UL 2167

STANDARD FOR SAFETY

Water Mist Nozzles for Fire Protection Service

FIRE-GAS

مدرس ، طراح و مشاور سیستم های (آتش نشانی ، تهویه ، اگزاست و فشار مثبت)

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

Second Edition, Dated March 9, 2021

Summary of Topics

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

– Revisions to Clarify Requirement, Enhance Alignment With UL Sprinkler Standards, And Update Testing Details

– Hydrostatic Strength

– Revisions to Shipboard Light and Ordinary Hazard Area Fire Tests

– Light Hazard Area Fire Test

– Revisions to Performance Based Acceptance Criteria for Ordinary Hazard Fire Tests and Installation Instructions

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

No Text on This Page

MARCH 9, 2021

ANSI/UL 2167-2021

UL 2167

Standard for Water Mist Nozzles for Fire Protection Service

First Edition – December, 2002

Second Edition

March 9, 2021

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

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

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

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INTRODUCTION

1 Scope

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

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

2 Units of Measurement

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

3 Components

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

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

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

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

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

4 Undated References

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

5 Glossary

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

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

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

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

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

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

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

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

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

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

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

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

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

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

a) Automatic – A thermosensitive device designed to react at a predetermined temperature by automatically releasing water mist into a designated area or volume.

b) Coated – A nozzle which has a factory applied coating for corrosion protection.

c) Concealed – A recessed nozzle with a ceiling cover plate.

d) Flush – A nozzle in which all or part of the body, including the inlet thread, is mounted above the lower plane of the ceiling.

e) Fusible Element – A nozzle that opens under the influence of heat by the melting of a component.

f) Glass Bulb – A nozzle that opens under the influence of heat through pressure resulting from expansion of the enclosed fluid.

g) Hybrid – A nozzle that opens by the influence of heat or by an independent fire detection system.

h) Multiple Orifice – A nozzle having two or more outlet orifices.

i) Open – A nozzle without a thermosensitive element which discharges water mist.

j) Pendent – A nozzle that is arranged in such a way that water mist is directed downward by striking a distribution plate or by nozzle orientation.

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

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

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

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

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

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

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

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

5.19 PRESSURE –

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

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

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

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

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

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

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

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

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

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

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

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

CONSTRUCTION

6 General

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

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

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

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

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

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

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

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

7 Protective Covers

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

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

8 Strainer and Filter

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

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

PERFORMANCE

9 General

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

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

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

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

10 Water Mist Nozzle Requirements

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

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

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

a) Marking;

b) Conformity of the nozzles with the manufacturer's drawings and specifications; and

c) Obvious defects.

11 Exposure Tests On Nozzles Incorporating Polymeric Gaskets

11.1 Nozzles with polymeric seals

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

11.2 Corrosive exposures

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

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

11.3 Temperature cycling exposure

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

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

11.4 Hydrocarbon exposure followed by moist air exposure

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

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

11.5 Hydrocarbon exposure followed by water immersion exposure

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

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

12 Nominal Operating Temperatures

12.1 The nominal operating temperatures of automatic nozzles shall be as indicated in Table 12.1.

Table 12.1
Nominal Operating Temperature Values

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

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

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

13 Operating Temperature Test

13.1 Automatic nozzles shall open within a temperature range of:

$$X \pm (0.035X + 0.62)° C$$

$$[X \pm (0.035X)° F$$

in which:

X is the nominal operating temperature.

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

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

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

14 Discharge Coefficient Test

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

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

in which:

K is the nozzle flow constant;

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

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

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

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

15 Water Distribution Test

15.1 The discharge characteristics of the nozzle shall be determined in accordance with 15.2 – 15.7.

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

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

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

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

15.6 Discharge water at a flow rate corresponding to the minimum discharge pressure specified in the manufacturer's design and installation manual for at least 10 minutes and record the amount of water collected in each pan. Determine the smallest square pattern of water collection pans that contain at least 22.5 percent of the total water discharged. Twice the number of pans along a side of this square pattern is assumed to be the diameter, D, of the discharge pattern.

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

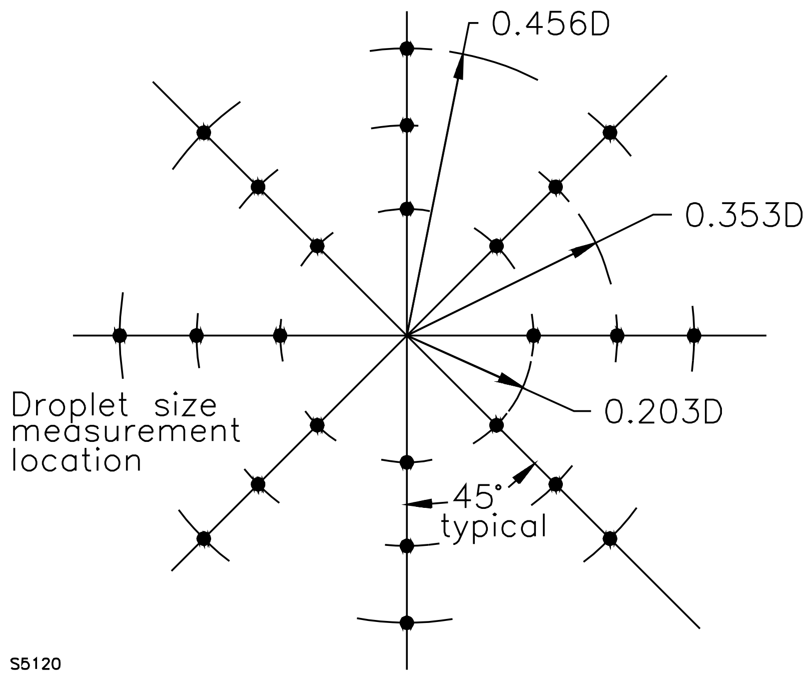
15.8 The results of the water distribution test are to be used to determine when additional fire tests are required as a result of changes in the discharge pattern over the operating pressure range.

16 Water Droplet Size and Velocity

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

Figure 16.1

Droplet Size Measurement Locations



D is the diameter of the discharge pattern as determined in 15.6.

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

16.3 The droplet size distribution and water discharge distribution measurements are to be made at the minimum and maximum rated pressure of the nozzle. The droplet size distribution at each measurement location and pressure is to be weighted proportionally against the corresponding relative flow rate per unit area of water discharge. The nozzle droplet size distribution is to be reported as a single summation of the weighted cumulative count and volume percent droplet distributions for all measurement locations. The summation shall be calculated and presented using the guidance in Supplement SC.

16.4 Standard Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis, ASTM E799, is to be used for guidance in performing the droplet size distribution measurements, including determination of appropriate size class bounds and the minimum-to-maximum droplet diameter range at each location.

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

17 Function Test

17.1 When tested in accordance with 17.3 – 17.4:

a) An open nozzle fitted with a protective device for the outlet shall operate within 5 seconds after the application of pressure; and

b) Within 5 seconds after the operation of the heat responsive element an automatic nozzle shall operate as intended.

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

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

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

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

18 Deflector/Orifice Assembly Test

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

19 Body Strength Test

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

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

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

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

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

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

20 Strength of Glass Bulb Elements

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

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

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

21 Strength of Fusible Elements

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

21.2 Fusible heat-responsive elements are to be subjected to loads in excess of the maximum design load L_d, which produce failure within and after 1000 hours. At least 10 samples are to be subjected to different loads up to 15 times the maximum design load. Abnormal failures which are not related to evaluation of the fusible material are to be rejected. A full logarithmic regression analysis using the method of least squares is to be performed. From the analysis, the load at 1 hour, L_o, and the load at 1000 hours, L_m, is to be calculated where:

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

For sample calculations, see Supplement SB.

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

22 Leak Resistance

22.1 An automatic nozzle shall not show any sign of leakage when tested as specified in 22.2.

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

23 Hydrostatic Strength

23.1 A nozzle shall not rupture, operate, or release any parts when tested as specified in 23.2.

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

24 Heat Exposure

24.1 Glass bulb nozzles

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

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

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

24.2 Uncoated automatic nozzles

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

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

a) Four nozzles are to be subjected to the tests specified in 22.2;

b) Four nozzles are to be subjected to the test of 17.1 (two nozzles at the minimum functional pressure and two nozzles at the rated pressure); and

c) Four nozzles shall comply with the requirements of 13.1.

Table 24.1
Test Temperatures for Coated and Uncoated Automatic Nozzles

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

24.3 Coated automatic nozzles

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

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

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

a) Four nozzles are to be subjected to the tests specified in 22.2;

b) Four nozzles are to be subjected to the test of 17.1 (two nozzles at the minimum functional pressure and two nozzles at the rated pressure); and

c) Four nozzles shall comply with the requirements of 13.1.

25 Thermal Shock

25.1 Glass bulb nozzles shall not be damaged when tested by the method specified in 25.2 and 25.3. Proper operation shall not be identified as damage.

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

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

26 Corrosion Tests

26.1 Stress corrosion test for brass nozzles and parts

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

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

26.1.3 The samples are to be degreased and exposed for 10 days to a moist ammonia-air mixture in a glass container of volume 0.02 ±0.01 m^3 (0.7 ±0.1 ft^3).

26.1.4 A sufficient amount of aqueous ammonia solution, having a density of 0.94 g/cm^3 (0.034 lb/in^3), is to be maintained in the bottom of the container. The lowest portion of the samples are to be positioned 38.1 mm (12.7 mm, -0 mm) [1-1/2 (+1/2, -0) inches] above the liquid surface and supported by an inert tray. A volume of aqueous ammonia solution corresponding to 0.01 ml per cubic centimeter of the volume of the container produces the following atmospheric concentrations: 35 percent ammonia, 5 percent water vapor, and 60 percent air.

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

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

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

26.2 Stress-corrosion cracking of stainless steel nozzles and parts

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

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

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

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

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

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

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

26.3 Sulfur dioxide/carbon dioxide corrosion

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

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

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

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

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

26.4 Hydrogen sulfide corrosion

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

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

26.4.3 The nozzles to be tested are to be suspended in their normal mounting position inside the test chamber. On five days out of every seven, an amount of hydrogen sulfide equivalent to 1.0 percent of the volume of the chamber is to be introduced into the test chamber from a commercial gas cylinder. Prior to each introduction of gas, the remaining gas-air mixture from the previous day is to be thoroughly purged from the chamber. On the two days of every seven that this does not occur, the chamber is to remain closed and no purging or introduction of gas is to be provided. During the exposure, the gas-air mixture is to be gently stirred by means of a small fan located in the chamber. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

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

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

26.5 Salt spray corrosion

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

26.5.2 Ten nozzles are to be exposed to a salt spray within a fog chamber. During the corrosive exposure, the outlet of open nozzles is to be sealed as specified in the manufacturer's design and installation instructions and the inlet is to be sealed by a plastic cap after the nozzles have been filled with deionized water. The salt solution is to be a 20 percent by mass sodium chloride solution in distilled water. The pH is to be between 6.5 and 7.2 and the density between 1.126 g/ml and 1.157 g/ml when atomized at 35 °C (95 °F). A means of controlling the atmosphere in the chamber is to be provided. The specimens are to be supported in their normal operating position and exposed to the salt spray (fog) in a chamber having a volume of at least 0.43 m^3 (15 ft^3) in which the exposure zone is to be maintained at a temperature of 35 ±2 °C (95 ±3.6 °F). The temperature is to be recorded at least once per day and at least 7 hours apart except weekends and holidays when the chamber is not normally opened. Salt solution is to be supplied from a recirculating reservoir through air-aspirating nozzles, at a pressure between 0.7 bar (10 psi) and 1.7 bar (24.6 psi). Salt solution runoff from exposed samples is to be collected and is to not return to the reservoir for recirculation.

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

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

26.6 Nozzles intended for corrosive atmospheres

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

26.7 Moist air exposure

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

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

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

27 Dezincification Test of Brass Parts

27.1 General

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

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

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

27.2 Reagent

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

27.3 Test pieces

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

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

27.4 Method

27.4.1 Each test piece is to be placed in the middle of the beaker containing the copper (II) chloride solution so that the test surface is vertical and at least 15 mm (0.59 inch) above the bottom of a glass beaker covered with suitable plastic foil, for example polyethylene, secured with elastic thread or another method of sealing using non-metallic compound. A total of 250 ml (+50 ml, -10 ml) [0.066 gallon (+0.013 gallon, -0.0026 gallon)] of the copper (II) chloride solution is required per 100 mm^2 (0.155 square inch) of exposed surface of the test piece.

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

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

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

28 Integrity of Nozzle Coatings

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

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

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

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

28.2 Resistance to low temperatures

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

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

28.3 Resistance to high temperature

28.3.1 Coated nozzles shall comply with the requirements of 24.3.

29 Water Hammer

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

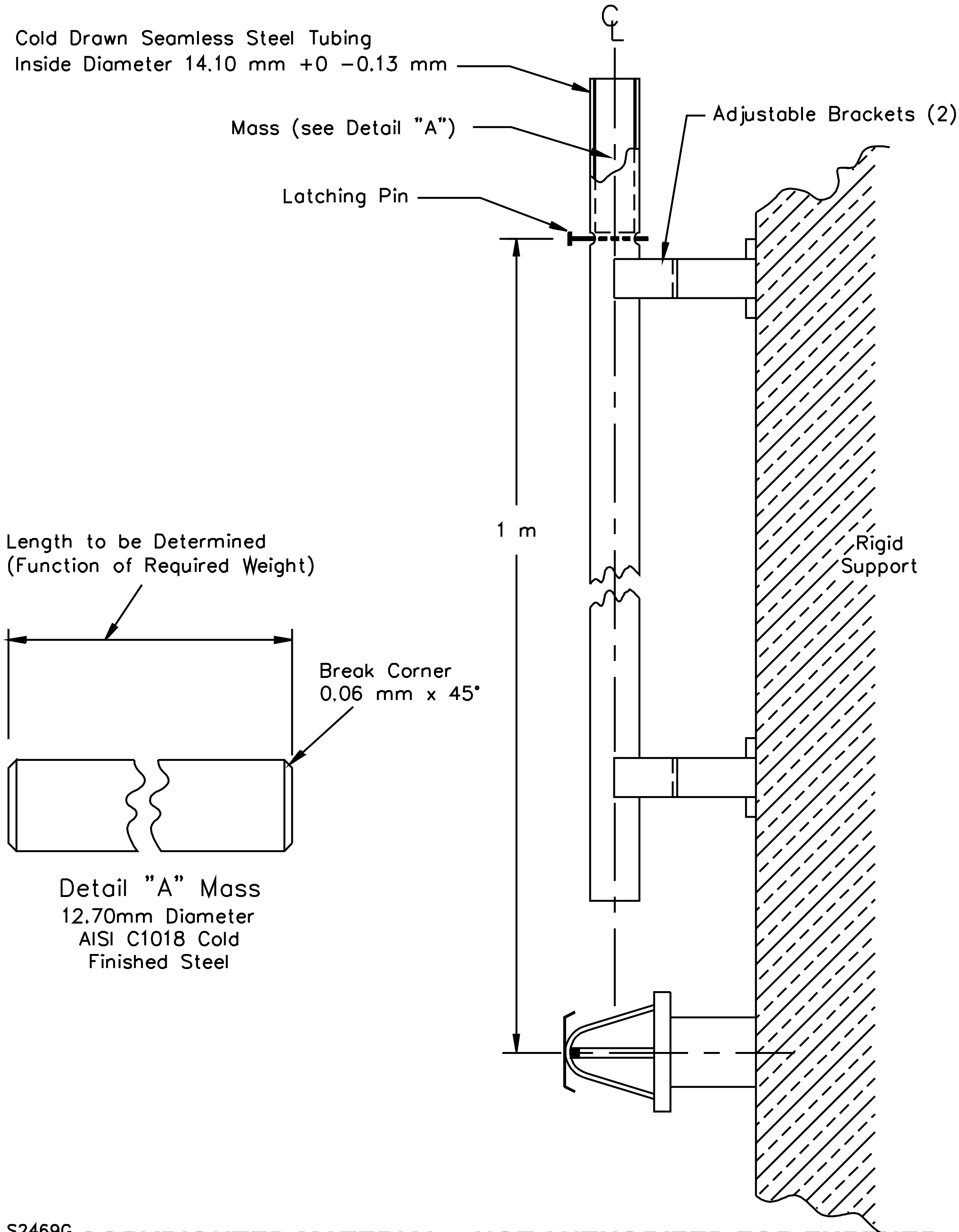
29.2 Five nozzles are to be connected in their normal operating position to the test equipment. After purging the air from the nozzles and the test equipment, 3000 cycles of pressure varying from 4 ±2 bar (58 ±29 psi) to the test pressure are to be generated. The pressure is to be raised from 4 bar to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

30 Impact Test for Protective Covers

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

Figure 30.1

Impact Test Apparatus for Protective Covers



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30.2 Five sample automatic nozzles having glass bulb heat responsive elements with their protective covers are to be mounted in the horizontal position and impacted with a cylindrical mass equivalent to the mass of the nozzle to the nearest 15-gram increment from a height of one meter onto the geometric center of the glass bulb heat responsive element. Five additional samples are to be tested with the impact applied to the opposite side of the nozzle if the cover is designed to provide unsymmetrical protection. If the glass bulb extends beyond the perimeter of the nozzle deflector, an additional five samples are to be mounted in the vertical position and impacted with the same cylindrical mass from a height of one meter onto the geometric center of the glass bulb heat responsive element. The mass is to be prevented from impacting more than once upon each sample. Following the impact, each nozzle is to be visually examined and there shall be no evidence of cracks, breaks, or any other damage to the glass bulb. Each sample nozzle shall then withstand a hydrostatic pressure of twice the rated working pressure for 1 minute without leakage. In addition, each sample shall then operate as intended when subjected to the Plunge Test, Section 32, when tested in the standard orientation.

31 Dynamic Heating

31.1 When tested in the standard orientation, automatic nozzles shall have a Response Time Index (RTI) not exceeding 50 $(m \cdot s)^{0.5}$ [90$(ft \cdot s)^{0.5}$] and a Conductivity Factor (C) less than 1 $(m/s)^{0.5}$ [3.3$(ft/s)^{0.5}$]. When tested at an angular offset of 25 degrees to the worst case orientation, the RTI shall not exceed 250 percent of the value of RTI in the standard orientation. The Plunge Test of Section 30 and the Prolonged Plunge Test of Section 33 are to be used to determine the C and RTI values.

31.2 After exposure to the corrosion tests described in 26.3 – 26.5, automatic nozzles are to be tested in the standard orientation as defined in 5.26 to determine the post exposure RTI. All post exposure RTI values shall not exceed the RTI and C limits specified in 30.1. In addition, the average RTI value shall not exceed 130 percent of the pre-exposure average value. All post exposure RTI values are to be calculated as in 33.8 using the pre-exposure conductivity factor (C).

32 Plunge Test

32.1 Tests shall be conducted to determine standard and worst case orientations. Ten additional plunge tests are to be performed at both of the identified orientations except that the worst case orientation shall be tested at an angular offset from the worst case orientation as specified in 31.1. The RTI is to be calculated as described in 33.8 and 33.9 for each orientation, respectively. The plunge tests are to be conducted using a brass nozzle mount designed such that the mount or water temperature rise does not exceed 2 °C (3.6 °F) for the duration of an individual plunge test up to a response time of 55 seconds. The temperature is to be measured by a thermocouple heatsinked and embedded in the mount not more than 8 mm (0.3 inch) radially outward from the root diameter of the internal thread or by a thermocouple located in the water at the center of the nozzle inlet. When the response time is greater than 55 seconds, the mount or water temperature in degrees Celsius is to not increase more than 0.036 times the response time in seconds for the duration of an individual plunge test.

32.2 The nozzle under test is to have 1 to 1.5 wraps of polytetrafluoroethylene (PTFE) sealant tape applied to the nozzle threads. It is to be screwed into a mount to a torque of 15 ±3 N·m (133 ±26 lb-in). Each nozzle is to be mounted on a tunnel test cover and maintained in a conditioning chamber a minimum of 30 minutes until the nozzle and cover reach ambient temperature. At least 25 ml (0.8 oz) of water, conditioned to ambient temperature, is to be introduced into the nozzle inlet prior to testing.

32.3 To record the response time, a timer, accurate to ±0.01 second, is to be used to record the time between when the nozzle is plunged into the tunnel and operation of the heat responsive element.

32.4 A tunnel is to be utilized with air flow and temperature conditions at the test section (nozzle location) within the range of conditions (where tunnel conditions limit the maximum equipment error to 3 percent) shown in Table 32.1. To minimize radiation exchange between the sensing element and the boundaries confining the flow, the test section of the apparatus is to be designed to limit radiation effects to within 3 percent of calculated RTI values (A method for determining radiation effects is by conducting comparative plunge tests on a blackened (high emissivity) metallic test specimen and a polished (low emissivity) metallic test specimen).

32.5 The range of permissible tunnel operating conditions is shown in Table 32.1. The operating condition shall be maintained for the duration of the test with the tolerances as specified by the footnotes of Table 32.1.

Table 32.1
Plunge Oven Test Conditions

Temperature rating		Oven temperature[a]		Air velocity[b]	
°C	(°F)	°C	(°F)	m/s	(ft/s)
57 – 77	(135 – 171)	129 – 141	(264 – 286)	1.65 – 1.85	(5.4 – 6.1)
79 – 107	(175 – 225)	191 – 203	(376 – 397)	1.65 – 1.85	(5.4 – 6.1)
121 – 149	(250 – 300)	282 – 300	(540 – 572)	1.65 – 1.85	(5.4 – 6.1)
163 – 191	(325 – 376)	382 – 432	(720 – 810)	1.65 – 1.85	(5.4 – 6.1)

[a] The air temperature shall be known and maintained constant within the test section throughout the test to an accuracy of ±1 °C (±1.8 °F) for the air temperature range of 129 – 141 °C (264 – 286 °F) and within ±2 °C (±3.6 °F) for all other air temperatures.

[b] The air velocity shall be known and maintained constant throughout the test to an accuracy of ±0.03 m/s (±0.1 ft/s).

33 Prolonged Plunge Test

33.1 The prolonged plunge test is an iterative process used to determine the conductivity factor (C) and requires up to twenty nozzle samples. A new nozzle sample is to be used for each test. The nozzle under test is to be prepared in accordance with 32.2. A timer as specified in 32.3 is to be used.

33.2 The mount temperature is to be maintained at 20 ±0.5 °C (68 ±0.9 °F) for the duration of each test. The air velocity in the tunnel test section at the nozzle location is to be maintained within ±2 percent of the set velocity, and the air temperature is to be maintained during the test as specified in Table 33.1.

Table 33.1
Plunge Oven Test Conditions for Conductivity Determinations

Nominal nozzle temperature		Oven temperature		Maximum variation of air temperature during test	
°C	(°F)	°C	(°F)	°C	(°F)
57	(135)	85 – 91	(185 – 196)	±1.0	(±1.8)
58 – 77	(136 – 171)	124 – 130	(255 – 266)	±1.5	(±2.7)
79 – 107	(175 – 225)	193 – 201	(379 – 394)	±3.0	(±5.4)
121 – 149	(250 – 300)	287 – 295	(549 – 563)	±4.5	(±8.1)
163 – 191	(325 – 376)	402 – 412	(756 – 774)	±6.0	(±10.8)

33.3 The range of permissible tunnel operating conditions is shown in Table 33.1.

33.4 To determine C, the nozzle is to be immersed in the test stream at various air velocities for a maximum of 15 minutes. When C is determined to be less than 0.5 $(m/s)^{0.5}$ [1.6 $(ft/s)^{0.5}$], a C of 0.25 $(m/s)^{0.5}$ [0.8 $(ft/s)^{0.5}$] is to be assumed for calculating the RTI value. Velocities are to be chosen such that actuation is bracketed between two successive test velocities. That is, two velocities are to be established such that at the lower velocity (u_l) actuation does not occur in the 15 minute test interval. At the next higher velocity (u_h), actuation must occur within the 15 minute time limit. If the nozzle does not operate at the highest velocity, the air temperature is to be increased to the next higher temperature rating.

33.5 The test velocity shall be chosen to ensure the following:

$$\left(\frac{U_h}{U_l}\right)^{0.5} \leq 1.1$$

33.6 The test C is to be the average of the values calculated at the two velocities using the following equation:

$$C = (\Delta T_g / \Delta T_{ea} - 1)u^{0.5}$$

in which:

Δ T_g is the actual gas (air) temperature minus the mount temperature (T_m) in °C;

Δ T_{ea} *is the mean liquid bath operating temperature minus the mount temperature (*T_m*) in °C; and*

u is the actual air velocity in the test section in m/s.

33.7 The nozzle *C* value is to be determined by repeating the bracketing procedure three times and calculating the numerical average of the three *C* values. This nozzle *C* value is to be used to calculate all standard orientation *RTI* values for determining compliance with 31.1.

33.8 The equation used to determine the *RTI* value is as follows:

$$RTI = \frac{-t_r\,(u)^{0.5}\,(1 + C / u^{0.5})}{In\ \ [1 - \Delta T_{ea}\,(1 + C / (u)^{0.5}) / \Delta T_g]}$$

in which:

t_r is the response time of nozzles in seconds;

u is the actual air velocity in the test section of the tunnel in m/s from Table 32.1;

Δ T_{ea} is the mean liquid bath operating temperature of the nozzle minus the ambient temperature in °C;

Δ T_g is the actual air temperature in the test section minus the ambient temperature in °C; and

C is the conductivity factor.

33.9 The equation used to determine the *RTI* for the worst case orientation is as follows:

$$RTI_{wc} = \frac{-t_{r-wc}\,(u)^{0.5}\,[1 + C(RTI_{wc} / RTI) / (u)^{0.5}]}{In\ \ \{1 - \Delta T_{ea}\,[1 + C(RTI_{wc} / RTI) / (u)^{0.5}] / \Delta T_g\}}$$

in which:

$t_{r\text{-}wc}$ is the response time of the nozzles in seconds for the worst case orientation.

33.10 All variables are known at this time from the equation in 33.8 except RTI_{wc} (Response Time Index for the worst case orientation) which is to be solved iteratively using the equation in 33.9.

34 Heat Resistance

34.1 Unless specifically limited for installation in residential one- and two-family dwellings and manufactured homes, a nozzle shall be resistant to high temperatures when tested in accordance with 34.2. After exposure, the nozzle shall not show:

a) Visual breakage or deformation;

b) Changes in the discharge coefficient exceeding 10 percent; and

c) Changes in the single discharge characteristics of the Water Distribution Test described in Section 15, exceeding 10 percent.

34.2 One nozzle body in its normal installation position is to be heated in an oven at 800 °C (1472 °F) for 15 minutes. Holding the threaded inlet, the nozzle body is to be removed and promptly immersed in a 15 °C (59 °F) water bath.

35 Vibration

35.1 A nozzle shall withstand the effects of vibration without deterioration of its performance characteristics when tested in accordance with 35.2 – 35.4. After the vibration test of 35.2 – 35.4, the nozzle shall not show visible deterioration or loss of any parts. Automatic nozzles shall comply with the requirements of 17.3 and 21.1 and open nozzles shall comply with 23.2.

35.2 Five automatic nozzles and five open nozzles with their outlets sealed as specified in the manufacturer's design and installation instructions are to be fixed vertically to a vibration table and subjected at room temperature to sinusoidal vibrations along the axis of the connecting thread.

35.3 The nozzles are to be vibrated continuously from 5 Hz to 40 Hz at a maximum rate of 5 minutes/octave and an amplitude of 1 mm (1/2 peak-to-peak value). When one or more resonant points are detected, the nozzles after coming to 40 Hz are to be vibrated at each of these resonant frequencies for 120 hours. If no resonance points are detected, the vibration from 5 Hz to 40 Hz is to be continued for 120 hours.

35.4 Following the vibration exposure, the automatic nozzles are to be subjected to the leakage test in accordance with 22.1 and the functional test in accordance with 17.1 – 17.3 at the minimum functional pressure. The open nozzles are to be subjected to the hydrostatic strength test in accordance with 23.1.

36 Rough Usage Test

36.1 Nozzles shall withstand the effects of rough usage without deterioration of its performance characteristics. Following 3 minutes of tumbling as described in 36.3, there shall be no visible damage which alters the discharge characteristics. Automatic nozzles shall comply with the requirements of 22.1 and 31.2 and open nozzles with the requirements of 23.2.

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

36.3 Five samples are to be individually placed in a vinyl-lined, right hexagonal, prism-shaped drum designed to provide a tumbling action. The drum is to have an axis of rotation of 250 mm (10 inches). The distance between opposite sides shall be 305 mm (12 inches). For each test, one sample and five 38.1 mm (1.5 inch) hardwood cubes shall be placed in the drum. The drum is to be rotated at 1 revolution per second for 3 minutes; then the sample shall be removed from the drum and examined for signs of damage.

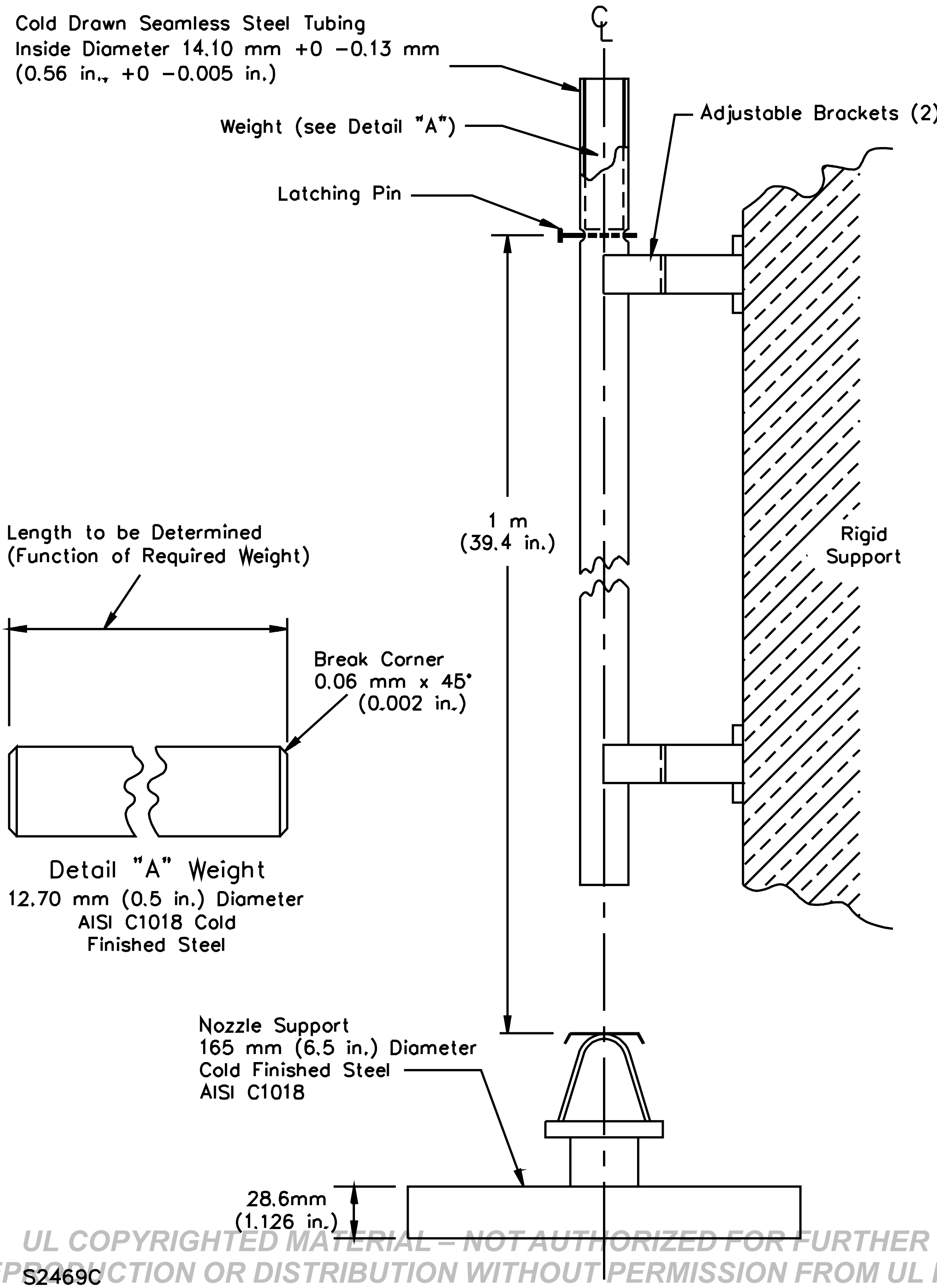
37 Impact Test

37.1 Nozzles shall have adequate strength to withstand handling, transport, and installation impacts without deterioration of their performance or reliability. Impact resistance shall be determined in accordance with 37.2 and 37.3.

37.2 Five nozzles are to be tested by dropping a mass onto each nozzle along the axial center line of waterway. The kinetic energy of the dropped mass at the point of impact is to be equivalent to a mass equal to that of the test nozzle dropped from a height of 1 m (39.4 inches) as shown in Figure 37.1. The mass is to be prevented from impacting more than once upon each sample.

Figure 37.1

Impact Test Apparatus



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37.3 Following the test, a visual examination of each nozzle shall not show signs of fracture, deformation, or other deficiency. When no fracture, deformation, or other deficiency is detected automatic nozzles shall comply with the Leak Resistance Test, Section 22, and the Function Test, Section 17, when tested at their minimum operating or standby pressure only. Open nozzles shall comply with the hydrostatic strength requirement described in 23.2 at twice the rated pressure.

38 Lateral Discharge

38.1 A nozzle shall not prevent the operation of adjacent automatic nozzles when tested in accordance with 38.2 and 38.3.

38.2 Water is to be discharged from the open nozzle at the maximum discharge pressure. A second automatic nozzle located at the minimum distance specified by the manufacturer is to be mounted on a pipe parallel to the pipe discharging water.

38.3 The nozzle orifices or distribution plates are to be placed 560 mm (22 inches), 355 mm (14 inches), and 150 mm (6 inches) below a flat smooth horizontal ceiling for three separate tests, respectively. The top of a square tray measuring 300 by 300 by 100 mm (12 by 12 by 4 inches) high is to be positioned 150 mm (6 inches) below the heat responsive element for each test. The tray is to be filled with 0.5 L (16 fl oz) of heptane. After ignition, the automatic nozzle is to operate before the heptane is consumed.

39 Thirty-Day Leakage Resistance

39.1 An automatic nozzle shall not leak, sustain distortion, or sustain other mechanical damage when subjected to twice the rated pressure for 30 days. Following this exposure, the nozzle shall be subjected to the test described in 36.2 and 36.3.

39.2 Five nozzles are to be installed on a water filled test line maintained under a constant pressure of twice the rated pressure for 30 days at an ambient temperature of 20 – 25 °C (68 – 77 °F).

39.3 The nozzles are to be inspected visually at least weekly for leakage. Following completion of this 30 day test, all samples shall comply with the leak resistance requirements specified in 22.1, and shall exhibit no evidence of distortion or other mechanical damage.

40 Vacuum Resistance

40.1 Automatic nozzles shall not exhibit distortion, mechanical damage, or leakage after being subjected to the test in 40.2.

40.2 Three nozzles are to be subjected to a vacuum of 460 mm (18 inches) of mercury applied to a nozzle inlet for 1 minute at an ambient temperature of 20 – 25 °C (68 – 77 °F). Following this test, each sample is to be examined to verify that no distortion or mechanical damage has occurred and that each sample complies with leak resistance requirements specified in 22.1.

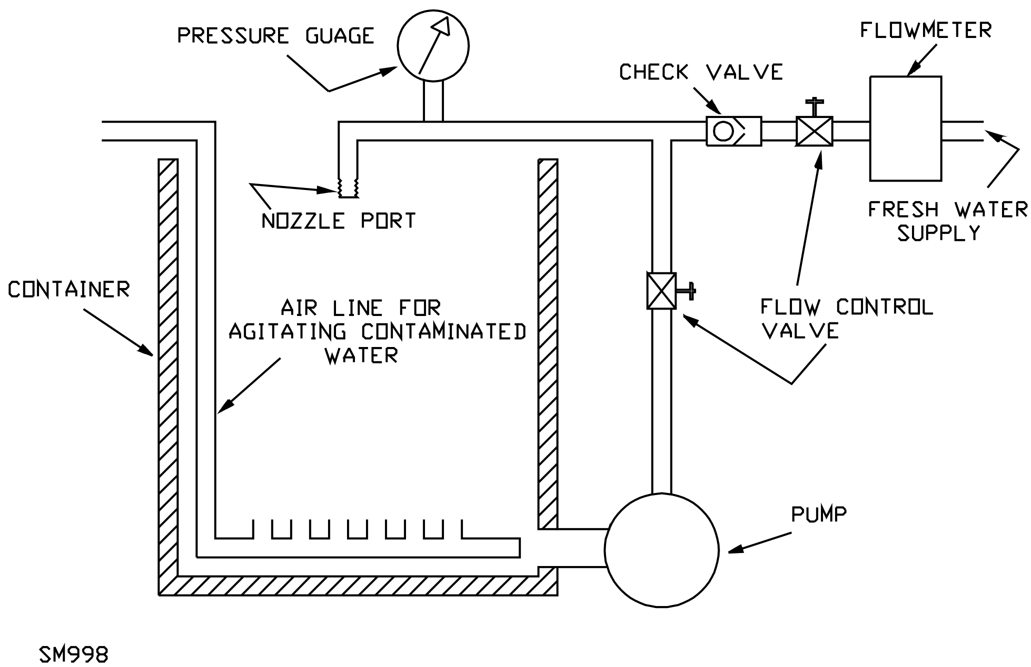
41 Clogging Test

41.1 A water mist nozzle shall show no evidence of clogging when exposed to continuously flowing water, contaminated in accordance with 41.4, at a test pressure of 16 bar (232 psi) or as specified in the manufacturer's design and installation instructions if the rated pressure is less. The amount of contaminant is to be proportionally reduced in each sieve designation by 50 percent for nozzles limited for use with corrosion resistant system and piping materials and by 90 percent for nozzles having a rated pressure of 50 bar (725 psi) or higher and limited for use with corrosion resistant system and piping materials. When nozzles are required to be used with corrosion resistant system and piping materials, a water supply connection filter or strainer as required in the manufacturer's design and installation instructions shall be permitted to be installed between the container storing the water and contaminant solution and the nozzle when conducting the clogging test.

41.2 During testing, nozzles, strainers, filters, or other devices shall not be flushed, removed, or cleaned. A typical test apparatus is shown in Figure 41.1.

Figure 41.1

Typical Clogging Test Apparatus



Note: When permitted in 41.1, a water supply filter or strainer may be installed between the container storing the water and contaminant solution and the water mist nozzle.

41.3 Prior to conducting the clogging test, the flow rate of water through the water mist nozzle and strainer, filter, or other devices as specified in 8.1, is to be measured at the test pressure as described in 41.1. Following the 30 minutes of flow with contaminated water, the flow rate through the nozzle and strainer, filter, or other devices as specified in 8.1 is to be remeasured at the test pressure as described in 41.1 and shall be within 10 percent of the original value.

41.4 The water and contaminant solution used for the clogging test is to be mixed in a proportion of 60 L (15.9 gal) of tap water with the weight of contaminants as described in Table 41.1, or a reduced amount of contaminants as permitted in 41.1 when corrosion resistant system and piping materials are specified for use with the nozzle. The solution is to be continuously agitated during the test.

Table 41.1
Contaminant for Contaminated-Water Cycling Test

Sieve designation	Nominal sieve opening, mm	Grams of contaminant (±5 percent)		
		Pipe scale	Top soil	Sand
No. 25	0.706	0	456	200
No. 50	0.297	82	82	327
No. 100	0.150	84	6	89
No. 200	0.074	81	0	21
No. 325	0.043	153	0	3
	Total	400	544	640

NOTE – Sieve designations correspond with those specified in the Standard Specification for Wire – Cloth Sieves for Testing Purposes, 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.

42 Freezing Test

42.1 Following exposure to the freezing conditions in 42.2, an automatic nozzle shall either operate, shall leak at a pressure up to their functional operating pressure, or shall not sustain any damage when water pressure is applied; and, shall comply with the requirements of 22.1 and Dynamic Heating, Section 31.

42.2 Five sample nozzles are to be individually connected to the test fixture having a minimum internal volume of 50 ml (3 in^3). The test fixture is to be completely filled with water and exposed to an atmosphere of minus 29 ±5 °C (minus 20 ±9 °F) for 24 hours. 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 up to their minimum functional pressure. When no leakage is detected at a pressure up to the minimum functional pressure, the samples shall then comply with the requirements of Leak Resistance, Section 22 and Dynamic Heating, Section 31. The test is to be repeated when the test apparatus, other than a nozzle, fractures due to the freezing.

43 Shipboard Machinery Space Fire Tests

43.1 General

43.1.1 When tested in accordance with 43.1 – 43.7, a water mist system nozzle intended for the protection of shipboard Category A engine rooms shall extinguish the test fires and prevent re-ignition.

43.1.2 The test method described in this section is intended to evaluate the extinguishing effectiveness of total compartment water mist nozzles intended to protect shipboard Category A engine rooms and cargo pump rooms. See Table 43.1.

43.1.3 The requirements in this section apply to systems using ceiling-mounted nozzles for Class 1 and Class 2 engine rooms and multiple levels of nozzles for Class 3 engine rooms, that are able to be utilized in conjunction with a separate bilge area fire-protection system. There shall be no use of nozzles to reduce the risk of specific hazards by direct application. However, when referenced in the manufacturer's design and installation instructions, additional nozzles are to be installed along the perimeter of the compartment to screen openings.

Table 43.1
Classification of Shipboard Category A Engine Room

Class	Typical engine room features	Typical net volume	Typical oil flow and pressure in fuel and lubrication systems
1	Auxiliary engine room, small main machinery or purifier room.	500 m^3 (17,660 ft^3)	Fuel or light diesel oil: Low pressure 0.15 – 0.20 kg/s (0.33 – 0.44 lb/s) at 3 – 6 bar (43.5 – 87 psi) High pressure 0.02 kg/s (0.04 lb/s) at 200 – 300 bar (2900 – 4350 psi)
			Lubrication oil: 3 – 5 bar (43.5 – 72.5 psi)
			Hydraulic oil: 150 bar (2175 psi)
2	Main diesel machinery in medium sized ships such as passenger ferries.	3000 m^3 (105,950 ft^3)	Fuel or light diesel oil: Low pressure 0.4 – 0.6 kg/s (0.9 – 1.3 lb/s) at 3 – 8 bar (43.5 – 116 psi) High pressure 0.030 kg/s (0.066 lb/s) at 250 bar (3625 psi)
			Lubrication oil: 3 – 5 bar (43.5 – 72.5 psi)
			Hydraulic oil: 150 bar (2175 psi)
3	Main diesel machinery in large ships such as oil tankers and container ships	>3000 m^3 (105,950 ft^3)	Fuel or light diesel oil: Low pressure 0.7 – 1.0 kg/s (1.54 – 2.2 lb/s) at 3 – 8 bar (43.5 – 116 psi) High pressure 0.20 kg/s
			Lubrication oil: 3 – 5 bar (43.5 – 72.5 psi)
			Hydraulic oil: 150 bar (2175 psi)

43.2 Test apparatus

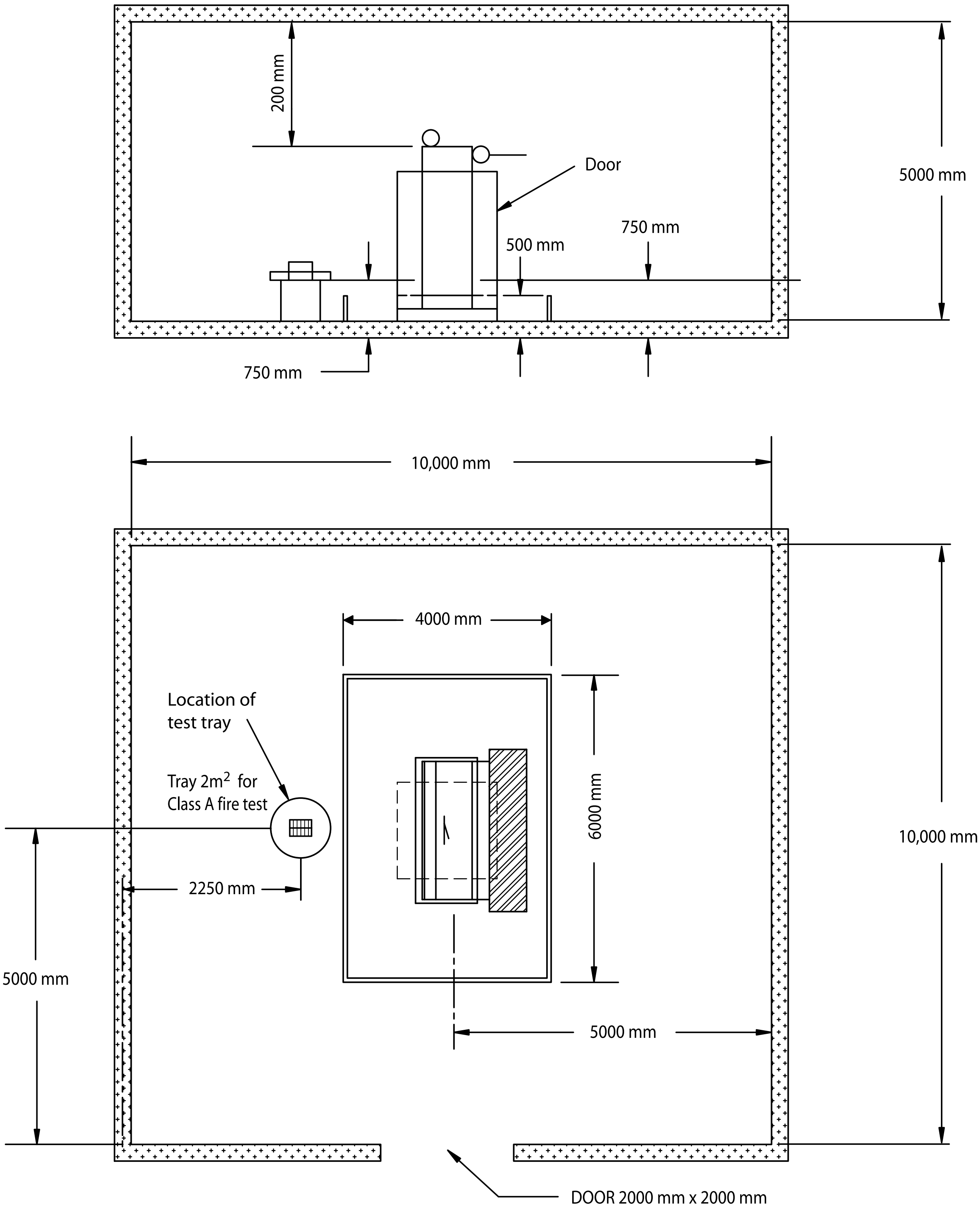
43.2.1 The machinery space fire test apparatus is to consist of the following:

a) A steel floor plate assembly which is 4 by 6 by 0.75 m (13.1 by 19.7 by 2.4 ft) high surrounding the engine mock-up. The sides of the floor plate assembly are to be fitted with solid steel plates 0.5 m (19 inches) high. One 2 by 2 by 0.25 m (6.5 by 6.5 by 0.8 ft) high steel tray shall be positioned under the engine mock-up and floor plate assembly as shown in Figure 43.1 – Figure 43.3.

b) A simulated engine 1 by 3 by 3 m (3.25 by 10 by 10 ft) high constructed of nominal 5 mm (0.2 inch) thick sheet steel. A 1 by 3 by 0.1 m (3.25 by 10.0 by 0.3 ft) high steel tray is to be positioned on top of the simulated engine. The engine mock-up is to be fitted with 2 steel tubes 0.3 m (1 ft) in diameter 3 m (10 ft) in length and a solid flat steel grating 0.7 by 3.5 m (2.3 by 11.5 ft) in length. See Figure 43.1 – Figure 43.3.

Figure 43.1

Engine Mock-Up Detail



Note: All dimensions in mm unless otherwise noted.

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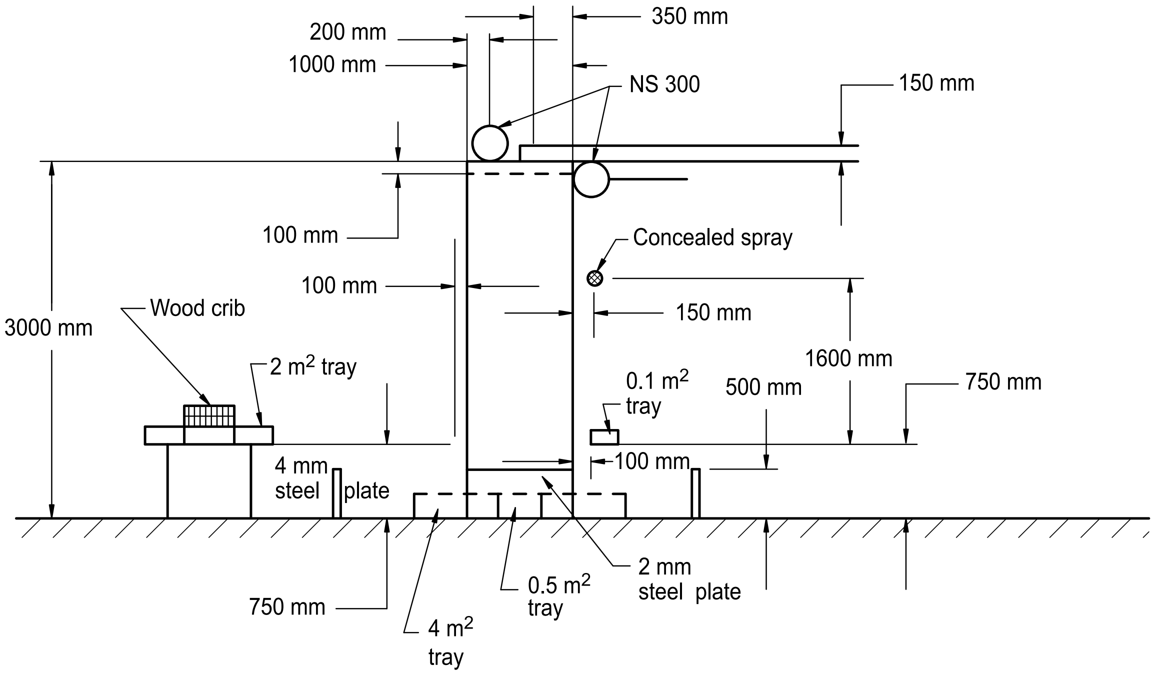
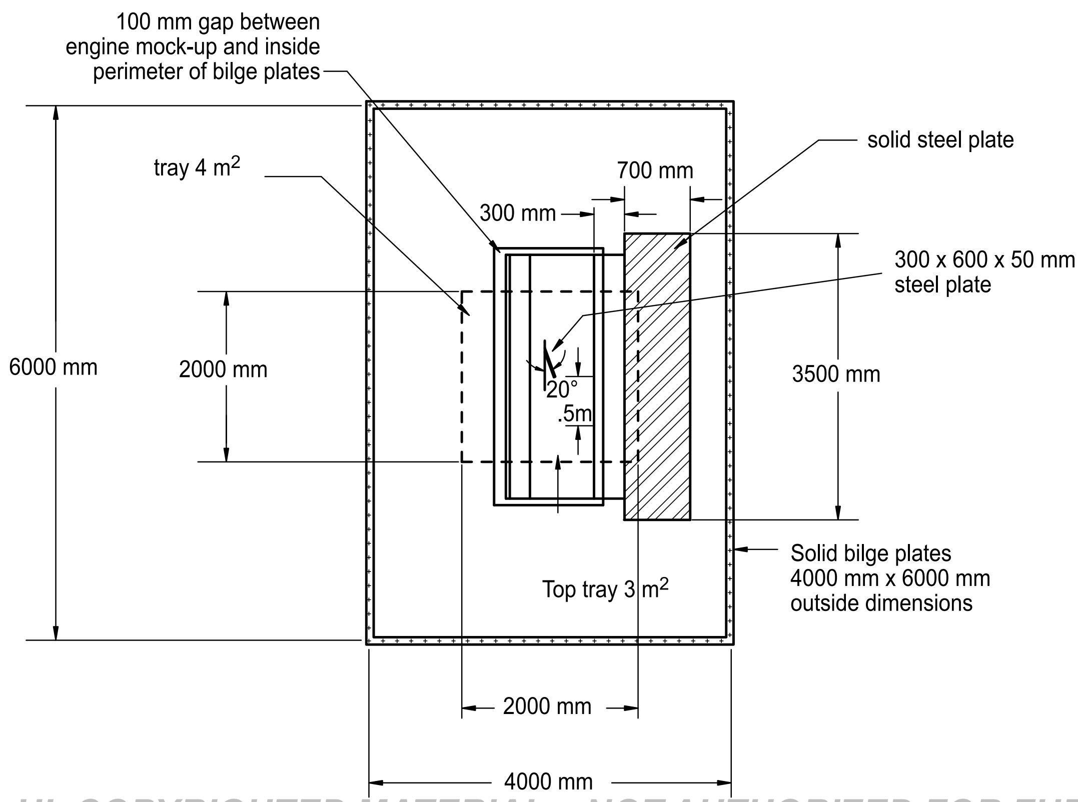
Figure 43.2

Engine Mock-Up Detail





Note: All dimensions in millimeters unless otherwise noted.

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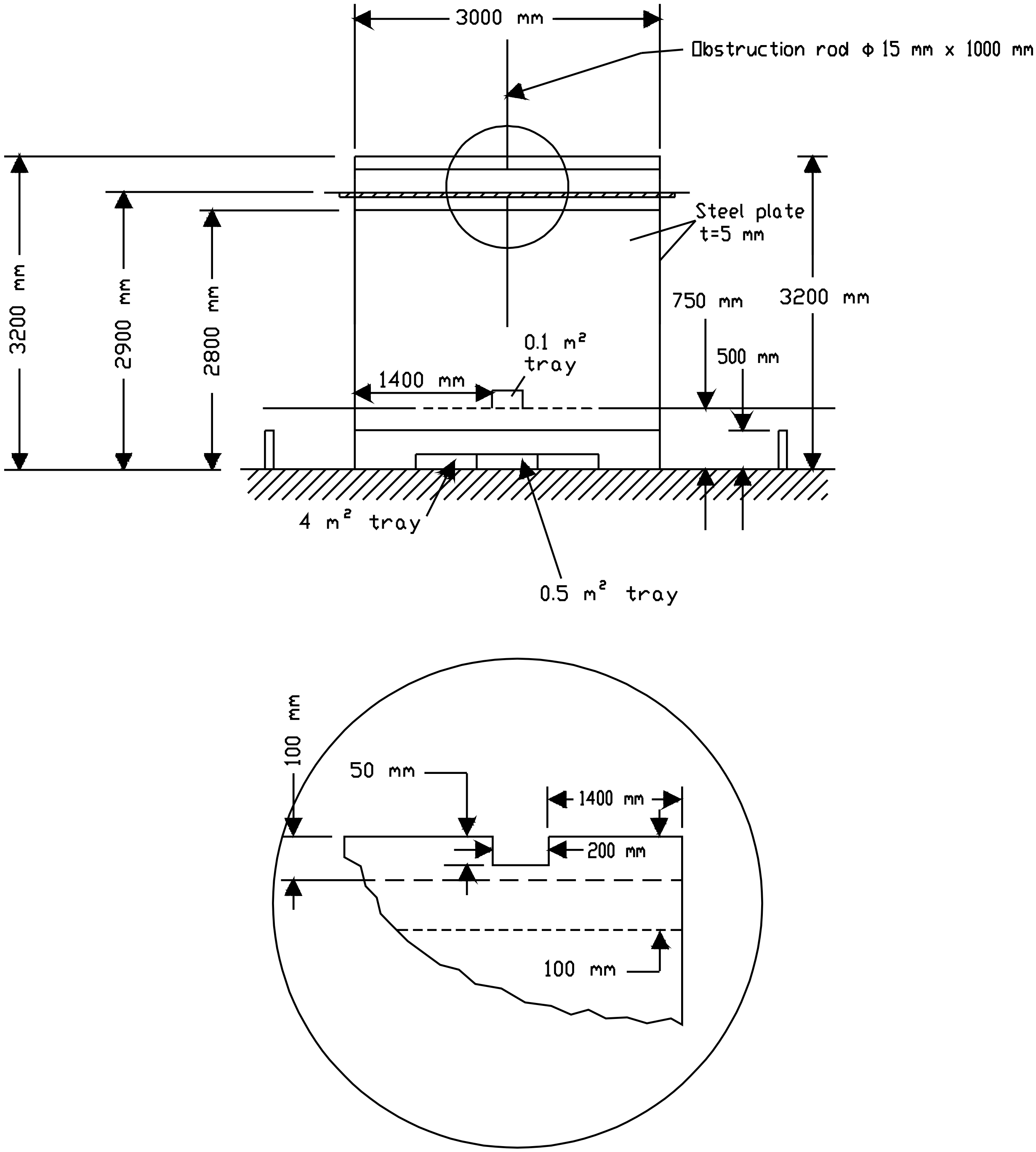
Figure 43.3

Engine Mock-Up Detail



Note: All dimensions in millimeters unless otherwise noted.

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43.3 Test enclosure

43.3.1 For a Class 1 engine room, the fire tests shall be conducted in a test enclosure having dimensions of 10 by 10 by 5 m (32.8 by 32.8 by 16.4 ft) high. Ventilation is to be provided through a minimum 2 by 2 m (6.6 by 6.6 ft) door opening.

43.3.2 For a Class 2 engine room, the fire tests shall be conducted in a test enclosure having a floor area greater than 100 m^2 (1080 ft^2), a ceiling height of between 5 and 7.5 m (16.4 – 24.6 ft) up to a total volume of 3000 m^3 (105,950 ft^3). Ventilation is to be provided through a minimum 2 m by 2 m (6.6 by 6.6 ft) door opening.

43.3.3 For a Class 3 engine room, the fire tests shall be conducted in an open space having a minimum floor area of 300 m^2 (3230 ft^2), a ceiling height in excess of 10 m (32.8 ft), a ceiling area of at least 10 by 10 m (32 by 32 ft), and no restriction on supply air.

43.4 Fire tests

43.4.1 A series of fire tests are to be conducted to demonstrate that at the end of water and fuel discharge, there is to be complete extinguishment with no fire spread or re-ignition, using the various sprays, test fuels, and fire locations as described in Table 43.2. For the spray fire tests, the spray nozzles, discharge pressures, test fuels, flow rates, fuel temperature, and nominal heat release rates are described in Table 43.3. For fires in the test trays, the fuel depth is to be at least 50 mm (2 inches) on a water base. Freeboard is to be 150 ±10 mm (6 ±0.4 inches).

Table 43.2
Fire Tests for Shipboard Class A Engine Rooms

Test No.	Fire scenario	Test fuel
1	Low pressure horizontal spray on top of simulated engine centered below four nozzles	Commercial fuel oil or light diesel oil
2	Low pressure spray on top of simulated engine centered below four nozzles with the oil spray nozzle angled upward at a 45° angle to strike a 12 – 15 mm (0.5 – 0.6 inch) rod 1 m (39.4 inches) away	Commercial fuel oil or light diesel oil
3	Low pressure concealed horizontal spray fire on side of simulated engine with the oil spray nozzle positioned 0.1 m in from the end of the engine	Commercial fuel oil or light diesel oil
4	Combination of worst spray fire from Tests 1 – 3 and fires in 4 m^2 (43 ft^2) trays under and 3 m^2 (32.4 ft^2) trays on top of the simulate engine.	Commercial fuel oil or light diesel oil
5	High pressure horizontal spray fire on top of the simulated engine centered below four nozzles	Commercial fuel oil or light diesel oil
6	Low pressure low flow concealed horizontal spray fire on side of the simulated engine with the oil spray nozzle 0.1 m (4 inches) in from the end of the engine and a 0.1 m^2 (1 ft^2) tray positioned 1.4 m (4.6 ft) in from the engine and at the inside of the solid bilge floor	Commercial fuel oil or light diesel oil
7	0.5 m^2 (5.4 ft^2) tray central under engine mock-up	Heptane
8	0.5 m^2 (5.4 ft^2) tray central under engine mock-up	SAE 10W30 mineral based lubrication oil
9	0.5 m^2 (5.4 ft^2) tray on top of bilge plate under exhaust plate	Heptane
10	Flowing fire (0.25 kg/s) from top of engine mock-up	Heptane
11	Class A wood crib in 2 m^2 (21.52 ft^2) test tray of heptane with 30 second pre-burn. The test tray is to be positioned 0.75 m above the floor as shown in Figure 43.1 and Figure 43.2.	UL 1626 wood crib and heptane

Table 43.2 Continued on Next Page

Table 43.2 Continued

Test No.	Fire scenario	Test fuel
12	A steel plate 30 by 60 by 5 cm (12 by 24 by 2 inches) offset 20° to the spray nozzle is to be heated to 350 °C (662 °F) by the low pressure, low flow spray nozzle 0.5 m (19.2 inches) from the front edge of the plate. When the plate reaches 350 °C (662 °F), the system is activated. Following system shut-off, there shall be no re-ignition of the spray.	Heptane
13	2 by 2 m (6.6 by 6.6 ft) tray under engine mock-up	Commercial fuel oil or light diesel.

Table 43.3
Oil Spray Fire Test Parameters

Test parameter	Category A Engine Room		
Fire type	Low pressure	Low pressure, low flow	High pressure
Spray nozzle	Wide spray angle (120 – 125°) full cone type	Wide spray angle (80°) full cone type	Standard angle [at 6 Bar (87 psi)] full cone type
Nominal fuel pressure	8 Bar (116 psi)	8.5 Bar (123 psi)	150 Bar (2125 psi)
Fuel flow	0.16 ±0.01 kg/s	0.03 ±0.005 kg/s	0.050 ±0.002 kg/s
Fuel temperature	20 ±5 °C (68 ±9 °F)	20 ±5 °C (68 ±9 °F)	20 ±5 °C (68 ±9 °F)
Nominal heat release rate	5.8 ±0.6 MW	1.1 ±0.1 MW	1.8 ±0.2 MW
Fuel	Commercial fuel oil or light diesel oil	Commercial fuel oil or light diesel oil for Fire Test 6 and heptane for Fire Test 12	Commercial fuel oil or light diesel oil

43.4.2 Fire Test Nos. 1 – 6 and 13 described in Table 43.2 are to be conducted using commercial fuel oil or a light diesel oil. Fire Test Nos. 7 and 9 – 12 are to be conducted using heptane. Fire Test No. 8 is to be conducted using SAE 10W30 mineral based lubrication oil.

43.4.3 The wood crib (see Figure 45.2), specified in Fire Test No. 11 (see Table 43.2), is to weigh 5.4 – 5.9 kg (11.9 – 13 lb) and is to be dimensioned 300 by 300 by 300 mm (12 by 12 by 12 inches). The crib is to consist of eight alternate layers of four trade size 38.1 by 38.1 mm (1.5 by 1.5 inch) kiln-dried spruce or fir lumber 300 mm (12 inches) 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. After the wood crib is assembled, it is to be conditioned at a temperature of 49 ±5 °C (120 ±9 °F) for not less than 16 hours. 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 shall not exceed 5 percent prior to the fire test. The wood crib is to be supported on blocks such that the base of the crib is even with the top of the water level in the 2 m^2 (21.5 ft^2) test tray.

43.4.4 Re-ignition Fire Test No. 12 (see Table 43.2) is to be conducted using a 300 by 600 by 50 mm (11.8 by 23.6 by 2 inches) thick steel plate positioned as shown in Figure 45.2. The water flow is to be activated when the steel plate reaches a temperature of 350 +5, -0 °C (662 +9, -0 °F). Prior to ignition of the heptane spray fire, the steel plate may be preheated using an external heating source.

43.4.5 Fire Test Nos. 4, 7, 8, and 13 (see Table 43.2) are not required if the use of a separate bilge fire-protection extinguishing system is specified in the manufacturer's design and installation instructions as developed from representative bilge area fire tests.

43.5 Extinguishing system

43.5.1 The water mist nozzles, and bilge extinguishing system when required, is to be installed to protect the compartment in accordance with the manufacturer's design and installation instructions. For Class 3 engine rooms, the maximum vertical distance between levels of nozzles shall not exceed 7.5 m (24.6 ft) and the first level of nozzles shall be installed at a height of 5 – 7.5 m (16.4 – 24.6 ft) above the floor. For bilges more than 0.75 m (2.46 ft.) in depth, nozzles or a separate fire extinguishing system shall be installed in accordance with the manufacturer's design and installation instructions as developed from representative fire tests.

43.5.2 Fire tests are to be conducted with the water mist nozzles positioned at the maximum distance from the test apparatus, maximum volume per nozzle, maximum enclosure ventilation rate, maximum distance of nozzles below the ceiling, maximum spacing between nozzles, and at the minimum operating pressure(s) specified in the manufacturer's design and installation instructions.

43.6 Test procedure

43.6.1 A test tray, is to be filled with at least 50 mm (2 inches) of test fuel on a water base. Freeboard is to be 150 ±10 mm (6 ±0.4 inch).

43.6.2 For fuel spray fire tests, the fuel flow and pressure is to be measured before each test. The fuel pressure is to be measured at time intervals not exceeding 5 seconds during each test.

43.6.3 After the ignition of all test fuels, a pre-burn time is to be provided in the following manner:

a) 2 minutes for oil tray fires;

b) 5 – 15 seconds for the oil spray and heptane fires; and

c) 30 seconds for the wood crib.

At the conclusion of each respective pre-burn, the extinguishing system is activated with allowances for water delivery times.

43.6.4 The water pressure in the piping to each nozzle is to be measured continuously on the high pressure side of a pump or equivalent equipment at intervals not exceeding 5 seconds. Alternatively, the flow may be determined by measuring the average system operating pressure and knowing the K factor of the nozzles, or by the use of a water flow measuring device.

43.6.5 After the pre-burn, water to the nozzles is to be discharged for a maximum of 50 percent of the discharge time specified by the manufacturer. At the end of discharge, there is to be complete extinguishment and no re-ignition. The oil or heptane spray is to be shut-off 15 seconds after extinguishment.

43.7 Test observations

43.7.1 The test compartment and engine mock-up temperatures are to be recorded before and after each fire test. Manufacturers have the option of having the oxygen content in the test compartment monitored during each fire test.

43.7.2 The following observations shall be recorded:

a) Start of ignition procedure;

b) Ignition;

c) Flowing fuel pressure for fuel spray fire tests;

d) Time of extinguishing system activation;

e) Time of fire extinguishment;

f) System operating pressure versus time;

g) Time when extinguishing system was shut-off;

h) Time of re-ignition, when it occurs;

i) Time when oil or heptane spray was shut-off;

j) Damage to any extinguishing system components; and

k) Depth of fuel in all test trays.

44 Shipboard Passenger Cabin Fire Tests

44.1 General

44.1.1 Water mist nozzles intended for use in shipboard passenger cabin areas up to 12 m^2 (129 ft^2) and/or corridors up to 1.5 m (4.9 ft) in width shall comply with the cabin fire test methods described in this Section. When the water mist nozzles are also intended for shipboard passenger cabin areas greater than 12 m^2 (129 ft^2) in area, the fire tests described in Section 45, Shipboard Passenger Cabins Greater than 12 m^2, shall be conducted.

44.2 Fire tests

44.2.1 The following series of 4 passenger cabin and 3 corridor fire tests shall be conducted with automatic activation of the nozzles at the minimum operating pressure specified by the manufacturer. The fires are to be ignited using a 75 mm (3 inch) cube of insulating fiberboard soaked in 115 ml (4 fl oz) of heptane and wrapped in a plastic bag and positioned as indicated for each passenger cabin fire test. For the corridor fire tests, the igniter is to be located in the center at the base of the pile of foam pieces on one side of the test stand.

a) Lower Bunk Bed Fire Test. The fire is to be arranged in one lower bunk bed with igniter at the front (towards the door) centerline of the pillow.

b) Upper Bunk Bed Fire Test. The fire is to be arranged in one upper bunk bed with the igniter located at the front (toward the door) centerline of the pillow.

c) Arsonist Fire Test. The fire is to be arranged by spreading 1 L (0.26 gal) of white spirits evenly over one lower bunk bed and backrest 30 seconds prior to ignition. The igniter is to be located in the lower bunk bed at the front (towards the door) centerline of the pillow.

d) Disabled Nozzle Fire Test. The water mist nozzle(s) in the passenger cabin is to be disabled. The fire is to be arranged in one lower bunk bed with the igniter located at the front (towards the door) centerline of the pillow.

e) Corridor Fire Test Under One Nozzle. The fire source is to be located against the corridor wall below one nozzle.

f) Corridor Fire Test Between Two Nozzles. The fire source is to be located against the corridor wall between two nozzles.

g) Ventilation Fire Test. The worst of the corridor fire tests (e) or (f) is to be repeated with an ambient air velocity of 0.3 – 0.4 m/s (1 – 1.33 ft/s) measured at the midpoint between the floor and the ceiling in the center of the corridor.

44.2.2 Water mist nozzles installed in accordance with 44.1.1 shall comply with the following:

a) No flashover of the passenger cabin or corridor shall occur except in the Disabled Nozzle Fire Test in 44.2.1(d);

b) The temperature and damage criteria shall comply with Table 44.1;

c) Operation of any automatic water mist nozzles located in the corridor in Fire Tests a and b in Table 44.1 shall not occur;

d) No more than two automatic water mist nozzles shall operate in Fire Tests e – g in Table 44.1; and

e) The fire shall not propagate in the corridor beyond the nozzles adjacent to the door opening in the disabled nozzle fire test.

Table 44.1
Performance Criteria for Cabin and Corridor Fire Tests

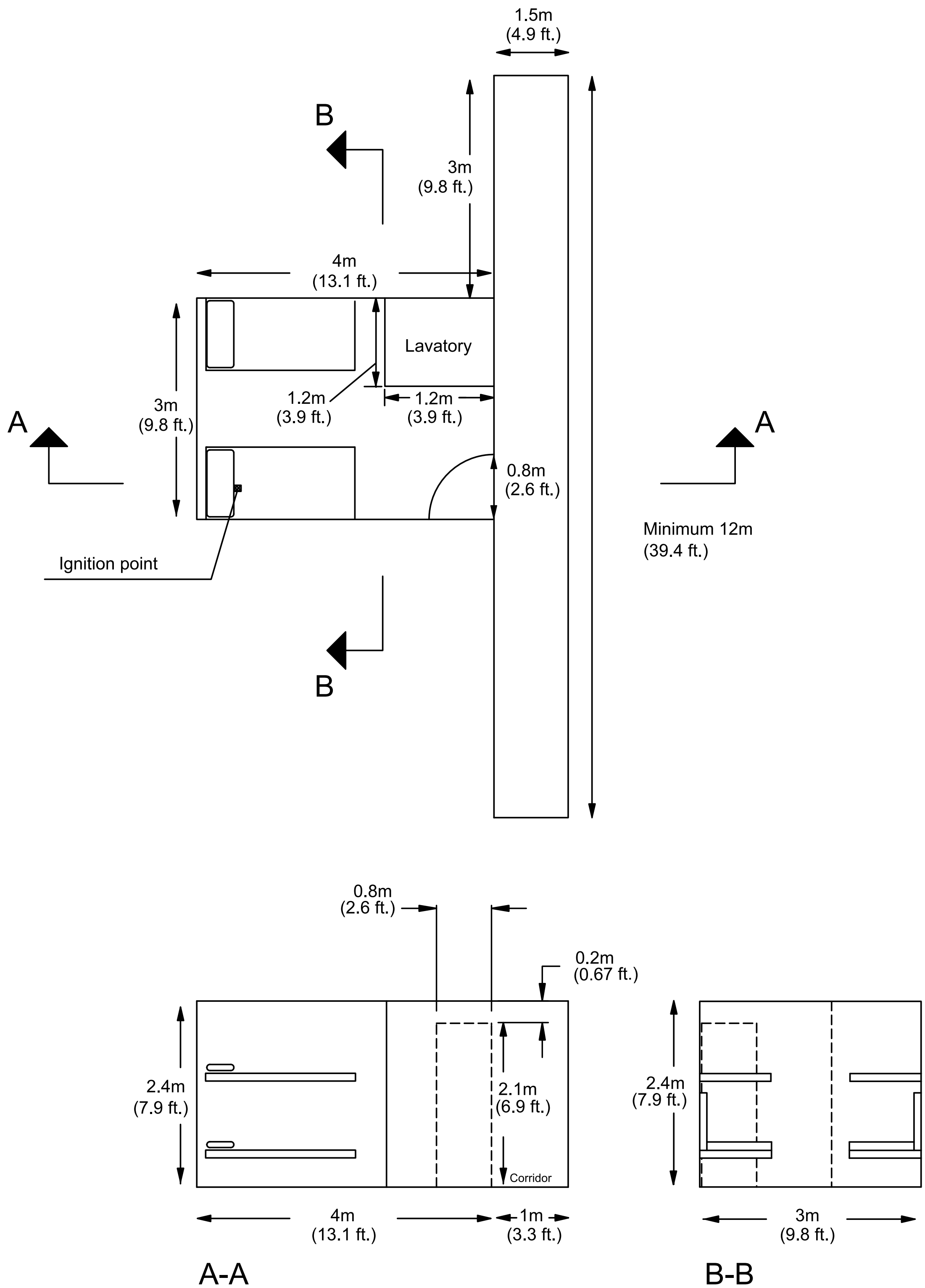
Test	Maximum 30 second average ceiling temperature in cabin		Maximum 30 second average gas temperature in cabin		Maximum 30 second average ceiling temperature in corridor		Maximum damage to fire source, percent	Other criteria
a	360 °C	(680 °F)	320 °C	(608 °F)	120 °C	(248 °F)	40 percent lower bunk bed and 10 percent upper bunk bed	No nozzles in corridor shall operate
b	360 °C	(680 °F)	320 °C	(608 °F)	120 °C	(248 °F)	40 percent upper bunk bed	No nozzles in corridor shall operate
c	–	–	–	–	120 °C	(248 °F)	–	–
d	–	–	–	–	400 °C	(752 °F)	–	–
e – g	–	–	–	–	120 °C	(248 °F)	–	Only nozzles directly above or adjacent to the fire source shall operate

44.3 Test arrangement

44.3.1 The fire tests are to be conducted in a 3 by 4 by 2.4 m (10 by 13 by 8 ft) high cabin centrally connected to a 1.5 by 12 m (5 by 39.4 ft) long corridor 2.4 m (8 ft) high. The walls of the corridor and of the passenger cabin are to be constructed of nominal 12.7 mm (0.5 inch) thick wall board. The cabin is to be provided with one opening, 0.8 m (2.6 ft) wide by 2.2 m (7.2 ft) high with a 0.2 (0.67 ft) lintel above the opening. The cabin is to be provided with a closed window in the wall opposite the corridor for observation purposes during the fire tests. See Figure 44.1.

Figure 44.1

Cabin and Corridor Details



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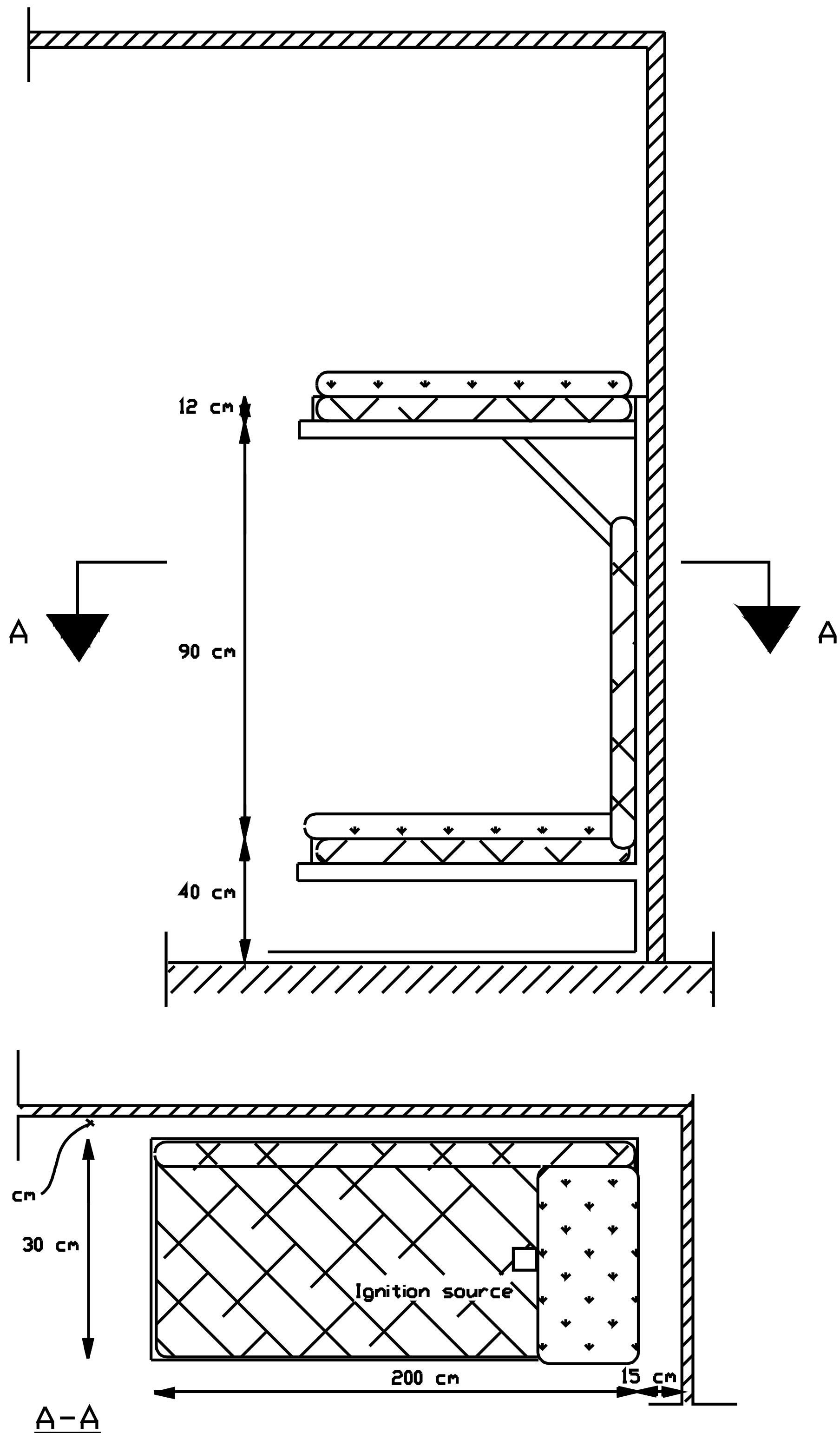
44.3.2 The cabin and corridor ceiling is to be covered with acoustical panels.

The ceiling panels are to be 12 – 15 mm (0.5 – 0.6 inch) thick and have a marked FSI of 25. Plywood panels having a nominal thickness of 3 mm (0.125 inch) and a marked FSI of 200 are to be placed on the walls of the cabin and corridor.

44.3.3 Two pullman type bunk beds with upper and lower bunks are to be installed along opposite walls of the cabin. See Figure 44.1. The frame of the bunk beds shall be of nominal 2 mm (0.08 inch) thick steel. Each bunk bed is to be fitted with 2000 by 800 by 100 mm (79 by 32 by 4 inches) mattresses fabricated from polyether foam and having a cotton fabric cover. Pillows measuring 500 by 800 by 100 mm (20 by 32 by 4 inches) are fabricated from the mattress material. The cut edge shall be positioned toward the doorway. A mattress is to form a backrest for the lower bunk bed and is to be arranged in an upright position to prevent it from falling. See Figure 44.2.

Figure 44.2

Bunk Bed Arrangement



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44.3.4 The mattresses for this test are to be made of non-fire retardant polyether foam having a nominal density of 33 kg/m^3 (2 lb/ft^3). The cotton fabric is to not be fire retardant and is to have an area weight of 140 – 180 g/m^2 (0.3 – 0.4 lb/ft^2). When tested in accordance with ISO/5660-01, Fire Tests – Reaction to Fire – Part 1: Rate of Heat Release from Building Products, (ASTM E1354), the mattress material shall comply with the following criteria:

a) The test conditions shall consist of an irradiance of 35 kW/m^2, a horizontal position, and no frame retainer;

b) Sample size shall be a nominal 100 by 100 by 50 mm (4 by 4 by 2 inches) thick;

c) Time to ignition shall be 4 ±2 seconds;

d) The three minute average (Heat Release Rate) HRR shall be 270 ±50 kW/m^2;

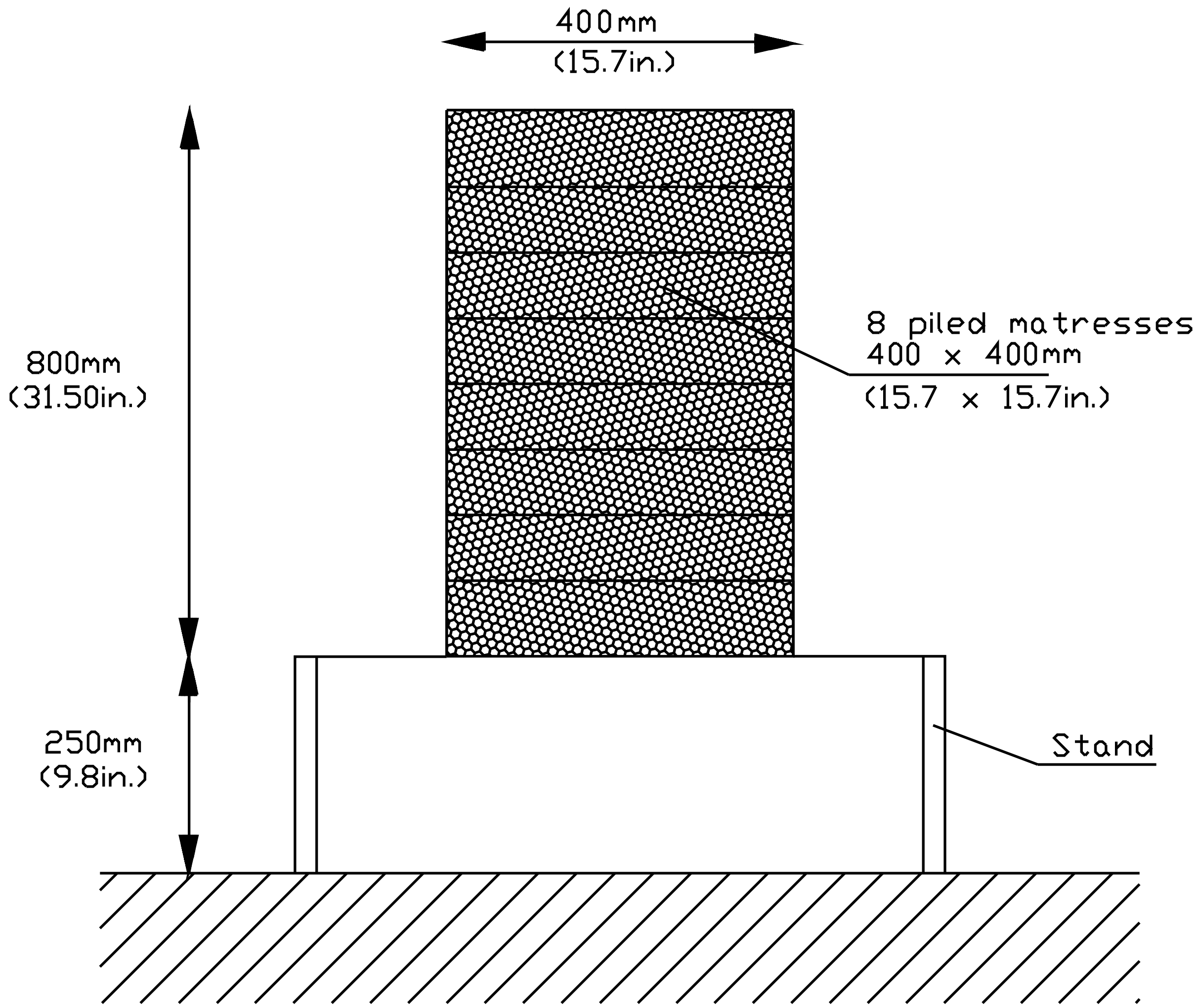
e) Minimum heat of combustion shall be 25 MJ/kg; and

f) Total heat release shall be 50 ±12 MJ/m^2.

44.3.5 The corridor fire test is to be conducted using 8 mattress pieces, fabricated from pure polypropylene oxide polyol, without covers measuring 400 by 400 by 100 mm (16 by 16 by 4 inches) placed on a steel test stand 250 mm (10 inches) high and in a steel test basket to prevent the pile from falling over and positioned under one or between 2 water mist nozzles. See Figure 44.3. For the corridor fire test, the walls and ceiling are to be fitted with plywood panels and ceiling tiles as specified in 44.3.2. The mattress stand is to be positioned 50 mm (2 inches) from one wall. The mattress pieces are to be ignited using a 75 mm (3 inch) cube of insulated fiberboard soaked in 115 ml (4 fl oz) of heptane and placed in a plastic bag. The igniter is to be located in the center at the base of the pile of foam pieces on one side of the test stand.

Figure 44.3

Shipboard Corridor Fire Fuel Package



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44.3.6 The water mist nozzles are to be installed to protect the cabin and corridor in accordance with the manufacturer's design and installation instructions subject to the following:

a) When only one water mist ceiling nozzle is to be installed in the cabin, it is to not be placed in the shaded area of Figure 44.4; and

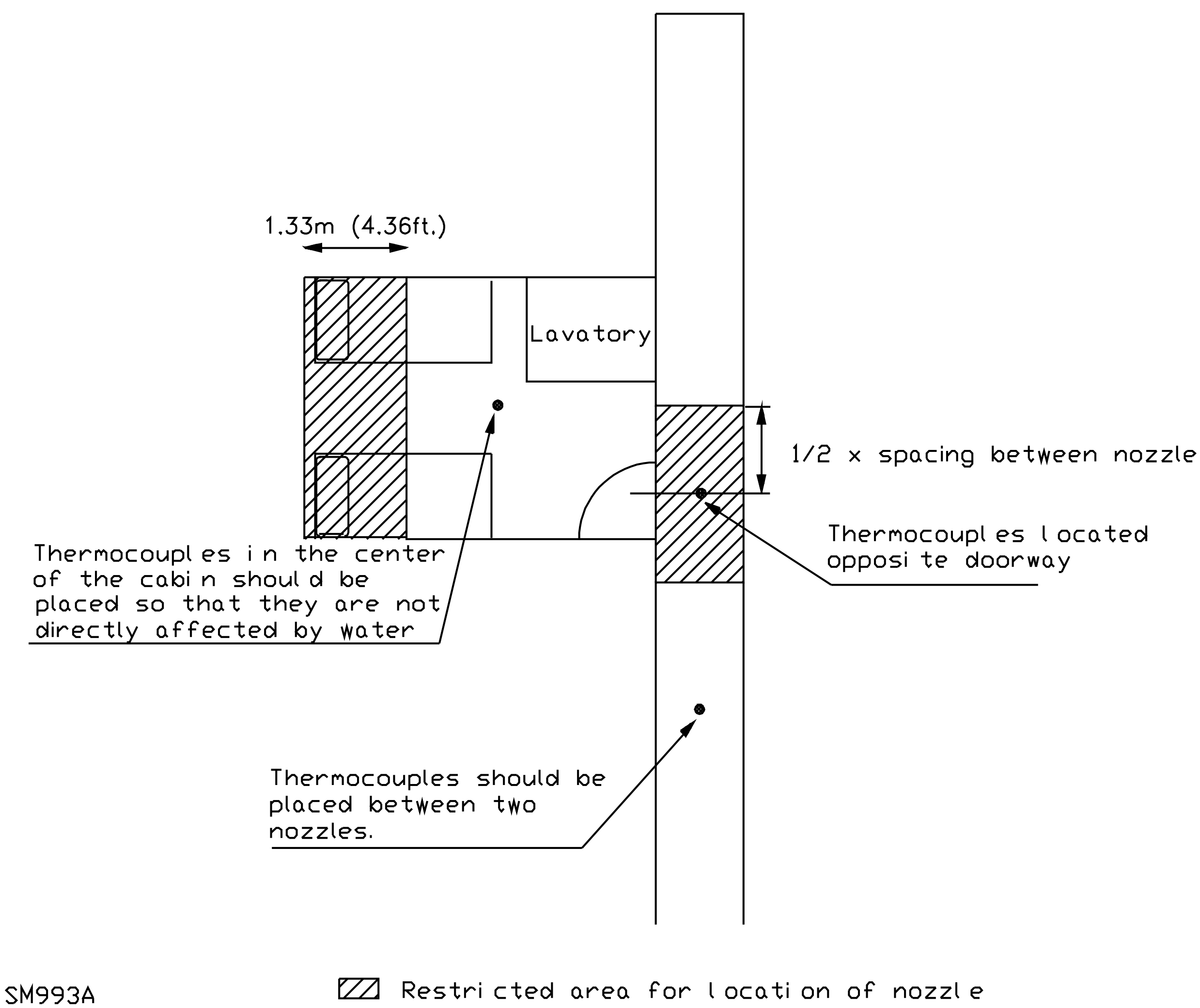
b) Corridor water mist nozzles are to not be placed nearer to the centerline of the cabin doorway than one half the maximum spacing as specified by the manufacturer.

Exception: When the manufacturer's design and installation instructions require a corridor nozzle outside of each cabin doorway, a single nozzle is to be located outside the doorway and additional nozzles are to be placed in the corridor at their maximum spacing.

c) Sidewall nozzles mounted in the cabin are to be installed on the centerline of the front wall adjacent to the doorway, aimed toward to the center of the cabin.

Figure 44.4

Location of Thermocouples in the Cabin/Corridor and Areas Restricted for Location of Nozzles



44.4 Test procedure

44.4.1 During each fire test, the following temperatures are to be recorded at least once every 2 seconds using chromel-alumel thermocouples with a nominal thickness not exceeding 0.5 mm (0.02 inches):

a) The ceiling surface temperatures above the ignition source in the cabin and in the center of the corridor directly opposite the cabin doorway using thermocouples embedded in the ceiling from above such that the thermocouple bead is flush with the ceiling; and

b) The ceiling gas temperature 75 mm (3 inches) below the ceiling in the center of the cabin.

c) For fire test 44.2.1(e), the ceiling surface temperature is to be measured above the fire source.

d) For fire test 44.2.1(f), the ceiling temperature is to be measured in the center of the corridor adjacent to the fire source.

44.4.2 Each fire test is to be conducted for 10 minutes after activation of the first water mist nozzle. After 10 minutes of water application, any fire remaining is to be manually extinguished. Damage to the bunk beds is to be calculated as follows:

a) Lower bunk bed damage is to be determined by adding the quantity of the percent damage of the horizontal mattress and backrest plus 25 percent of the damage to the pillow and dividing the total quantity by 2.25; and

b) Upper bunk bed damage is to be determined by adding the quantity of the percent damage of the horizontal mattress plus 25 percent of the damage to the pillow and dividing the total quantity by 1.25.

44.5 Test observations

44.5.1 The following observations are to be made during each fire test:

a) Ignition time;

b) Water mist nozzle activation time;

c) Time when water flow is shut-off;

d) Damage to fire source;

e) Temperature recordings;

f) Flow rate or flowing pressure at each nozzle versus time; and

g) Total number of operating nozzles.

45 Shipboard Passenger Cabins Greater than 12 m^2

45.1 General

45.1.1 When tested in accordance with 45.2.1 – 45.5.5, water mist nozzles intended to be installed in passenger cabins greater than 12 m^2 (129 ft^2) comply with the following criteria:

a) The maximum ceiling temperature 6.4 mm (1/4 inch) behind the finished ceiling surface shall not exceed 260 °C (500 °F);

b) The maximum temperature 76 mm (3 inches) below the ceiling shall not exceed 316 °C (608 °F);

c) The fire source shall not be completely consumed;

d) There shall be no flashover in the cabin; and

e) The maximum number of nozzles operating in the fire shall not exceed the maximum design specified in the manufacturer's installation instructions.

45.2 Test arrangement

45.2.1 These fire tests are to be conducted in a 2.4 m (8 ft) high room having equal sides and a floor area of at least 24 m^2 (260 ft^2) and not more than 80 m^2 (860 ft^2). The room is to be fitted with doorway openings in two opposite corners of the room. Each opening is to be 0.8 m (2.6 ft) wide and 2.2 m (7.2 ft) high, which provides for a 200 mm (8 inch) lintel above the openings. The walls of the room are to be constructed of nominal 12.7 mm (1/2 inch) thick wall board.

45.2.2 The test room ceiling is to be covered with acoustical tiles or gypsum board attached to furring strips. Acoustical panels used in the 1.2 by 1.2 m (4 by 4 ft) area directly over the fire source are to be 0.6 by 1.2 m (2 by 4 feet), have a density of 216 ±24 kg/m^3 (13.5 ±1.5 lb/ft^3), a nominal thickness of 12.7 mm (1/2 inch), and have a Flame Spread Index of 25 when tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. For each test, new acoustical panels are to be installed in the 1.2 by 1.2 m (4 by 4 ft) area directly over the fire source.

45.2.3 Douglas fir 3-ply panels measuring 1.2 by 2.4 m (4 by 8 ft) 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 by being attached to 12.7 mm (1/2 inch) thick wood furring strips. The panels are to be approximately 6.4 mm (1/4 inch) thick with each ply constructed of Douglas fir. The plywood panels are to be conditioned at 21 ±3 °C (70 ±5 °F) and 50 ±10 percent relative humidity for at least 72 hours prior to test. See Figure 45.1. The Douglas fir plywood panels are to have the burning characteristic properties shown in Table 45.1.

Figure 45.1

Fire Test Arrangement for Passenger Cabins Greater Than 12 m²

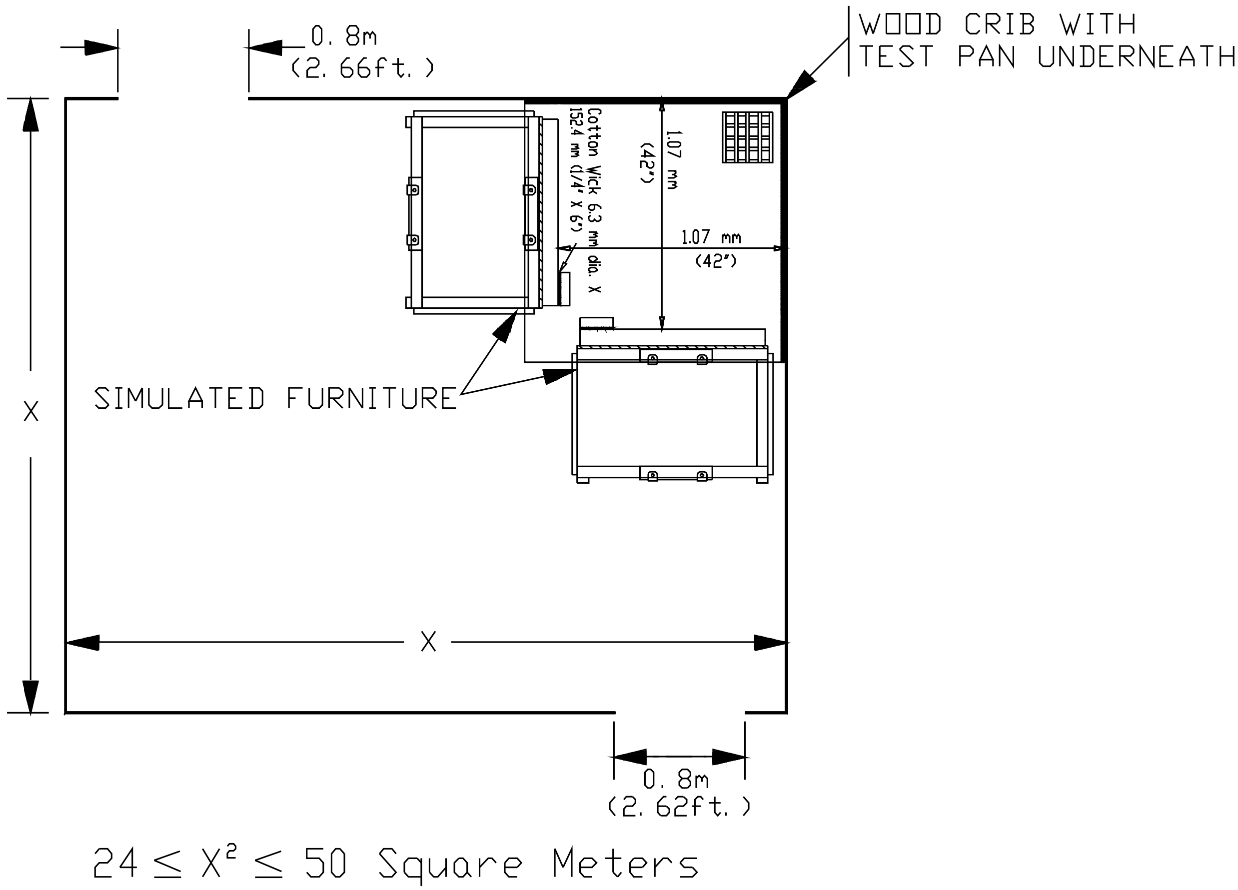


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Table 45.1
Douglas Fir Plywood Panels Burning Characteristic Properties

Property	Test Method	Range
Flame Spread Index	Standard for the Surface Burning Characteristics of Building Materials,UL 723	130 ±30
Critical Heat Flux	Use of Cone Calorimeter at radiant heat fluxes of 25, 35, and 50 kW/m^2	15 ±3 kW/m^2
Thermal Response Parameter	Use of Cone Calorimeter at radiant heat fluxes of 25, 35, and 50 kW/m^2	220 ±50 $kW(s^{0.5})/m^2$

45.3 Fire source

45.3.1 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 15 cm (6 inch) long by 6.4 mm (1/4 inch) diameter cotton wicks soaked in heptane. See Figure 45.1 for fire source placement in the test room.

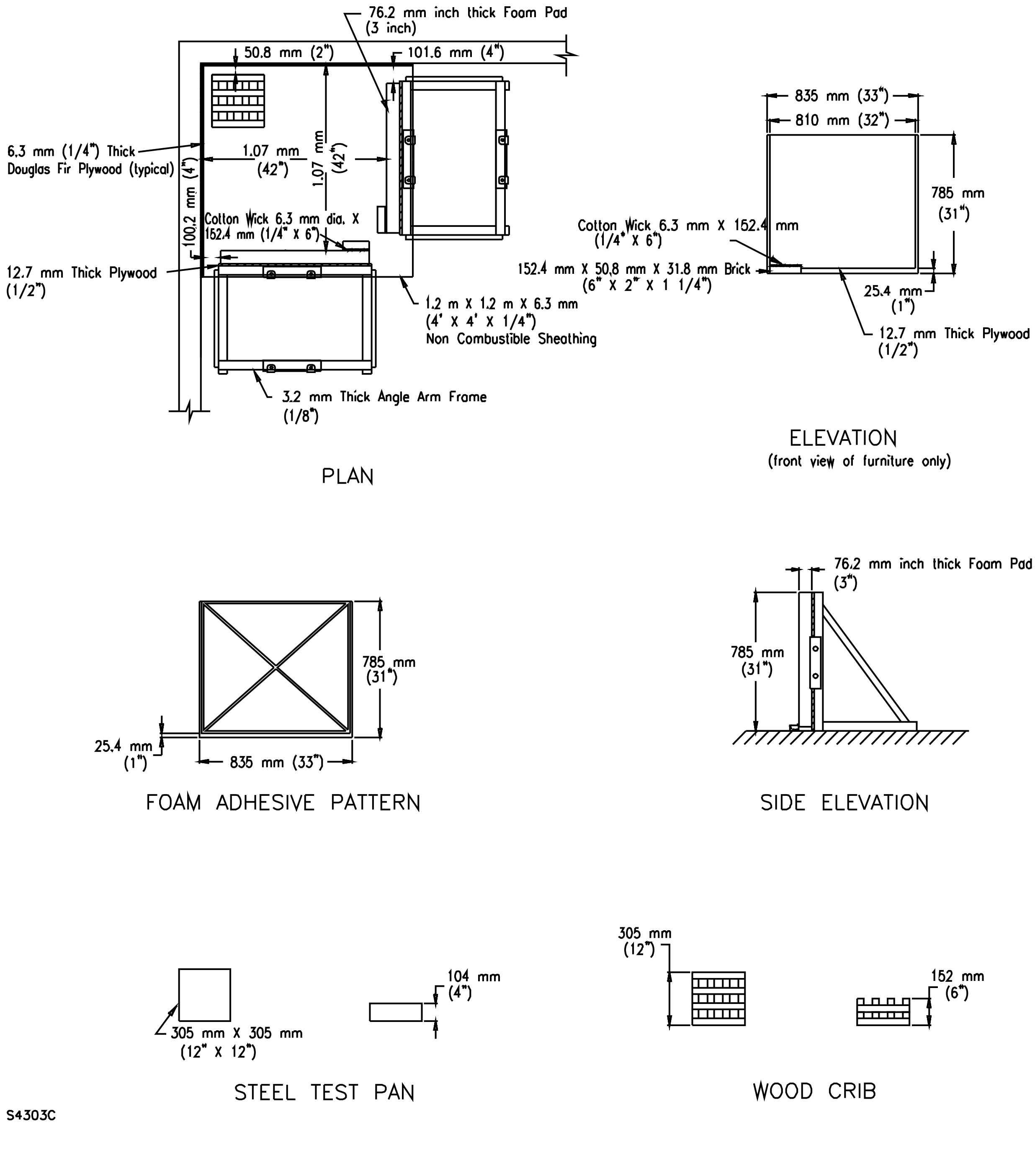
45.3.2 The wood crib is to weigh 2.5 to 3.2 kg (5.5 to 7 lbs) and is to be dimensioned 305 by 305 by 152 mm (12 by 12 by 6 inches) high. The crib is to consist of four alternate layers of four trade size 38.1 by 38.1 mm (1-1/2 by 1-1/2 inch) kiln-dried spruce or fir lumber 305 mm (12 inches) long. The 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.

45.3.3 After the wood crib is assembled, it is to be conditioned at a temperature of 104 ±5 °C (220 ±9 °F) for not less than 24 hours or more than 72 hours. Following the conditioning, the crib is to be placed in a plastic bag and stored at room temperature for at least 4 hours before being used in a test.

45.3.4 The wood crib is to be placed on top of a nominal 300 by 300 by 100 mm (12 by 12 by 4 inch) high, 2.5 mm (0.10 inch) thick, steel test pan positioned on the floor near a corner of the test enclosure. The wood crib is to be positioned 50 mm (2 inches) from each wall. See Figure 45.2.

Figure 45.2

Fire Test Crib and Simulated Furniture Fuel Package



45.3.5 The simulated furniture is to consist of two 76 mm (3 inches) thick uncovered pure polypropylene oxide polyol foam cushions having a density of 27.2 to 30.4 kg/m^3 (1.70 to 1.90 lb/ft^3) and measure 760 by 810 mm (30 by 32 inches). Each foam cushion is to be glued to a 790 by 840 mm (31 by 33 inches) nominal 12.7 mm (1/2 inch) thick plywood backing using an aerosol urethane foam adhesive. The foam cushion is glued to the plywood backing as illustrated in Figure 45.2 leaving a 12.7 mm (1/2 inch) spacing on both sides and a 25 mm (1 inch) spacing along the bottom. The foam cushion and plywood backing assembly is to be conditioned at 21 ±2.8 °C (70 ±5 °F) and 50 ±10 percent relative humidity for at least 24 hours. Prior to each test, the foam and plywood backing assembly is to be removed from the conditioning chamber and 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 shown in Table 45.2.

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

Table 45.2
Polyether Foam Burning Characteristic Properties

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 a 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	22 ±3 kJ/g

45.4 Nozzle installation

45.4.1 Water mist nozzles are to be installed in the test room for each fire test in accordance with the manufacturer's design and installation instructions.

Each nozzle shall be equipped with the same heat responsive element and temperature rating. Nozzles are to be installed with their deflector/spray orifices located 75 mm (3 inches) below the ceiling or as specified in the manufacturer's design and installation instructions. The distance between the outer nozzles and the closest wall of the cabin shall be one-half the maximum spacing between nozzles specified in the manufacturer's design and installation instructions. The distance between nozzles is to be the maximum specified in the manufacturer's design and installation instructions.

45.4.2 Nozzles are to be positioned with their frame arms parallel and perpendicular to the cabin walls unless the lightest discharge orientation is readily identifiable or when the spray pattern of the nozzles are demonstrated to be equivalent in both orientations. Nozzles without frame arms are to be oriented so that the lightest discharge density as determined in the Water Distribution Test, Section 15 is directed toward the fire area.

45.5 Test procedure

45.5.1 The test room is to have a starting ambient temperature of 27 ±3 °C (81 ±5 °F) measured at a thermocouple located 76 mm (3 inches) below the ceiling within 0.2 m (7.9 inches) horizontally from the nozzle closest to the corner with the fuel package. The acoustical panel ceiling material temperature is to be measured above the center of the wood crib using a thermocouple embedded 6.5 mm (0.25 inches) into the ceiling tile. All water from previous testing shall be removed such that there is no visible water on the floor, ceiling, or walls.

45.5.2 The temperatures at each thermocouple location are to be continuously recorded during the test using 0.8 mm (0.03 inch), chromel-alumel thermocouples. The thermocouples are to be shielded from impingement of water from the nozzle discharge and are to be made by being twisted 3 times and a bead is to be formed using an oxyacetylene torch, or other equivalent means of measuring temperature.

45.5.3 One-half liter (16 oz) of water and 0.24 L (8 oz) of heptane are to be placed in a pan directly below the wood crib located 50 mm (2 inches) from the wall panels. The heptane in the pan located beneath the crib is to be ignited and the heptane soaked cotton wicks are to be ignited immediately following the heptane pan ignition.

45.5.4 The fire test is to be conducted for 10 minutes after the ignition of the wood crib.

45.5.5 The water flow rate to the nozzles is to be the minimum design flow rate specified in the manufacturer's design and installation instructions. The minimum nozzle flow rating shall be the same for single and multiple operating nozzles. The test is to be repeated using the maximum design flow rate specified in the manufacturer's design and installation instructions.

46 Shipboard Public Space Fire Tests

46.1 General

46.1.1 Water mist nozzles intended for the protection of shipboard light hazard public spaces shall comply with the fire tests described in 46.2. Nozzles which are intended for use in shipboard ordinary hazard areas of public spaces shall also comply with the fire tests described in 46.2 and 46.3.

46.2 Shipboard light hazard areas

46.2.1 When tested as described in 46.2, water mist nozzles installed to protect shipboard light hazard areas shall comply with the following:

a) The open public space fire as described in 46.2 shall be suppressed or controlled as evidenced by no more than a 50 percent consumption of the mattresses in any single test or an average loss not greater than 35 percent in any series of open or corner fire tests conducted at the same ceiling height excluding the disabled nozzle fire test;

b) There shall be no ignition or charring of either target sofa in the corner public space fire test described in 46.2.3 ;

c) There shall be no more than 70 percent consumption of the mattresses during the open space disabled nozzle test; and

d) The maximum 30 second average ceiling surface temperature above ignition, measured using a thermocouple embedded on the ceiling such that its bead is flush with the ceiling, shall not exceed 360 °C (680 °F). The maximum 30 second average ceiling gas temperature, measured 75 ±1 mm (3 inches) below the ceiling, shall not exceed 220 °C (428 °F) when measured:

1) In four locations 1.8 m (5.9 ft) in a radius from ignition, orientated 90° relative to each other, for the open area public space fire tests; and

2) 0.2 m (8 inches) horizontally outward from the nozzle closest to the corner for the corner public space fire tests.

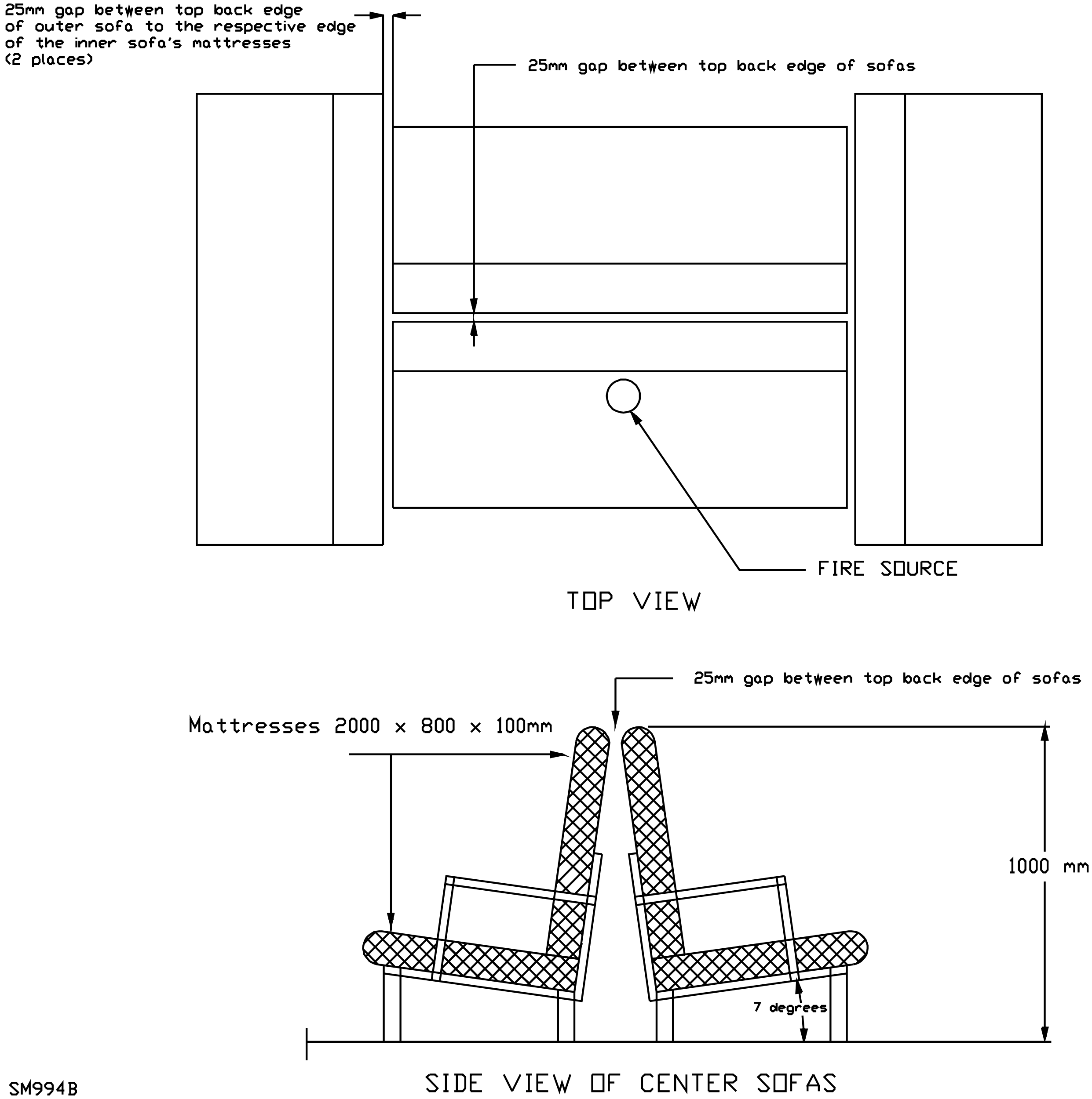
46.2.2 The open area public space fire tests are to be conducted in a test room fitted with a ceiling at least 80 m^2 (860 ft^2) in area with no dimension less than 8 m (26 ft). The ceiling shall be non-combustible except that at least a 1 m^2 (10.8 ft^2) area above the ignition is to be covered with cellulosic acoustical ceiling tiles having a marked FSI of 25. The acoustical panels are to have a nominal thickness of 12 to 16 mm (0.50 to 0.62 inches). A minimum 1.0 m (3.3 ft) space between the perimeter of the ceiling and any wall of the building shall be provided for the venting of gases. The public space fire tests are to be conducted with a ceiling height of 2.5 m (8.2 ft) for one set of tests and at 5 m (16.4 ft) for the second set of tests.

46.2.3 The public space corner fire tests are to be conducted in a corner constructed by two 4.8 m (15.7 ft) wide wallboard walls. Douglas fir 3-ply panels as described in 45.2.3 and Figure 45.1 or plywood panels having a nominal thickness of 3 mm (0.125 inches) thick and a marked FSI of 200 are to be placed on the walls. The ceiling is to be fitted with cellulosic acoustical ceiling tiles having a marked FSI of 25 at least 3.6 m (12 ft) from each corner wall. The acoustical panels are to have a nominal thickness of 12 to 16 mm (0.50 to 0.62 inches).

46.2.4 The open area public space fire tests are to be conducted under the center of the ceiling. The fire source consists of four sofas constructed from 2000 by 800 by 100 mm (79 by 32 by 4 inches) non fire-retardant polyether mattresses fitted with a non fire-retardant fabric cover. Specifications for the mattresses and cover are described in 44.3.4. Each sofa is to include two mattresses. The sofas are to be structurally supported with rectangular bottom and backrest steel frames constructed of angle, square or rectangular steel stock having a thickness not less than 3 mm (0.12 inch). The dimensions of the bottom frame is to be 2000 by 700 mm (79 by 28 inches) and the dimensions of the back rest is to be 2000 by 725 mm (79 by 29 inches). The bottom and backrest mattresses are to be supported on the frame with three 25 ±5 mm (1.0 ±0.2 inches) wide steel stock spaced 500 mm (20 inches) apart front to back for the bottom mattress and top to bottom for the back rest. An additional steel support of the same steel stock is to be installed for the full 2000 mm (79 inches) sofa length at the midpoint of the bottom and backrest frames. The support members are to be welded to the frames. A means such as a small steel plate located directly below the ignitor shall be provided to keep the ignitor in the intended position,. Each sofa shall have a rectangular armrest on each end. The armrests are to be constructed of similar steel stock and are to be approximately 600 mm (24 inches) in length and 300 mm (12 inches) in height. The rear section of the armrest shall be attached to the bottom frame approximately 70 mm (2.9 inches) from the backrest. The assembled frames shall be supported by four legs of similar steel stock. The two rear legs are to be 205 mm (8 inches) in height and the front legs are to be 270 mm (11 inches) in height. The bottom mattress is to be installed first with its long edge located against the backrest frame and then the mattress for the backrest is to be installed. The backrest mattress shall be supported to maintain their vertical orientation during fire testing by means such as restraining hooks or the like. See Figure 48.1. The sofas are to be arranged and spaced 25 mm (1 inch) apart as shown in Figure 46.1. The ignition location is to be centered under one nozzle for the first fire test, centered between two nozzles for the second fire test, and centered between four nozzles for the third fire test. For the fire test between two nozzles, the nozzles should be located in a plane perpendicular to the longitudinal flue space between the two center sofas. For the disabled nozzle test, the ignition is to be located directly under the disabled nozzle.

Figure 46.1

Fire Test Arrangement



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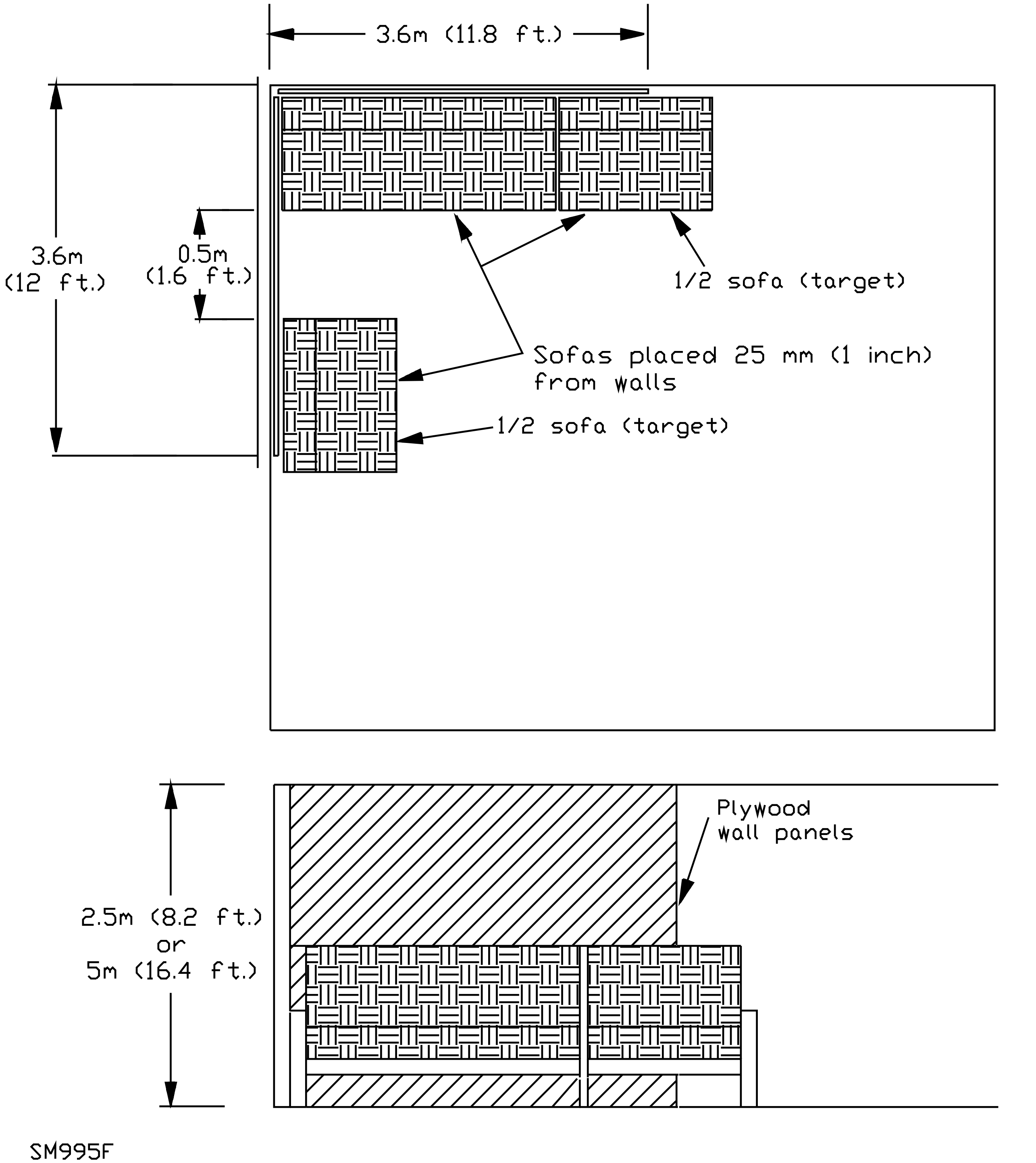
46.2.5 The ignition source is to consist of a porous material such as insulating fiberboard. The ignitor dimensions are to be a nominal a 75 mm (3 inch) square cube or circular shape having a length of 75 mm (3 inches) that is to be soaked in 120 ml (4 fl oz) of heptane and placed in a plastic bag. The bag is to then be placed in the center of the bottom mattress (seat cushion) of one of the sofas. See Figure 46.1.

46.2.6 For the corner public space fire tests, the fire source is to consist of one full sofa and two half target sofas constructed from 2000 by 800 by 100 mm (79 by 32 by 4 inch) polyether mattresses fitted with a cotton fabric cover. See 44.3.4 for mattress and cover specifications. The sofas are to be positioned in the corner of a test enclosure fitted with combustible wall paneling and ceiling tile. The primary corner sofa is to be placed with the backrest 25 mm (1 inch) from the wall with one of the target sofas located 100 mm (4 inches) from this sofa on the right side and the other target sofa located 500 mm (20 inches) from primary corner sofa on the left side. The sofas are to be arranged as shown in Figure 46.2. The igniter described 46.2.5 is to be placed on the full sofa up against the backrest and adjacent to the corner wall.

Figure 46.2

Corner Fire Test Arrangement



46.2.7 For the open area test, a minimum of 16 nozzles are to be installed at their maximum spacing. For the corner test, a minimum of four nozzles shall be installed in a 2 by 2 arrangement. Water mist nozzles are to be installed below the ceiling at the maximum spacing specified in the manufacturer's design and installation instructions. The distance between the perimeter nozzles and the corner walls shall be one-half the maximum spacing specified in the manufacturer design and installation instructions. For nozzles with frame arms, tests are to be conducted with the frame arms positioned both perpendicular and parallel to the system supply piping, unless the lightest discharge orientation is readily identifiable or when the spray patterns of the nozzles are demonstrated to be equivalent in both orientations. Nozzles without frame arms shall be orientated so that the lightest discharge density, as determined visually or by the Water Distribution Test, Section 15, is directed towards the fire area.

46.2.8 Water is to be applied at the minimum operating pressure specified in the manufacturer's design and installation instructions for 10 minutes after operation of the first nozzle. The water flow and operating pressure is to be monitored during each test.

46.2.9 The following observations are to be made during each test:

a) Time of ignition;

b) Activation times of each nozzle;

c) Nozzle flowing pressure or water flow rate;

d) Time of flashover, when it occurs;

e) Time when target sofas ignite;

f) Time when water is shut-off;

g) Description of damage to each mattress, walls, and ceiling; and

h) Total quantity of water used.

46.3 Shipboard ordinary hazard areas

46.3.1 Water mist nozzles installed to protect shipboard ordinary hazard areas, such as storage rooms and shopping areas, shall comply with the following:

a) No ignition or charring of target cartons;

b) Limit damage to no more than 50 percent of the plastic cups in the fire source cartons; and

c) Ceiling steel temperatures shall not exceed 540 °C (1000 °F) for more than 5 minutes. When the temperature exceeds 540 °C for between 1 and 5 minutes, the use of a non-combustible ceiling construction shall be specified in the manufacturer's design and installation instructions.

46.3.2 For the test arrangement, the fire tests are to be in a test room having a ceiling at least 80 m^2 (860 ft^2) in area with no dimension less than 8 m (26 ft). The ceiling is to be covered over the fire area with noncombustible panels and set at a height of 2.5 m (8.2 ft). These panels are to be nominally 600 by 1220 by 12.7 mm (24 by 48 by 0.5 inches) thick.

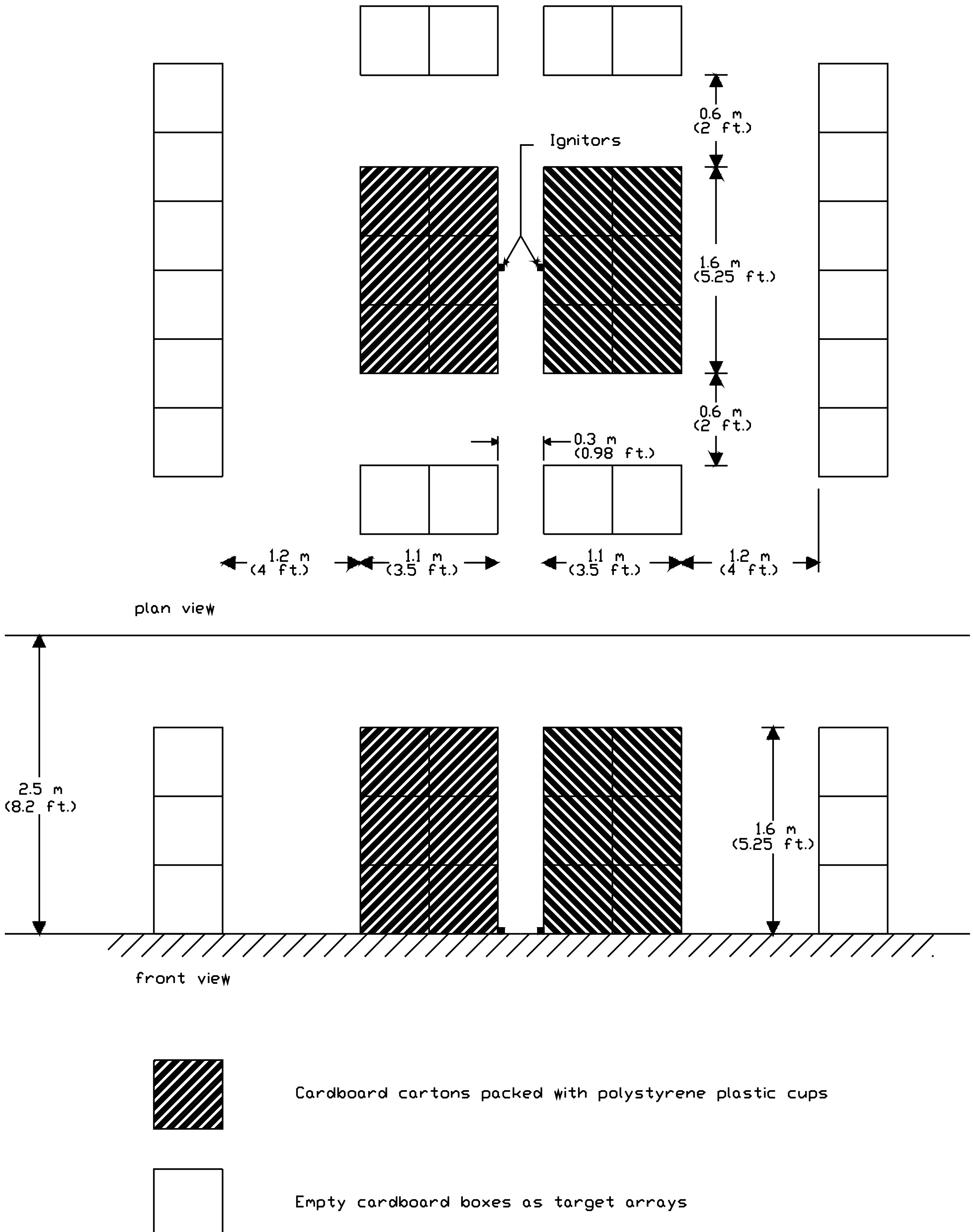
46.3.3 Thermocouples are to be positioned adjacent to each nozzle to record the nozzle operating times. Thermocouples shall also be centered above ignition 50 mm (2 inches) below the ceiling and with the thermocouple bead flush with the ceiling. To record steel beam temperatures, a steel beam is to be fitted with 5 thermocouples embedded half way into the beam. One thermocouple is to be centered and the other 4 positioned 25 and 45 mm (9 and 18 inches) from the center position.

46.3.4 For nozzles with frame arms, tests are to be conducted with the frame arms positioned both perpendicular and parallel to the system supply piping, unless the lightest discharge orientation is readily identified or when the spray patterns of the nozzles are demonstrated to be equivalent in both orientations. For nozzles without frame arms, the nozzles are to be oriented so that the lightest discharge density, as determined by the Water Distribution Test, Section 15, is directed towards the fire area.

46.3.5 The fire source is to consist of two piled stacks of corrugated cartons which are 2 wide by 3 long by 3 high (shown in Figure 46.3) and are packed with polystyrene unexpanded plastic cups with a 300 mm (12 inch) flue space. Each carton is to have nominal dimensions of 530 by 530 by 530 mm (21 by 21 by 21 inches) high and is to contain 125 nominal one-half liter (16 fl oz) capacity polystyrene cups consisting of 5 layers of 25 cups with each cup in an individual compartment formed by cardboard separators. The total weight of each carton is to be 6.4 ±0.4 kg (14 ±1 lb) of which 3.6 ±0.3 kg (8 ±0.7 lb) is the weight of the plastic cups.

Figure 46.3

Shipboard Ordinary Hazard Test Arrangement



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46.3.6 Six 1.6 m (63 inch) high arrays of empty corrugated cartons are to be arranged on each side of the plastic cup array as shown in Figure 46.3. The cartons shall be stabilized to prevent displacement.

46.3.7 The fire test is to be conducted with the ignition under one and centered between two and four nozzles. For tests between two nozzles, the nozzles should be located in a plane perpendicular to the longitudinal flue space. The fire is to be ignited using two 75 mm (3 inch) cubes of fiberboard. Each cube is to be soaked in 120 ml (4 fl oz) of heptane and wrapped in a plastic bag. The igniters are to be placed on the floor, each against the base of one of the two central stacks and simultaneously ignited. See Figure 46.3. Water is to be applied at the minimum operating pressure specified in the manufacturer's design and installation instructions for 10 minutes after operation of the first nozzle. Immediately after the test has been terminated, the fire is to be manually extinguished.

47 Residential Dwelling Units Fire Tests

47.1 General

47.1.1 When tested as described in 47.2 – 47.4 using the minimum (not less than 2.4 m [8 ft.]) and maximum ceiling heights specified by the manufacturer, water mist nozzles intended for use in dwelling units shall limit temperatures as specified in (a) – (d) and operate no more than one nozzle. During the fire test, the nozzles shall limit temperatures as follows:

a) The maximum temperature 76 mm (3 inches) below the ceiling at either location as illustrated in Figure 47.1 – Figure 47.3 shall not exceed 316 °C (600 °F);

b) The maximum temperature at the location 1.6 m (63 inches) above the floor shall not exceed 93 °C (200 °F);

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

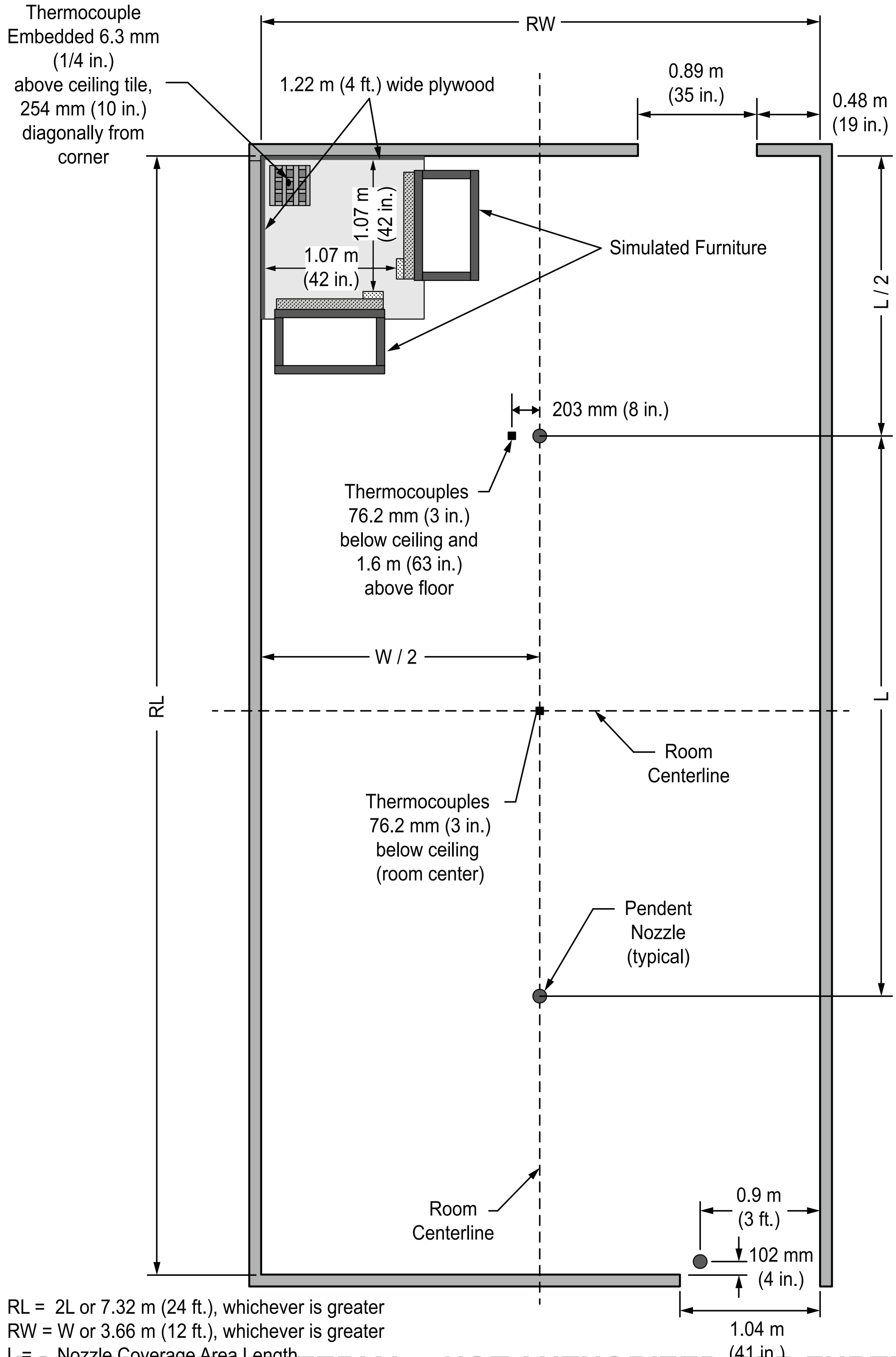
d) The maximum ceiling material temperature 6 mm (0.25 inches) behind the finished ceiling surface directly over the center of the wood crib shall not exceed 260 °C (500 °F).

47.2 Test arrangement

47.2.1 Water mist nozzles in each temperature rating are to be subjected to the tests described in 47.2.2 – 47.2.9. See Figure 47.1 for the test arrangement to be used for pendent style nozzles and Figure 47.2 and Figure 47.3 for sidewall style nozzles.

Figure 47.1

Residential Area Fire Test Arrangement – Pendent Style Nozzles

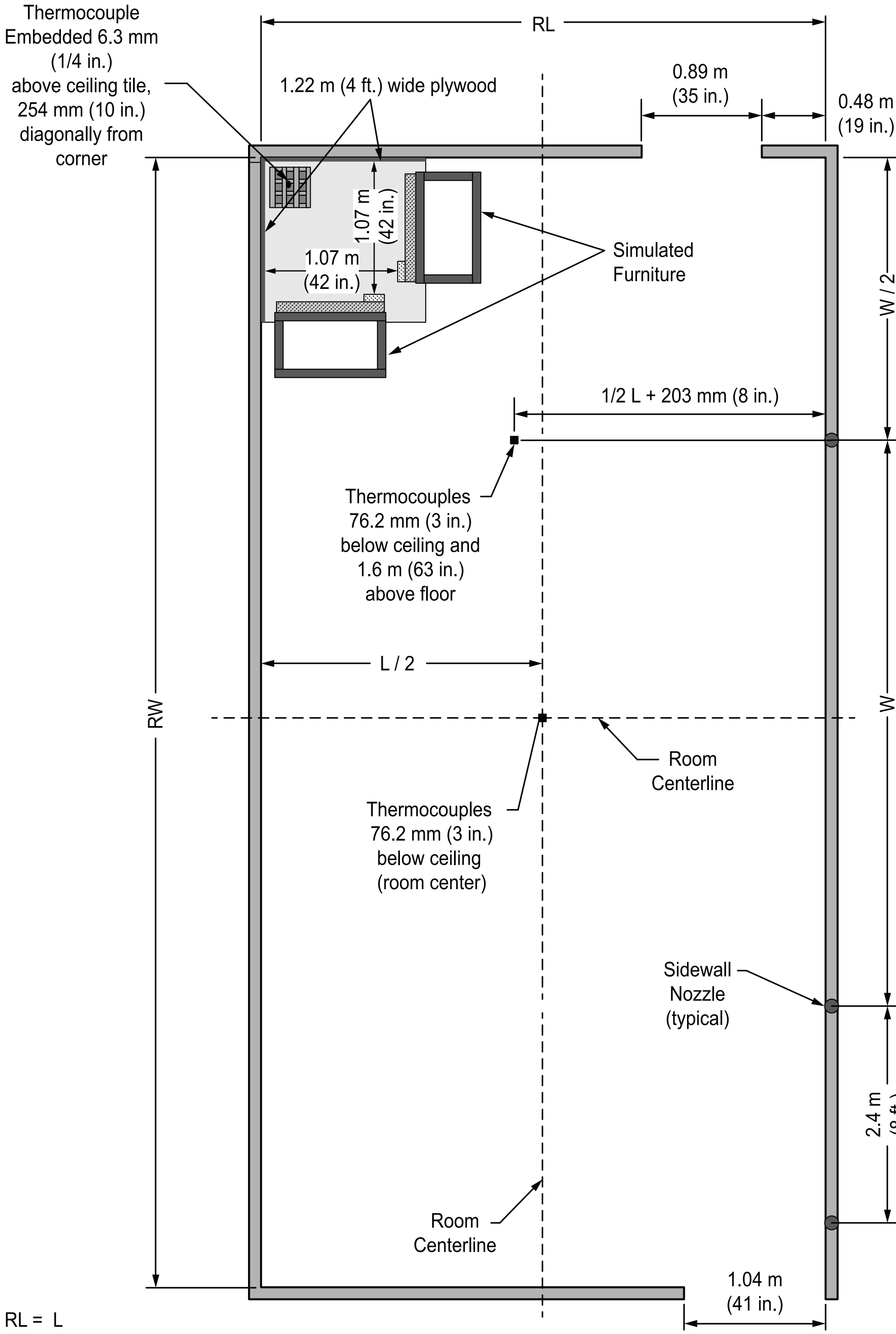


RL = 2L or 7.32 m (24 ft.), whichever is greater
RW = W or 3.66 m (12 ft.), whichever is greater
L = Nozzle Coverage Area Length
W = Nozzle Coverage Area Width

su1203

Figure 47.2

Residential Area Fire Test Arrangement No. 1 – Sidewall Style Nozzles



RL = L

RW = 1-1/2 W + 2.74 m (9 ft.) or 8.23 m (27 ft.), whichever is greater

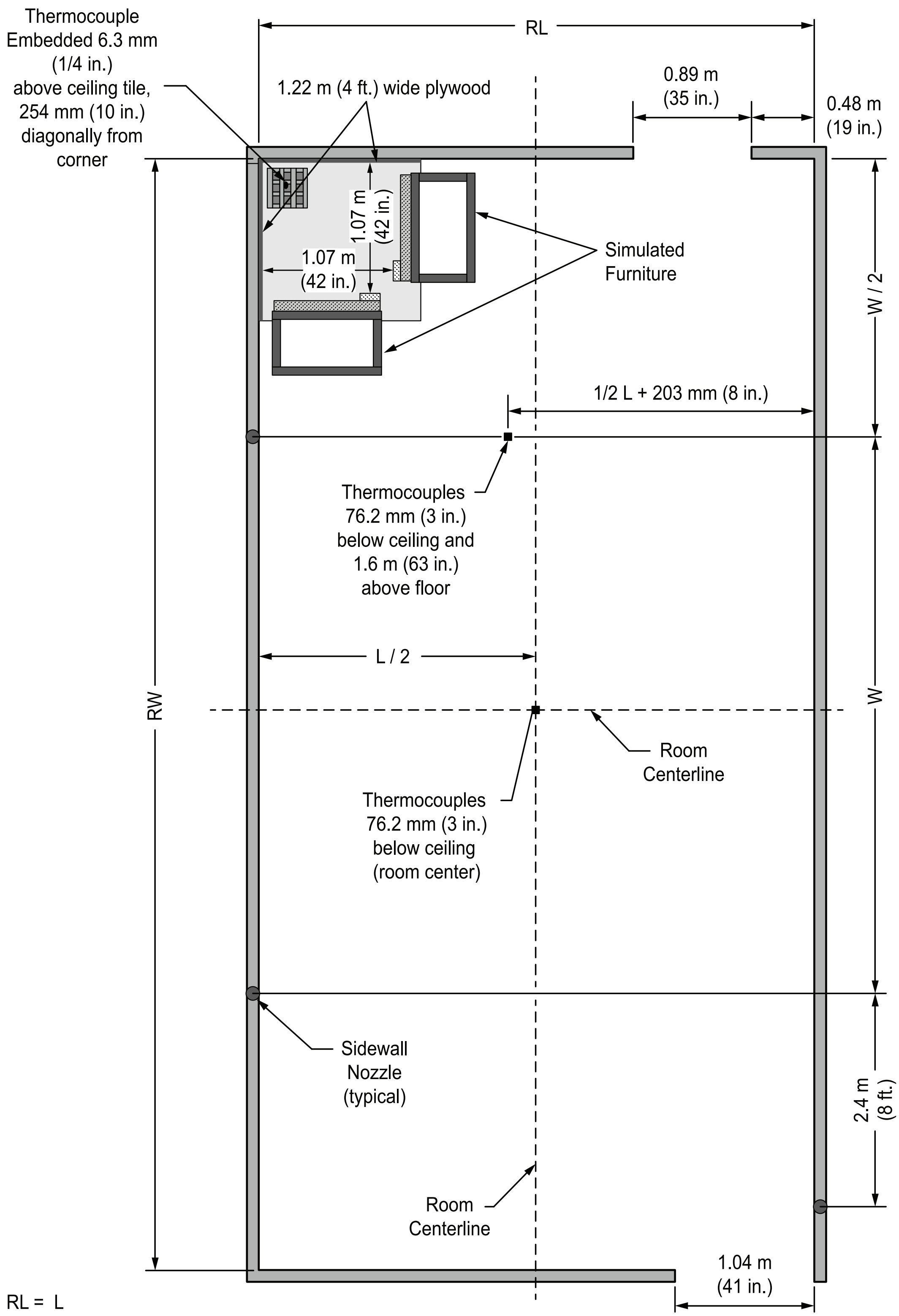
L = Nozzle Coverage Area Length

W = Nozzle Coverage Area Width

su1204

Figure 47.3

Residential Area Fire Test Arrangement No. 2 – Sidewall Style Nozzles



RL = L

RW = 1-1/2 W + 2.74 m (9 ft.) or 8.23 m (27 ft.), whichever is greater

L = Nozzle Coverage Area Length

W = Nozzle Coverage Area Width

su1205

47.2.2 Tests shall be conducted in a test room having dimensions as specified in Figure 47.1 for pendent style nozzles and Figure 47.2 and Figure 47.3 for sidewall style nozzles.

47.2.3 The test room ceiling is to be covered with acoustical panels or gypsum board attached to furring strips. Acoustical panels used in the 1.2 by 1.2 m (4 by 4 ft) area directly over the fire source are to be 0.6 by 1.2 m (2 by 4 feet), have a density of 216 ±24 kg/m^3 (13.5 ±1.5 lb/ft^3), a thickness of 12.7 mm (1/2 inch), and have a Flame Spread Index of 25 when tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. For each test, new acoustical panels are to be installed in the 1.2 by 1.2 m (4 by 4 ft) area directly over the fire source.

47.2.4 The test room is to have provisions for ventilation through two door openings on opposite test room walls. Each opening is to be 2.2 m (7.3 ft) high. The door widths are to be in accordance with Figure 47.1, Figure 47.2, and Figure 47.3.

47.2.5 Douglas fir 3-ply panels measuring 1.2 by 2.4 m (4 by 8 ft) are to be placed on two of the test room walls extending from a common corner. For tests using a 2.4 m (8 ft) high ceiling, one panel is to be placed on each wall. For taller ceilings, the 1.2 m (4 ft) wide fir panel on each wall shall be extended to a maximum height of 4.9 m (16 ft). The panels are to be approximately 6.4 mm (1/4 inch) thick with each ply constructed of Douglas fir. The plywood panels are to be conditioned at 21 ±3 °C (70 ±5 °F) and 50 ±10 percent relative humidity for at least 72 hours prior to test. They are to be placed on the walls by being attached to 12.7 mm (1/2 inch) thick wood furring strips. The Douglas fir plywood panels are to have the burning characteristic properties shown in Table 45.1.

47.2.6 Two automatic nozzles are to be installed and pressurized in the test room for each fire test in accordance with the manufacturer's design and installation instructions. The nozzles are to be installed with their heat responsive element located 76 mm (3 inches) below the ceiling or as specified in the manufacturer's design and installation instructions. A third unpressurized nozzle installed near the doorway shall be as follows:

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

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

1) 51 mm (2 inches) below the ceiling for pendent style nozzles; and

2) 102 mm (4 inches) below the ceiling and 51 mm (2 inches) from the wall for sidewall style nozzles.

47.2.7 For pendent style nozzles, the nozzle closest to the corner with the fire source is to be oriented with the plane of the frame arms parallel to the rear wall for the first series of tests. When the nozzle does not have frame arms, it is to be oriented with the least amount of water directed toward the corner with the fuel package. The second nozzle is to be oriented parallel to the first nozzle. The tests are to be repeated with the nozzle with frame arms rotated 90 degrees counter clockwise. For a nozzle without frames, the second series of tests is to be conducted with the nozzle orientated such that the greatest amount water is directed toward the corner with the fuel package.

47.2.8 For sidewall style nozzles, the nozzles shall be tested using both test arrangements referenced in Figure 47.2 and Figure 47.3, in a manner as follows:

a) With its heat responsive element located 102 mm (4 inches) below the ceiling;

b) With its heat responsive element located at the minimum distance below the ceiling as specified in the installation instructions if the minimum distance is less than 102 mm (4 inches); and

c) With its heat responsive element located at the maximum distance below the ceiling as specified in the installation instructions if the maximum distance exceeds 151 mm (6 inches) below the ceiling.

47.2.9 For both pendent and sidewall style nozzles, tests are to be conducted at both the minimum and maximum operating pressures, or, if intended to be connected to a declining pressure source, following a declining pressure curve.

47.3 Fire source

47.3.1 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 15 cm (6 inch) long by 6.4 mm (1/4 inch) diameter cotton wicks soaked in heptane.

47.3.2 The wood crib is to weigh 2.5 to 3.2 kg and is to be dimensioned 305 by 305 by 152 mm (12 by 12 by 6 inches) high. The crib is to consist of four alternate layers of four trade size 38.1 by 38.1 mm (1-1/2 by 1-1/2 inch) kiln-dried spruce or fir lumber 305 mm (12 inch) 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.

47.3.3 After the wood crib is assembled, it is to be conditioned at a temperature of 104 ±5 °C (220 ±9 °F) for not less than 24 hours or more than 72 hours. Following the conditioning, the crib is to be placed in a plastic bag and stored at room temperature for at least 4 hours before being used in a test. The wood crib is to be placed on top of a nominal 300 by 300 by 100 mm (12 by 12 by 4 inch) high, 2.5 mm (0.010 inch) thick, steel test pan positioned on the floor near a corner of the test enclosure. The wood crib is to be positioned 50 mm (2 inches) from each wall.

47.3.4 The simulated furniture is to consist of two 76 mm (3 inch) thick uncovered pure polypropylene oxide polyol, polyether foam cushions having a density of 27.2 to 30.4 kg/m^3 (1.70 to 1.90 lb/ft^3) and measure 760 by 810 mm (30 by 32 inches). Each foam cushion is to be glued to a 790 by 840 mm (31 by 33 inch) nominal 12.7 mm (1/2 inch) plywood backing using an aerosol urethane foam adhesive. The foam pad is glued to the plywood backing as illustrated in Figure 45.2 leaving a 12.7 mm (1/2 inch) spacing on both sides and a 25 mm (1 inch) spacing along the bottom. The foam cushion and plywood backing assembly is to be conditioned at 21 ±2.8 °C (70 ±5 °F) and 50 ±10 percent relative humidity for at least 24 hours. Prior to each test, the foam and plywood backing assembly is to be removed from the conditioning chamber and 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 shown in Table 45.2.

47.3.5 The entire fire test package is to be placed on top of a 6 mm (1/4 inch) thick cement board sheathing or equivalent noncombustible sheathing material having dimensions of 1.2 by 1.2 m (4 by 4 feet). For each test, a new or dried sheathing shall be used.

47.4 Test method

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

47.4.2 The temperatures at each thermocouple location are to be continuously recorded during the test using 0.81 mm diameter (20 AWG) chromel-alumel thermocouples or thermocouples providing equivalent temperature measuring results. The thermocouples are to be shielded from impingement of water from the nozzles.

47.4.3 One-half liter (16 oz) of water and 0.24 L (8 oz) of heptane are to be placed in a pan directly below the wood crib located 50 mm (2 inches) from the wall panels. The heptane in the pan located beneath the crib is to be ignited and the heptane soaked cotton wicks are to be ignited immediately following the heptane pan ignition.

47.4.4 If a nozzle operates in less than 45 seconds, the water discharge is to be delayed until 45 seconds.

47.4.5 The fire test is to be conducted for 30 minutes after the ignition of the wood crib unless after 10 minutes, all combustibles are extinguished or only the wood crib is sustaining combustion, at which time the test is to be terminated.

48 Light Hazard Area Fire Tests

48.1 General

48.1.1 In addition to complying with the residential area fire tests described in Section 47, water mist nozzles intended to protect light hazard areas shall comply with the following when tested as described in Section 48:

a) The open area fire tests as described in Section 48 shall be suppressed or controlled as evidenced by no more than a 50 percent consumption of the mattresses in any single test or an average loss not greater than 35 percent in any series of open and corner fire tests conducted at the same ceiling height;

b) There shall be no ignition or charring of either target sofa in the corner public space fire test described in 48.3.2;

c) The number of operated nozzles shall not exceed 66.7 percent of the number of nozzles specified by the manufacturer to be included in the system hydraulic design. See 53.2(k);

d) At least one nozzle beyond each operated nozzle shall remain unoperated; and

e) The maximum 30 second average ceiling surface temperature above ignition, measured using a thermocouple embedded on the ceiling such that its bead is flush with the ceiling, shall not exceed 360 °C (680 °F). The maximum 30 second average ceiling gas temperature, measured 75 ±1 mm (3 inches) below the ceiling, shall not exceed 220 °C (428 °F) when measured:

1) In four locations 1.8 m (5.9 ft) from ignition, oriented 90° relative to each other and positioned such as to minimize direct wetting by the water spray from the nozzles, for the open area public space fire tests; and

2) 0.2 m (8 inches) horizontally outward from the nozzle closest to the corner for the corner public space fire tests.

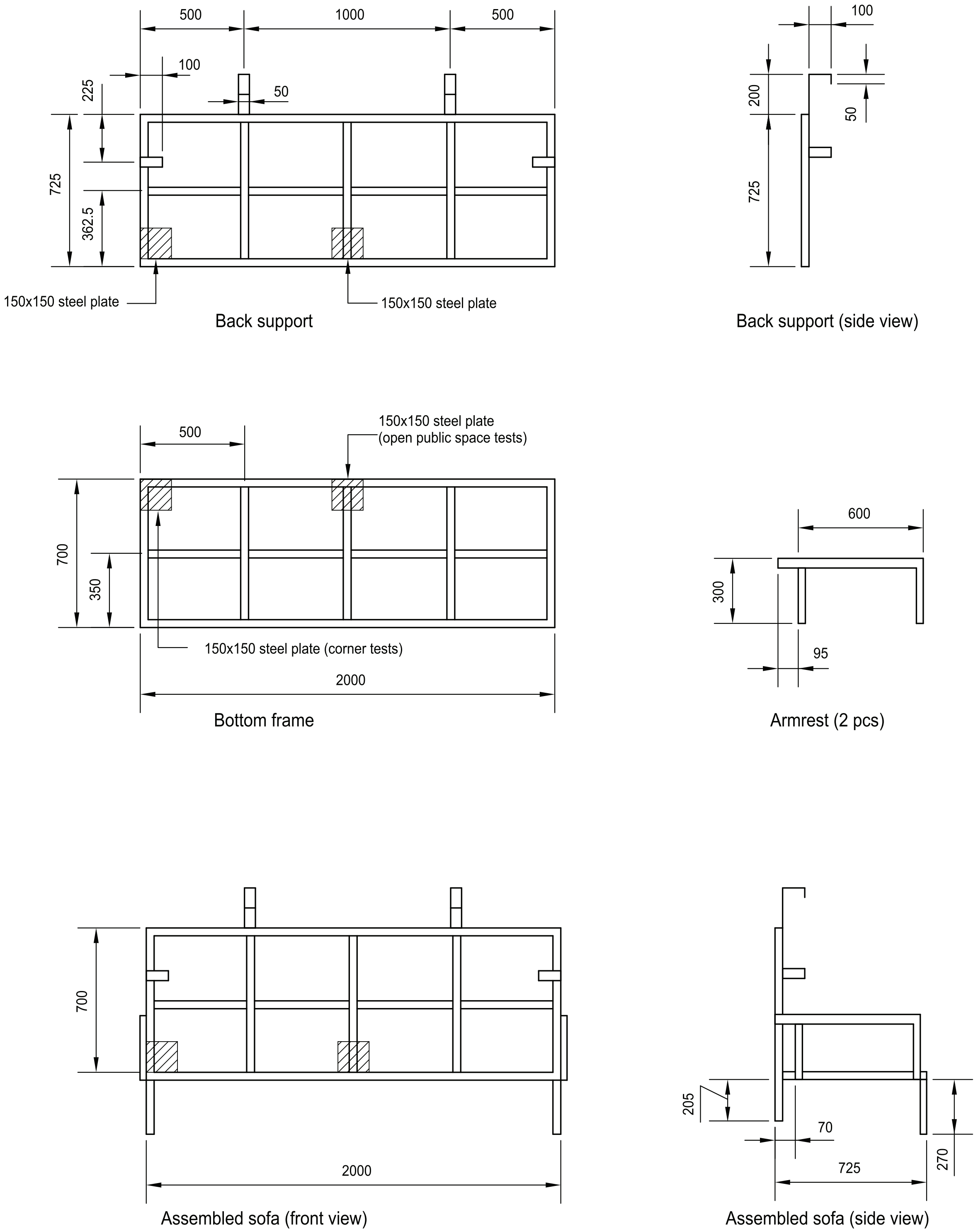
48.2 Open Area Fire Tests

48.2.1 The open area fire tests are to be conducted in a well ventilated test room fitted with a ceiling at least 80 m^2 (860 ft^2) in area with no dimension less than 8 m (26 ft). The ceiling shall be non-combustible except that at least a 1 m^2 (10.8 ft^2) area above the ignition is to be covered with cellulosic acoustical ceiling tiles having a marked FSI of 25. A minimum 0.5 m (1.7 ft) space between the perimeter of the ceiling and any wall of the building shall be provided for the venting of gases. Fire tests are to be conducted with a ceiling height of 2.5 m (8.2 ft) for one set of tests and at the maximum ceiling height specified by the manufacturer for the second set of tests.

48.2.2 The open area public space fire tests are to be conducted under the center of the ceiling. The fire source consists of four sofas constructed from 2000 by 800 by 100 mm (79 by 32 by 4 inches) non fire-retardant polyether mattresses fitted with a non-fire-retardant fabric cover constructed of 100 % cotton. Specifications for the mattresses are described in 44.3.4. Each sofa is to include two mattresses. The sofas are to be structurally supported with rectangular bottom and backrest steel frames constructed of angle, square or rectangular steel stock having a thickness not less than 3 mm (0.12 inch). The dimensions of the bottom frame is to be 2000 by 700 mm (79 by 28 inches) and the dimensions of the back rest is to be 2000 by 725 mm (79 by 29 inches). The bottom and backrest mattresses are to be supported on the frame with three 25 ±5 mm (1.0 ±0.2 inches) wide steel stock spaced 500 mm (20 inches) apart front to back for the bottom mattress and top to bottom for the back rest. An additional steel support of the same steel stock is to be installed for the full 2000 mm (79 inches) sofa length at the midpoint of the bottom and backrest frames. The support members are to be welded to the frames. A means such as a small steel plate located directly below the ignitor shall be provided to keep the ignitor in the intended position. Each sofa shall have a rectangular armrest on each end. The armrests are to be constructed of similar steel stock and are to be approximately 600 mm (24 inches) in length and 300 mm (12 inches) in height. The rear section of the armrest shall be attached to the bottom frame approximately 70 mm (2.9 inches) from the backrest. The assembled frames shall be supported by four legs of similar steel stock. The two rear legs are to be 205 mm (8 inches) in height and the front legs are to be 270 mm (11 inches) in height. The bottom mattress is to be installed first with its long edge located against the backrest frame and then the mattress for the backrest is to be installed. The backrest mattress shall be supported to maintain their vertical orientation during fire testing by means such as restraining hooks or the like. See Figure 48.1 for details. The sofas are to be arranged and spaced 25 mm (1 inch) apart as shown in Figure 46.1.

Figure 48.1

Sofa Frame Details – Typical



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48.2.3 The open area fire tests are to be conducted as described in Table 48.1 with the nozzles installed at their maximum spacing and within the limitations contained in the manufacturer's design and installation instructions. A minimum of 16 nozzles are to be installed.

Table 48.1
Light Hazard Open Area Fire Test

Test number	Water mist nozzle orientation	Nozzle pressure	Temperature rating	Diffuser to ceiling distance[a]
1.	Between 2 nozzles (see 45.2.4) with frame arms or lightest discharge parallel to the flue between sofas.	Minimum	Maximum	Maximum
2.	Between 2 nozzles (see 45.2.4) with frame arms or lightest discharge perpendicular to the flue between sofas.	Minimum	Maximum	Maximum
3.	Under 1 nozzle using worst case orientation from tests 1 and 2.	Minimum	Maximum	Maximum
4.	Between 4 nozzles using worst case orientation from tests 1 and 2.	Minimum	Maximum	Maximum
5.	Worst case from tests 1 – 4.	Minimum	Minimum	Minimum
6.	Worst case from tests 1 – 4.	Maximum	Maximum	Maximum
7.	Worst case from tests 1 – 4.	Minimum	Maximum	Minimum

[a] Testing at both minimum and maximum distance is only required when the diffuser to ceiling distance specified by manufacturer exceeds ±50 mm (±2 inches).

48.2.4 For the fire test between two nozzles, the nozzles should be located in a plane perpendicular to the longitudinal flue space between the two center sofas. For nozzles with frame arms, tests are to be conducted with the frame arms positioned both perpendicular and parallel to the system supply piping, unless the lightest discharge orientation is readily identifiable or when the spray patterns of the nozzles are demonstrated to be equivalent in both orientations. Nozzles without frame arms shall be orientated so that the lightest discharge density, as determined visually or by the Water Distribution Test, Section 15, is directed towards the fire area.

48.3 Corner Area Fire Tests

48.3.1 The corner fire tests are to be conducted in a corner constructed by two walls that extend 1.2 m (4 ft.) beyond the last row of installed nozzles. Douglas fir 3-ply panels as described in 45.2.3 and Figure 45.1 or plywood panels having a nominal thickness of 3 mm (0.125 inches) thick and a marked FSI of 200 are to be placed on the walls by being attached to 1/2 inch (12.7 mm) thick wood furring strips. The ceiling is to be fitted with cellulosic acoustical ceiling tiles having a marked FSI of 25 at least 3.6 m (12 ft) from each corner wall. The acoustical panels are to have a nominal thickness of 12 to 16 mm (0.50 to 0.62 inches). Fire tests are to be conducted with a ceiling height of 2.5 m (8.2 ft) and at the maximum ceiling height specified by the manufacturer.

48.3.2 The fire source is to consist of one full sofa and two half or full target sofas constructed from 2000 by 800 by 100 mm (79 by 32 by 4 inch) polyether mattresses fitted with a cotton fabric cover. See 44.3.4 for mattress and cover specifications and 48.2.2 for information on the sofa construction. The sofas are to be positioned in the corner of a test enclosure fitted with the combustible wall paneling and ceiling tile. The primary corner sofa is to be placed with the backrest 25 mm (1 inch) from the wall with one of the target sofas located 100 mm (4 inches) from this sofa on the right side and the other target sofa located 500 mm (20 inches) from primary corner sofa on the left side. The sofas are to be arranged as shown in Figure 46.2.

48.3.3 For the corner area tests, a minimum of 16 nozzles having the maximum temperature rating are to be installed at their maximum distance below the ceiling and at the maximum spacing specified in the manufacturer's design and installation instructions. The distance between the perimeter nozzles and the corner walls shall be one-half the maximum spacing specified in the manufacturer's design and installation instructions. The tests are to be conducted at the minimum nozzle pressure specified in the manufacturer's design and installations instructions.

48.4 Ignition Source and Test Documentation

48.4.1 The ignition source is to consist of a porous material such as insulating fiberboard. The ignitor is to be either square or cylindrical. The dimensions are to be a nominal a 60 mm (2.4 inch) square or 75 mm in diameter. The ignitor length is to be a nominal 75 mm (3 inches) and is to be soaked in 115 ml (4 fl oz) of heptane and placed in a plastic bag. For the open area fire tests, the ignitor is to be placed in the center of the bottom mattress (seat cushion) of one of the sofas. See . For the corner area fire tests, the igniter is to be placed on the full sofa up against the backrest and adjacent to the corner wall. See Figure 46.2.

48.4.2 Water is to be applied at the minimum operating pressure specified in the manufacturer's design and installation instructions for 30 minutes after the ignition of the wood crib, unless after 10 minutes, 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 and operating pressure is to be monitored and recorded during each test.

49 Ordinary Hazard Group 1 Fire Tests

49.1 General

49.1.1 Water mist nozzles intended for the protection of ordinary hazard group 1 areas shall comply with both the open area and corner fire test scenarios described in this section.

49.2 Open area fire tests

49.2.1 When tested in accordance with 49.2 – 49.4, water mist nozzles intended for the protection of ordinary hazard group 1 commodities shall comply with the following criteria:

a) Ceiling steel temperatures shall not exceed 540 °C (1000 °F) for more than 5 minutes. When the temperature exceeds 540 °C for 1 – 5 minutes, the use of a non-combustible ceiling construction shall be specified in the manufacturer's design and installation instructions;

b) Number of operating nozzles shall not exceed 66.7 percent of the number of nozzles specified by the manufacturer to be included in the system hydraulic design. See 53.2(k);

c) Not more than 50 percent damage to the Class II commodity; and

d) No breaching or flashover of the ceiling.

49.3 Test arrangement

49.3.1 The open area fire tests are to be conducted in a test room fitted with a ceiling having provisions for venting of gases around the perimeter. The open space around the perimeter shall be at least 0.5 m (1.7 ft). The ceiling shall be large enough to accommodate nozzles installed in such a manner that there is at least one unoperated nozzle beyond each operating nozzle.

49.3.2 The ceiling is to be covered over the fire area with non-combustible ceiling panels and set at the maximum height specified in the manufacturer's design and installation instructions, but in no case less than 3 m (10 ft). When the maximum ceiling height exceeds 3 m (10 ft.), an additional test using the conditions described in Test No. 5 of Table 49.1 is to be conducted with the ceiling located to provide the minimum nozzle clearance to commodity.

49.3.3 Thermocouples are to be positioned adjacent to each nozzle to record the nozzle operating times. Thermocouples shall also be centered above ignition 50 mm (2 inches) below the ceiling and with the thermocouple bead flush with the ceiling. To record steel beam temperatures, a steel beam 50 by 50 by 1280 mm (2 by 2 by 48 inch) long and 6.3 mm (0.25 inch) thick is to be attached flush with the ceiling and centered over ignition. The steel beam is to be fitted with 5 thermocouples embedded half way into the beam. One thermocouple is to be centered and the other 4 are located symmetrically at a distance of 225 and 450 mm (9 and 18 inches) from the center position.

49.4 Fire source

49.4.1 The fire source is to consist of a 4 wide by 5 long by 2 high array of Class II commodity with 150 mm (6 inch) longitudinal and transverse flue spaces. Each Class II commodity consists of double triwall corrugated cartons containing a five sided (open bottom) metal liner on a 107 by 107 by 12.7 cm (42 by 42 by 5 inch) high two-way hardwood pallet. The steel liner and two cartons form a 107 cm (42 inch) cube. The moisture content of the cartons is to be within 6 to 12 percent.

49.5 Test procedure

49.5.1 The fire tests described in Table 49.1 are to be conducted with the nozzles installed at their maximum spacing and within the limitations contained in the manufacturer's design and installation instructions.

Table 49.1
Open Area Fire Test

Test number	Water mist nozzle orientation	Operating pressure	Temperature rating	Diffuser to ceiling distance[b]
1.	Between 2 nozzles in a direction transverse to the ignition location with frame arms or lightest discharge parallel to longitudinal flue.	Minimum	Maximum	Maximum
2.	Between 2 nozzles in a direction transverse to the ignition location with frame arms or lightest discharge perpendicular to longitudinal flue.	Minimum	Maximum	Maximum
3.	Under 1 nozzle using worst case orientation from tests 1 and 2.	Minimum	Maximum	Maximum
4.	Between 4 nozzles using worst case orientation from tests 1 and 2.	Minimum	Maximum	Maximum
5.	Worst case from tests 1 – 4.	Minimum	Minimum[a]	Minimum
6.	Worst case from tests 1 – 4.	Maximum	Maximum	Maximum
7.	Worst case from tests 1 – 4.	Minimum	Maximum	Minimum

[a] Nominal 68 °C (155 °F) nozzles can be used in all of the fire tests provided the manufacturers' design and installation instruction only permits the use of 79 °C (175 °F) nozzles near sources of elevated temperature, i.e. space heaters.

[b] Only required when the diffuser to ceiling distance specified by manufacturer exceeds ±50 mm (±2 inches).

49.5.2 The ignition source for the fire test is to consist of 0.7 kg (1.5 lb) of shredded newspaper positioned on the floor. See Figure 49.2 for further details on ignition location.

49.5.3 The fire test is to be conducted for 45 minutes or until the fire is extinguished, if extinguishment occurs within 45 minutes of ignition.

49.5.4 At the completion of the test, the water is to be shut off and any remaining fires are to be extinguished. The cartons are then to be examined visually to determine compliance with the requirements specified in 49.2.1(c).

49.6 Corner fire tests

49.6.1 When tested in accordance with 49.7 – 49.9, water mist nozzles intended for the protection of ordinary hazard group 1 commodities shall comply with the following criteria:

a) Not more than 50 percent damage to the storage array;

b) Not more than 5 percent damage to either target array; and

c) No breaching or flashover of the ceiling.

49.7 Test arrangement

49.7.1 The corner fire tests are to be conducted in a two-sided enclosure having the maximum height and a minimum ceiling area equal to the coverage area provided by 4 nozzles installed in a 2 by 2 nozzle arrangement or 9 nozzles installed in a 3 by 3 nozzle arrangement, at the option of the manufacturer, at the maximum nozzle spacing specified in the manufacturer's design and installation instructions. The ceiling is to be fitted with acoustical ceiling tiles having a marked FSI of 25.

49.7.2 The enclosure is to have 2 adjacent walls at least 6.1 m (20 ft) in length forming a corner which are to be fitted with paneling having a marked FSI of 200. The panels are to be attached to the walls using nominal 50 mm (2 inches) wide by 12.7 mm (0.5 inches) thick furring strips on 0.6 m (2 ft) centers.

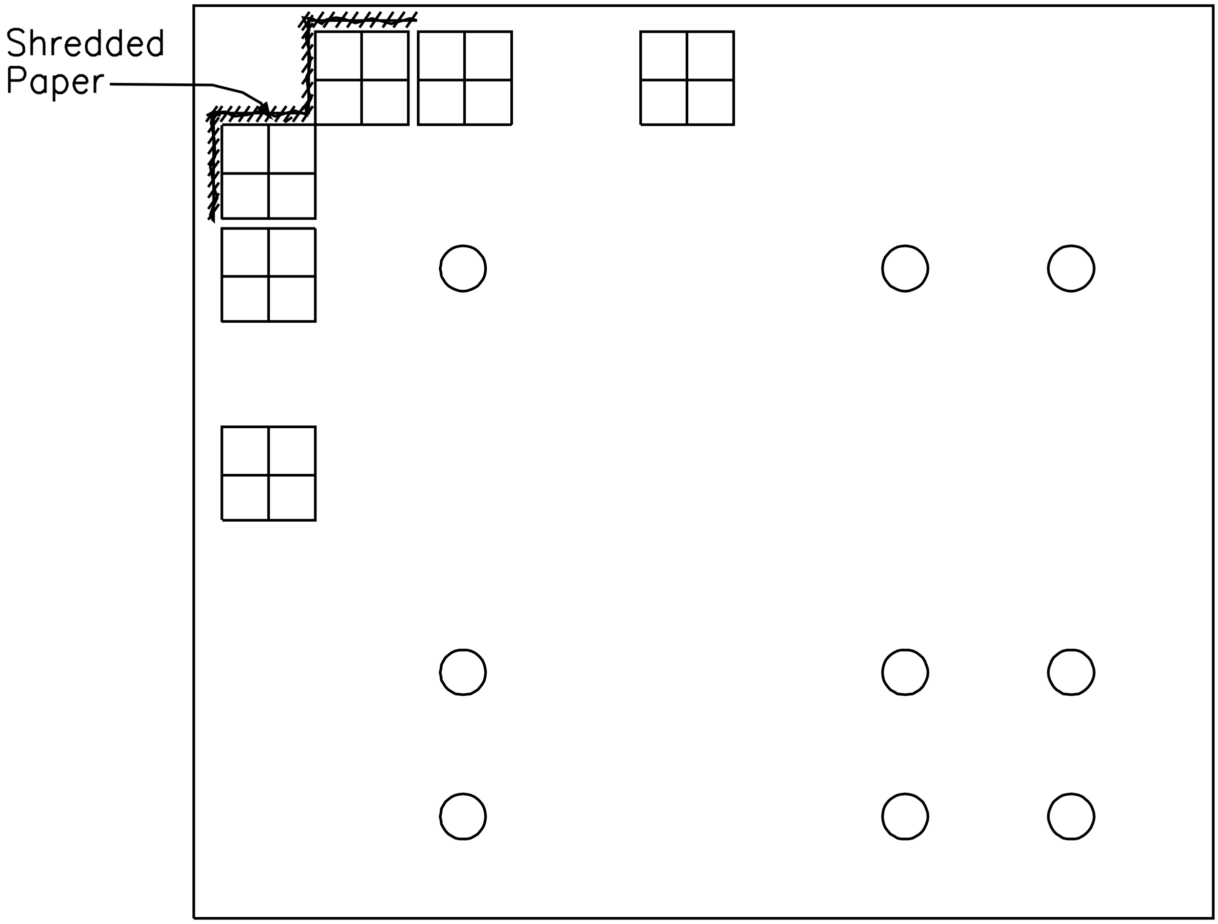
49.7.3 Thermocouples are to be positioned adjacent to each nozzle to record the nozzle operating time. Thermocouples are also to be centered above ignition 75 mm (3 inches) below the ceiling and with the thermocouple bead flush with the ceiling.

49.8 Fire source

49.8.1 The fire source is to consist of 96 corrugated cartons as described in 46.3.4 except that the polystyrene cups are omitted. Two 2 by 4 by 4 arrays are to be positioned in the corner of the enclosure as illustrated in Figure 49.1. Each array is to be 1280 mm (48 inches) from the corner and 150 mm (6 inches) away from one of the walls forming the corner. Two target arrays, 2 by 2 by 4 high, are to be positioned 1280 mm (48 inches) from the end of each storage array. See Figure 49.1.

Figure 49.1

Ordinary Hazard Group 1 Corner Fire Test



Ignition – 1.5 Lbs. (0.68kg) of shredded paper to be distributed as shown above to facilitate burning behind the commodity.

◯ – 4 or 9 water mist nozzles at manufacturer's option.

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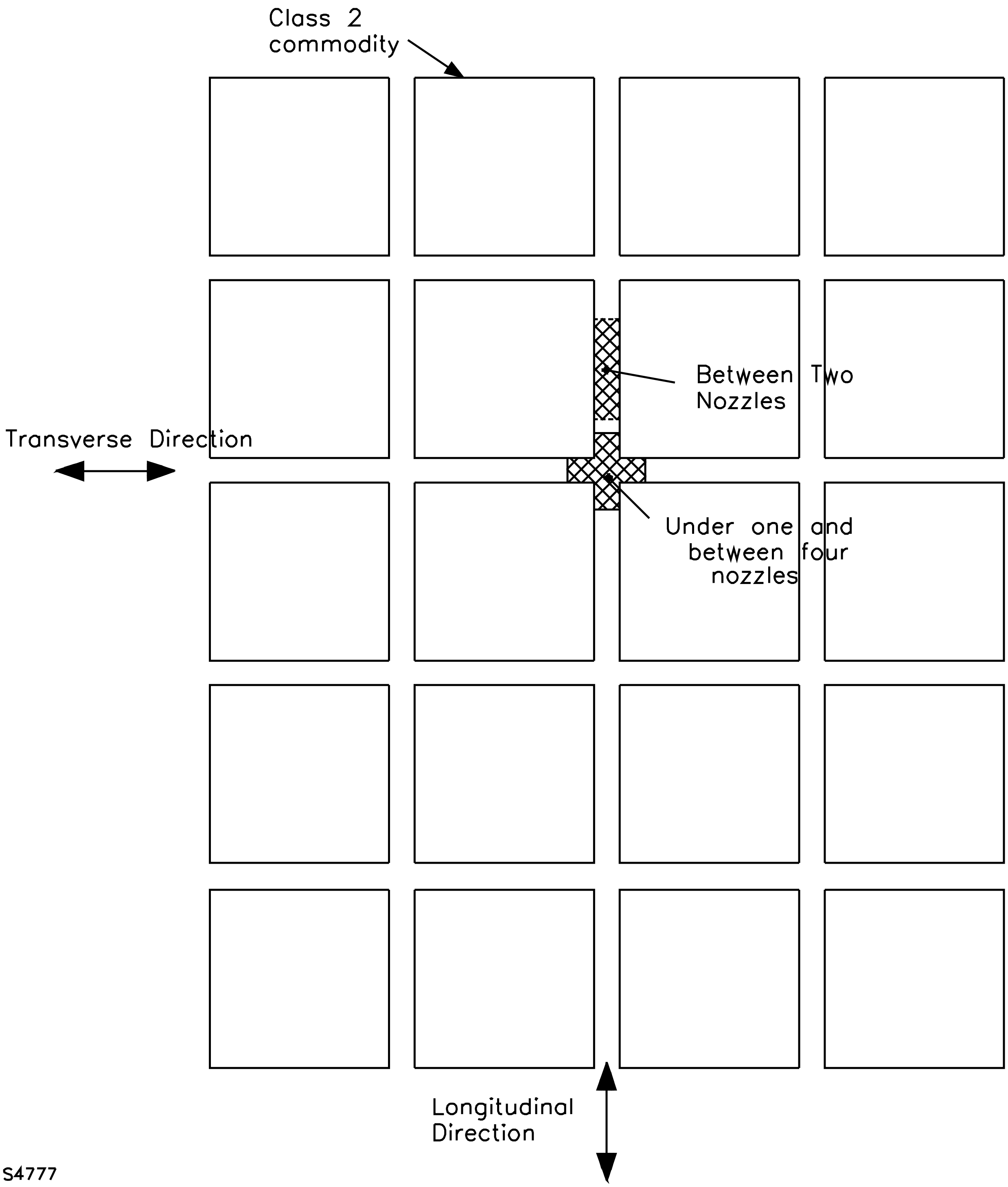
Figure 49.2

Plan View of OH-1 Open Area Fire Test Arrangement



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49.9 Test procedure

49.9.1 The fire tests are to be conducted with nozzles having the highest temperature rating at their maximum spacing and maximum distance below the ceiling as specified in the manufacturer's design and installation instructions.

49.9.2 The ignition source for the fire test is to consist of 0.68 kg (1.5 lb) of shredded newspaper on the floor adjacent to the cartons in the corner as illustrated in Figure 49.1. After ignition, water is to be supplied to the nozzles at their minimum operating or declining pressure.

49.9.3 The fire test is to be conducted for 30 minutes or until the fire is extinguished.

49.9.4 At the completion of the 30 minute test, the water is to be shut off and any remaining fires extinguished. The cartons are then to be examined visually to determine compliance with the requirements specified in 49.6.1.

50 Ordinary Hazard Group 2 Fire Tests

50.1 General

50.1.1 Water mist nozzles intended for the protection of ordinary hazard group 2 areas shall comply with both the open area and corner fire test scenarios described in this section.

50.2 Open area fire tests

50.2.1 When tested in accordance with 50.2 – 50.5.4, water mist nozzles intended for the protection of ordinary hazard group 2 commodities shall comply with the following criteria:

a) Ceiling steel temperatures shall not exceed 540 °C (1000 °F) for more than 5 minutes. When the temperature exceeds 540 °C for between 1 and 5 minutes, the use of a non-combustible ceiling construction shall be specified in the manufacturer's design and installation instructions;

b) Number of operating nozzles shall not exceed 66.7 percent of the number of nozzles specified by the manufacturer to be included in the system hydraulic design. See 53.2(k);

c) Not more than 60 percent damage to the Group A plastic commodity in the main storage array;

d) Not more than 5 percent of the plastic cups in the Group A plastic commodity target arrays shall be melted or distorted; and

e) No ignition or charring of the empty cardboard carton target arrays.

50.3 Test arrangement

50.3.1 The open area fire tests are to be conducted in a test room fitted with a ceiling having provisions for venting of gases around the perimeter. The open space around the perimeter shall be at least 0.5 m (1.7 ft). The ceiling shall be large enough to accommodate nozzles installed in such a manner that there is at least one unoperated nozzle beyond each operating nozzle.

50.3.2 The ceiling is to be covered over the fire area with non-combustible ceiling panels and set at the maximum height specified in the manufacturer's design and installation instructions, but in no case less than 2.5 m (8 ft). When the maximum ceiling height exceeds 2.5 m (8 ft.), an additional test using the conditions described in Test No. 5 of Table 49.1 is to be conducted with the ceiling located 2.5 m (8 ft) above the floor.

50.3.3 Thermocouples are to be positioned adjacent to each nozzle to record the nozzle operating times. Thermocouples shall also be centered above ignition 50 mm (2 inches) below the ceiling and with the thermocouple bead flush with the ceiling. To record steel beam temperatures, a steel beam is to be fitted with 5 thermocouples embedded half way into the beam. One thermocouple is to be centered and the other 4 positioned 225 and 450 mm (9 and 18 inches) from the center position.

50.4 Fire source

50.4.1 The fire source is to consist of two piled stacks of corrugated cartons which are 2 wide by 3 long by 3 high and four target arrays, 1 wide by 2 long by 3 high, which are packed with polystyrene unexpanded plastic cups with a 305 mm (12 inch) flue space. Each carton is to be 533 by 533 by 533 mm (21 by 21 by 21 inches) high and is to contain 125 nominal one-half liter (16 fl oz) capacity polystyrene cups consisting of 5 layers of 25 cups with each cup in an individual compartment formed by corrugated separators. See Figure 46.3 for general layout.

50.4.2 The two 1.6 m (63 inch) high arrays of empty corrugated cartons are to be arranged on each side of the plastic cup array as shown in Figure 46.3. The cartons shall be stabilized to prevent displacement.

50.5 Test procedure

50.5.1 The fire tests described in Table 49.1 are to be conducted with the nozzles installed at their maximum spacing and within the limitations contained in the manufacturer's design and installation instructions.

50.5.2 The fire test is to be ignited using two 75 mm (3 inch) cubes of fiberboard. Each cube is to be soaked in 115 ml (4 oz) of heptane and placed in a plastic bag. The igniters are to be placed on the floor, each against the base of one of the two center stacks and simultaneously ignited. See Figure 46.3.

50.5.3 The fire test is to be conducted for 30 minutes or until the fire is extinguished.

50.5.4 At the completion of the 30 minute test, the water is to be shut off and any remaining fires are to be extinguished. The cartons are then to be examined visually to determine compliance with the requirements specified in 49.2.1.

50.6 Corner fire tests

50.6.1 When tested in accordance with 50.7 – 50.9.4, water mist nozzles intended for the protection of ordinary hazard group 2 commodities shall comply with the following criteria:

a) Not more than 50 percent damage to the storage array;

b) Not more than 5 percent damage to either target array; and

c) No breaching or flashover of the ceiling.

50.7 Test arrangement

50.7.1 The corner fire tests are to be conducted in an enclosure having the maximum ceiling height and a minimum area equal to the coverage area provided by 4 nozzles installed in a 2 by 2 nozzle arrangement or 9 nozzles in a 3 by 3 nozzle arrangement, at the manufacturer's option, at the maximum nozzle spacing specified in the manufacturer's design and installation instructions. The ceiling is to be fitted with acoustical ceiling tiles having a marked FSI of 25.

50.7.2 The enclosure is to have 2 adjacent walls at least 6.1 m (20 ft) in length forming a corner which are to be fitted with paneling having a marked FSI of 200. The panels are to be attached to the walls using nominal 50 mm (2 inches) wide by 12.7 mm (0.5 inch) thick furring strips on 0.6 m (2 ft) centers.

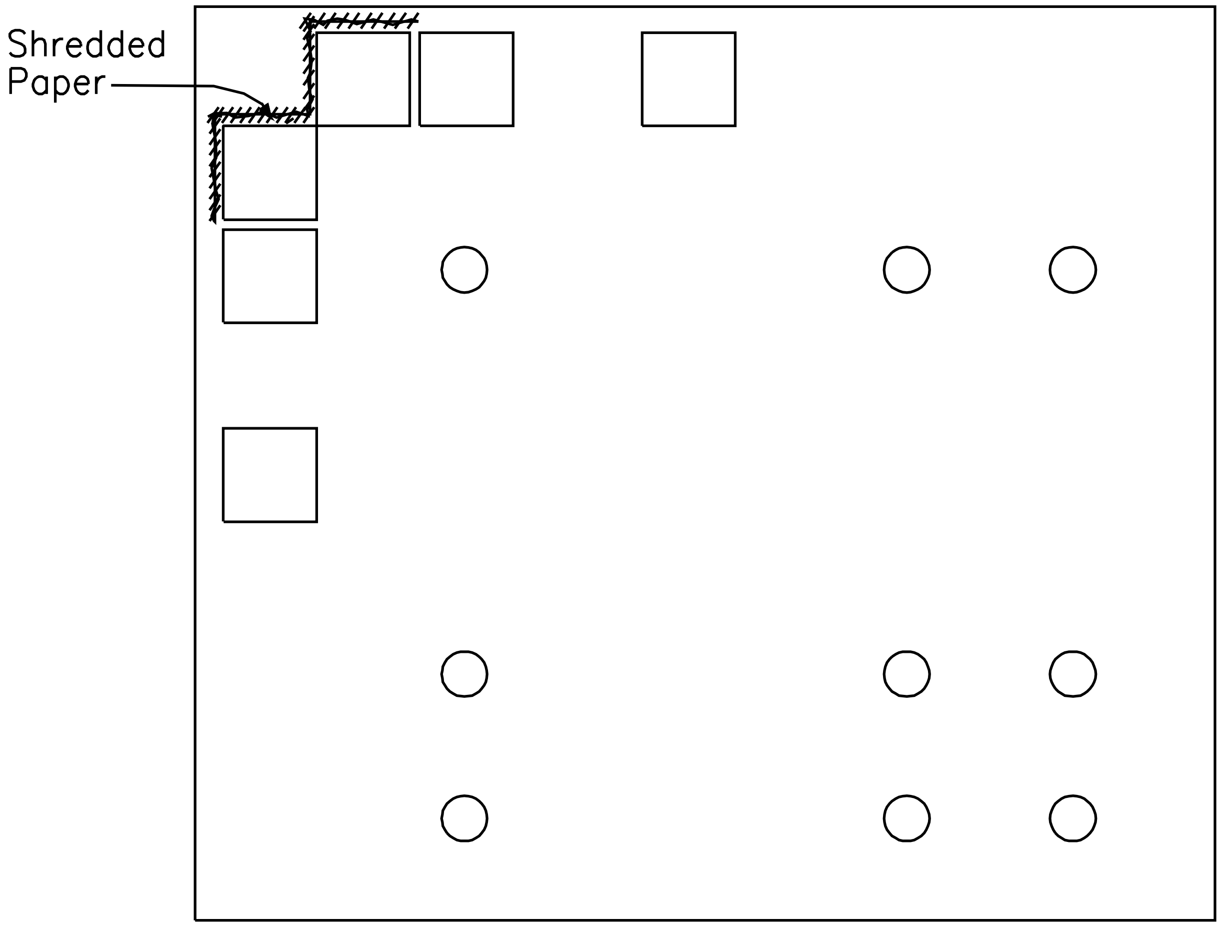
50.7.3 Thermocouples are to be positioned adjacent to each nozzle to record the nozzle operating time. Thermocouples are also to be centered above the ignition source, 75 mm (3 inches) below the ceiling and with the thermocouple bead flush with the ceiling.

50.8 Fire source

50.8.1 The fire source is to consist of 18 corrugated cartons of plastic cups as described in 50.4.1. Two 1 by 2 by 3 high arrays are to be positioned in the corner of the enclosure as illustrated in Figure 50.1. Each array is to be 1280 mm (48 inches) from the corner and 150 mm (6 inches) away from one of the walls forming the corner. Two target arrays, each 1 by 1 by 3 high, are to be positioned 533 mm (21 inches) from the end of each storage array. See Figure 50.1.

Figure 50.1

Ordinary Hazard Group 2 Corner Fire Test



Ignition – 1.5 Lbs. (0.68kg) of shredded paper to be distributed as shown above to facilitate burning behind the commodity.

◯ – 4 or 9 water mist nozzles at manufacturer's option.

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50.9 Test procedure

50.9.1 The fire tests are to be conducted with nozzles having the highest temperature rating at their maximum spacing and maximum distance below the ceiling as specified in the manufacturer's design and installation instructions.

50.9.2 The ignition source for the fire test is to consist of 0.68 kg (1.5 lb) of shredded newspaper on the floor adjacent to the cartons in the corner as illustrated in Figure 50.1. After ignition, water is to be supplied to the nozzles at their minimum operating pressure.

50.9.3 The fire test is to be conducted for 30 minutes or until the fire is extinguished.

50.9.4 At the completion of the 30 minute test, the water is to be shut off and any remaining fires extinguished. The cartons are then to be examined visually to determine compliance with the requirements specified in 50.6.1.

MANUFACTURING AND PRODUCTION TESTS

51 Production Leakage Test

51.1 The manufacturer shall provide regular production control, inspection, and tests. The program shall include the test specified in 51.2, for each automatic nozzle.

51.2 Automatic nozzles shall not leak when subjected to a minimum hydrostatic pressure of 3.45 MPa (500 psi), or twice the rated pressure, whichever is greater, maintained for a period of no less than 2 seconds.

52 Glass Bulb Integrity Test

52.1 After being subjected to the production leakage test, a glass bulb nozzle assembly shall be evaluated for integrity of the glass bulb for cracking, breaking, or other damage as indicated by the loss of fluid. For example, the bubble in each glass bulb shall be examined at room ambient temperature. The nozzle shall then be heated in a circulating air oven or liquid bath to 5 °C below the minimum operating temperature range of the sprinkler. The bubble shall then be examined to determine the bubble size has been reduced in accordance with the glass bulb manufacturer's specifications. After cooling, the bubble size shall again be examined to determine the bubble returned to the original size within the tolerance allowed by the glass bulb manufacturer.

INSTRUCTIONS

53 Design and Installation Instructions

53.1 A copy of the manufacturer's design and installation instructions shall be furnished for use as a reference in the examination and testing of water mist nozzles.

53.2 The manufacturer's instructions shall reference the limitations of each device and shall include at least the following items:

a) Description and operation details of each water mist nozzle and all accessory equipment including identification of components or accessory equipment by part or model number;

b) Degree and type of protection afforded by the system and limitations for each fire use type, including maximum area and height of the hazard or enclosure;

c) Type of pipe, tubing, and fittings to be used;

d) Typical nozzle placement and specific limitations and recommendations for correct nozzle installation and effective protection;

e) Discharge nozzle limitations, including maximum dimensional and area coverage, minimum clearance (as applicable), minimum and maximum installation height limitations, and nozzle location in the protected volume;

f) Details for the proper installation of the nozzle;

g) Operating pressure ranges of the nozzle;

h) Information regarding the inspection of a nozzle after installation;

i) Reference to the Standard on Water Mist Fire Protection Systems, NFPA 750, for installation and system design requirements;

j) Statements that the forced ventilation systems shall be shut down at time of mist application;

k) Reference to the applicable standard for the number of automatic nozzles to be included in the water mist system hydraulic design. For Light Hazard (Section 48), Ordinary Hazard Group 1 (Section 49) and Ordinary Hazard Group II (Section 50) areas, the number of automatic nozzles to be included in the water mist system hydraulic design is to be based upon the results of the fire tests described in the referenced sections. In no case shall the number of nozzles to be included in the system design be less than 140 m^2 (1500 ft^2) or as otherwise specified by the authority having jurisdiction;

l) Reference to the Standard on Water Mist Fire Protection Systems, NFPA 750 for the system design and water supply requirements for Residential Dwelling Units (Section 47);

m) For Residential Dwelling Units (Section 47), reference to use under smooth, flat, horizontal ceilings and when installed in multistory structures, the highest level of nozzles installed in a tall ceiling shall be above all openings leading into communicating spaces from the compartment containing the tall ceiling; and

n) Information regarding acceptable water supplies to be used in conjunction with the water mist nozzles;

o) Reference to use indoors under smooth, flat, horizontal ceilings unless otherwise investigated for use under other ceiling configurations or installation conditions; and

p) Reference to the Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection System, NFPA 25 for the inspection, testing and maintenance requirements.

MARKING

54 Water Mist Nozzle Marking

54.1 Each nozzle complying with the requirements of this Standard shall be permanently marked as follows:

a) Trademark or manufacturer's name;

b) Model identification;

c) Manufacturer's factory identification (this is only required when the manufacturer has more than one nozzle manufacturing facility);

d) Nominal year of manufacture (automatic nozzles only);

e) Nominal operating temperature (automatic nozzles only);

f) K-factor (this is only required when a given model nozzle is

available with more than 1 orifice size); and

g) When glass bulb nozzles are manufactured with more than one supplier of glass bulbs, each nozzle shall have a distinctive marking to identify the glass bulb manufacturer.

54.2 With reference to 54.1(d), the nominal year of manufacture includes the last three months of the preceding year and the first six months of the following year.

54.3 Except for coated and plated nozzles, the nominal operating temperature range shall be color-coded on the nozzle to identify the nominal rating and shall be in accordance with Table 12.1. The color code shall be visible on the yoke arms holding the distribution plate for fusible element nozzles, and shall be indicated by the color of the liquid in glass bulbs. All nozzles shall be stamped, cast, engraved, or color-coded in such a way that the nominal rating is recognizable even when the nozzle has operated.

54.4 In countries where color-coding of yoke arms of glass bulb nozzles is required, the color code for fusible element nozzles shall be used.

54.5 Recessed housings, when provided, shall be marked for use with the corresponding nozzles unless the housing is a non-removable part of the nozzle.

54.6 Protective covers shall be orange in color and shall be marked to indicate that the cover must be removed before the nozzle system is placed in service. The marking shall be placed on the cover so it is visible after nozzle installation.

SUPPLEMENT SA – TOLERANCE LIMIT CALCULATION METHOD

SA1 General

SA1.1 The calculation method for determining compliance with the statistical tolerance limit requirements specified in 20.1 is specified in SA2 – SA4.

SA2 Calculation of Standard Deviation

SA2.1 Calculate the mean and unbiased standard deviation for the glass bulb design load and glass bulb strength. The sample unbiased standard deviation (S) is calculated from the formula:

$$S = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \overline{X})^2}{n-1}}$$

in which:

$\overline{X}$ = sample mean

X_i = individual values of each sample tested

n = number of samples tested

SA3 Determination of K Factor

SA3.1 Determine K, where K is a factor from Table SA3.1, K factors for one-sided tolerance limits for normal distributions.

Table SA3.1
K Factors for One-Sided Tolerance Limits for Normal Distribution

n	Strength of heat responsive element test for frangible bulb types (Section 20) γ = 0.99 p = 0.99 (99 percent of samples)
10	5.075
11	4.282
12	4.633
13	4.472
14	4.336
15	4.224
16	4.124
17	4.038
18	3.961
19	3.893
20	3.832
21	3.776
22	3.727
23	3.680
24	3.638

Table SA3.1 Continued on Next Page

Table SA3.1 Continued

n	Strength of heat responsive element test for frangible bulb types (Section 20) γ = 0.99 p = 0.99 (99 percent of samples)
25	3.601
30	3.446
35	3.334
40	3.250
45	3.181
50	3.124

SA4 Comparison of Tolerance Limits

SA4.1 Upon accumulation of data points for glass bulb design load and glass bulb strength and the selection of the appropriate respective values for K, compliance with the requirement shall be confirmed by verifying that $TL_1 > 2TL_2$.

$$TL_1 = \overline{X}_1 - KS_1$$

$$TL_2 = \overline{X}_2 - KS_2$$

in which:

TL_1 = lower tolerance limit for bulb strength

TL_2 = upper tolerance limit for bulb strength

$\overline{X}_1$ = mean bulb strength in pounds

$\overline{X}_2$ = mean assembly load in pounds

K_1 = bulb strength factor from Table SA3.1

K_2 = assembly load factor from Table SA3.1

S_1 = sample unbiased standard deviation for $\overline{X}_1$

S_2 = sample unbiased standard deviation for $\overline{X}_2$

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

The formula given in 21.2 is based on the intention of providing fusible elements that are not susceptible to failure resulting from creep stresses during a reasonable period of service. The duration of 876,600 hours (100 years) was specified only as a statistical value with an ample safety factor. No other significance is intended as many other factors govern the useful life of a nozzle.

Loads causing failure by creep, and not by an unnecessarily high initial distortion stress, are applied and the times noted. The given requirement then approximates to the extrapolation of the full logarithmic regression curve by means of the following analysis.

The observed data is used to determine, by means of the method of least square, the load at 1 hour, L_o, and the load at 1000 hours, L_m. One way of stating this is that, when plotted on full logarithmic paper, the slope of the line determined by L_m and L_o shall be greater than or equal to the slope determined by the maximum design load at 100 years, L_d, and L_o, or:

$$\frac{(In\ L_m - In\ L_o)}{In\ 1000} \geq \frac{(In\ L_d - In\ L_o)}{In\ 876{,}600}$$

This is then reduced as follows:

$$In\ L_m \geq (In\ L_d - In\ L_o)\frac{In\ 1000}{In\ 876{,}600} + In\ L_o$$

in which:

$In\ L_m \geq 0.5048\ (In\ L_d - In\ L_o) + In\ L_o$

$In\ L_m \geq 0.5048\ In\ L_d + In\ L_o\ (1 - 0.5048)$

$In\ L_m \geq 0.5048\ In\ L_d + 0.4952\ In\ L_o$

With an error of 1 percent, the formula is approximated by:

$$In\ L_m \geq 0.5(In\ L_d + In\ L_o)$$

or, compensating for errors:

$$L_m \geq 0.99(L_d - L_o)^{0.5}$$

or:

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

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SUPPLEMENT SC – NOZZLE DROPLET SIZE DISTRIBUTION SUMMATION METHOD

SC1 General

SC1.1 The calculation method for determining the summation of the weighted cumulative count and volume percent droplet distributions specified in 16.3 is specified in SC2 and SC3. An example of the presentation of rate per unit area weighted droplet size distribution is shown in Figure SC3.1.

SC2 Calculation for Single Location and Bin Size

SC2.1 For a single measurement location, *x*, and bin size, *y*:

Cumulative count percent (single bin),

$$c_y = n_y / n_x + c_{y-1}$$

where:

n_y = number of droplets in a single bin size for location *x*

n_x = total number of droplets in the sample at location *x*

Proportional flow rate per unit area,

$$p_x = f_x / F$$

where:

f_x = flow rate per unit area at location *x*

F = total cumulative flow rate for all locations (Σf_x)

Flow weighted cumulative count percent (single bin),

$$w_y = c_y p_x + w_{y-1}$$

The above equations are to be used for all locations and all bin sizes.

SC3 Calculation for Summation of All Measurement Locations

SC3.SC3.1 For the summation of all measurement location data:

Flow weighted cumulative count percent (single bin),

$$c_y = \Sigma w_y$$

Flow weighted cumulative volume (single bin),

$$V1_y = (b_y{}^3) / 6)\,(c_y - c_{y-1}) + V_{y-1}$$

where:

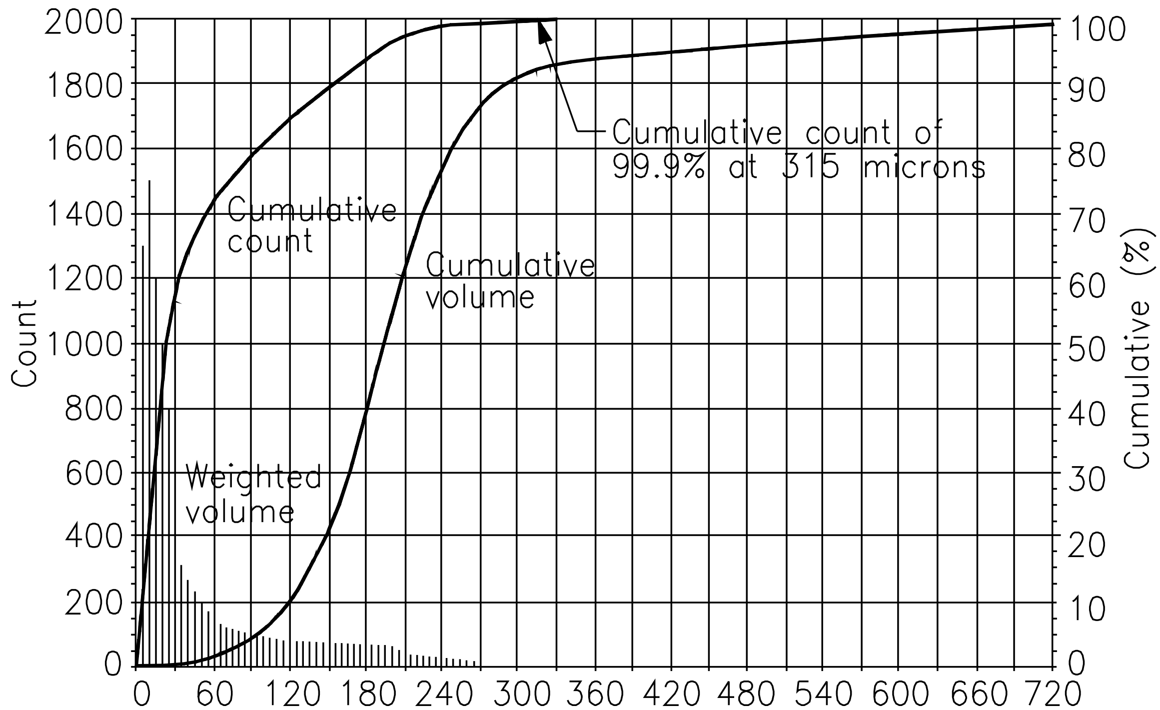
b_y = minimum diameter for bin size *y*

Flow weighted cumulative volume percent (single bin),

$$V2_y = V1_y / \Sigma V1_y$$

Figure SC3.1

Example of Flow Rate Per Unit Area Weighted Droplet Size Distribution



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