4. The wall surface between the installed sidewall sprinklers shall be completely wetted from the floor to within 4 ft (1.22 m) below the deflector.

54.5.3 Two sprinklers are to be installed below a ceiling in their intended installation position, each supplied with water through 1 in piping in front of a 20 ft wide by 8 ft high (6.1- by 2.4-m) wall section. For dry type sprinklers, the minimum length to be produced is to be tested. The sprinklers are to be attached to the 1 in piping as follows:

a) Upright and pendent type – by means of a 90° elbow, 1 in close nipple, and a 1- by 1 in 90° elbow;

b) Horizontal type – by means of a 90° elbow; and

c) Dry type – by means of a tee.

The two sprinklers are to be installed with their deflectors 6 in (152 mm) from the wall and spaced 10 ft (3.05 m) apart, with frame arms in a uniform direction. One hundred 1-ft (305-mm) square collection pans are to be located in a 10-by 10-ft (3.05- by 3.05-m) square, centered between the sprinklers and extending 2 to 12 ft (0.61 to 3.65 m) outward from the wall. The sprinkler deflectors are to be located 4 in (102 mm) below a ceiling and the maximum distance below the ceiling as specified in the installation instructions if the maximum distance exceeds 4 in (102 mm) below a ceiling. The ceiling is to be located 8 ft (2.4 m) above the floor. See Figure 54.8.

54.5.4 For 1.4 (20), 1.9 (27), 2.8 (40), 4.2 (57), and 5.6 (80) nominal “K” factor sprinklers, the water flow rate through each sprinkler is to be 15 gpm (57 L/min). For 8.0 (115) nominal “K” factor sprinklers, the water flow rate through each sprinkler is to be 21 gpm (80 L/min). In addition, sprinklers rated for pressures exceeding 175 psig (1.2 MPa) are to be tested at a flow rate corresponding to a pressure of 75 psig (517 kPa) less than the rated pressure.

54.5.5 Water is to be discharged for a minimum of 10 min. The water wetting the wall behind the sprinkler is to be collected, measured, and the percentage of the total discharge calculated. The water impinging on the back wall is to flow downward on the surface of a nonporous plastic material that is to be placed over the surface of the wall. The water is to be directed from the plastic into a row of collection pans on the floor adjacent to the wall. The pans along the back wall are to be provided with a shield/cover located within 2 in (50 mm) of the wall so that the water collected in the pans is primarily from the water impinging on the back wall. The amount collected in each pan is to be measured and recorded to determine the amount and uniformity of discharge.

54.6 Wall wetting test for ECLH and ECOH sprinklers

54.6.1 When tested as described in 54.6.2 – 54.6.4, and installed as specified by the manufacturer, each sprinkler shall wet the entire area of the wall surfaces of the test room to a minimum height of 30 in (762 mm) above the floor.

54.6.2 The wall wetting tests are to be conducted in an enclosed room having the maximum dimensions intended for the sprinkler as specified by the manufacturer and a ceiling 8 ft (2.4 m) high.

54.6.3 Sidewall type sprinklers are to be installed at the greatest intended distance from the wall and at the minimum and maximum intended distance below the ceiling. For dry type sprinklers, the minimum length to be produced is to be tested. The piping configuration shown in Figure 55.3 is to be used.

54.6.4 The manufacturer's specified minimum water flow rate is to be used. For sprinklers having a pressure rating greater than 175 psig (1.2 MPa), tests are also to be conducted at a flow rate corresponding to a pressure of 75 psig (517 kPa) less than the rated pressure is to be used for the largest rated spacing. The water is to flow for at least 1 min. After 1 min of water flow, the flow is to be discontinued and each of the four walls examined to determine whether they are continuously wet from the floor to at least 30 in (762 mm) above the floor.

54.7 Distribution tests for ECOH sprinklers

54.7.1 The water collected in any individual collection pan, the average water collected for all collection pans in the distribution area, and the average water collected for collection pans in any 16 ft^2 (1.5 m^2) square area shall comply with the values specified in Table 54.5 with sprinkler deflector distances above the collection pans specified in Table 54.5. The sprinklers shall be tested using the coverage areas specified by the manufacturer.

Table 54.5
Pan Collection Values

	Sprinkler coverage area		Number of collection pans	Deflector to pan distance		Water flow per sprinkler		Minimum collection in any individual pan		Minimum average collection in any 16 ft² square area		Minimum average collection in all pans	
	ft	(m)		ft	(m)	gpm	(l/min)	gpm/ft²	(mm/min)	gpm/ft²	(mm/min)	gpm/ft²	(mm/min)
ECOH Pendent and Upright	14 x 14	(4.3 x 4.3)	64	7.5	(2.29)	30	(113)	0.075	(3.21)	0.11	(4.71)	0.15	(6.42)
			64	7.5	(2.29)	39	(147)	0.10	(4.28)	0.15	(6.42)	0.20	(8.66)
			64	3.0	(0.91)	30	(113)	0.03	(1.28)	0.08	(3.42)	0.15	(6.42)
			64	3.0	(0.91)	39	(147)	0.03	(1.28)	0.11	(4.71)	0.20	(8.66)
	16 x 16	(4.9 x 4.9)	100	7.5	(2.29)	39	(147)	0.075	(3.21)	0.11	(4.71)	0.15	(6.42)
			100	7.5	(2.29)	51	(193)	0.10	(4.28)	0.15	(6.42)	0.20	(8.66)
			100	3.0	(0.91)	39	(147)	0.03	(1.28)	0.08	(3.42)	0.15	(6.42)
			100	3.0	(0.91)	51	(193)	0.03	(1.28)	0.11	(4.71)	0.20	(8.66)
	18 x 18	(5.5 x 5.5)	144	7.5	(2.29)	49	(185)	0.075	(3.21)	0.11	(4.71)	0.15	(6.42)
			144	7.5	(2.29)	65	(246)	0.10	(4.28)	0.15	(6.42)	0.20	(8.66)
			144	3.0	(0.91)	49	(185)	0.03	(1.28)	0.08	(3.42)	0.15	(6.42)
			144	3.0	(0.91)	65	(246)	0.03	(1.28)	0.11	(4.71)	0.20	(8.66)
	20 x 20	(6.1 x 6.1)	196	7.5	(2.29)	60	(227)	0.075	(3.21)	0.11	(4.71)	0.15	(6.42)
			196	7.5	(2.29)	80	(302)	0.10	(4.28)	0.15	(6.42)	0.20	(8.66)
			196	3.0	(0.91)	60	(227)	0.03	(1.28)	0.08	(3.42)	0.15	(6.42)
			196	3.0	(0.91)	80	(302)	0.03	(1.28)	0.11	(4.71)	0.20	(8.66)
ECOH Sidewall[1]	16 x 16	(4.9 x 4.9)	256	6.67	(2.03)	39	(147)	NR	NR	0.05	(2.0)	0.11	(4.71)
			256	6.67	(2.03)	51	(193)	NR	NR	0.05	(2.0)	0.15	(6.42)
			256	3	(0.91)	39	(147)	NR	NR	0.05	(2.0)	0.11	(4.71)
			256	3	(0.91)	51	(193)	NR	NR	0.05	(2.0)	0.15	(6.42)
	16 x 18	(4.9 x 5.5)	288	6.67	(2.03)	43	(163)	NR	NR	0.05	(2.0)	0.11	(4.71)
			288	6.67	(2.03)	58	(220)	NR	NR	0.05	(2.0)	0.15	(6.42)
			288	3	(0.91)	43	(163)	NR	NR	0.05	(2.0)	0.11	(4.71)
			288	3	(0.91)	58	(220)	NR	NR	0.05	(2.0)	0.15	(6.42)
	16 x 20	(4.9 x 6.1)	320	6.67	(2.03)	48	(182)	NR	NR	0.05	(2.0)	0.11	(4.71)

Table 54.5 Continued on Next Page

Table 54.5 Continued

	Sprinkler coverage area		Number of collection pans	Deflector to pan distance		Water flow per sprinkler		Minimum collection in any individual pan		Minimum average collection in any 16 ft^2 square area		Minimum average collection in all pans	
	ft	(m)		ft	(m)	gpm	(l/min)	gpm/ft^2	(mm/min)	gpm/ft^2	(mm/min)	gpm/ft^2	(mm/min)
			320	6.67	(2.03)	64	(242)	NR	NR	0.05	(2.0)	0.15	(6.42)
			320	3	(0.91)	48	(182)	NR	NR	0.05	(2.0)	0.11	(4.71)
			320	3	(0.91)	64	(242)	NR	NR	0.05	(2.0)	0.15	(6.42)

NR – No requirement

[1] For other sidewall sprinkler coverage areas, the number of collection pans is equal to the sprinkler coverage area and the two water flows are to be calculated based upon sprinkler discharge densities of 0.15 gpm/ft^2 and 0.20 gpm/ft^2 multiplied by the rated coverage area.

54.7.2 For pendent and upright ECOH sprinklers, four open sprinklers are to be installed in their intended position (upright or pendent) in 1.5 by 1.5 by 3/4 in (38.1 by 38.1 by 19.1 mm) tees, each supplied with water through two 1.5 in (38.1 mm) diameter pipes with sprinklers placed at the corners of spacings specified by the manufacturer. The upright and pendent sprinkler deflectors are to be located 7 in (178 mm) below flat ceiling and frame arms are to be parallel to the piping on which it is installed.

54.7.2A For sidewall ECOH sprinklers, two open sprinklers are to be installed in their intended position in 1.5 by 1.5 by 3/4 in (38.1 by 38.1 by 19.1 mm) tees, each supplied with water through two 1.5 in (38.1 mm) diameter pipes with sprinklers placed at the edge of their spacings as specified by the manufacturer. The sidewall sprinkler deflectors are to be tested at both their minimum and 12 in (305 mm) below a flat ceiling which is the maximum permitted for these type of sprinklers.

54.7.2B For dry type sprinklers, the minimum length to be produced is to be tested. A ceiling mounted sprinkler type is to be installed as specified by the manufacturer.

54.7.3 Collection pans, having dimensions of 1 ft^2 (305 mm^2), are to be centered below the sprinklers at distances below the sprinkler deflectors as specified in Table 54.5.

54.7.4 Water is to be discharged for 10 min. The amount collected in each pan is to be measured, and the density in gpm/ft^2 (mm/min) calculated.

54.8 Residential sprinkler water distribution test – Horizontal surface

54.8.1 Acceptance criteria

54.8.1.1 When installed in accordance with the installation instructions and tested at each rated spacing as described in 54.8.2.1.1 – 54.8.2.3.2, a residential sprinkler shall distribute water over a horizontal surface such that the application rate for any 1 ft^2 (0.09 m^2) area within the design area (the maximum area the sprinkler is intended to protect) shall be at least 0.02 gpm/ft^2 (0.8 mm) except that:

a) No more than four 1 ft^2 areas for each quadrant shall be allowed to be at least 0.015 gpm/ft^2 (0.6 mm) for upright and pendent sprinklers; and

b) No more than eight 1 ft^2 areas (0.09 m^2) shall be allowed to be at least 0.015 gpm/ft^2 (0.6 mm) for each half (split along the sprinkler centerline) of the design area for sidewall sprinklers.

Exception: Testing at a 15 ft by 15 ft (4.6 m by 4.6 m) rated spacing shall not be required provided:

a) The sprinkler is rated for a 16 ft by 16 ft (4.9 m by 4.9 m) spacing,

b) The rated flow at the 15 ft by 15 ft (4.6 m by 4.6 m) spacing is not less than 90 percent of the rated flow at the 16 ft by 16 ft (4.9 m by 4.9 m) spacing and

c) The discharge pressure complies with 10.2.

54.8.2 Test method

54.8.2.1 General

54.8.2.1.1 Tests are to be conducted on an individual sprinkler using design flow rates specified in the installation instructions. In addition, for sprinklers having a pressure rating greater than 175 psig (1.2 Mpa), tests are to be conducted at the maximum rated spacing using a flow corresponding to a pressure of 75 psig (517 kPa) less than the rated pressure. The water distribution test is to be conducted for 20 min at each flow rate, except a shorter duration can be used if a pan within the collected area has reached its capacity.

54.8.2.1.2 Dry-type sprinklers are to be tested using the shortest available length and the longest available length, if the K-factor for the longest length deviates by more than 5 % from the shortest available length.

54.8.2.1.3 An open horizontal sidewall residential sprinkler is to be installed in its intended position in a reducing pipe fitting having a 1 in (25 mm) inlet and an outlet the same size as the sprinkler inlet, and is to be supplied with water through 1 in piping. The minimum nipple length leading to the sprinkler fitting shall not be less than 10 in (254 mm). The sprinkler is to be installed under a smooth, flat ceiling extending at least over the water collection pans. The sprinkler deflector is to be located in its intended position as specified in the installation instructions. After the initial test to measure the water collected for half of the design area, a second test shall be conducted to measure the water collected for the other half (other side of the sprinkler deflector) of the design area.

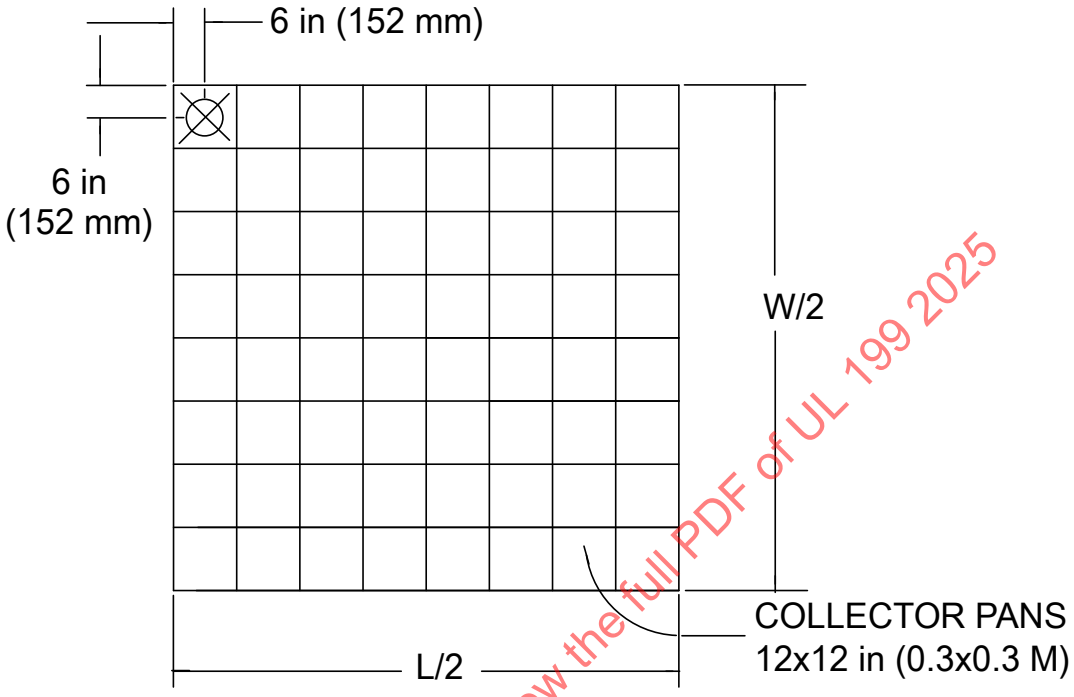
54.8.2.1.4 An open pendent, recessed pendent, flush pendent, concealed pendent, or upright residential sprinkler is to be installed in its intended position as specified in the installation instructions in a reducing pipe fitting having a 1 in (25 mm) inlet and an outlet the same size as the sprinkler inlet, and is to be supplied with water through 1 in piping. Recessed, flush, and concealed sprinklers are to be installed in their intended position as specified in the installation instructions under a minimum 4 ft by 4 ft (1.2 by 1.2 m) square, smooth, flat ceiling area. The sprinkler deflector is to be located in its intended position as specified in the installation instructions. A pendent, upright, flush, or concealed sprinkler is also to be tested after being rotated 90° about its vertical axis after being tested as initially installed.

54.8.2.2 Upright, pendent, flush, and concealed sprinklers

54.8.2.2.1 Collector pans measuring 1 ft^2 (0.09 m^2) are to be placed on the floor in one quadrant of the sprinkler's discharge pattern. See Figure 54.9. The tops of the pans are to be 8 ft (2.4 m) below the ceiling.

Figure 54.9

Horizontal Surface Water Collection for Upright and Pendent Sprinklers



⊗ = PENDENT OR UPRIGHT SPRINKLER

W = COVERAGE WIDTH

L = COVERAGE LENGTH

S3137F

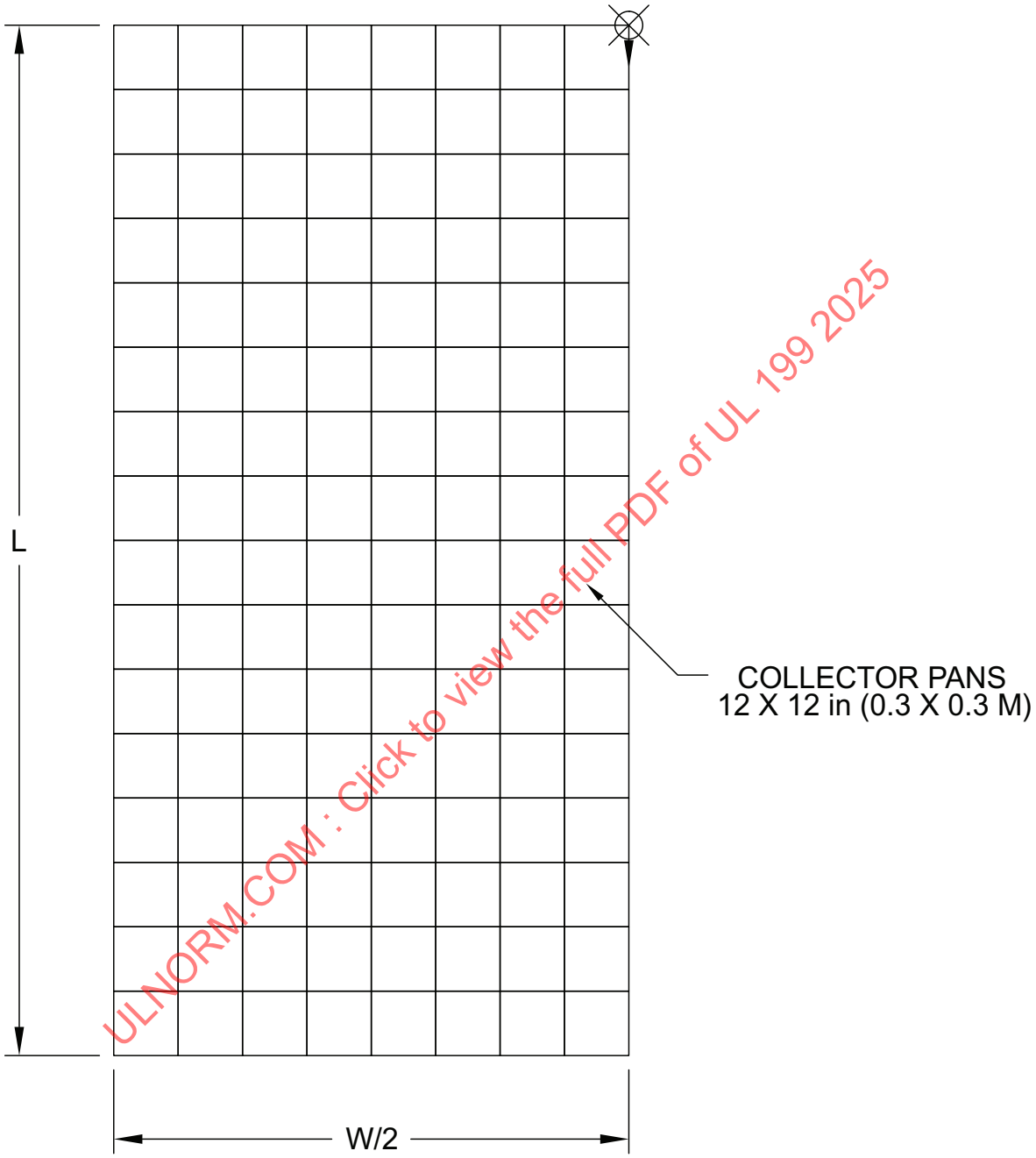
54.8.2.2.2 At the completion of water flow, the water collected is to be measured to verify compliance with the requirements in 54.8.1.1.

54.8.2.3 Sidewall sprinklers

54.8.2.3.1 Collector pans measuring 1 ft^2 (0.09 m^2) are to be placed as shown in Figure 54.10. The tops of the pans are to be 6.8 ft (2.1 m) below the ceiling. See Figure 54.10.

Figure 54.10

Horizontal Surface Water Collection for Sidewall Sprinklers



= SIDEWALL SPRINKLER

W = COVERAGE WIDTH

L = COVERAGE LENGTH

54.8.2.3.2 At the completion of water flow, the water collected is to be measured to verify compliance with the requirements in 54.8.1.1.

54.9 Residential sprinkler water distribution test – Vertical surface

54.9.1 Acceptance criteria

54.9.1.1 When installed in accordance with the installation instructions and tested at each rated spacing as described in 54.9.2.1 – 54.9.2.6, a residential sprinkler shall distribute water in a uniform manner over vertical surfaces as follows:

a) Walls within the coverage area shall be wetted to at least within 28 in (711 mm) of the ceiling with one sprinkler discharging water at the specified design flow rate.

b) For square coverage areas, each wall within the coverage area shall be wetted with at least 5 % of the sprinkler flow; for rectangular coverage areas, each wall within the coverage area shall be wetted with a proportional water amount based on 20 % of the total sprinkler discharge in accordance with the following formula:

$$WW = 20\%\left(\frac{D}{P}\right)$$

where:

WW = Required amount of water collected on a wall, %

D = Wall length, ft, and

P = Total perimeter of coverage area, ft.

Exception: Testing at a 15 ft by 15 ft (4.6 m by 4.6 m) rated spacing shall not be required provided:

a) The sprinkler is rated for a 16 ft by 16 ft (4.9 m by 4.9 m) spacing,

b) The rated flow at the 15 ft by 15 ft (4.6 m by 4.6 m) spacing is not less than 90 percent of the rated flow at the 16 ft by 16 ft (4.9 m by 4.9 m) spacing and

c) The discharge pressure complies with 10.2.

54.9.2 Test method

54.9.2.1 Tests are to be conducted on an individual sprinkler using flow rates specified in the installation instructions. In addition, for sprinklers having a pressure rating greater than 175 psig (1.2 Mpa), tests are to be conducted at the maximum rated spacing using a flow corresponding to a pressure of 75 psig (517 kPa) less than the rated pressure. Each water distribution test is to be conducted for a minimum of 10 min, except a shorter duration can be used if a pan within the collected area has reached its capacity.

54.9.2.2 Dry-type sprinklers are to be tested using the shortest available length and the longest available length, if the K-factor for the longest length deviates by more than 5 % from the shortest available length.

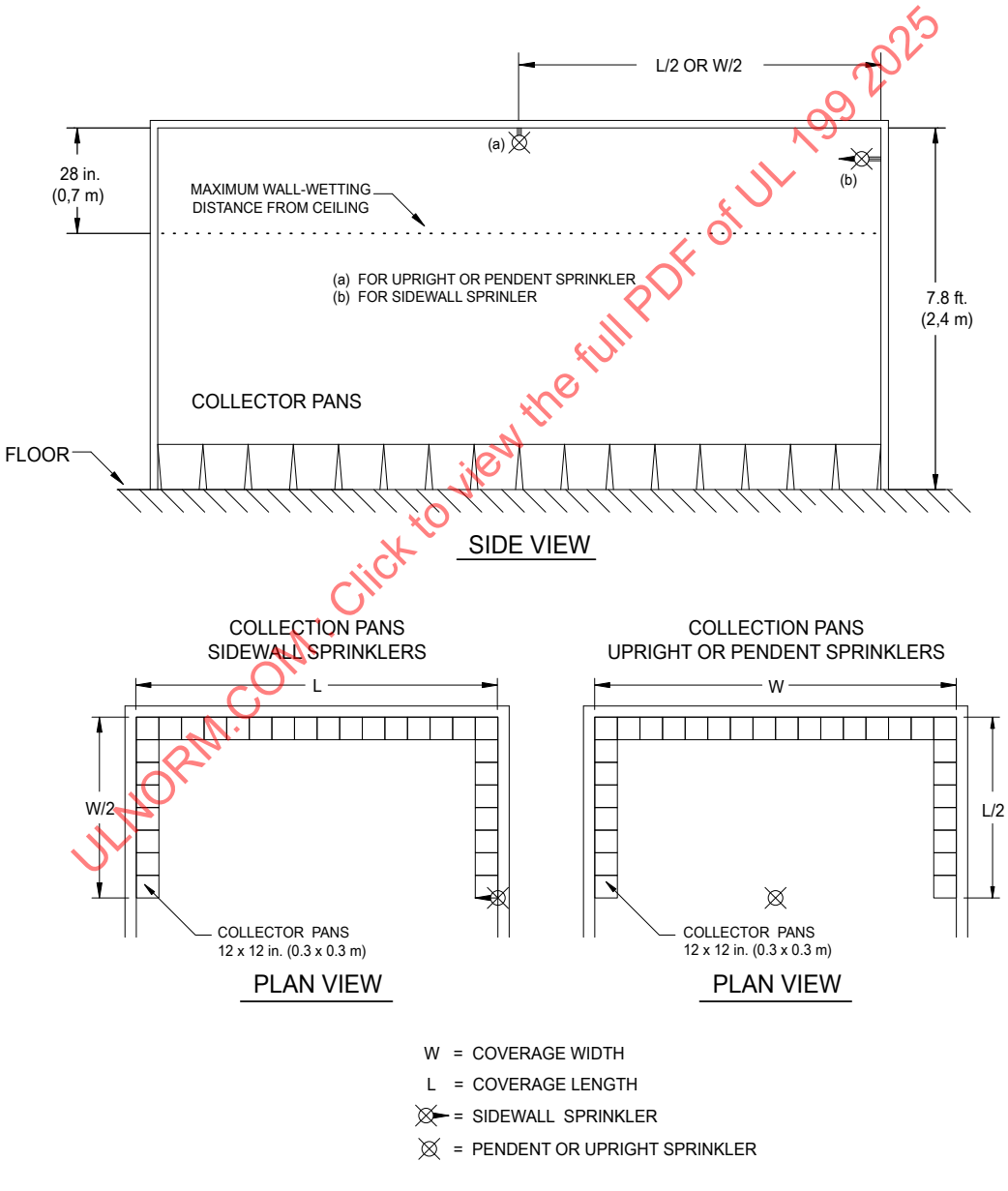
54.9.2.3 An open residential sprinkler is to be installed in its intended position in a pipe fitting having a 1-in inlet and an outlet the same size as the sprinkler inlet, and is to be supplied with water through 1-in piping. The sprinkler deflector is to be located in its intended position as specified in the installation instructions. A pendent or upright sprinkler is to be tested at a 90° rotation after being tested as initially installed.

54.9.2.4 Collector pans are to be used to determine that at least 5 % of the sprinkler flow is discharged onto each wall (see 54.9.2.5). The walls of the test room are to be nonporous or have a nonporous covering so that water impinging on the walls can be collected and measured.

54.9.2.5 The collector pans are to measure 1 ft^2 (0.09 m^2) and are to be placed on the floor against the walls for the length and width of specified coverage. They are to be 6.8 ft (2.1 m) below the ceiling. The pans along the walls are to be provided with a shield/cover located within 2 in (50 mm) of the walls so that the water collected in the pans is primarily from the water impinging on the walls. See Figure 54.11.

Figure 54.11

Vertical Water Collection



S5527a

54.9.2.6 The specified water flow rate is to be established and the test is to be conducted for a minimum of 10 min or until a pan is filled with water, whichever comes first. At the completion of the test, the water collected and the height of wall wetting is to be measured to determine compliance with the requirements in 54.9.1.1.

54.10 Distribution tests for pendent ESFR sprinklers having a nominal K-factor of 14.0 or 16.8

54.10.1 When tested as described in 54.10.3 – 54.10.4, the water distribution for a pendent ESFR sprinkler having a nominal K-factor of 14.0 and 16.8 shall comply with the requirements described in Table 54.6.

Exception: An ESFR sprinkler is permitted to have distribution characteristics different from those specified in Table 54.6, when fire suppression is demonstrated during full scale fire tests representing the installation conditions, protected storage configurations, and protected commodity specified for the sprinkler.

Table 54.6
Water Distribution Test Parameters and Requirements

Number of sprinklers centered over the water collection system	Sprinkler spacing ft	Pipe spacing ft	Deflector to water collector clearance ft-in	Minimum flue space (4 pans) average gpm/ft^2	Minimum 20-pan average density gpm/ft^2	Minimum non-flue space individual, at least 10 pans gpm/ft^2	Minimum non-flue space individual pan gpm/ft^2
1	0	0	14-6	1.7	0.91	0.50	0.24
2	10	0	4-2	N/R	0.77	0.60	0.20
2	0	10	4-2	N/R	0.75	0.60	0.20
4	10	10	4-2	N/R	0.71	0.60	0.37

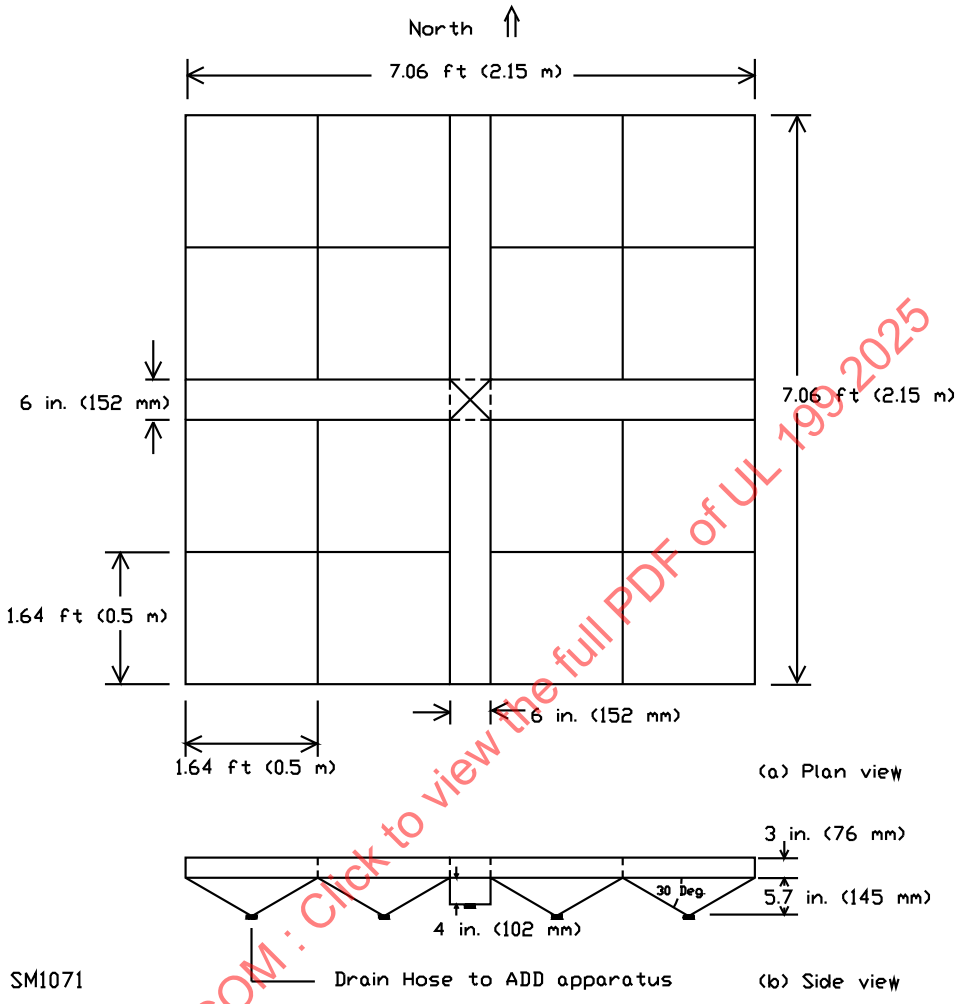
54.10.2 For dry-type sprinklers, the minimum and maximum lengths to be produced are to be tested.

54.10.3 The tests are to be performed at a 75 psig (517 kPa) discharge pressure for sprinklers having a nominal K-factor of 14.0 and 52 psi (359 kPa) for sprinklers having a nominal K-factor of 16.8. Open sprinklers are to be installed onto nominal 2-in diameter or larger piping with the pendent style sprinklers positioned 13 ±1 in (330 ±25 mm) below the ceiling and upright style sprinklers positioned 6 ±1 in (152 ±25 mm) below the ceiling and at the minimum distance above the pipe specified by the manufacturer. Each test is to be conducted three times with different sprinkler samples used for each test.

54.10.4 Twenty water collection pans are to be positioned as shown in Figure 54.12. Each water collection pan in the non-flue space is to be 19.7 in (0.5 m) square. The 16 non-flue space water collection pans are to be located in four groups of four pans as illustrated in Figure 54.12. The four flue space collection pans are to be 6 in (152 mm) wide and as shown in Figure 54.12. The water is to be collected for a minimum of 5 min.

Figure 54.12

Distribution Collection Pans



54.11 Thrust force test for pendent ESFR sprinklers having a nominal K-factor of 14.0 or 16.8

54.11.1 When tested as described in 54.11.3, an open, pendent ESFR sprinkler having a nominal K-factor of 14.0 and 16.8 shall provide an average center core thrust force of at least 2.1 lb/ft^2 (10 kg/m^2).

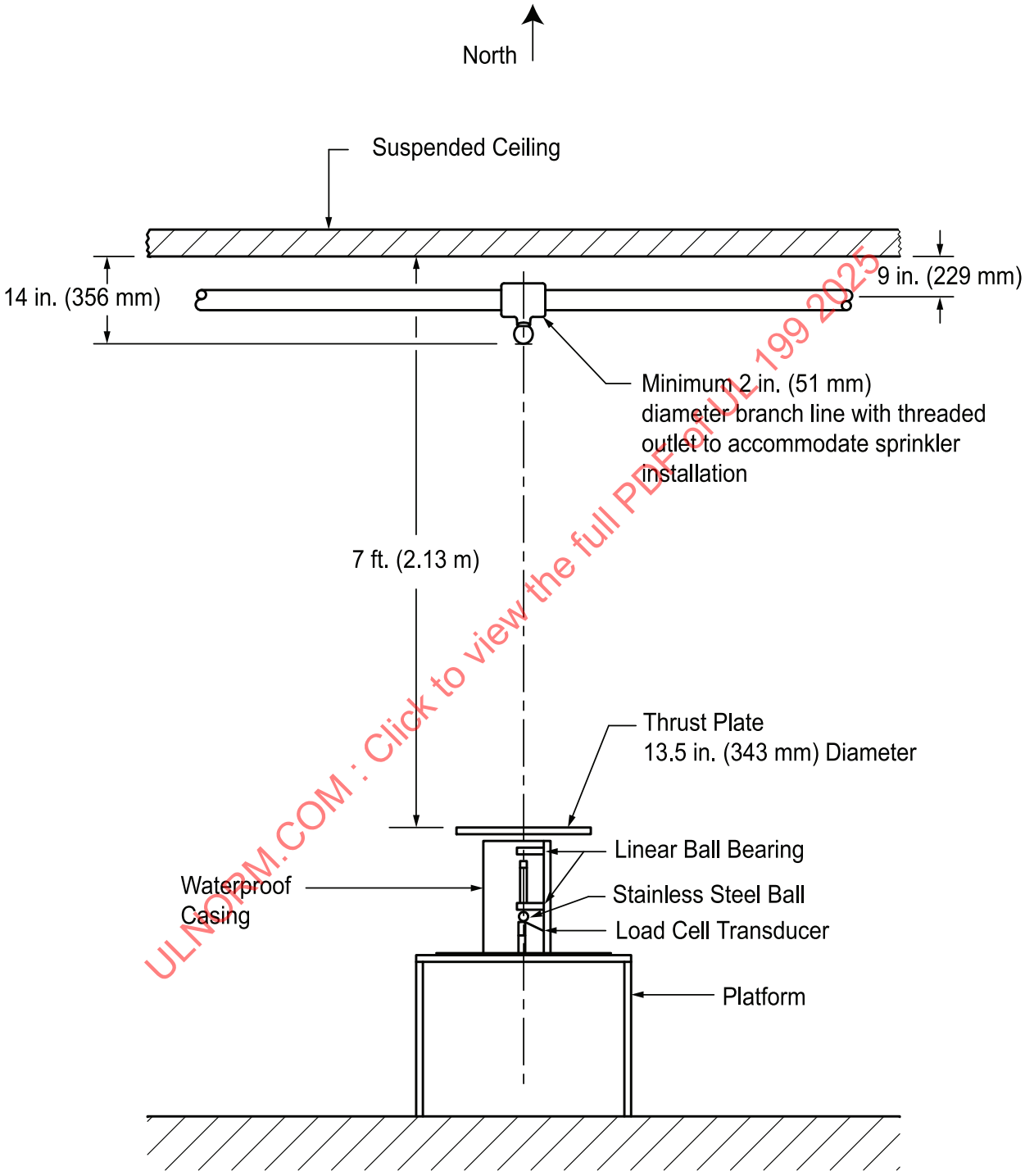
Exception: An ESFR sprinkler is able to have a center core thrust force characteristic different from that specified in 54.11.1, when fire suppression is demonstrated during full scale fire tests representing the installation conditions, protected storage configurations, and protected commodity specified for the sprinkler.

54.11.2 For dry-type sprinklers, the minimum and maximum lengths to be produced are to be tested.

54.11.3 Three sample sprinklers are to be installed individually onto the test apparatus. The center core thrust force over a nominal 13.5 in (343 mm) diameter plate is to be measured directly under a single sprinkler discharging water at a pressure of 75 psi (517 kPa) for sprinklers having a nominal K-factor of 14.0 and 52 psi (359 kPa) for sprinklers having a nominal K-factor of 16.8. The sprinkler is to be installed above the test apparatus shown in Figure 54.13. The test duration is to be 5 min and the data collected for each sample sprinkler is to be averaged over the 5 min period.

Figure 54.13

Thrust Force Measurement



54.12 Lateral discharge tests

54.12.1 Acceptance criteria

54.12.1.1 While discharging water at a service pressure of 75 psig (0.517 kPa) less than the rated pressure, an open sprinkler shall not prevent the operation of second ordinary-temperature rated automatic sprinkler of the same type and response located at the distance specified in Table 54.7 when tested as described in 54.12.2 – 54.12.6.

54.12.2 Upright and pendent sprinklers

54.12.2.1 An upright or pendent automatic sprinkler of the type noted in Table 54.7 in the ordinary temperature rating shall be installed on piping at a distance specified in Table 54.7 from a second open sprinkler of the same type and response. Ceiling sprinklers are to be tested in their most recessed condition. The sprinklers shall be on separate parallel pipelines.

54.12.3 Sidewall sprinklers

54.12.3.1 For sidewall sprinklers, an automatic and open sprinkler in the ordinary temperature rating is to be installed on the same pipe line with the sprinklers located at a distance apart as specified in Table 54.7 to discharge water perpendicular to the pipe line. The test is to be conducted with the sprinklers located at distances specified in Table 54.7 below a flat ceiling and 6 in (152 mm) away from a back wall.

54.12.4 Exposure to heat and flame

54.12.4.1 Water is to be discharged from the open sprinkler at a service pressure of 75 psig (0.517 kPa) less than the rated pressure. Under this condition, the automatic sprinkler is to be exposed to the heat and flame from a 1 ft^2 (305 mm^2) square pan, 4 in (102 mm) deep, containing 1 pint (0,47 l) of heptane and 1 pint (0,47 l) of water. Observations are to be made for operation of the automatic sprinkler. The test is to be conducted at each of the deflector to ceiling distances specified for each type of sprinkler listed in Table 54.7.

54.12.5 Intermediate level sprinklers

54.12.5.1 An ordinary-temperature rated automatic sprinkler is to be installed in the center of and located 7 ft, 6 in (2.29 m) below four open sprinklers of the same type which are located on the corners of a 10- by 10-ft (3- by 3-m) square. Water is to be discharged from the open sprinklers at a service pressure of 7 psig (48 kPa) per sprinkler except for ESFR and CMSA sprinklers which are to discharge water at the lowest pressure used for the testing referenced in 55.8, 55.9 or 55.10, as applicable. Under this condition, the automatic sprinkler is to be exposed to the heat and flame from a 1-ft (305-mm) square pan, 4 in (102 mm) deep, containing 1 pint (0.47 L) of heptane) and 1 pint (0.47 liter) of water. The top of the pan is to be located 6 in (152 mm) below the heat-responsive element of the closed sprinkler. The test is then to be repeated with the closed sprinkler 5 ft (1.52 m) below the four open sprinklers.

54.12.6 Specific application sprinklers

54.12.6.1 Specific application sprinklers intended for horizontal concealed spaces shall be tested in accordance with 54.12.4, but shall have a 4 ft (1.2 m) long section of trade size 2 by 4 in [nominal 1.5 in (3.8 cm) by 3.5 in (8.9 mm)] lumber installed at the ceiling on its flat side and located between the two sprinklers, 4 in (102 mm) horizontally from the sprinkler discharging water.

54.12.6.2 Specific application sprinklers intended for windows shall be tested in accordance with 54.12.4.

54.12.7 Consumption of heptane

54.12.7.1 In all test conditions, the automatic sprinkler shall operate before the heptane is consumed.

Table 54.7
Lateral Discharge Test Parameters

Sprinkler type	Distance between sprinkler, ft (m)	Distance from top of pan to sprinkler heat responsive element, in (mm)	Distance from ceiling,[1] in (mm)
Standard Coverage Pendent, Upright, and ESFR	6 (1.83)	6 (152)	6, 14 and 22 (152, 356 and 559)
Standard Coverage Sidewall	6 (1.83)	6 (152)	4 and 12 (102 and 305)
Extended Coverage Pendent and Upright	8 (2.4) or minimum distance specified by installation instructions	6 (152)	6, 14 and 22 (152, 356 and 559)
Extended Coverage Sidewall	8 (2.4) or minimum distance specified by installation instructions	6 (152)	4 and 12 (102 and 305)
Residential Pendent and Upright	8 (2.4) or minimum distance specified by installation instructions	12 (305)	4 (102)[2]
Residential Sidewall	8 (2.4) or minimum distance specified by installation instructions	12 (305)	4 and 12 (102 and 300)
Specific application – windows	6 (1.83) or minimum distance specified by the installation instructions	6 (152)	4 (102)
Specific application – horizontal concealed spaces	8 (2.4) or minimum distance specified by installation instructions	6 (152)	4 (102)
Note 1 – See 54.12.2.1 for ceiling sprinklers. Note 2 – Recessed sprinklers can be tested in the recessed condition in lieu of 4 in (102 mm) below ceiling.			

FIRE TESTS

55 Fire Test Requirements

55.1 General

55.1.1 An automatic sprinkler shall comply with the requirements as referenced in Table 55.1 based upon the sprinkler type.

55.1.2 The application of representative fire tests that differ from those described herein shall be permitted when protection is requested by the manufacturer for specific fire hazards or storage arrangements.

Table 55.1
Fire Test by Sprinkler Type

Sprinkler type	Requirements
All pendent and upright standard coverage sprinklers, including flush, recessed and concealed that have a nominal K-factor not exceeding 8.0 gpm/(psi)$^{1/2}$ [115 L/min/(bar)$^{1/2}$]. All sidewall standard coverage sprinklers, including flush, recessed and concealed that have a nominal K-factor of 5.6 gpm/(psi)$^{1/2}$ [80 L/min/(bar)$^{1/2}$] or 8.0 gpm/(psi)$^{1/2}$ [115 L/min/(bar)$^{1/2}$] intended for use in ordinary hazard occupancies. All ECOH sprinklers, including flush, recessed and concealed types.	55.2 350 lb (159 kg) Wood Crib Fire Test
All ECLH sprinklers, including flush, recessed and concealed types	55.3 ECLH Sprinkler Fire Tests
All ECOH sprinklers, including flush, recessed and concealed types	55.4 ECOH Sprinkler Piled Stock Fire Tests
Residential pendent, upright and sidewall including flush, recessed and concealed	55.5 Residential Sprinkler Fire Tests
Flow control type sprinklers	55.6 Flow Control (FC) Sprinkler Piled Stock Fire Test
CMDA storage sprinklers	55.7 CMDA Storage Sprinkler Large Scale Fire Tests
CMSA storage sprinklers	55.8 CMSA Storage Sprinkler Large Scale Fire Tests
All pendent ESFR sprinklers	55.9 ESFR Sprinkler Large Scale Fire Tests
Pendent ESFR sprinklers having nominal K-factor of 14.0 gpm/(psi)$^{1/2}$ [200 L/min/(bar)$^{1/2}$] or 16.8 gpm/(psi)$^{1/2}$ [240 L/min/(bar)$^{1/2}$]	55.10 Actual Delivered Density (ADD) Tests for Pendent ESFR Sprinklers Having a Nominal K-factor of 14.0 or 16.8
Specific application – windows	55.11 Fire Tests for Specific Application Sprinklers Intended to Protect Windows
Specific application – horizontal concealed spaces	55.12 Fire Tests for Specific Application Sprinklers Intended for Use in Horizontal Concealed Spaces

55.2 350 Pound (159 kg) wood crib fire test

55.2.1 General

55.2.1.1 When tested as described in 55.2.2 – 55.2.4 while discharging water at the flow rates as shown in Table 55.2; and for sprinklers having a rated pressure exceeding 175 psig (1.2 MPa), at a flow rate corresponding to a pressure of 75 psig (517 kPa) less than the rated pressure; four open sprinklers shall:

a) Limit the loss in weight of the wood crib to not more than 20 %; and

b) Result in the ceiling temperature reduced to a value less than 530 °F (277 °C) above ambient within 5 min after start of water discharge. Additionally, from the time the temperature initially falls below 530 °F (277 °C) above ambient to the end of the test, the ceiling temperature shall not exceed this value for more than three consecutive min and the average temperature for this period shall not exceed 530 °F (277 °C) above ambient.

55.2.1.2 Sidewall, 1.4, 1.9, 2.8, and 4.2 nominal “K” factor, and extended coverage type sprinklers, intended for use in light hazard occupancies only, are not to be subjected to the 350 Pound (159 kg) Wood Crib Fire Test, 55.2.

Table 55.2
Flows for 350 Pound (159 kg) Wood Crib Fire Test

Sprinkler description	Spacing		Test flow per sprinkler	
	ft	(m)	gpm	(l/min)
Spray type, Nominal K = 5.6 (80)	10 x 10	(3.05 x 3.05)	15 and 25	(57 and 95)
Spray type, Nominal K = 8.0 (115)	10 x 10	(3.05 x 3.05)	21 and 35	(79 and 132)
Sidewall, Nominal K = 5.6 (80)	10 x 20	(3.05 x 6.1)	15 and 25	(57 and 95)
Sidewall, Nominal K = 8.0 (115)	10 x 20	(3.05 x 6.1)	21 and 35	(79 and 132)
Pendent and Upright ECOH	12 x 12	(3.7 x 3.7)	22 and 29	(83 and 110)
	14 x 14	(4.3 x 4.3)	30 and 39	(114 and 148)
	16 x 16	(4.9 x 4.9)	39 and 51	(148 and 193)
	18 x 18	(5.5 by 5.5)	49 and 65	(185 and 246)
	20 x 20	(6.1 by 6.1)	60 and 80	(227 and 303)
Sidewall ECOH[1]	16 x 16	(4.9 x 4.9)	39 and 51	(148 and 193)
	16 x 18	(4.9 by 5.5)	43 and 58	(163 and 220)
	16 x 20	(4.9 by 6.1	48 and 64	(182 and 242)

[1] For other sidewall ECOH coverage areas, the two test flows are to be calculated based upon sprinkler discharge densities of 0.15 gpm/ft^2 and 0.20 gpm/ft^2 multiplied by the rated coverage area.

55.2.2 Test method – spray upright, spray pendent, ceiling, dry, or recessed or extended coverage for ordinary hazard occupancies types

55.2.2.1 Four open standard coverage sprinklers of the upright, pendent, ceiling, or dry type are to be installed on 10 by 10 ft (3.05 by 3.05 m) spacings. ECOH sprinklers are to be installed at their rated spacings. Sprinkler frame arms are to be parallel to the piping and the wood crib centered between the four sprinklers. For pendent and upright ECOH sprinklers, an additional fire test is to be conducted at the maximum rated spacing, using the highest flow indicated in Table 55.2 for the applicable spacing, with the crib positioned in a location yielding the least amount of water collected during the Distribution Tests for ECOH sprinklers, 54.7. The test room is to be a minimum of 60 by 60 ft (18.3 by 18.3 m) square. The piping grid is to be connected to a water-supply piping system. See Figure 55.2.

55.2.2.2 Dry-type sprinklers are to be tested using the shortest available length produced by the manufacturer and installed into tees rather than elbows in the piping system.

55.2.2.3 The deflectors of upright sprinklers are to be located 7 in (178 mm) below the ceiling. The deflectors of pendent sprinklers are to be located 12 in (305 mm) below the ceiling. Each ceiling sprinkler (flush, concealed, or recessed type) is to be mounted in the center of a 4 by 4 ft (1.2 by 1.2 m) ceiling section in accordance with the manufacturer's installation instructions.

55.2.3 Test method – sidewall types for ordinary hazard use

55.2.3.1 Four open sidewall sprinklers are to be installed at the corners of a piping grid. Standard coverage sidewall sprinklers are to be installed on a 10 by 20 ft (3.05 by 6.1 m) piping grid with 10 ft (3.05 m) between sprinklers on two separate branch lines that are installed 20 ft (6.1 m) apart. Sidewall ECOH sprinklers are to be installed on a piping grid at each rated spacing. The sprinkler deflectors are to be located 7 in (178 mm) for upright sidewall sprinklers, 9-1/2 in (241 mm) for horizontal sidewall sprinklers, and 12 in (305 mm) for pendent sidewall sprinklers from the ceiling. The sprinklers are to be positioned such that two sprinklers on a branch line are aligned with two sprinklers installed on the adjacent branch line and discharge water directly toward its opposing sprinkler.

55.2.4 Test method – all types

55.2.4.1 The test is to be conducted in a vented test room having a 15 ft, 9 in (4.8 m) high smooth, flat, horizontal ceiling. The piping grid is to be connected to the water supply.

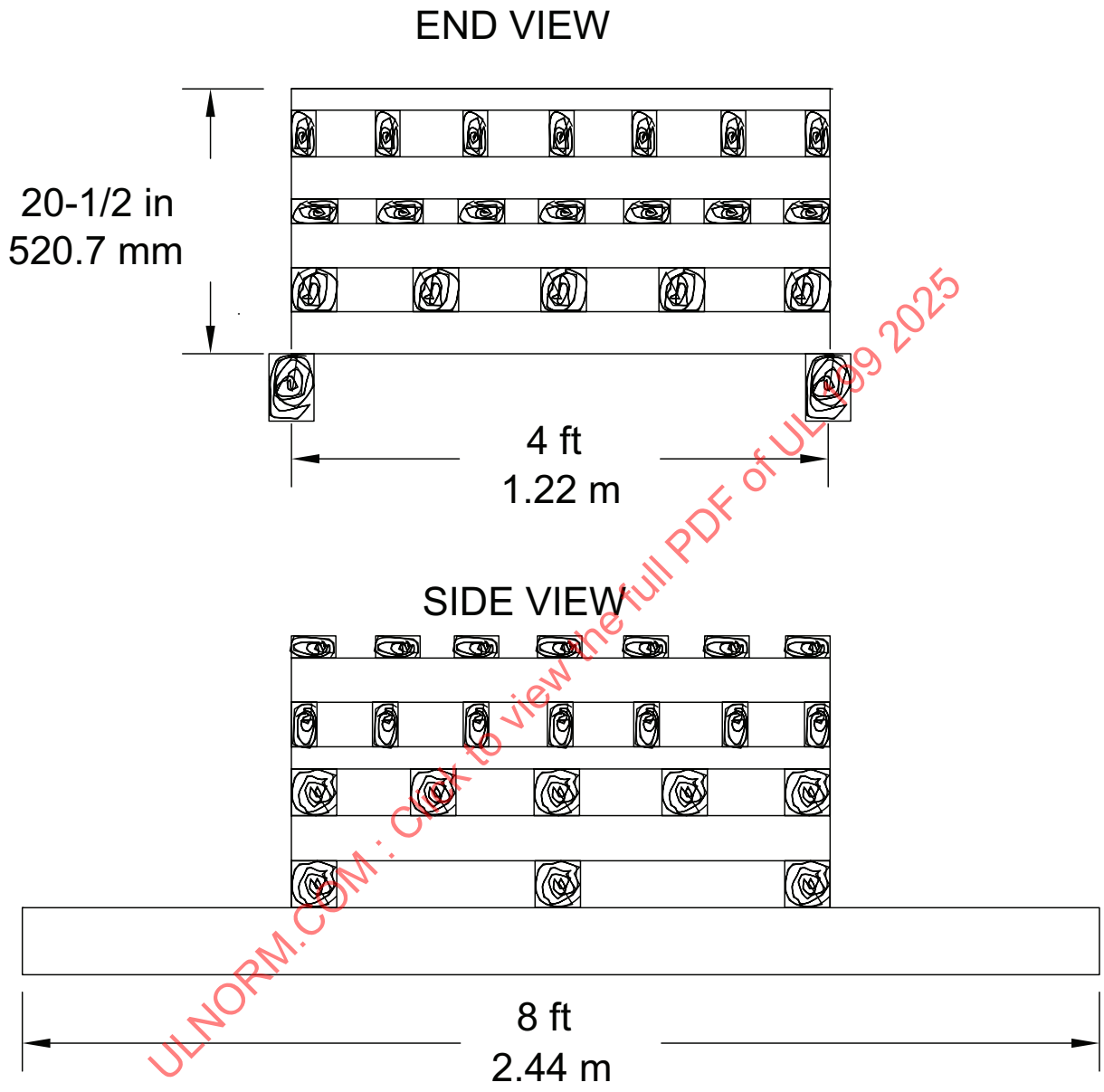
55.2.4.2 The fire employed for these tests is to combine the use of a combustible liquid (heptane, see 5.20) torch and a crib of wood weighing approximately 350 lbs (159 kg).

55.2.4.3 The wood crib is to consist of layers of trade size 2- by 4-in [nominal 1-1/2 by 3-1/2 in (38.1 by 88.9 mm)], trade size 4- by 4-in [nominal 3-1/2 by 3-1/2 in (88.9 by 88.9 mm)] and trade size 4- by 6-in [nominal 3-1/2 by 5-1/2 in (88.9 by 138 mm)] kiln-dried spruce or fir lumber (moisture content 6 to 12 %) having the configuration and support illustrated by Figure 55.1.

55.2.4.4 The alternate layers of lumber are to consist of the sizes specified in 55.2.4.3 of the lengths specified in Figure 55.1, and placed at right angles to the adjacent layers as illustrated in Figure 55.1. The individual wood members in each layer are to be evenly spaced from each other, and form a square crib, 4- by 4-ft (1.22- by 1.22-m) in area and 21-1/2 in (546 mm) high, supported, in turn, by the two 8 ft (2.44 m) long, 4- by 6-in (104- by 152-mm) stringers. The total crib weight is to be determined and recorded.

Figure 55.1

350 Pound (159 kg) Fire Test Crib



s2316c

Quantity	Description of material
2	4- by 6-in trade size lumber, 8 ft (2.44 m) long
13	4- by 4-in trade size lumber, 4 ft (1.22 m) long
28	2- by 4-in trade size lumber, 4 ft (1.22 m) long

Note: 1 in = 25.4 mm

1 ft = 0.305 m

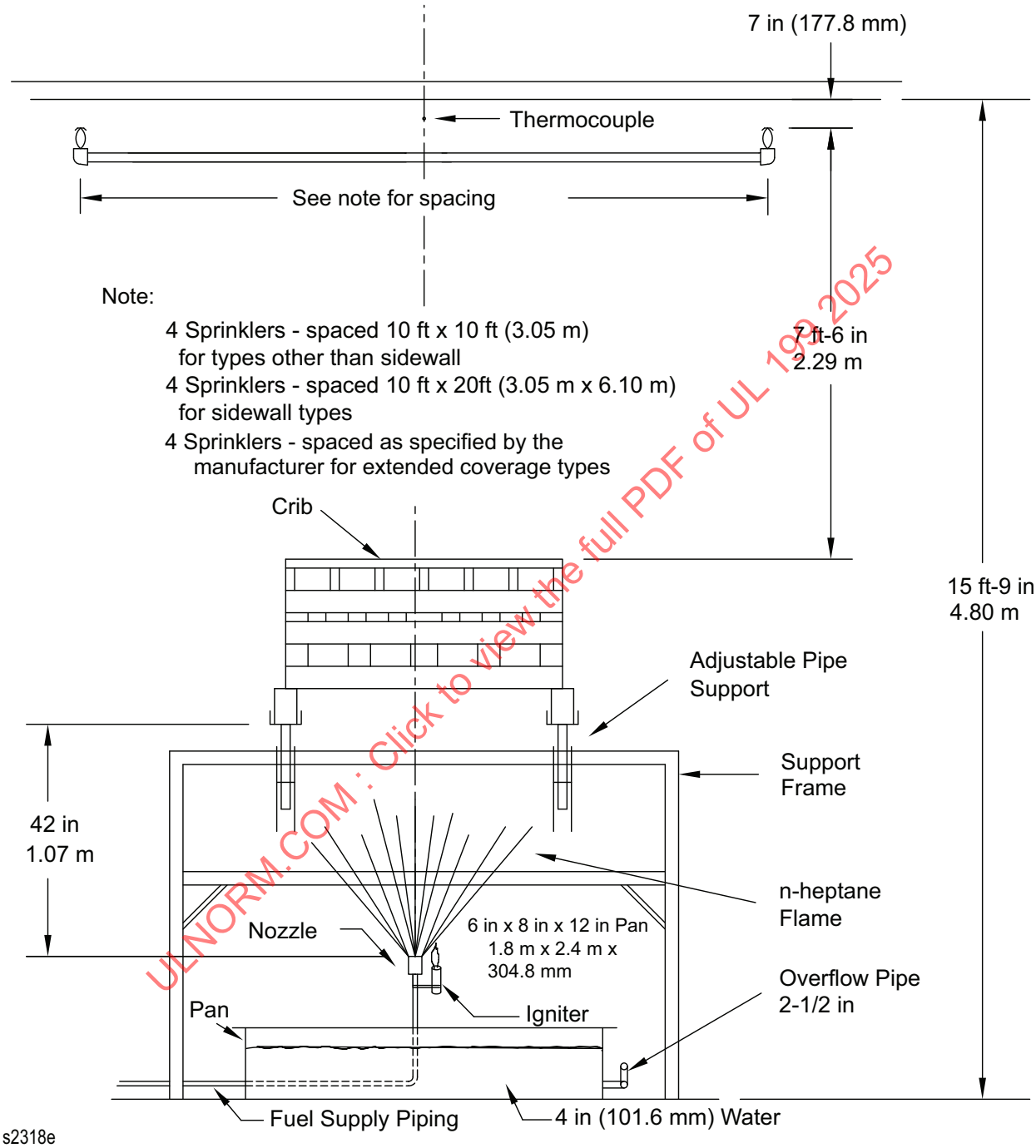
55.2.4.5 The crib is to be supported by a steel framework as illustrated in Figure 55.2, or the equivalent. The crib supports are to be located beyond the edges of a 6- by 8-ft (1.83- by 2.44-m) steel pan.

55.2.4.6 The top of the wood crib is to be 7-1/2 ft (2.29 m) below the deflectors of the test sprinklers.

55.2.4.7 The steel pan is to be 6 by 8 ft (1.83 by 2.44 m) by 12 in (305 mm) deep, constructed of steel not less than 3/16 in (5.4 mm) thick. The top edges are to be reinforced by a continuous steel angle section. The pan is to be liquid-tight and is to be filled prior to test with water to a depth of approximately 4 in (102 mm). The pan is to be provided with a means for draining to maintain the 4 in (102 mm) water level.

Figure 55.2

Typical Fire Test Arrangement



55.2.4.8 At a location in the pan and directly under the vertical axis of the wood crib, an atomizing nozzle is to be placed and arranged to spray heptane vertically upward. The nozzle and its supply piping are to be arranged as shown by Figure 55.2. To prevent flameout, an igniter is to be located near the nozzle. The igniter shall be any convenient device that prevents flameout, such as a container partially filled with heptane.

55.2.4.9 The atomizing nozzle[a] is to form a hollow-spray pattern having an included angle of 75° when atomizing heptane at the rate of 0.9 gpm (3.4 L/min).

[a] A nozzle having these characteristics is the Catalog Number WS-15 Industrial Nozzle as produced by the Delavan Manufacturing Co., West Des Moines, Iowa 50265.

55.2.4.10 A means for supplying and metering the fuel is to be furnished.

55.2.4.11 The temperatures at the ceiling level are to be continuously recorded during the test, utilizing an unprotected 20 AWG (0.52 mm^2) chromel-alumel thermocouple centrally located above the test crib 2 in (50.8 mm) from the ceiling. The relation of the thermocouple to the ceiling and the crib is to be as illustrated in Figure 55.2.

55.2.4.12 The fuel flow is to be started and the torch ignited immediately. The 30-min test period is to begin when the torch is ignited. Water application is to be started after a minimum free-burning time of 1 min or after a ceiling temperature of 1400 °F (760 °C) is attained, whichever occurs last. Thirty min after ignition, the fuel flow to the torch is to be stopped, and after any residual fire in the crib is extinguished, the water is to be turned off.

55.2.4.13 The crib is then to be dried and weighed. The drying is to be accomplished either by using an oven or by storing the crib for 7 days after the test in a sheltered area. The values of the crib weight measured before the test (6 to 12 % moisture content) and after drying are to be corrected to the value at 0 % moisture before calculations are performed to determine compliance with the 20 % weight loss requirement specified in 55.2.1.1.

55.2.4.14 The average temperature for the time interval between the time at which the ceiling temperature first falls below a temperature of 530 °F (295 °C) above initial ambient and the time at the end of the test is to be computed by comparing the area under the curve determined by the recorded ceiling temperatures with the area beneath a straight line drawn at the temperature point 530 °F (295 °C) above initial ambient. The area beneath the curve of the recorded ceiling temperatures shall be the lesser of the two areas.

55.3 ECLH sprinkler fire tests

55.3.1 General

55.3.1.1 When tested as described in 55.3.2 – 55.3.4, an extended coverage sprinkler for light-hazard occupancies shall limit the average loss of weight of three wood cribs to not more than 35 %.

55.3.1.2 The fire test is to be conducted in a room having the maximum dimensions intended for the sprinkler as specified by the manufacturer for each flow rating.

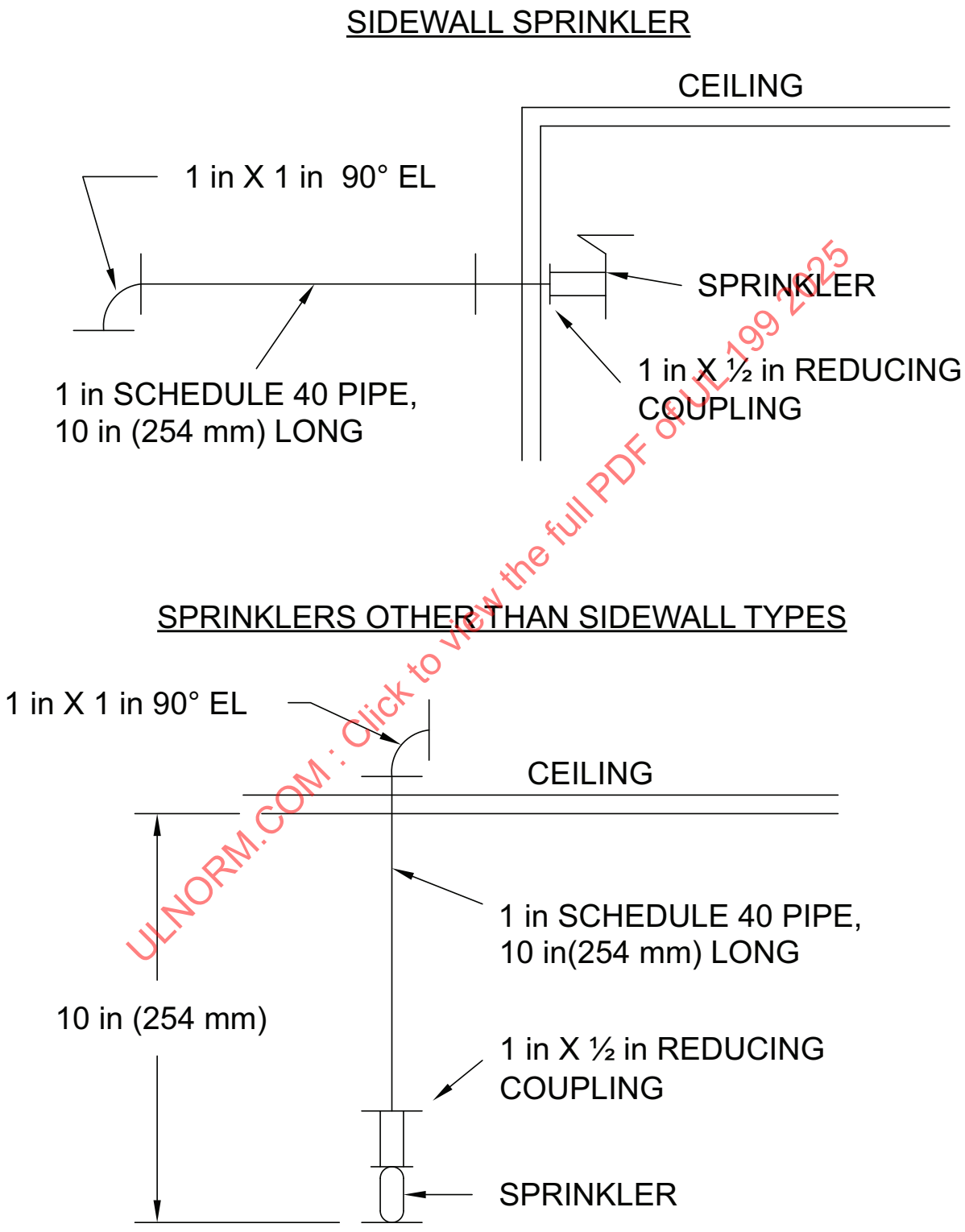
55.3.1.3 Recessed or concealed sprinklers with vented escutcheons are to be installed in a manner that does not inhibit air flow through the escutcheon (unblocked).

55.3.2 Test method – sidewall type

55.3.2.1 For a sidewall type sprinkler intended for installation at distances from a smooth (unobstructed) ceiling between 4 and 6 in (102 and 152 mm), one sprinkler is to be installed on a wall with the deflector located 4 in (102 mm) below a smooth (unobstructed), horizontal ceiling, as illustrated in Figure 55.3. For a sidewall type sprinkler intended for installation at distances below the ceiling exceeding 6 in (152 mm), two series of tests are to be conducted, one with the sprinkler installed 4 in (102 mm) below the ceiling and a second test series with the sprinkler installed at the maximum distance below the ceiling specified by the manufacturer. A sidewall type sprinkler intended for use with obstructed ceilings, such as those ceilings having beams, is to be similarly installed, except that the obstructions specified by the manufacturer are to be incorporated into the ceiling. The base of a horizontal type sprinkler is to be installed adjacent to the wall. The deflector of an upright or pendent type sidewall sprinkler is to be mounted at the minimum clearance from the wall specified by the manufacturer. A sidewall type sprinkler is to be installed using a 10-in (254-mm) long, 1-in (25.4-mm) diameter nipple with reducing coupling installed with axis perpendicular to the wall. See Figure 55.3.

Figure 55.3

Piping Arrangements for ECLH Sprinkler Fire Tests



s3158c

55.3.3 Test method – ceiling, pendent, or upright types

55.3.3.1 A sprinkler of the ceiling, pendent, or upright type is to be installed in its intended installation position with the deflector 10 in (254 mm) below the ceiling, unless specifically designed for other positions (such as ceiling sprinkler installations). See Figure 55.3.

55.3.4 Test method – all types

55.3.4.1 Water distribution measurements are to be conducted in an enclosed room with an open sprinkler discharging water at the minimum flow rate and maximum area of coverage specified by the manufacturer. The minimum flow rate is to be not less than a minimum water density of 0.1 gpm/ft^2 (4.0 mm/min) for the specified coverage area. For sprinklers rated at a pressure exceeding 175 psig (1.2 MPa), tests are also to be conducted using a flow rate corresponding to a pressure of 75 psig (517 kPa) less than the rated pressure for the largest rated spacing. Water collection pans that are 12 in (305 mm) square, and 12 in (305 mm) deep with a lip on one edge, are to be located on the floor of the enclosed room in the areas of the 11 crib locations as shown in Figure 55.4. The distribution data are to be recorded and used in determining the specific positions of the wood cribs as required for the second and third fire tests specified in 55.3.4.2.

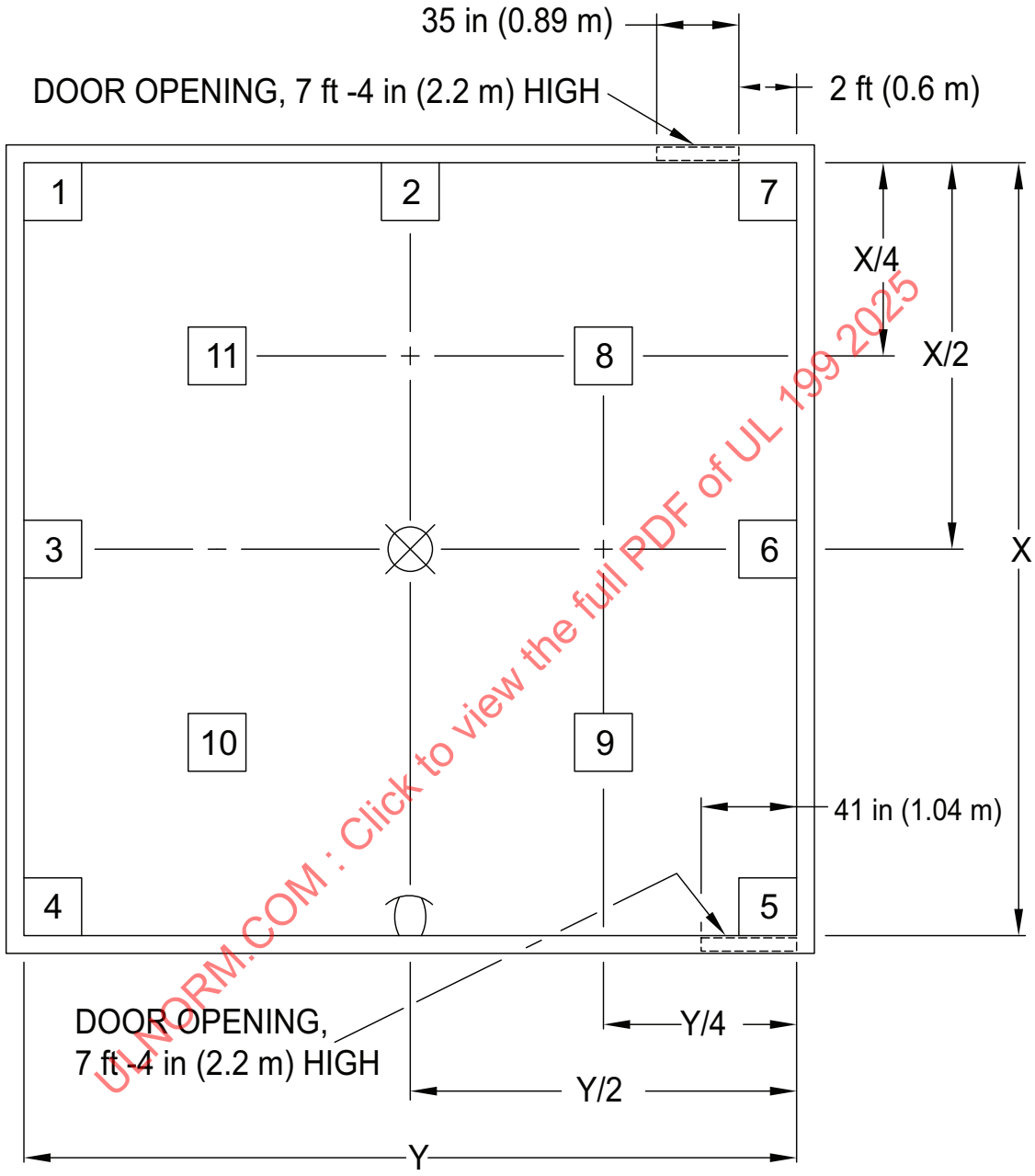
55.3.4.2 A series of three fire tests are to be conducted at each flow rate using automatic sprinklers in the maximum temperature rating. For the first fire test, a wood crib as specified in 55.3.4.4 – 55.3.4.6 is to be located at Crib Location 1 of the test enclosure, see Figure 55.4. For the second fire test, the wood crib is to be located at Crib Location 2, 3, 4, 5, 6, or 7, see Figure 55.4, whichever location had the least amount of water collected during the distribution determinations. However, when Crib Location 5, 6, or 7 had the least amount of water collected then:

a) A sprinkler other than a sidewall type is to be rotated 180° and the crib placed in Crib Location 1, 3, or 4, whichever is opposite the crib location that had the least amount of water collected; and

b) A sidewall type sprinkler is to be installed on the wall near Crib Location 2.

Figure 55.4

Location of Fire Test Cribs for ECLH Sprinklers



⊗ — SPRINKLER OTHER THAN SIDEWALL TYPE (WHEN OTHER THAN SIDEWALL TYPE IS BEING TESTED)

∩ — SIDEWALL TYPE SPRINKLER (WHEN SIDEWALL TYPE IS BEING TESTED)

□ — POSSIBLE CRIB LOCATION (SEE TEXT FOR SPECIFIC LOCATION DETERMINATIONS)

s3159c

55.3.4.3 For the third fire test, the wood crib is to be located in the center of one of the four quadrants of the test room (see Figure 55.4, Crib Location 8, 9, 10, or 11), whichever had the least amount of water collected during the distribution determination. However, when Crib Location 8 or 9 had the least amount of water collected, then:

a) A sprinkler other than a sidewall type is to be rotated 180° and the fire placed in Crib Location 10 or 11, whichever is opposite the crib location that had the least amount of water collected; and

b) A sidewall type sprinkler is to be installed on the wall near Crib Location 2.

55.3.4.4 The wood crib is to be dimensioned 20 by 20 by 15 in (508 by 508 by 381 mm) high and weigh 33 ±2 lbm (15 ±1 kg).

55.3.4.5 The wood crib is to consist of ten alternate layers of five trade size 2- by 2-in [nominal 1-1/2- by 1-1/2-in (38.1- by 38.1-mm)] kiln-dried spruce or fir lumber 20 in (508 mm) long. The alternate layers of the lumber are to be placed at right angles to the adjacent layers. The individual wood members in each layer are to be evenly spaced along the length of the previous layer of wood members and stapled to the adjacent members.

55.3.4.6 After the wood crib is assembled, it is to be conditioned at a temperature of 120 ±10 °F (49 ±5 °C) for not less than 48 h. Following the conditioning, the moisture content of the crib is to be measured with a probe type moisture meter. The moisture content of the crib at any measurement location is not to exceed 8 % prior to weighing the crib for the fire test.

55.3.4.7 For each test, the crib is to be placed on four bricks that are 4 in (102 mm) high, one at each corner of the crib, that are contained in a 21 by 21 by 4 in (533 by 533 by 102 mm) deep steel pan filled with 1/4 gallon (0.95 L) of heptane on a 1-in (25.4 mm) layer of water. When the crib position is in a corner, the edge of the crib is to be positioned 1/2 in (12.7 mm) from both walls. A noncombustible ceiling material shall be installed immediately above each fire location.

55.3.4.8 The test room enclosure and sprinkler sample are to be maintained at a temperature of 75 ±15 °F (24 ±8 °C) prior to each test. The room is not to have provisions for ventilation other than that provided by the two door openings shown in Figure 55.4.

55.3.4.9 The water flow for the sprinkler is to be preset for the flow rate specified in 55.3.4.1. The test room doors are to be fully opened. The heptane is to be ignited. The test is to be conducted for 10 min after the ignition of the heptane. Ten min after ignition, the water for the sprinkler is to be turned off. When the fire in the crib has not been extinguished, it is to be carefully extinguished to prevent further destruction of the crib. The crib is to be removed from the test enclosure and is to be conditioned at a temperature of 120 ±10 °F (49 ±5 °C) for not less than 48 h.

55.4 ECOH sprinkler piled stock fire tests

55.4.1 When tested as described in 55.4.2 – 55.4.9, the water discharge from the sprinkler shall:

a) Not result in operation of more than the maximum number of sprinklers specified in Table 55.3 within 45 min of the start of the test.

b) Result in the ceiling temperature to be reduced to a value less than 530 °F (276 °C) above ambient within 5 min after start of water discharge from the third operating sprinkler. Additionally, from the time the temperature initially falls below 530 °F (276 °C) above ambient to the end of the test, the ceiling temperature shall not exceed this value for more than three consecutive min and the average temperature for this period shall not exceed 530 °F (276 °C) above ambient.

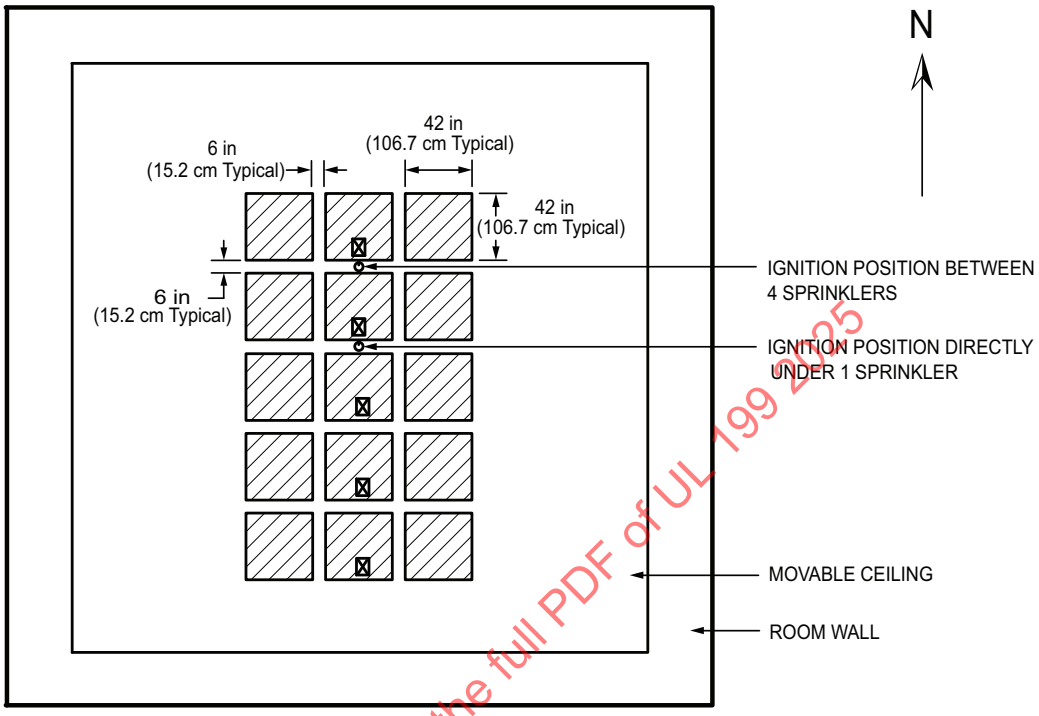
Table 55.3
Piled Stock Fire Test Conditions and Criteria

Sprinkler coverage area		Test flow per sprinkler		Maximum number of sprinklers to operate
ft	(m)	gpm	(l/min)	
20 by 20	(6.1 by 6.1)	80	(302)	5
18 by 18	(5.5 by 5.5)	65	(246)	5
16 by 16	(4.9 by 4.9)	51	(193)	6
14 by 14	(4.3 by 4.3)	39	(147)	8

55.4.2 The test room for the fire tests shall have provisions for venting the heat and smoke and for drainage of the sprinkler discharge. A wet pipe automatic sprinkler system shall be installed below a smooth, flat, non-combustible horizontal ceiling unless otherwise specified in the test conditions. Sprinklers shall be supplied through a looped or gridded piping system consisting of nominal 2 or 2.5 in (50 or 65 mm) diameter pipe. See Figure 55.5 for a typical test room.

Figure 55.5

Location of Piled Cartons



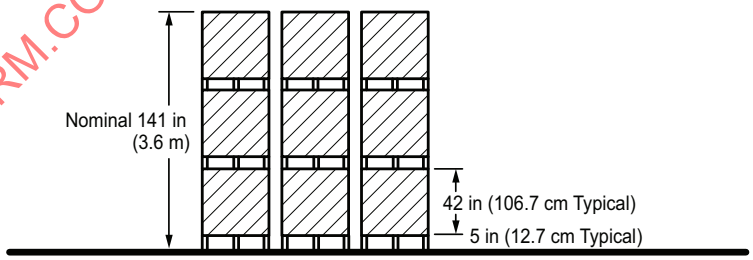
o – IGNITION SOURCE 1-1/2 LBS (0.68 kg) SHREDDED PAPER

⊠ – THERMOCOUPLE POSITIONED 2 in (5.1 cm) BELOW CEILING ABOVE BOXES

NOTE - THERMOCOUPLES ALSO POSITIONED NEXT TO EACH SPRINKLER

PLAN VIEW

CARTON ARRANGEMENT



– STANDARD CLASS II COMMODITY

ELEVATION VIEW
(CARTONS ONLY)

su1380b

55.4.3 In the first fire test, at least 16 sprinklers are to be installed in the test room at the maximum sprinkler spacing specified by the manufacturer with the ignition source located between four automatic sprinklers arranged to discharge water as specified in Table 55.3. The sprinkler deflectors are to be located 12 in (305 mm) below the ceiling. A clearance of 18 in (457 mm) between the sprinkler deflector and the commodity is to be provided.

55.4.4 In the second test, at least 25 sprinklers are to be installed in the test room, using the minimum rated coverage area specified by the manufacturer, with the ignition source located directly below one sprinkler with each sprinkler flowing water corresponding to the values specified in for the applicable coverage area. The sprinkler deflectors are to be located approximately 3 in (76.2 mm) below the ceiling for upright sprinklers and approximately 12 in (305 mm) below the ceiling for pendent sprinklers. A nominal clearance of 10 ft (3.05 m) between the sprinkler deflector and the top of commodity is to be provided.

55.4.5 The piled stock is to consist of 45 Standard Class II commodity in a three pallet-cartons wide by five long by three high-palletized arrangement. See Figure 55.5. The moisture content of the cardboard boxes as measured in representative samples shall be within 8 ±3 %. A 6-in (152-mm) free space is to be maintained between all carton stacks.

55.4.6 The ignition source for the first fire test is to consist of 1.5 lb (0.68 kg) of shredded paper placed on the floor as illustrated in Figure 55.5 and ignited.

55.4.7 Temperatures are to be recorded by means of thermocouples located near the ceiling, which are to be located 2 in (50.8 mm) below the ceiling and 6 in (152 mm) from the centerline of the flue above each of the stored commodity in the center of the test array. See Figure 55.5. Additional thermocouples are to be located next to the heat sensitive element of each sprinkler.

55.4.8 The waterflow during sprinkler discharge is to be continuously monitored so that the waterflow is to be adjusted as required during the test to provide the applicable sprinkler discharge flow specified in Table 55.3.

55.4.9 The fire test is to be continued for 45 min after ignition.

55.5 Residential sprinkler fire test

55.5.1 General

55.5.1.1 When fire tested as described in 55.5.1.2 – 55.5.4.1, a residential sprinkler shall limit temperatures as specified in 55.5.1.1 (a) – (d) when tested at each rated spacing referenced in the installation instructions. Additionally, a maximum of two residential sprinklers shall operate. The sprinklers shall limit temperatures as follows:

a) The maximum temperature 3 in (76 mm) below the ceiling at either location as illustrated in Figure 55.6 to Figure 55.8 shall not exceed 600 °F (316 °C).

b) The maximum temperature 5-1/4 ft (1.6 m) above the floor shall not exceed 200 °F (93 °C).

c) The temperature at the location described in (b) shall not exceed 130 °F (54 °C) for more than any continuous 2-min period.

d) The maximum ceiling material temperature 1/4 in (6.4 mm) behind the finished ceiling surface shall not exceed 500 °F (260 °C).

See Figure 55.6 (pendent, upright, flush, recessed pendent, and concealed sprinklers) or Figure 55.7 and Figure 55.8 (sidewall sprinklers) for temperature measuring locations.

55.5.1.2 Residential sprinklers in each temperature rating are to be subjected to the tests specified in 55.5.2.1 – 55.5.4.1.

Exception: Testing at a 15 ft by 15 ft (4.6 m by 4.6 m) rated spacing shall not be required provided:

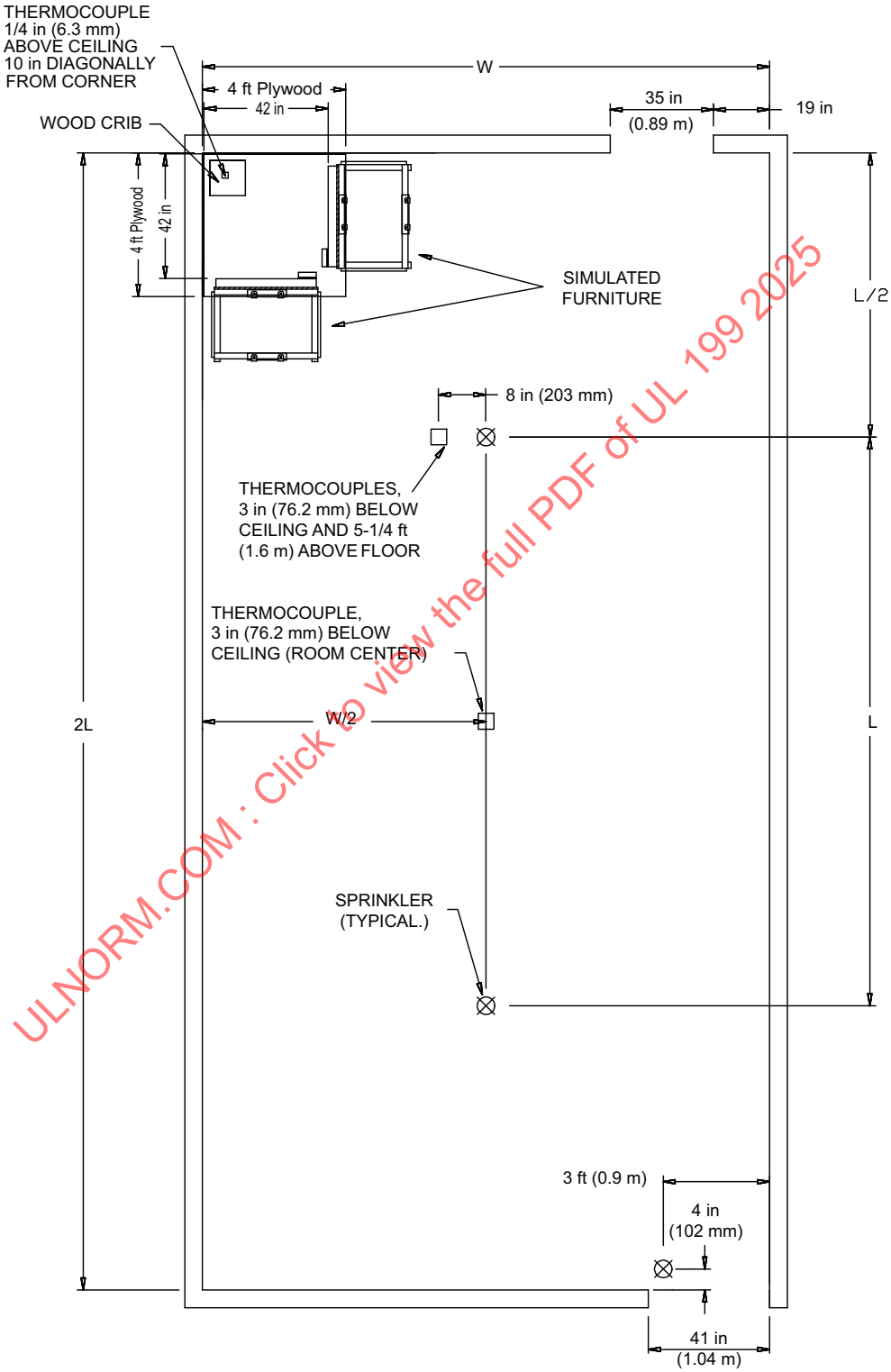
a) The sprinkler is rated for a 16 ft by 16 ft (4.9 m by 4.9 m) spacing;

b) The rated flow at the 15 ft by 15 ft (4.6 m by 4.6 m) spacing is not less than 90 % of the rated flow at the 16 ft by 16 ft (4.9 m by 4.9 m) spacing; and

c) The discharge pressure complies with 10.2.

Figure 55.6

Fire Test Arrangement – Residential Pendent, Upright, Flush, Recessed Pendent, and Concealed Sprinklers

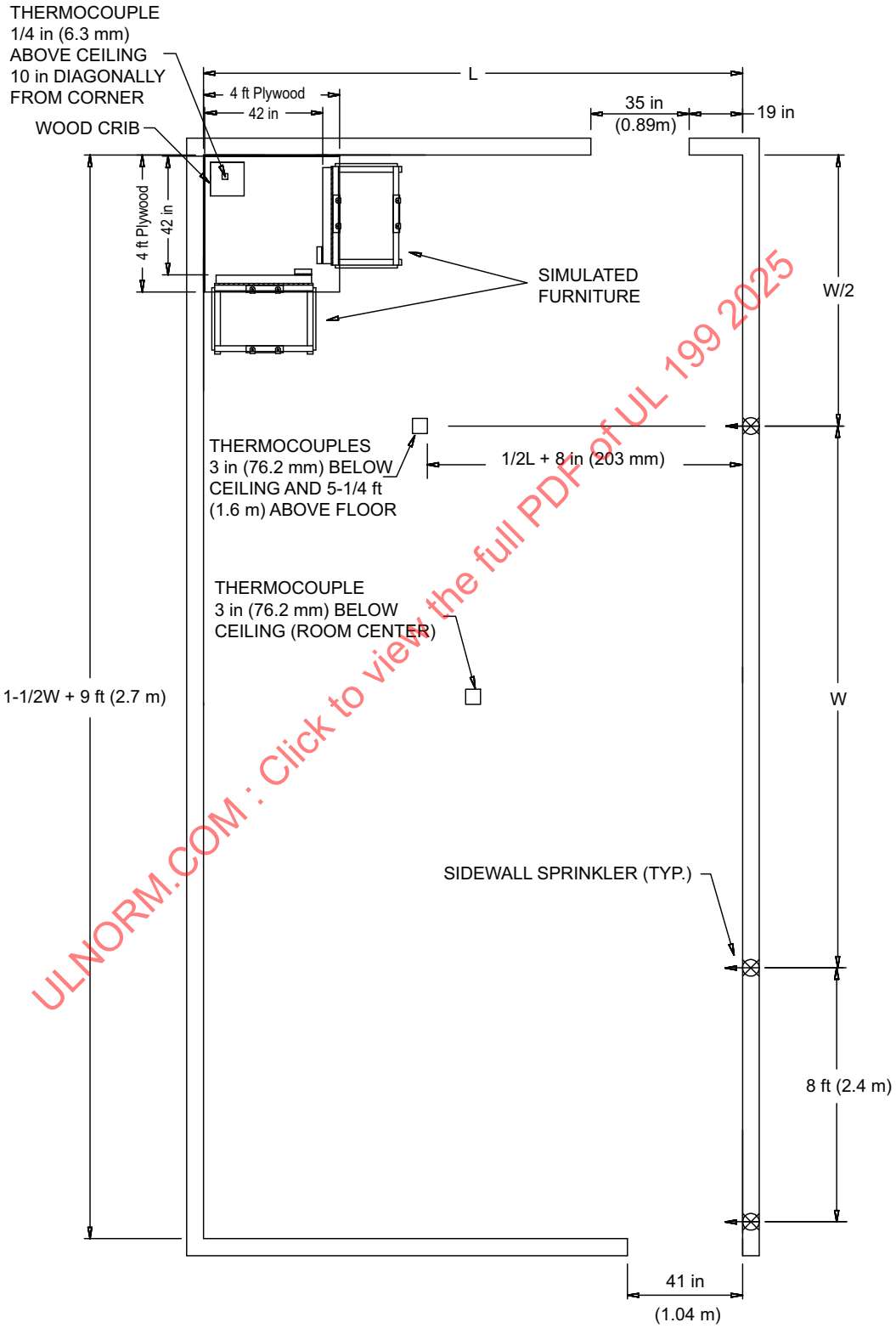


L = Coverage length
W = Coverage width

s4300e

Figure 55.7

Fire Test Arrangement – Residential Sidewall Sprinklers, Test Arrangement No. 1

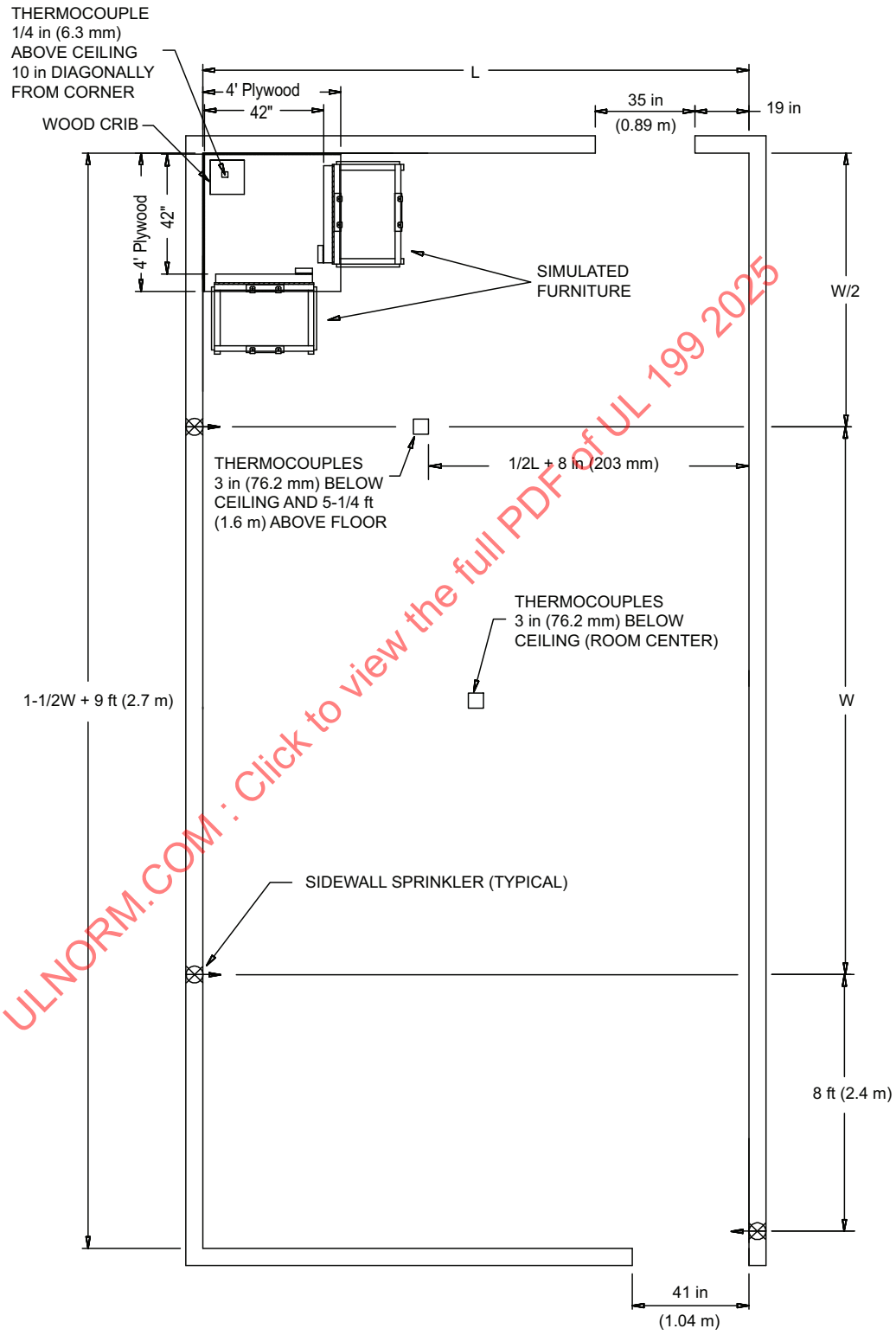


L = Coverage length
W= Coverage width

s4301d

Figure 55.8

Fire Test Arrangement – Residential Sidewall Sprinklers, Test Arrangement No. 2



L = Coverage length
W = Coverage width

s4302d

55.5.2 Test arrangement

55.5.2.1 General

55.5.2.1.1 Pendent, upright, flush, recessed pendent, and concealed sprinklers are to be subjected to the fire test arrangement in Figure 55.6, and sidewall sprinklers are to be subjected to both fire test arrangements in Figure 55.7 and Figure 55.8.

55.5.2.2 Test room

55.5.2.2.1 The test room dimensions for pendent, upright, flush, recessed pendent, and concealed sprinklers are to be the rated sprinkler coverage width by twice the rated coverage length by a nominal 8 ft (2.4 m) high ceiling. The test room dimensions for sidewall sprinklers are to be the rated sprinkler coverage length by 1-1/2 times the rated sprinkler coverage width plus 9 ft (2.7 m) by a nominal 8 ft (2.4 m) high ceiling. See Figure 55.6 – Figure 55.8.

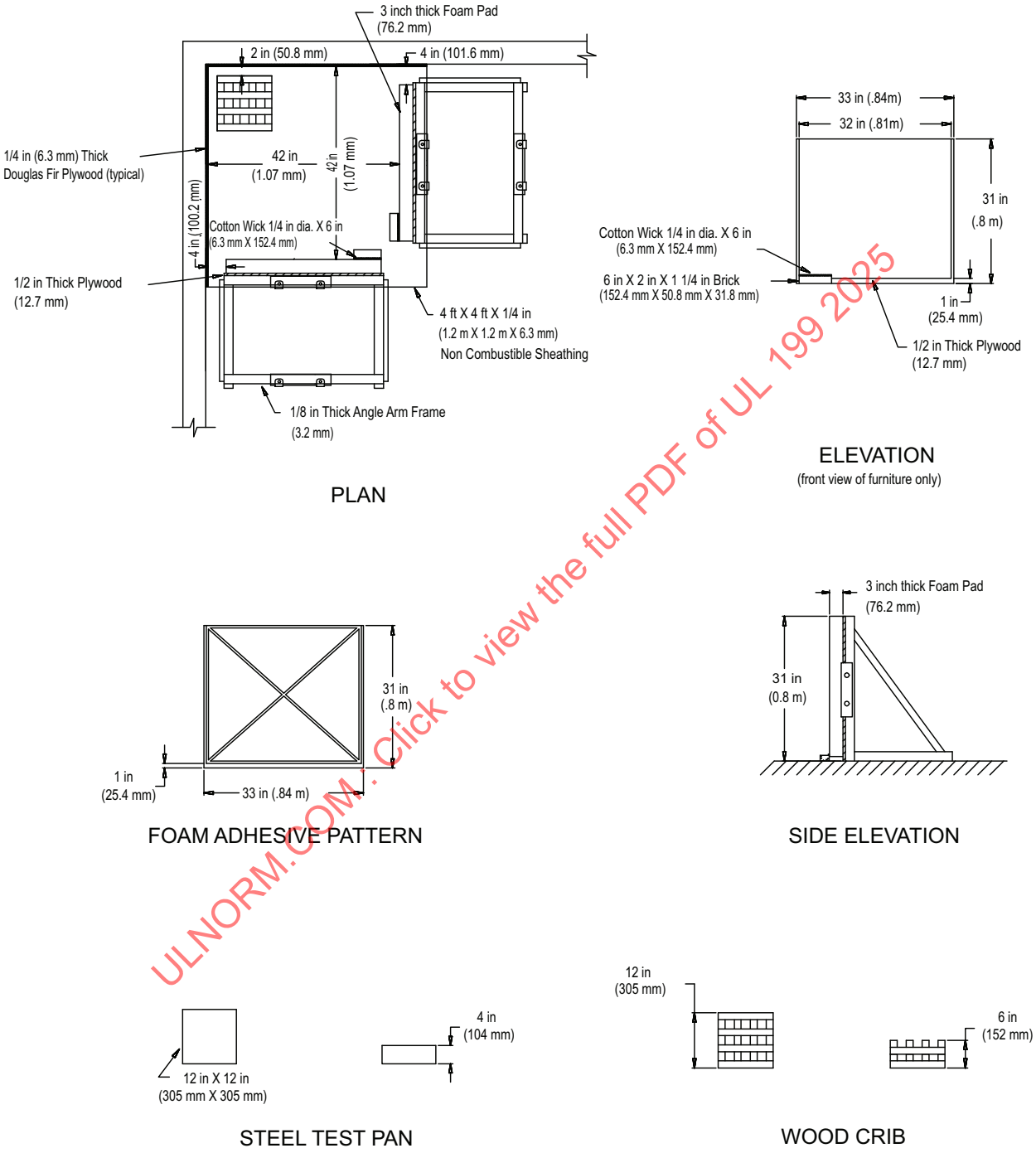
55.5.2.2.2 The test room ceiling is to be covered with acoustical panels or gypsum board attached to furring strips. Acoustical panels used in the 4 by 4 ft (1.2 by 1.2 m) area directly over the fire source are to measure 2 by 4 ft (0.6 by 1.2 m), be 1/2 in (12.7 mm) thick, have a density of 13.5 ±1.5 lb/ft^3 (216 ±24 kg/m^3), and have a maximum flame spread index of 25 when tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723 and the Method of Test for Surface Burning Characteristics of Building Materials and Assemblies, CAN/ULC-S102. For each test, new acoustical panels in the 4 by 4 ft (1.2 by 1.2 m) area directly over the fire source are to be installed.

55.5.2.2.3 The test room is to have provisions for ventilation through two door openings on opposite test room walls. Each opening is to be 7 ft 4 in (2.2 m) high, which provides for an 8 in (200 mm) lintel above the openings. The door widths are to be as specified in Figure 55.6 – Figure 55.8.

55.5.2.2.4 Douglas fir, 3-ply panels measuring 4 by 8 ft (1.2 by 2.4 m) are to be placed on two of the test room walls extending out from a common corner. One panel is to be placed on each wall. See Figure 55.9. The panels are to be 1/4 in (6.4 mm) thick with each ply constructed of Douglas fir. The plywood panels are to be conditioned at 70 ±5 °F (21 ±2.8 °C) and 50 ±10 % relative humidity for at least 72 h prior to test. They are to be placed on the walls by being attached to 1/2 in (12.7 mm) thick wood furring strips. The Douglas fir plywood panels shall have the burning characteristic properties specified in Table 55.4.

Figure 55.9

Simulated Furniture Fuel Package



s4303g

Table 55.4
Burning Characteristics for Plywood Panels

Property	Test method	Range
Flame Spread Index	Standard for Test for Surface Burning Characteristics of Building Materials, UL 723	130 ±30
Critical Heat Flux	Use of Cone Calorimeter at radiant heat fluxes between 10 and 20 kW/m^2	15 ±3 kW/m^2
Thermal Response Parameter	Use of Cone Calorimeter at radiant heat fluxes of 25, 35, 50 kW/m^2	220 ±50 kW·s$^{1/2}$/m^2

55.5.2.3 Fire source

55.5.2.3.1 The fire source is to consist of a wood crib and simulated furniture. The wood crib is to be ignited with a pan of heptane and the simulated furniture is to be ignited with two 6 in long by 1/4 in (6.4 mm) diameter cotton wicks soaked in heptane. See Figure 55.6 (pendent, upright, flush, recessed pendent, and concealed sprinklers) or Figure 55.7 and Figure 55.8 (sidewall sprinklers) for placement of the fire source in the test room.

55.5.2.3.2 The wood crib is to weigh 5.5 to 7 lbm (2.5 to 3.2 kg) and is to be dimensioned approximately 12 by 12 by 6 in high (305 by 305 by 152 mm). The crib is to consist of four alternate layers of four trade size 2 by 2 in [nominal 1-1/2 by 1-1/2 in (38.1 by 38.1 mm)] kiln-dried spruce or fir lumber 12 in (305 mm) long. The alternate layers of the lumber are to be placed at right angles to the adjacent layers. The individual wood members in each layer are to be evenly spaced along the length of the previous layer of wood members and stapled.

55.5.2.3.3 After the wood crib is assembled, it is to be conditioned at a temperature of 220 ±10 °F (104 ±5 °C) for not less than 24 h or more than 72 h. Following the conditioning, the crib is to be placed in a plastic bag and stored at room temperature for at least 4 h before being used in a test.

55.5.2.3.4 Recessed and concealed sprinklers having vented escutcheons are to be installed in the most recessed position in a manner that inhibits airflow through the escutcheons (blocked) by placing an 8-in thick (203 mm), R-25 fiberglass insulating batt entirely around and over the top of the sprinkler, and against the ceiling or wall in such a manner that the air flow through the escutcheon vents are inhibited by the insulation.

55.5.2.3.5 The simulated furniture is to consist of two 3 in (76 mm) thick uncovered pure polypropylene oxide polyol, polyether foam cushions having a density of 1.70 to 1.90 lb/ft^3 (27.2 to 30.4 kg/m^3) and measuring 32 by 30 in (810 by 760 mm). Each foam cushion is to be glued to a 33 by 31 in (840 by 790 mm), nominal 1/2 in (12.7 mm) thick plywood backing using an aerosol urethane foam adhesive. The foam cushion is to be glued on the plywood to provide for a 1/2 in (12.7 mm) space along the sides and a 1 in (25 mm) space at the bottom as illustrated in Figure 55.9. The foam cushion and plywood backing assembly is to be conditioned at 70 ±5 °F (21 ±2.8 °C) and 50 ±10 % relative humidity for at least 24 h prior to test. Prior to each test, the foam and plywood backing assembly is to be placed in a steel frame to provide support for holding each assembly in the vertical orientation. The polyether foam shall have the burning characteristic properties specified in Table 55.5.

Table 55.5
Polyether Foam Burning Characteristics

Property	Test method	Range
Peak Heat Release Rate (HRR) (Average of 5 samples)	Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter, ASTM E1354 at 30 kW/m^2 heat flux	345 ±85 kW/m^2
Heat of Combustion (Average of 5 samples)	Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter, ASTM E1354 at 30 kW/m^2 heat flux	22 ±3 kJ/g

55.5.2.3.6 The entire fire test package is to be placed on top of a 1/4 in (6.4 mm) thick cement board sheathing or equivalent noncombustible sheathing material having dimensions of 4 by 4 ft (1.2 by 1.2 m). For each test, a new or dried sheathing shall be used. See Figure 55.9.

55.5.2.4 Sprinkler installation

55.5.2.4.1 Three residential sprinklers are to be installed in the test room for each fire test. Two are to be installed at the rated length and width coverage dimensions, and the third is to be installed near the doorway furthest from the fire. For all sprinkler styles, the third sprinkler installed near the doorway shall be as follows:

a) The same heat responsive element and temperature rating as the other sprinklers within the room; and

b) Installed such that the center of the heat responsive element is:

1) 2 in (50.8 mm) below the ceiling for pendent, upright, flush, recessed pendent, and concealed sprinklers; and

2) 4 in (102 mm) below the ceiling and 2 in (50.8 mm) from the wall for sidewall sprinklers.

The two residential sprinklers nearest the fire source are to be installed in reducing pipe fittings having a 1 in (25 mm) inlet and an outlet the same size as the sprinkler inlet and be supplied with water through 1 in (25 mm) piping. The minimum nipple length leading to the sprinkler fitting shall not be less than 10 in (254 mm). Dry-type sprinklers are to be tested using the shortest available length and the longest available length, if the K-factor for the longest length deviates by more than 5 % from the shortest available length. See Figure 55.6 – Figure 55.9.

55.5.2.4.2 Pendent and upright sprinklers are to be installed with their deflectors located 3 in (76 mm) below the ceiling or as specified in the installation instructions if other than 3 in (76 mm) is specified. A pendent sprinkler also intended to be installed as a recessed pendent sprinkler shall be tested in the most recessed position in lieu of 3 in (76 mm) below the ceiling. Flush and concealed sprinklers are to be installed in their intended location as specified in the installation instructions. Pendent, upright, flush, recessed pendent and concealed sprinklers are to be tested in two orientations. One test is to be orientated such that the sprinkler frame arms or deflector pins are parallel to the short room wall and a second test is to be conducted with the sprinkler frame arms or deflector pins rotated 90°.

55.5.2.4.3 Recessed and concealed sprinklers having vented escutcheons are to be installed in the most recessed position in a manner that inhibits airflow through the escutcheons (blocked) by placing an 8-in thick (203 mm), R-25 fiberglass insulating batt entirely around and over the top of the sprinkler, and against the ceiling in such a manner that the air flow through the escutcheon vents are inhibited by the insulation.

55.5.2.4.4 A sidewall sprinkler shall be tested, using both test arrangements referenced in Figure 55.7 and Figure 55.8, in a manner as follows:

a) With its deflector located 4 in (102 mm) below the ceiling; and

b) With its deflector located at the maximum distance below the ceiling as specified in the installation instructions if the maximum distance exceeds 6 in (152 mm) below the ceiling.

55.5.3 Test method

55.5.3.1 Sprinklers intended for use in dry systems are to be tested with the water discharge delayed 15 s after the first sprinkler operates.

55.5.3.2 The test room is to have an ambient air temperature of 80 ±5 °F (27 ±3 °C) measured at the thermocouple located 3 in (76 mm) below the ceiling. See Figure 55.6 – Figure 55.8. All water from previous testing shall be removed such that there is no visible water on the floor, ceiling, or walls.

55.5.3.3 The temperatures at each thermocouple location are to be continuously recorded during the test using 20 AWG (0.8 mm) chromel-alumel thermocouples or thermocouples providing equivalent temperature measuring results. When water impingement impacts the thermocouple measurement, the thermocouples are to be shielded from water impingement using metallic tape attached to the wire. The tape is to be formed into an umbrella shape, large enough to protect the thermocouple ends.

55.5.3.4 Sixteen ounces (0.5 L) of water and eight ounces (0.24 L) of heptane are to be placed in a pan directly below the wood crib located 2 in (50 mm) from the wall panels.

55.5.3.5 The heptane in the pan located beneath the crib is to be ignited and the heptane soaked cotton wicks placed on bricks are to be ignited immediately following the heptane pan ignition.

55.5.3.6 The fire test is to be conducted for 30 min after the ignition of the wood crib, unless after 10 min, all the combustibles are extinguished or only the wood crib is sustaining combustion at which point the test is to be terminated. The water flow to the sprinklers is to be the minimum flow rate specified in the installation instructions for the sprinkler coverage area tested. In addition, for sprinklers having a pressure rating greater than 175 psig (1.2 Mpa), tests are to be conducted at the maximum rated spacing using a flow corresponding to a pressure of 75 psig (517 kPa) less than the rated pressure.

55.5.4 Supplementary test

55.5.4.1 When sprinkler coverage areas exceed 12 by 12 ft (3.7 by 3.7 m), and the sprinkler has not been investigated for a 12 by 12 ft (3.7 by 3.7 m) area using the same or a lesser flow rate as the next larger rated coverage area, the tests specified in 55.5.1.1 – 55.5.3.6 are to be repeated in a room size corresponding to a 12 by 12 ft (3.7 by 3.7 m) coverage area, using a water flow rate corresponding to the minimum flow rate required for the next larger coverage area.

55.6 Flow control (FC) sprinkler piled stock fire tests

55.6.1 When an FC sprinkler is tested under the conditions described in 55.6.2 – 55.6.8, the water discharge shall:

a) Limit the travel of the fire so that the fifth row of boxes as shown in Figure 55.11 does not sustain combustion.

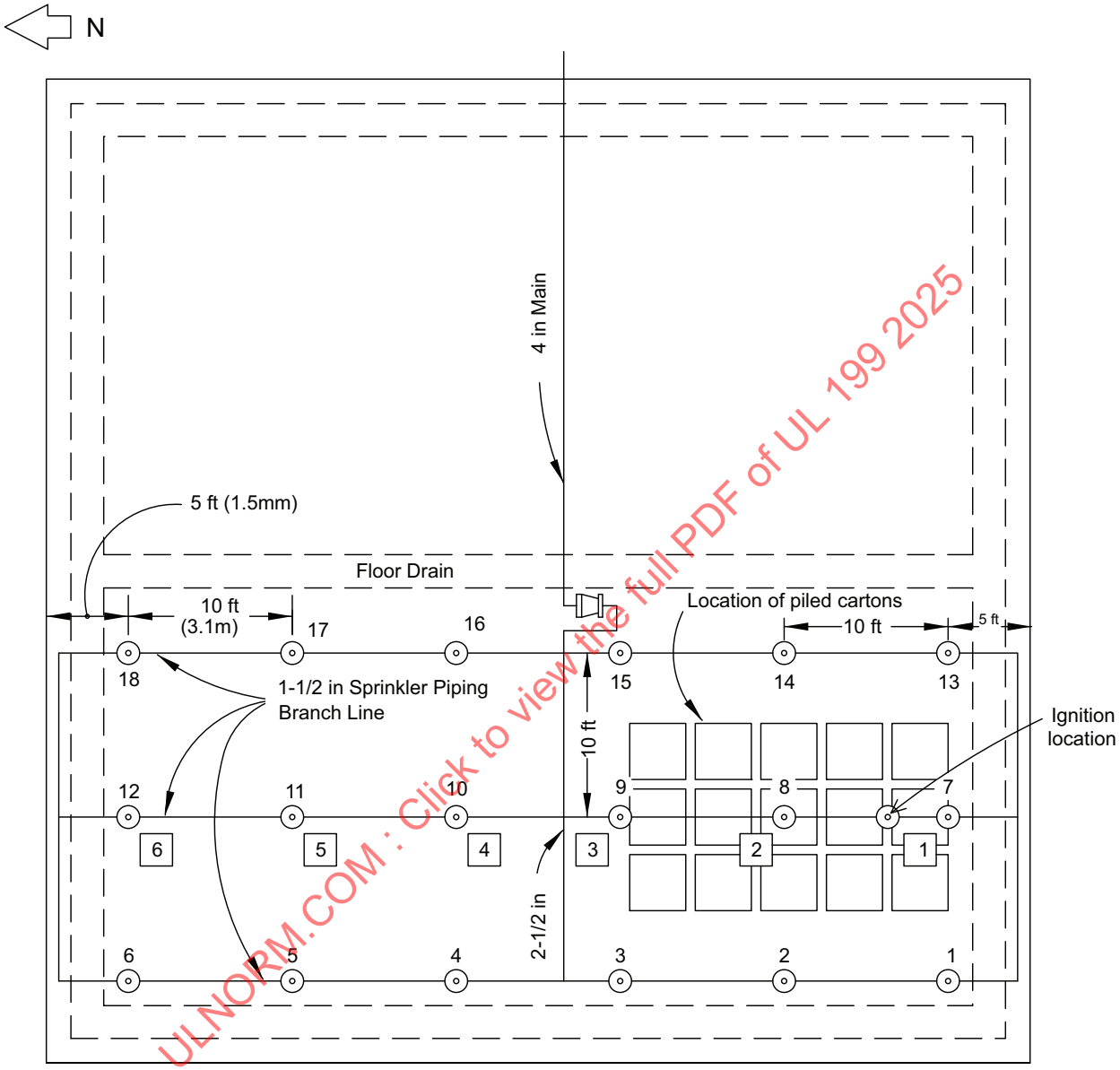
b) Result in the ceiling temperature being reduced to a value less than 530 °F (295 °C) above ambient within 5 min after start of water discharge.

c) Result in the ceiling temperature not exceeding 530 °F (295 °C) for more than three consecutive min and the average temperature not exceeding 530 °F (295 °C) from the time the temperature initially falls below 530 °F (295 °C) above ambient to the end of the test.

55.6.2 The test room is to have a ceiling 15 ft, 9 in (4.8 m) high. The test room is to have provisions for venting the heat and smoke and drainage of sprinkler discharge. See Figure 55.10 for a typical test room arrangement.

Figure 55.10

Location of FC Sprinklers and Piled Cartons



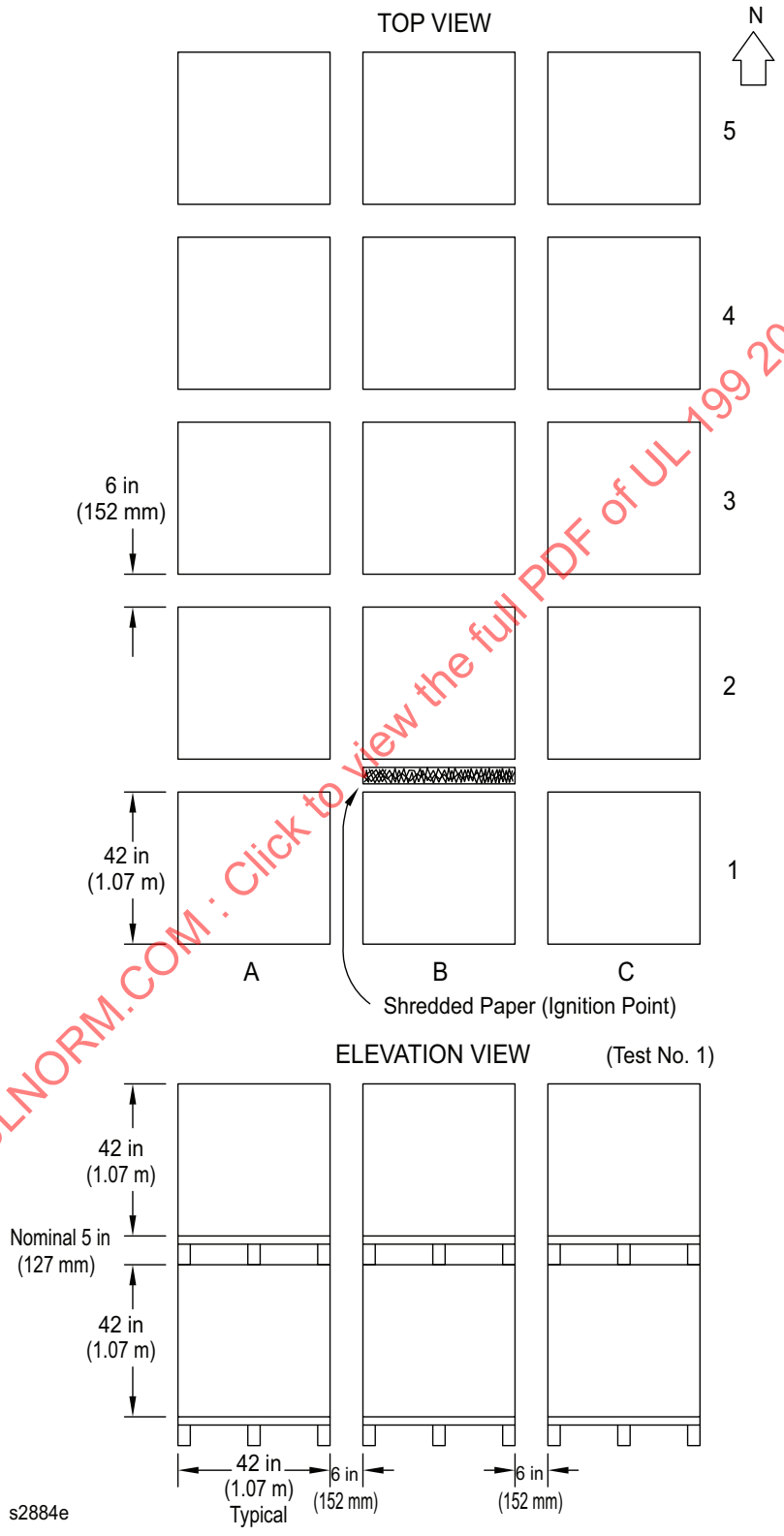
⊙ - Sprinkler Locations

□ - Thermocouples located 2 in (51mm) below ceiling above sprinklers on the center branch line.

s2883i

Figure 55.11

Carton Arrangement



Note: See Figure 55.5 for elevation view of Test No. 2.

55.6.3 Eighteen ordinary temperature rated sprinklers are to be installed using a sprinkler grid consisting of three 1-1/2 in (38 mm) minimum nominal diameter branch lines that are looped on both ends. Each branch line is to be individually supplied from a 2-1/2 in (65 mm) minimum nominal diameter cross main. The sprinkler grid is to provide a 10 by 10 ft (3.05 by 3.05 m) sprinkler spacing, and sprinkler deflectors are to be located a nominal 12 in (305 mm) below the ceiling. See Figure 55.10.

55.6.4 Temperatures are to be recorded by means of 24 thermocouples located near the ceiling. Six thermocouples, identified as Nos. 1 – 6 in Figure 55.10, are to be located 2 in (50.8 mm) below the ceiling and directly above the sprinklers, and 18 thermocouples are to be located next to the heat sensitive element of each sprinkler.

55.6.5 The waterflow during sprinkler discharge is to be continuously monitored so that the waterflow is capable of being adjusted as required during the test to provide the a sprinkler discharge density to open sprinklers as specified in 55.6.1.

55.6.6 The piled stock is to consist of Standard Class II commodity stored in a three pallet-carton wide by five long palletized arrangement. The moisture content of the cardboard boxes as measured in representative samples shall be within 8 ±3 %. A 6-in (152-mm) free space is to be maintained between all carton stacks. See Table 55.6 and Figure 55.11.

Table 55.6
Piled Stock Fire Test Conditions for FC Sprinklers

Test No.	Sprinkler spacing		Open sprinkler discharge density		Number of Class II commodities	Nominal storage height	
	ft	(m)	gpm/ft^2	(mm/min)		ft	(m)
1	10 x 10	(3.05 x 3.05)	0.15	(6.4)	30	8	2.4
2	10 x 10	(3.05 x 3.05)	0.20	(8.6)	45	12	3.6

55.6.7 The ignition source for the fire test is to consist of 1.5 lbs (0.68 kg) of shredded paper placed on the floor in the space between the first and second carton in the middle row as illustrated in Figure 55.11 and ignited.

55.6.8 The fire test is to be continued for 45 min after ignition and visual observations made for travel of fire during the test.

55.7 CMDA storage sprinkler large scale fire tests

55.7.1 When tested as described in 55.7.2 – 55.7.6 and Table 55.8 – Table 55.12, as applicable, the water discharge from a sprinkler shall be capable of controlling the large-scale fires described for each sprinkler such that compliance with the requirements in Table 55.7 is demonstrated. At the option of the manufacturer, the length of the stored commodity in the main and target arrays for the double row rack arrangements shall be permitted to be reduced to a nominal 24 ft (7.3 m) for any of the fire tests. If the fire spreads to the end of the main test array as indicated in Table 55.7, the manufacturer shall be permitted to reconduct the test using the nominal 32 ft (10 m) long array.

Table 55.7
CMDA Storage Sprinkler Fire Test Requirements

Criteria description	Standard coverage	Extended coverage
Nominal K-Factor, gpm/(psi)$^{1/2}$ [L/min/(bar)$^{1/2}$]	11.2 (160), 14.0 (200), and 16.8 (240)	16.8 (240) and 25.2 (360)
Maximum number of sprinklers permitted to operate	20	A number of sprinklers not exceeding a 2000 ft^2 (13.6 m^2) area based upon the installed sprinkler spacing
Maximum 1 min average steel temperature, °F (°C)	1000 (538)	1000 (538)
Permitted fire spread	No sustained combustion at the end of the main test array and none at the outer edges of the target array	No sustained combustion at the outer edge of the end of the main test array and none at the outer edges of the target array

55.7.2 The test room for these tests shall have provisions for venting the heat and smoke and for drainage of the sprinkler discharge.

55.7.3 A wet pipe automatic sprinkler system shall be installed below a smooth, flat, non-combustible horizontal ceiling unless otherwise specified in the test conditions. Water flow shall be controlled to maintain the required water discharge density specified for the sprinkler as referenced in Table 55.8, Table 55.9, Table 55.10, Table 55.11, or Table 55.12 as applicable. Representative sample sprinklers shall be installed at the spacing specified for each fire test. Sprinklers shall be installed throughout the test area and supplied through a looped or gridded piping system consisting of nominal 2 or 2.5 in (50 or 65 mm) diameter pipe.

Table 55.8
Fire Test Conditions for Nominal K=11.2 (160) CMDA Sprinklers

Test No.	Test 1	Test 2	Test 3
Storage type	Palletized	Double row rack	Double row rack
Commodity type	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. class II
Test array	See Figure 55.13	See Figure 55.14	See Figure 55.15
Nominal storage height, ft (m)	15 (4.6)	15 (4.6)	20 (6.1)
Nominal ceiling height, ft (m)	25 (7.6)	25 (7.6)	30 (9.1)
Sprinkler temperature rating	High temperature classification or maximum temperature rating, whichever is less	Minimum temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in (cm)	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright
Sprinkler spacing, ft x ft (m x m)	8 x 10 (2.4 x 3.0)	8 x 10 (2.4 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal discharge density, gpm/ft^2 (mm/min)	0.60 (24.5)	0.60 (24.5)	0.37 (15.1)
Ignition location	Between four	Under one	Between four
Test duration, min	30	30	30
Note – Actual distance is dependent upon sprinkler construction and branch line pipe diameter.			

Table 55.9
Fire Test Conditions for Nominal K=14.0 (200) CMDA Sprinklers

Test No.	Test 1	Test 2	Test 3	Test 4	Test 5
Storage type	Palletized	Double row rack	Double row rack	Double row rack	Double row rack
Commodity type	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. Class II	Std. Class II	Std. Class II
Test array	See Figure 55.13	See Figure 55.14	See Figure 55.15	See Figure 55.15	See Figure 55.15
Nominal storage height, ft (m)	15 (4.6)	15 (4.6)	20 (6.1)	20 (6.1)	20 (6.1)
Nominal ceiling height	25 (7.6)	25 (7.6)	30 (9.1)	Adjusted to achieve minimum clearance between sprinkler deflector and top of commodity	30 (9.1)
Sprinkler temperature rating	High temperature classification or maximum temperature rating, whichever is less	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in (cm)[a]	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright
Sprinkler spacing, ft x ft (m x m)	8 x 10 (2.4 x 3.0)	8 x 10 (2.4 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal discharge density, gpm/ft^2 (mm/min)	0.60 (24.5)	0.60 (24.5)	0.37 (15.1)	0.37 (15.1)	0.37 (15.1)
Ignition location	Between four	Under one	Between four	Between two on same branch line	Under one
Test duration	30	30	30	30	30

[a] Actual distance is dependent upon sprinkler construction and branch line pipe diameter.

Table 55.10
Fire Test Conditions for Nominal K=16.8 (240) CMDA Sprinklers

Test No.	Test 1	Test 2	Test 3
Storage type	Palletized	Double row rack	Double row rack
Commodity type	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic
Test array	See Figure 55.13	See Figure 55.14	See Figure 55.16
Nominal storage height, ft (m)	15 (4.6)	15 (4.6)	20 (6.1)
Nominal ceiling height, ft (m)	25 (7.6)	25 (7.6)	Adjusted to achieve minimum clearance between sprinkler deflector and top of commodity
Sprinkler temperature rating	High temperature classification or maximum temperature rating, whichever is less	Minimum temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in (cm)[a]	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright
Sprinkler spacing, ft x ft (m x m)	8 x 10 (2.4 x 3.0)	8 x 10 (2.4 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal discharge density, gpm/ft_2 (mm/min)	0.60 (24.5)	0.60 (24.5)	0.60 (24.5)
Ignition location	Between four	Under one	Between two on same branchline
Test duration, min	30	30	30

[a] Actual distance is dependent upon sprinkler construction and branch line pipe diameter.

Table 55.11
Fire Test Conditions for Nominal K=16.8 (240) CMDA EC Sprinklers

Test No.	Test 1	Test 2	Test 3	Test 4	Test 5[a]	Test 6
Storage type	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack
Commodity type	Std. class II	Std. class II	Std. class II	Std. class II	Std. class II	Std. cartoned group A plastic
Test array	See Figure 55.12	See Figure 55.12	See Figure 55.15	See Figure 55.15	See Figure 55.15	See Figure 55.16
Nominal storage height, ft (m)	15 (4.6)	15 (4.6)	20 (6.1)	20 (6.1)	20 (6.1)	20 (6.1)
Nominal ceiling height, ft (m)	25 (7.6)	Adjusted to achieve minimum clearance between sprinkler deflector and top of commodity	30 (9.1)	30 (9.1)	25 (7.6)	25 (7.6)
Sprinkler temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	High temperature classification or maximum temperature rating, whichever is less
Nominal deflector to ceiling distance, in (cm)[b]	12 (30.5) for pendent	12 (30.5) for pendent	12 (30.5) for pendent	12 (30.5) for pendent	12 (30.5) for pendent	12 (30.5) for pendent
	3 (7.6) for upright	3 (7.6) for upright	3 (7.6) for upright	3 (7.6) for upright	3 (7.6) for upright	3 (7.6) for upright
Sprinkler spacing ft x ft (m x m)	14 x 14 (4.3 x 4.3)	14 x 14 (4.3 x 4.3)	14 x 14 (4.3 x 4.3)	15 x 10 (4.6 x 3.0) (15 between branch lines)	14 x 14 (4.3 x 4.3)	10 x 10 (3.0 x 3.0)
Nominal discharge density, gpm/ft^2 (mm/min)	0.23 (9.4)	0.23 (9.4)	0.30 (12.2)	0.30 (12.2)	0.30 (12.2)	0.60 (24.5)
Ignition location	Under one	Between four	Between two on same branchline	Between two on separate branchline	Between four	Between two on same branchline
Test duration, min	30	30	30	30	30	30

[a] Test to be conducted with two barriers having a depth so that they extend not less than 3 in (75.6 mm) below the sprinkler deflector and not less than 22 ft (6.4 m) long installed perpendicular to the piping and spaced 7 ft (2.1 m) apart.

[b] Actual distance is dependent upon sprinkler construction and branch line pipe diameter.

Table 55.12
Fire Test Conditions for Nominal K=25.2 (360) CMDA EC Sprinklers

Test No.	Test 1	Test 2	Test 3	Test 4	Test 5[a]	Test 6	Test 7
Storage type	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Palletized
Commodity type	Std. class II	Std. class II	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic
Test array	See Figure 55.15	See Figure 55.15	See Figure 55.16	See Figure 55.14	See Figure 55.16	See Figure 55.16	See Figure 55.13
Nominal storage height, ft (m)	20 (6.1)	20 (6.1)	20 (6.1)	15 (4.6)	20 (6.1)	20 (6.1)	15 (4.6)
Nominal ceiling height, ft (m)	30 (9.1)	24 (7.3)	Adjusted to achieve minimum clearance between sprinkler deflector and top of commodity	25 (7.6)	25 (7.6)	25 (7.6)	25 (7.6)
Sprinkler temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	High temperature classification or maximum temperature rating, whichever is less	Minimum temperature rating	High temperature classification or maximum temperature rating, whichever is less
Nominal deflector to ceiling distance, in (cm)[b]	12 (30.5) for pendent	12 (30.5) for pendent	12 (30.5) for pendent	12 (30.5) for pendent	12 (30.5) for pendent	12 (30.5) for pendent	12 (30.5) for pendent
	3 (7.6) for upright	12 (30.5) for upright	12 (30.5) for upright	3 (7.6) for upright	12 (30.5) for upright	3 (7.6) for upright	3 (7.6) for upright
Sprinkler spacing ft x ft (m x m)	14 x 14 (4.3 x 4.3)	14 x 14 (4.3 x 4.3)	14 x 14 (4.3 x 4.3)	14 x 14 (4.3 x 4.3)	14 x 14 (4.3 x 4.3)	15 x 10 (4.6 x 3.0) (15 between branch lines)	14 x 14 (4.3 x 4.3)
Nominal discharge density, gpm/ft^2 (mm/min)	0.37 (15.1)	0.37 (15.1)	0.60 (24.5)	0.60 (24.5)	0.60 (24.5)	0.60 (24.5)	0.60 (24.5)
Ignition location	Under one	Between four	Between two on same branchline	Between two on same branchline	Between four	Between four	Between four
Test duration, min	30	30	30	30	30	30	30

[a] Test to be conducted with two barriers having a depth so that they extend not less than 3 in (75.6 mm) below the sprinkler deflector and not less than 22 ft (6.4 m) long installed perpendicular to the piping and spaced 7 ft (2.1 m) apart.

[b] Actual distance is dependent upon sprinkler construction and branch line pipe diameter.

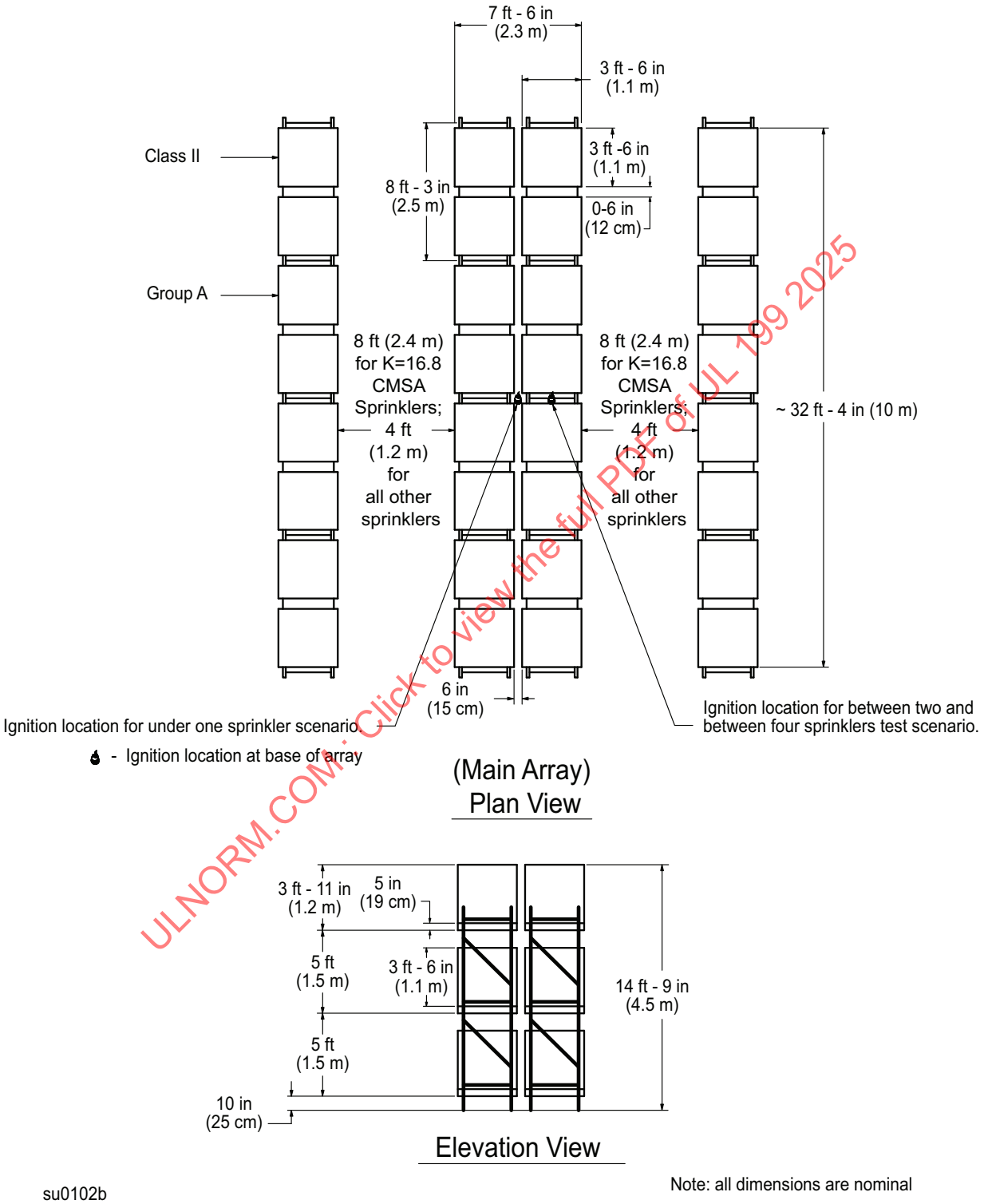
55.7.4 A nominal 4-ft (1.2-m) length of 2 by 2 by 0.25 in (50 by 50 by 6 mm) steel angle beam shall be mounted adjacent to the ceiling above the ignition location. Five equally spaced Type K, or equivalent, thermocouples shall be embedded in the steel angle beam to measure its temperature.

55.7.5 A means shall be provided to determine the time and number of sprinkler operations. Water pressure and flow shall be monitored and measured through calibrated flow meters. Significant events shall be monitored and recorded using calibrated timing devices located within the data acquisition system and manually.

55.7.6 The ignition source shall consist of either two or four cellulose cotton igniters positioned within the array near floor level as specified in Figure 55.12 – Figure 55.16. Each igniter is half of a standard igniter constructed from a nominal 3-in (76-mm) diameter by nominal 3-in (76-mm) long bundle soaked with 4 ±0.125 fl oz (118 ±3.7 ml) of gasoline and wrapped in a polyethylene bag.

Figure 55.12

Fire Test Array for Double Row Rack Storage of Standard Class II Commodity (Nominal 15 Ft High)

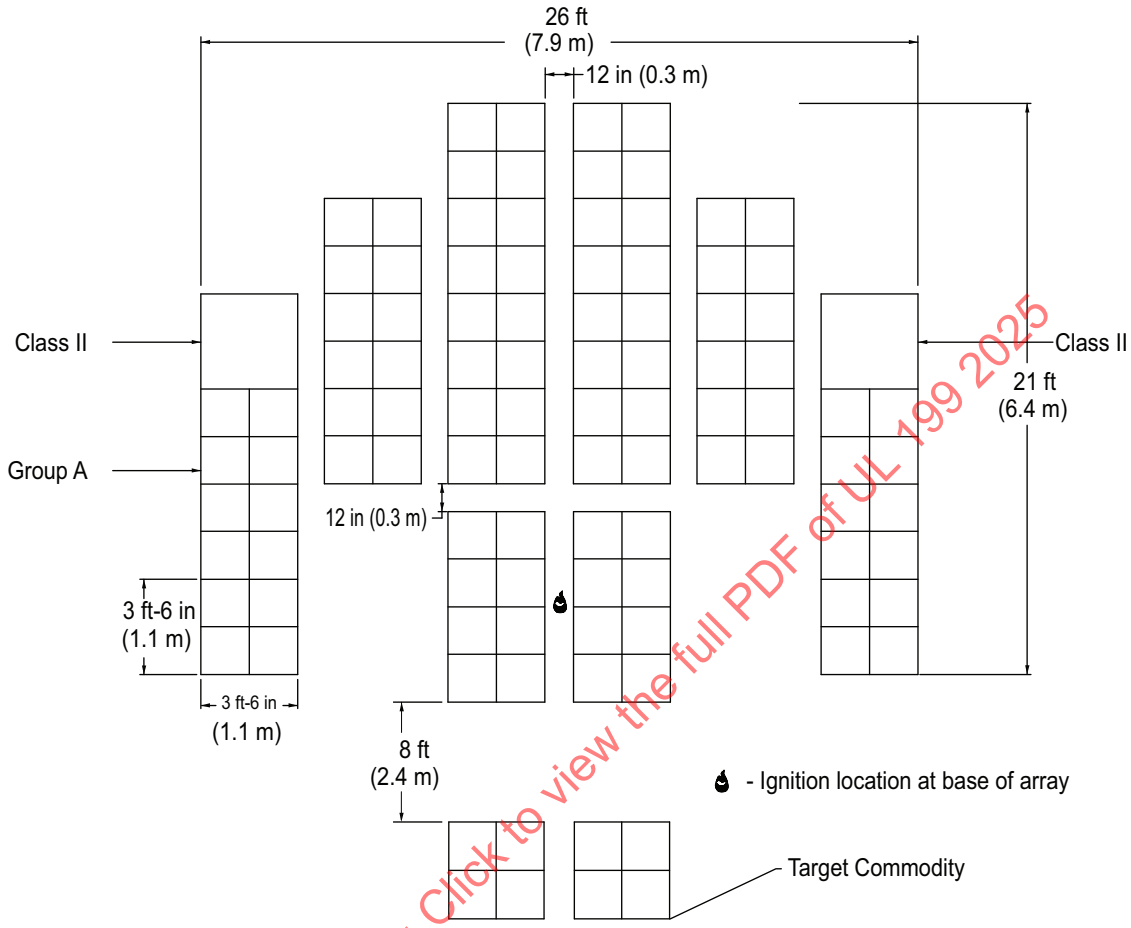


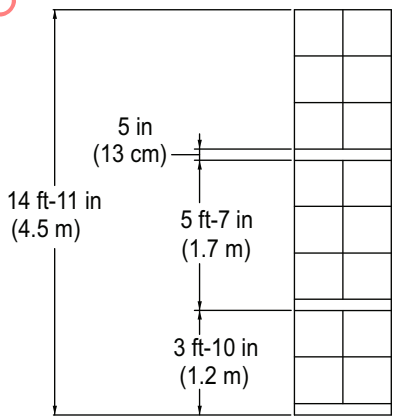
su0102b

Note: all dimensions are nominal

Figure 55.13

Fire Test Array for Palletized Storage of Cartoned Group A Plastic Commodity (Nominal 15 Ft High)



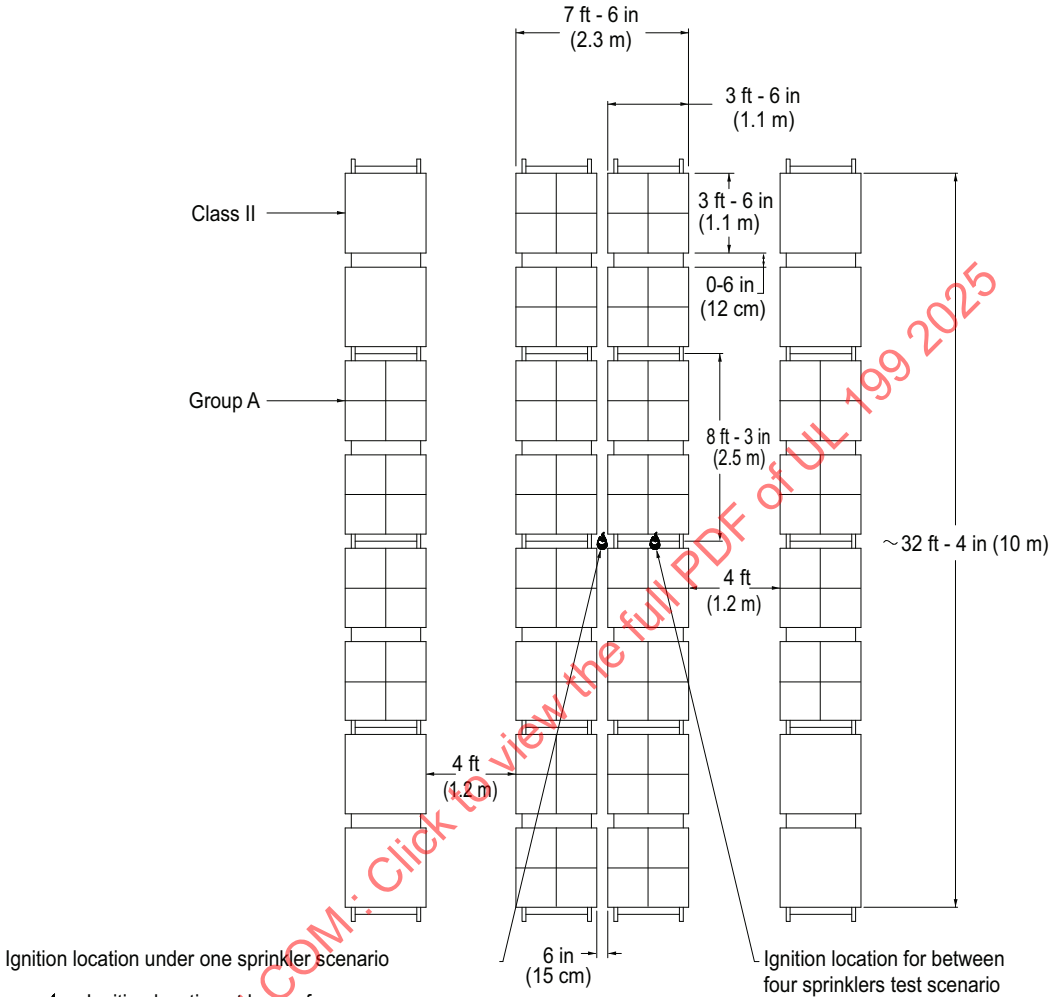


s4924c

Note: all dimensions are nominal

Figure 55.14

Fire Test Array for Double Row Rack Storage of Cartoned Group A Plastic Commodity (Nominal 15 Ft High)



Note: all dimensions are nominal

s4925c

Figure 55.15

Fire Test Array for Double Row Rack Storage of Standard Class II Commodity (Nominal 20 Ft High)

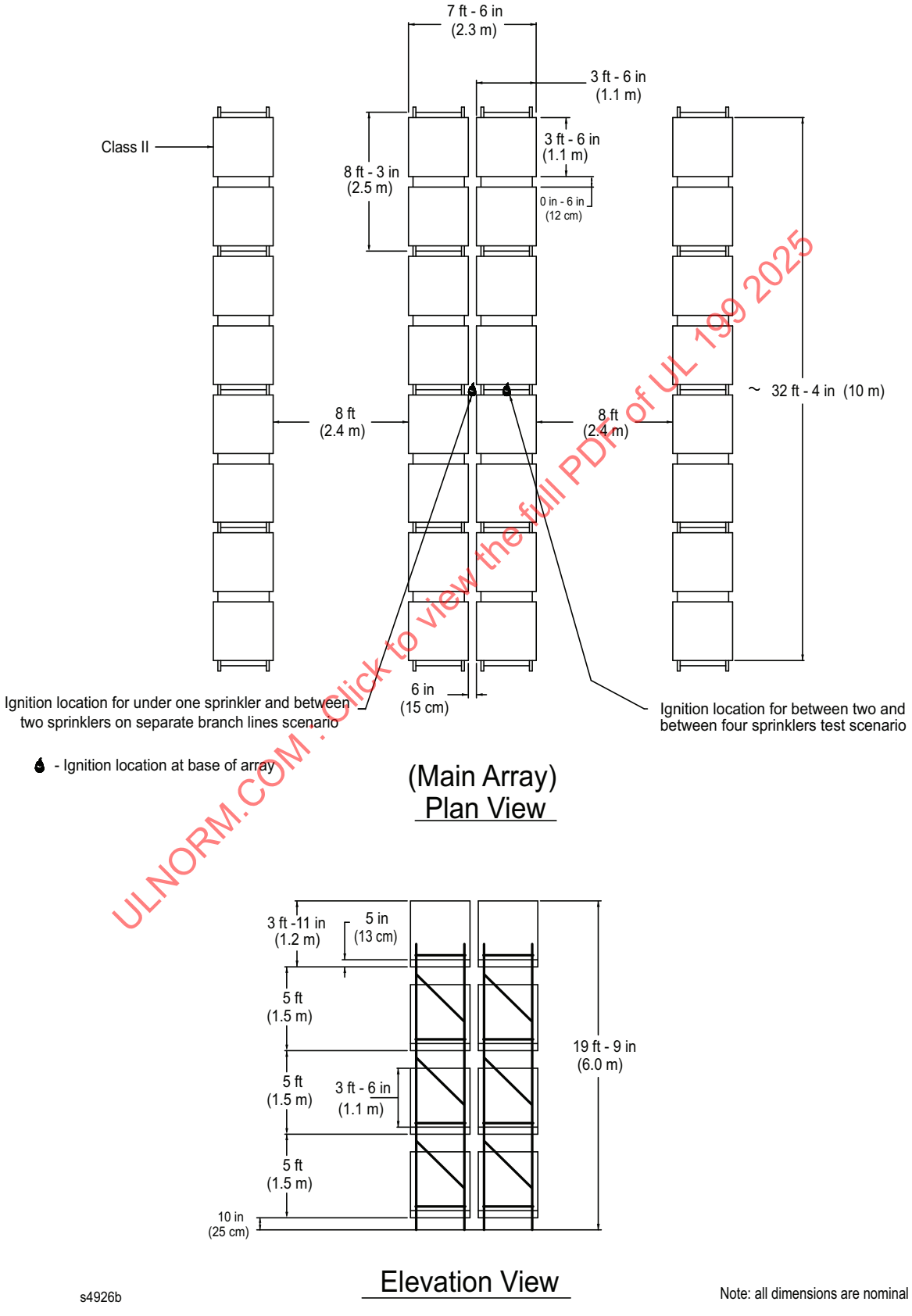
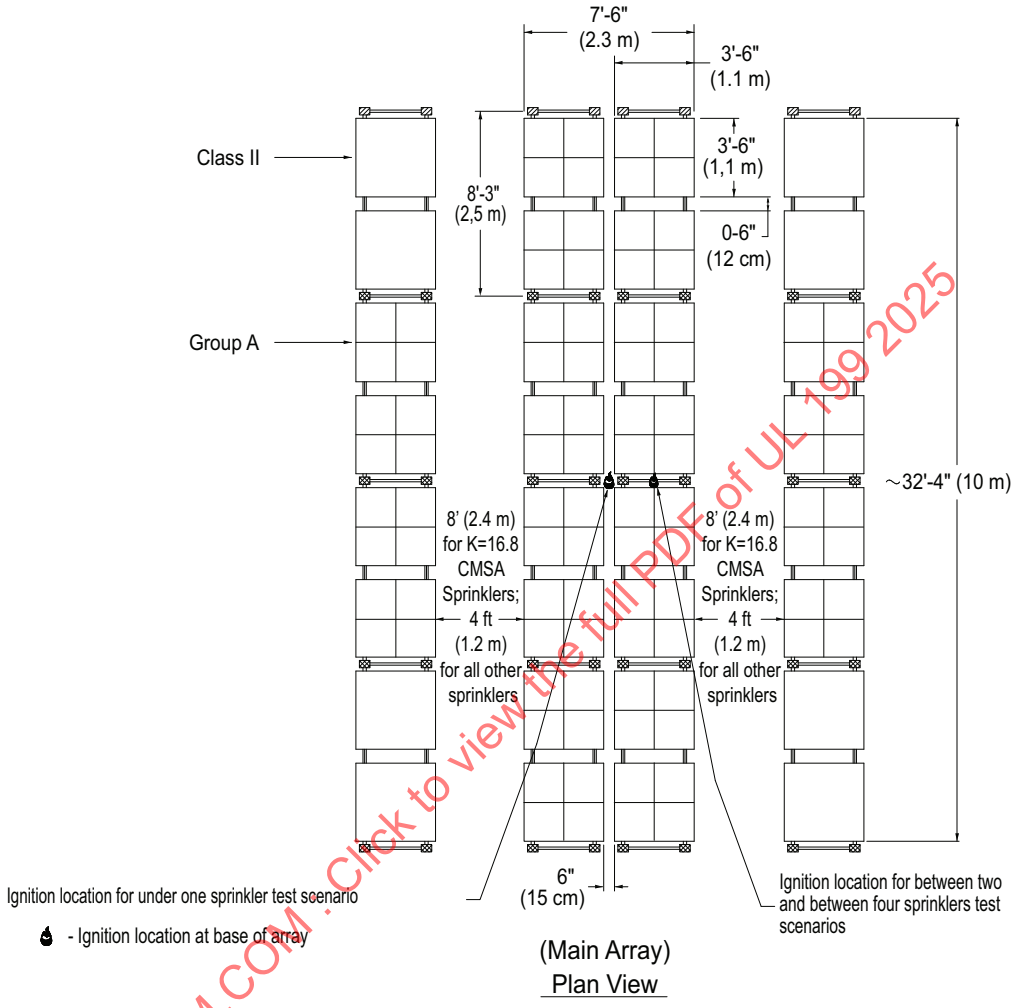


Figure 55.16

Fire Test Array for Double Row Rack Storage of Cartoned Group A Plastic Commodity (Nominal 20 Ft High)



s5305a

55.8 CMSA storage sprinkler large scale fire tests

55.8.1 When tested as described in 55.8.2 – 55.8.6 and Table 55.14 or Table 55.15, as applicable, the water discharge from a sprinkler shall be capable of controlling the large-scale fires described for each sprinkler such that compliance with the requirements in Table 55.13 is demonstrated. At the option of the manufacturer, the length of the stored commodity in the main and target arrays for the double row rack arrangements shall be permitted to be reduced to a nominal 24 ft (7.3 m) for any of the fire tests. If the fire spreads to the end of the main test array as indicated in Table 55.13, the manufacturer shall be permitted to reconduct the test using the nominal 32 ft (10 m) long array.

Table 55.13
CMSA Storage Sprinkler Fire Test Requirements

Nominal K-Factor, gpm/(psi)$^{1/2}$ (L/min/(bar)$^{1/2}$)	16.8 (240) and 19.6 (280)
Maximum number of sprinklers permitted to operate	15
Maximum 1 min average steel temperature, °F (°C)	1000 (538)
Permitted fire spread	No sustained combustion at the outer edge of the end of the main test array and none at the outer edges of the target array

55.8.2 The test room for these tests shall have provisions for venting the heat and smoke and for drainage of the sprinkler discharge.

55.8.3 A wet pipe automatic sprinkler system shall be installed below a smooth, flat, non-combustible horizontal ceiling. Water flow shall be controlled to maintain the required pressure at the sprinkler as referenced in Table 55.14 or Table 55.15, as applicable. The test pressure utilized for the fire testing shall be permitted to be less than the values referenced in Table 55.14 or Table 55.15, if requested by the manufacturer. Representative sample sprinklers shall be installed at the spacing specified for each fire test. Sprinklers shall be installed throughout the test area and supplied through a looped or gridded piping system consisting of nominal 2 or 2-1/2 in (50 or 65 mm) diameter pipe.

Table 55.14
Fire Test Conditions for Nominal K=16.8 (240) CMSA Storage Sprinklers Storage Height of 25 ft (6.1 m) and Maximum Ceiling Height of 30 ft (7.6 m)

Test No.	Test 1	Test 2	Test 3	Test 4
Storage type	Double row rack	Double row rack	Double row rack	Double row rack
Commodity type	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. class II
Test array	See Figure 55.16	See Figure 55.17	See Figure 55.16	See Figure 55.18
Nominal storage height, ft (m)	20 (6.1)	25 (7.6)	20 (6.1)	25 (7.6)
Nominal ceiling height, ft (m)	30 (9.1)	Adjusted to achieve minimum clearance between sprinkler deflector and top of commodity	30 (9.1)	30 (9.1)
Sprinkler temperature rating	Minimum temperature rating	High temperature classification or maximum temperature rating, whichever is less	Minimum temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in (cm)[a]	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright	12 (30.5) for pendent 3 (7.6) for upright
Sprinkler spacing ft x ft (m x m)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal pressure at sprinkler, psig, (Kpa)	22 (151)	22 (151)	22 (151)	10 (69)
Ignition location	Under one	Between four	Between two on same branchline	Between four
Test duration, min	30	30	30	30

[a] Actual distance is dependent upon sprinkler construction and branch line pipe diameter.

Table 55.15
Fire Test Conditions for Nominal K=19.6 (280) Pendent CMSA Storage Sprinklers for Use with a Maximum Storage Height of 35 ft (10.7 m) and Maximum Ceiling Height of 40 ft (12.2 m)

Test No.	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8
Storage type	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack
Commodity type	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic
Test array	See Figure 55.16	See Figure 55.17	See Figure 55.16	See Figure 55.19	See Figure 55.20	See Figure 55.19	See Figure 55.16	See Note 1
Nominal storage height, ft (m)	20 (6.1)	25 (7.6)	20 (6.1)	30 (9.1)	35 (10.7)	30 (9.1)	20 (6.1)	See Note 1
Nominal ceiling height, ft (m)	30 (9.1)	Adjusted to achieve minimum clearance between sprinkler deflector and top of commodity	30 (9.1)	40 (12.2)	Adjusted to achieve minimum clearance between sprinkler deflector and top of commodity	40 (12.2)	40 (12.2)	35 (10.7)
Sprinkler temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	See Note 1	See Note 1
Nominal deflector to ceiling distance, in (cm)	12 (30.5)	Maximum specified by manufacturer	Maximum specified by manufacturer	12 (30.5)	Maximum specified by manufacturer	Maximum specified by manufacturer	See Note 1	See Note 1
Sprinkler spacing ft x ft (m x m)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal discharge pressure psig (KPa)	16 (110)	16 (110)	16 (110)	30 (207)	30 (207)	30 (207)	30 (207)	25 (172)
Ignition location	Under one	Between four	Between two on same branchline	Under One (See Note 2)	Between four	Between two on same branchline	See Note 1	See Note 1
Test duration, min	30	30	30	30	30	30	30	30

Note 1 – Test scenario selected for this test is to be the most challenging based upon the results of previous tests.

Note 2 – Test is to be conducted with the three sprinklers located over the center of the storage array obstructed with a bar joist as permitted in the manufacturer's installation instructions if the sprinkler is intended to be installed less than 12 in (305 mm) horizontally from the bottom of the bar joist.

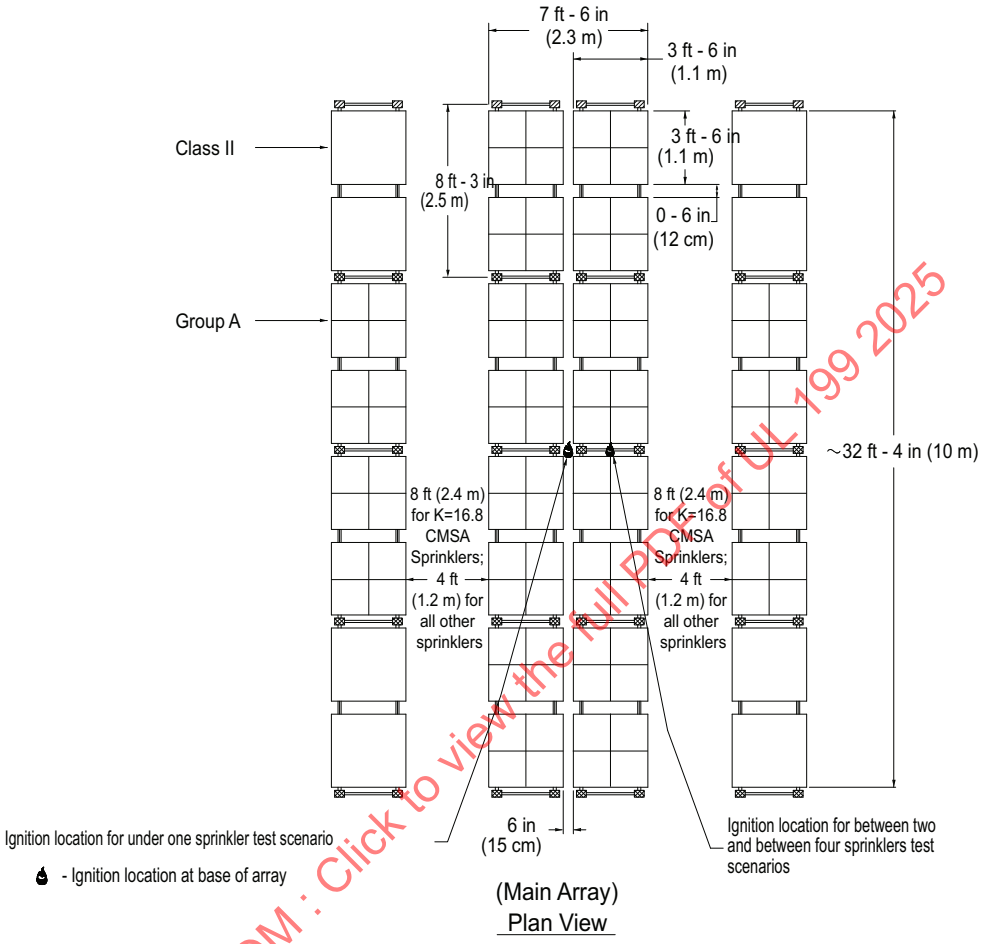
55.8.4 A nominal 4-ft (1.2-m) length of 2 by 2 by 0.25-in (50 by 50 by 6-mm) steel angle beam shall be mounted adjacent to the ceiling above the ignition location. Five equally spaced Type K, or equivalent, thermocouples shall be embedded in the steel angle beam to measure its temperature.

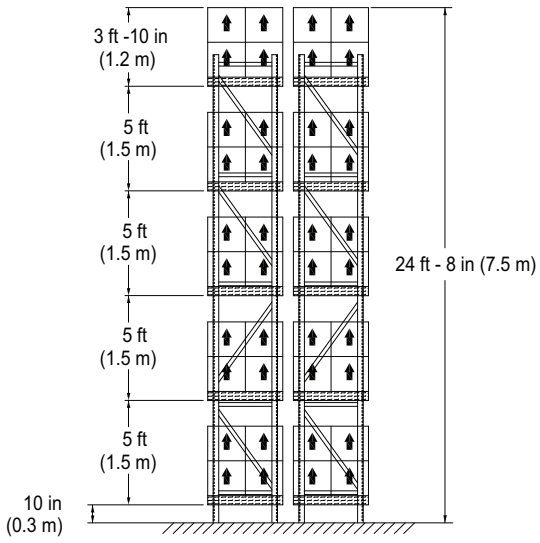
55.8.5 A means shall be provided to determine the time and number of sprinkler operations. Water pressure and flow shall be monitored and measured through calibrated flowmeters. Significant events shall be monitored and recorded using calibrated timing devices located within the data acquisition system and manually.

55.8.6 The ignition source shall consist of either two or four cellulose cotton igniters positioned within the array near floor level as specified in Figure 55.16, Figure 55.17, Figure 55.18, Figure 55.19 or Figure 55.20, as applicable. Each igniter is half of a standard igniter constructed from a nominal 3-in (76-mm) diameter by nominal 3-in (76-mm) long bundle soaked with 4 ±0.125 fl oz (118 ±3.7 ml) of gasoline and wrapped in a polyethylene bag.

Figure 55.17

Fire Test Array for Double Row Rack Storage of Cartoned Group A Plastic Commodity (Nominal 25 Ft High)

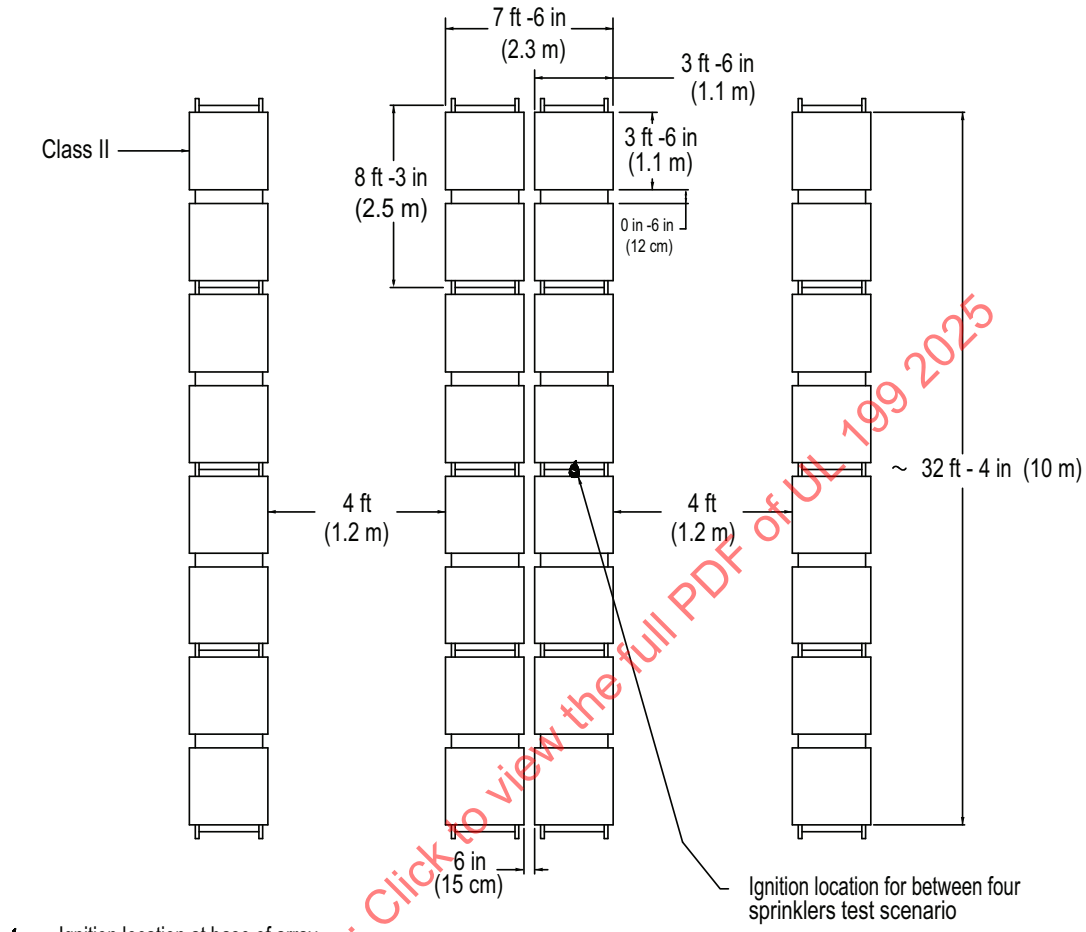


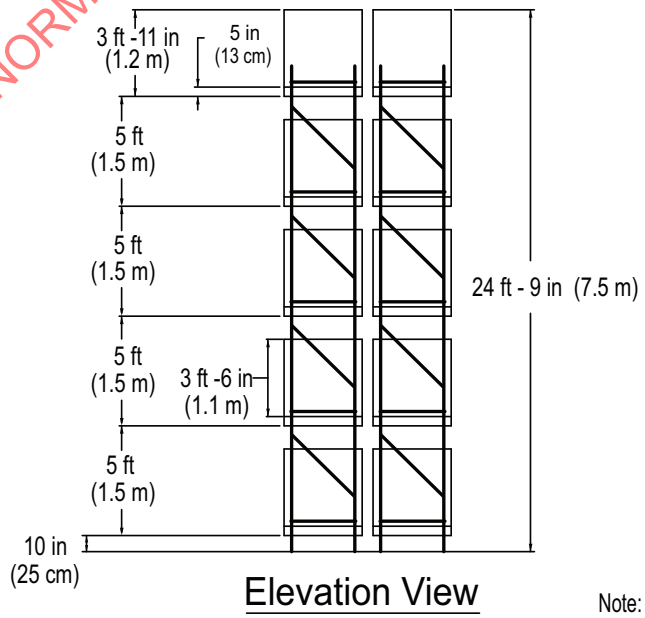


s5306b

Figure 55.18

Fire Test Array for Double Row Rack Storage of Standard Class II Commodity (Nominal 25 Ft High)



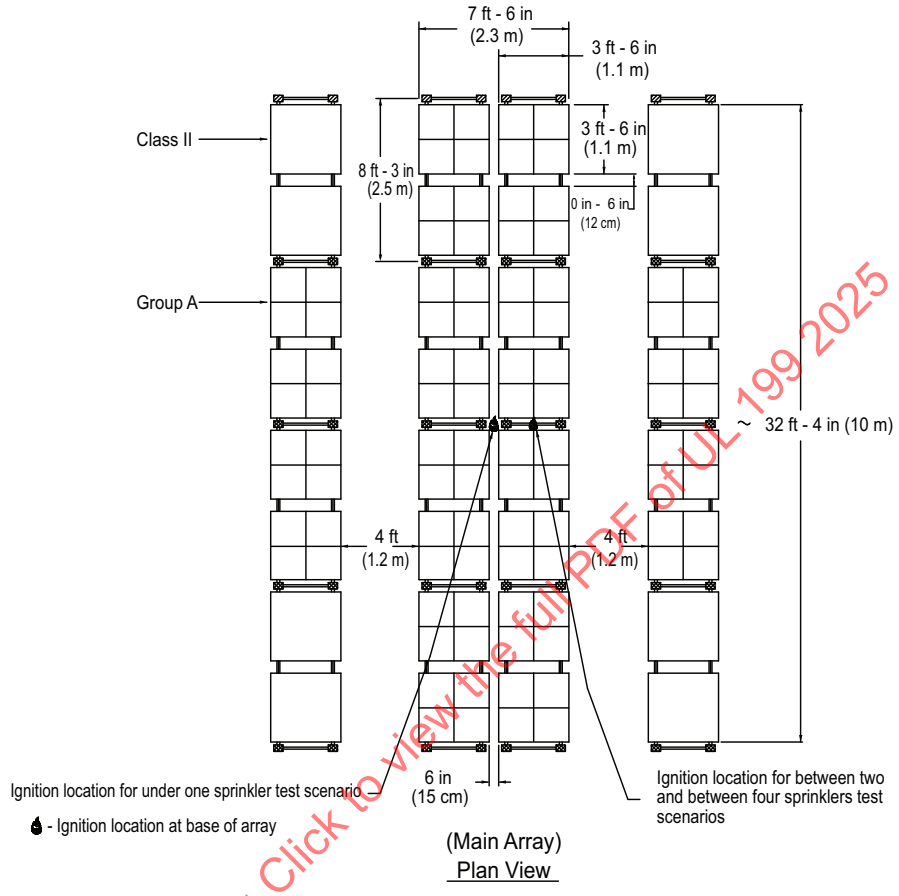


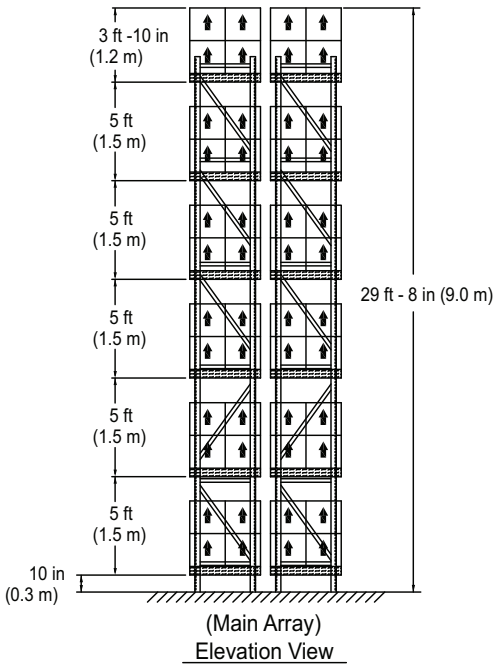
s4929c

Note: all dimensions are nominal

Figure 55.19

Fire Test for Double Row Rack Storage of Cartoned Group A Plastic Commodity (Nominal 30 Ft High)

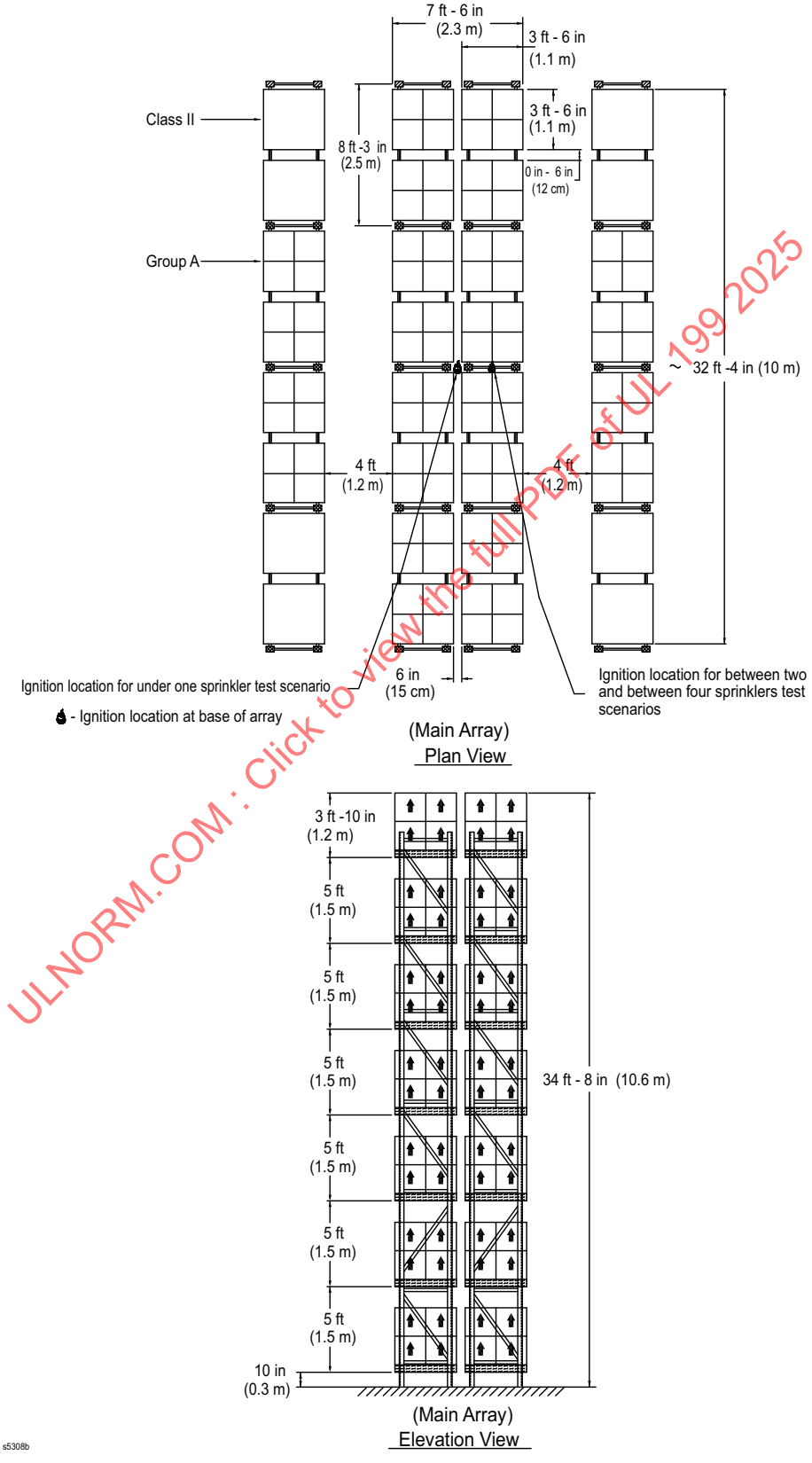




s5307b

Figure 55.20

Fire Test for Double Row Rack Storage of Cartoned Group A Plastic Commodity (Nominal 35 Ft High)



55.9 ESFR sprinkler large scale fire tests

55.9.1 When tested as described in 55.9.2 – 55.9.6, the water discharge from a sprinkler shall be capable of suppressing the large-scale fires described for each sprinkler such that compliance with the requirements in Table 55.16 is demonstrated. At the option of the manufacturer, the length of the stored commodity in the main and target arrays for the double row rack arrangements shall be permitted to be reduced to a nominal 24 ft (7.3 m) for any of the fire tests. If the fire spreads to the end of the main test array as indicated in Table 55.16, the manufacturer shall be permitted to reconduct the test using the nominal 32 ft (10 m) long array.

Table 55.16
Pendent ESFR Fire Test Requirements

Criteria to be evaluated	Test requirements	
Nominal K-Factor, gpm/(psi)$^{1/2}$(L/min/(bar)$^{1/2}$)	14.0, 16.8, 22.4, 25.2 and 28.0	
Maximum number of sprinklers permitted to operate	One within the test series	Remaining tests within the test series
	9	8
Maximum 1 min average steel temperature, °F (°C)	1000 (538)	
Regrowth of fire	No signs of regrowth at the end of the test as evidenced by significantly increasing steel or gas temperatures at the ceiling	
Fire spread	No sustained combustion at the end of the main test array and none at the outer edges of the target array	

55.9.2 The test room for these tests shall have provisions for venting the heat and smoke and for drainage of the sprinkler discharge.

55.9.3 A wet pipe automatic sprinkler system shall be installed below a smooth, flat, non-combustible horizontal ceiling unless otherwise specified in the test conditions. Water flow shall be controlled to maintain the required sprinkler discharge pressure specified in Table 55.17, Table 55.18, Table 55.19, Table 55.20, Table 55.21, Table 55.22 or Table 55.23 as applicable. The test pressure utilized for the fire testing shall be permitted to be less than the values referenced in Table 55.17, Table 55.18, Table 55.19, Table 55.20, Table 55.21, Table 55.22 or Table 55.23, if requested by the manufacturer. Representative sample sprinklers shall be installed at the spacing specified for each fire test. Sprinklers shall be installed throughout the test area and supplied through a looped piping system consisting of nominal 2.5 or 3 in (65 or 80 mm) diameter pipe. For the tests using a propylene glycol solution, the looped and supply piping shall initially be filled with the maximum volume and concentration of the propylene glycol and water mixture referenced in the manufacturer's instructions.

Table 55.17
Fire Test Conditions for Nominal K=14.0 and 16.8 Pendent ESFR Sprinklers for Use With a Maximum Storage Height of 35 ft (10.7 m) and Maximum Ceiling Height of 40 ft (12.2 m)

	Test 1
Storage type	Double row rack
Commodity type	Std. cartoned group A plastic
Test array	See Figure 55.16
Nominal storage height, ft (m)	20 (6.1)
Nominal ceiling height, ft (m)	40 (12.2)

Table 55.17 Continued on Next Page

Table 55.17 Continued

	Test 1
Sprinkler temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in (cm)	14 (35.6)
Sprinkler spacing, ft x ft (m x m)	10 x 10 (3.0 x 3.0)
Nominal discharge pressure, psig (kPa)	75 (518) for K=14.0
	52 (358) for K=16.8
Ignition location	Between two on same branchline
Duration of test after first sprinkler operation, min	30

Table 55.18
Fire Test Conditions for Nominal K=22.4 Pendent ESFR Sprinklers for Use With a Maximum Storage Height of 40 ft (12.2 m) and Maximum Ceiling Height of 45 ft (13.7 m)

	Test 1 (See Note 2)	Test 2 (See Note 3)	Test 3 (See Note 4)	Test 4	Test 5	Test 6	Test 7
Storage type	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack
Commodity type	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic
Test array	See Figure 55.16	See Figure 55.17	See Figure 55.16	See Figure 55.20	See Figure 55.21	See Figure 55.19	See Figure 55.17
Nominal storage height, ft (m)	20 (6.1)	25 (7.6)	20 (6.1)	35 (10.7)	40 (12.2)	30 (9.1)	25 (7.6)
Nominal ceiling height, ft (m)	30 (9.1)	30 (9.1)	30 (9.1)	45 (13.7)	Adjusted to achieve minimum clearance between sprinkler deflector and top of commodity	45 (13.7)	45 (13.7)
Sprinkler temperature rating	Minimum temperature rating	Maximum temperature rating	Minimum temperature rating	Minimum temperature rating	Maximum temperature rating	Minimum temperature rating	See Note 1
Nominal deflector to ceiling distance, in (cm)	14 (35.6)	Maximum specified by manufacturer	Maximum specified by manufacturer	14 (35.6)	Maximum specified by manufacturer	Maximum specified by manufacturer	See Note 1
Sprinkler spacing, ft x ft (m x m)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal discharge pressure, psig (kPa)	25 (172)	25 (172)	25 (172)	40 (276)	40 (276)	40 (276)	40 (276)
Ignition location	Under one	Between four	Between two on same branchline	Under one	Between four	Between two on same branchline	See Note 1
Duration of test after first sprinkler operation, min	30	30	30	30	30	30	30

Note 1 – Test scenario selected for this test is to be the most challenging based upon the results of previous tests.

Note 2 – This test shall be permitted to be waived if the sprinkler demonstrates compliance with the requirements of Test No. 2 of Table 55.24 (Actual Delivered Density (ADD) Measurement) at a pressure of 25 psi (172 kpa).

Note 3 – This test shall be permitted to be waived if the sprinkler demonstrates compliance with the requirements of Test No. 9 of Table 55.24 (Actual Delivered Density (ADD) Measurement) at a pressure of 25 psi (172 kpa).

Note 4 – This test shall be permitted to be waived if the sprinkler demonstrates compliance with the requirements of Test No. 5 of Table 55.24 (Actual Delivered Density (ADD) Measurement) at a pressure of 25 psi (172 kpa).

Table 55.19
Fire Test Conditions for Nominal K=22.4 Pendent ESFR Sprinklers for Use With a Maximum Storage Height of 43 ft (13.1 m) and Maximum Ceiling Height of 48 ft (14.6 m)

	Test 1	Test 2	Test 3	Test 4
Storage type	Double row rack	Double row rack	Double row rack	Double row rack
Commodity type	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic
Test array	See Figure 55.24	See Figure 55.23	See Figure 55.23	See Figure 55.22
Nominal storage height, ft (m)	43 (13.1)	38 (11.6)	38 (11.6)	28 (8.5)
Nominal ceiling height, ft (m)	48 (14.6)	48 (14.6)	48 (14.6)	48 (14.6)
Sprinkler temperature rating	Maximum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in (cm)	Maximum specified by manufacturer	Maximum specified by manufacturer	14 (35.6)	Maximum specified by manufacturer
Sprinkler spacing, ft x ft (m x m)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal discharge pressure, psig (kPa)	55 (379)	55 (379)	55 (379)	55 (379)
Ignition location	Between four	Between two on same branchline	Under one	See Note
Duration of test after first sprinkler operation, min	30	30	30	30
Note – Test scenario selected for this test is to be determined based upon the results of previous tests.				

Table 55.20
Fire Test Conditions for Nominal K=25.2 Pendent ESFR Sprinklers for Use With a Maximum Storage Height of 40 ft (12.2 m) and Maximum Ceiling Height of 45 ft (13.7 m)

	Test 1 (See Note 2)	Test 2 (See Note 3)	Test 3 (See Note 4)	Test 4	Test 5	Test 6	Test 7	Test 8
Storage type	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack
Commodity type	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic
Test array	See Figure 55.16	See Figure 55.17	See Figure 55.16	See Figure 55.20	See Figure 55.21	See Figure 55.19	See Note 1	See Figure 55.17
Nominal storage height, ft (m)	20 (6.1)	25 (7.6)	20 (6.1)	35 (10.7)	40 (12.2)	30 (9.1)	See Note 1	25 (7.6)
Nominal ceiling height, ft (m)	30 (9.1)	30 (9.1)	30 (9.1)	45 (13.7)	Adjusted to achieve minimum clearance between sprinkler deflector and top of commodity	45 (13.7)	40 (12.2)	45 (13.7)
Sprinkler temperature rating	Minimum temperature rating	Maximum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating	See Note 1	See Note 1
Nominal deflector to ceiling distance, in (cm)	14 (35.6)	Maximum specified by manufacturer	Maximum specified by manufacturer	14 (35.6)	Maximum specified by manufacturer	Maximum specified by manufacturer	See Note 1	See Note 1
Sprinkler spacing, ft x ft (m x m)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal discharge pressure, psig (kPa)	15 (103)	15 (103)	15 (103)	40 (276)	40 (276)	40 (276)	25 (172)	40 (276)
Ignition location	Under one	Between four	Between two on same branchline	Under one	Between four	Between two on same branchline	See Note 1	See Note 1
Duration of test after first sprinkler operation, min	30	30	30	30	30	30	30	

Note 1 – Test scenario selected for this test is to be the most challenging based upon the results of previous tests.

Note 2 – This test shall be permitted to be waived if the sprinkler demonstrates compliance with the requirements of Test No. 2 of Table 55.24 (Actual Delivered Density (ADD) Measurement) at a pressure of 15 psi (103 kpa).

Note 3 – This test shall be permitted to be waived if the sprinkler demonstrates compliance with the requirements of Test No. 9 of Table 55.24 (Actual Delivered Density (ADD) Measurement) at a pressure of 15 psi (103 kpa).

Note 4 – This test shall be permitted to be waived if the sprinkler demonstrates compliance with the requirements of Test No. 5 of Table 55.24 (Actual Delivered Density (ADD) Measurement) at a pressure of 15 psi (103 kpa).

Table 55.21
Fire Test Conditions for Nominal K=25.2 Pendent ESFR Sprinklers for Use With a Maximum Storage Height of 43 ft (13.1 m) and Maximum Ceiling Height of 48 ft (14.6 m)

	Test 1	Test 2	Test 3	Test 4
Storage type	Double row rack	Double row rack	Double row rack	Double row rack
Commodity type	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic
Test array	See Figure 55.24	See Figure 55.23	See Figure 55.23	See Figure 55.22
Nominal storage height, ft (m)	43 (13.1)	38 (11.6)	38 (11.6)	28 (8.5)
Nominal ceiling height, ft (m)	48 (14.6)	48 (14.6)	48 (14.6)	48 (14.6)
Sprinkler temperature rating	Maximum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in (cm)	Maximum specified by manufacturer	Maximum specified by manufacturer	14 (35.6)	Maximum specified by manufacturer
Sprinkler spacing, ft x ft (m x m)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal discharge pressure, psig (kPa)	45 (310)	45 (310)	45 (310)	45 (310)
Ignition location	Between four	Between two on same branchline	Under one	See Note
Duration of test after first sprinkler operation, min	30	30	30	30
Note – Test scenario selected for this test is to be determined based upon the results of previous tests.				

Table 55.22
Fire Test Conditions for Nominal K=25.2 Pendent ESFR Sprinklers with a Propylene Glycol/Water Solution

Test No.	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Storage type	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack	Double row rack
Commodity type	Std. Class II	Std. Class II	Std. Class II	Std. Class II	Std. Class II	Std. Class II
Test array	See Figure 55.25	See Figure 55.26	See Figure 55.26	See Figure 55.25	See Figure 55.27	See Figure 55.25
Nominal storage height, ft (m)	30 (9.1)	35 (10.7)	35 (10.7)	30 (9.1)	40 (12.2)	30 (9.1)
Nominal ceiling height, ft (m)	40 (12.2)	40 (12.2)	45.25 (13.8)	45.25 (13.8)	45.25 (13.8)	45.25 (13.8)
Sprinkler temperature rating	Maximum temperature rating	Maximum temperature rating	Maximum temperature rating	Maximum temperature rating	Maximum temperature rating	Maximum temperature rating
Nominal deflector to ceiling distance, in (cm)	14 (35.6)	14 (35.6)	14 (35.6)	14 (35.6)	14 (35.6)	14 (35.6)
Sprinkler spacing, ft x ft (m x m)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal discharge pressure, psig (kPa)	40 (276)	40 (276)	60 (414)	60 (414)	60 (414)	120 (818)
Ignition location	Under one	Between two on same branchline	Under one	Between two on same branchline	Between four	Between two on same branchline
Duration of test after first sprinkler operation, min	30	30	30	30	30	30

Table 55.23
Fire Test Conditions for Nominal K=28 Pendent ESFR Sprinklers for a Maximum Storage Height of 43 ft (13.1 m) and Maximum Ceiling Height of 48 ft (14.6 m)

	Test 1	Test 2	Test 3	Test 4
Storage type	Double row rack	Double row rack	Double row rack	Double row rack
Commodity type	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic	Std. cartoned group A plastic
Test array	See Figure 55.24	See Figure 55.23	See Figure 55.23	See Figure 55.22
Nominal storage height, ft (m)	43 (13.1)	38 (11.6)	38 (11.6)	28 (8.5)
Nominal ceiling height, ft (m)	48 (14.6)	48 (14.6)	48 (14.6)	48 (14.6)
Sprinkler temperature rating	Maximum temperature rating	Minimum temperature rating	Minimum temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in (cm)	Maximum specified by manufacturer	Maximum specified by manufacturer	14 (35.6)	Maximum specified by manufacturer
Sprinkler spacing, ft x ft (m x m)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)	10 x 10 (3.0 x 3.0)
Nominal discharge pressure, psig (kPa)	35 (241)	35 (241)	35 (241)	35 (241)
Ignition location	Between four	Between two on same branchline	Under one offset	Between two on same branchline
Duration of test after first sprinkler operation, min	30	30	30	30

55.9.4 A nominal 4-ft (1.2-m) length of 2 by 2 by 0.25 in (50 by 50 by 6 mm) steel angle beam shall be mounted adjacent to the ceiling above the ignition location. Five equally spaced Type K, or equivalent, thermocouples shall be embedded in the steel angle beam to measure its temperature.

55.9.5 A means shall be provided to determine the time and number of sprinkler operations. Water pressure and flow shall be monitored and measured through calibrated flowmeters. Significant events shall be monitored and recorded using calibrated timing devices located within the data acquisition system or manually recorded, as applicable.

55.9.6 The ignition source shall consist of either two or four cellulose cotton igniters positioned within the array near floor level as specified in Figure 55.16 – Figure 55.27. Each igniter is half of a standard igniter constructed from a nominal 3-in (76-mm) diameter by nominal 3-in (76-mm) long bundle soaked with 4 ±0.125 fl oz (118 ±3.7 ml) of gasoline and wrapped in a polyethylene bag.

Figure 55.21

Fire Test for Double Row Rack Storage of Cartoned Group A Plastic Commodity Nominal 40 ft (12.2 m) High

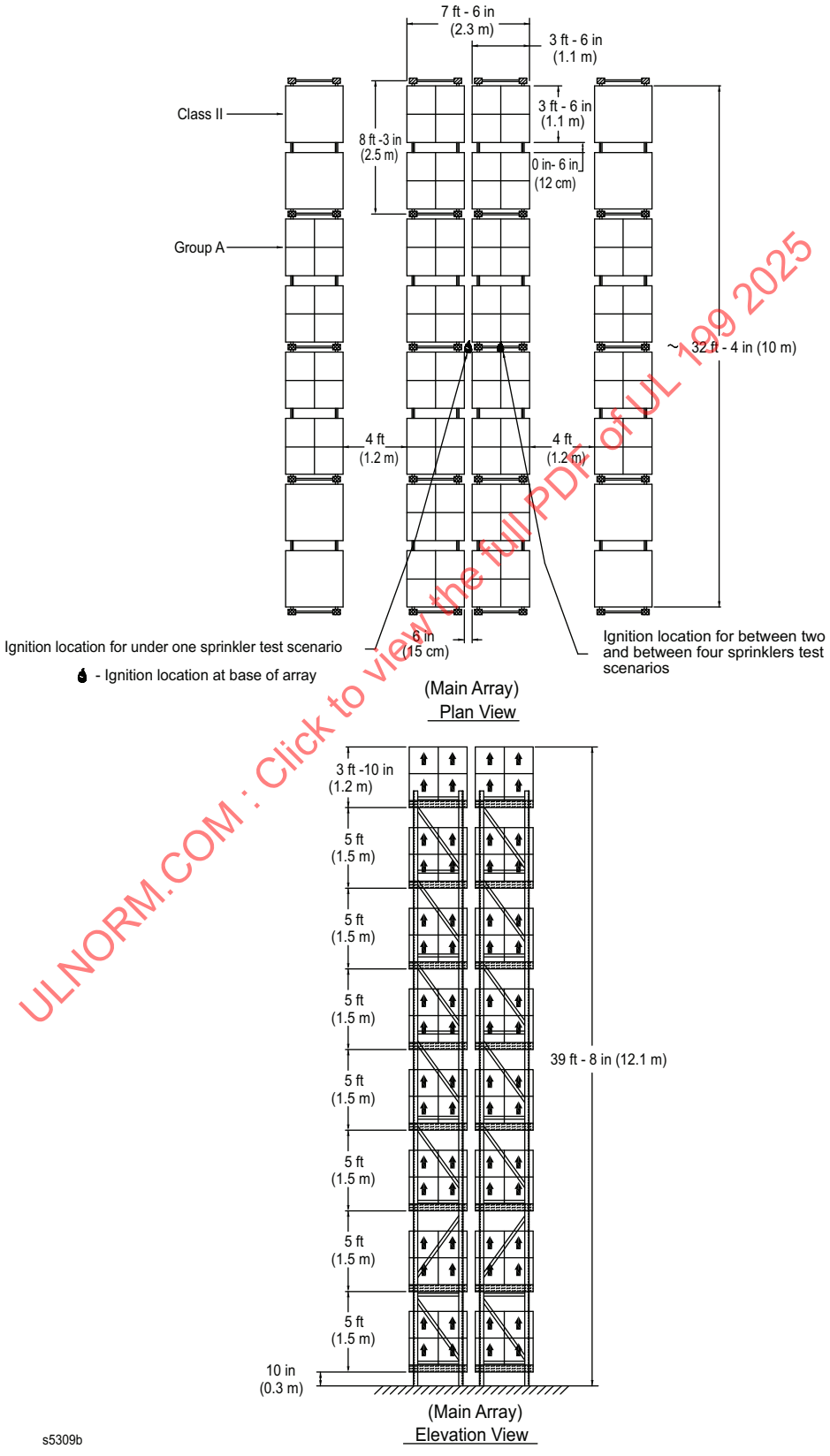


Figure 55.22

Fire Test for Double Row Rack Storage of Cartoned Group A Plastic Commodity Nominal 28 ft (8.5 m) High