INTERNATIONAL STANDARD

ISO 6182-1

Fourth edition
2021-05

Fire protection — Automatic sprinkler systems —

Part 1: Requirements and test methods for sprinklers

Protection contre l'incendie — Systèmes d'extinction automatiques du type sprinkler —

Partie 1: Prescriptions et méthodes d'essai des sprinklers

Reference number
ISO 6182-1:2021(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 5, Fixed firefighting systems using water.

This fourth edition cancels and replaces the third edition (ISO 6182-1:2014) which has been technically revised.

The main changes compared to the previous edition are as follows:

— Consolidation of the requirements for early suppression fast response (ESFR) sprinklers (ISO 6182-7:2020), domestic sprinklers (ISO 6182-10:2014) and extended coverage sprinklers (ISO 6182-13:2017) into a single document.

— Increased harmonization of test methods and requirements for the different types of sprinklers.

— Expanded scope to include extended coverage sprinklers for ordinary hazard occupancies and large K-factor storage type sprinklers.

— New water distribution and fire test methods as well as requirements for the additional sprinkler technologies.

— New requirements for electrically operated style sprinklers.

A list of all parts in the ISO 6182 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document includes requirements for conventional, spray, flat spray, sidewall, extended coverage, domestic and storage sprinklers, including early suppression fast response (ESFR) sprinklers, electrically activated sprinklers (EAS) and sprinklers with monitoring of activation (SMA).

Conventional sprinklers are the oldest of the fire sprinkler technologies. These sprinklers discharge water in a spherical discharge pattern such that 40 % to 60 % of the total water flow is initially discharged in the downward direction. In general, the use of this sprinkler technology is limited to applications where this discharge characteristic has been determined to be more effective than the spray sprinkler.

Spray sprinklers were developed in the 1950s and are used to provide fire protection for a wide range of fire risks, including those found in light hazard, ordinary hazard and extra hazard occupancies, as well as storage facilities.

Flat spray sprinklers have a wider spray angle than spray sprinklers and are generally limited to use in spaces with low clearances and storage racks in specific geographic regions.

Domestic sprinklers are intended to provide control of fires in domestic occupancies, to prevent flashover (total involvement) in the room of fire origin and to improve the probability for successful escape or evacuation of the occupants.

Extended coverage light hazard sprinklers are intended to provide control of fires in occupancies or portions of occupancies where quantity and/or combustibility of contents is low, such as office spaces.

Extended coverage ordinary hazard sprinklers are intended to provide control of fires in occupancies or portions of occupancies where quantity and/or combustibility of contents is moderate to high, such as mercantile areas.

Storage sprinklers, including ESFR sprinklers, are primarily intended to be used to provide fire protection for storage facilities.

Electrically activated sprinklers make it possible to activate more than one sprinkler simultaneously.

Sprinklers with monitoring of activation make it possible to detect the location of an actuated sprinkler.

Fire protection — Automatic sprinkler systems —

Part 1: Requirements and test methods for sprinklers

1 Scope

This document specifies performance and marking requirements and test methods for conventional, spray, flat spray, sidewall, extended coverage, domestic and storage sprinklers, including early suppression fast response (ESFR), electrically activated sprinklers (EAS) and sprinklers with monitoring of activation (SMA) for use in water-based fire protection systems. This document is not applicable to sprinklers with multiple orifices.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 5660-1, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 General

3.1.1
actual delivered density
ADD
rate at which water is deposited from an operating *sprinkler* (3.1.13) onto the top horizontal surface of a simulated burning combustible array

3.1.2
assembly load
force exerted on the sprinkler body excluding hydrostatic pressure

3.1.3
average design strength
glass bulb supplier's specified and assured lowest average axial design strength of any batch of 50 bulbs

3.1.4
coverage length
maximum length of the sprinkler coverage area

3.1.5
coverage width
maximum width of the sprinkler coverage area

3.1.6
design load
force exerted on the release element at the *service load* (3.1.12) of the *sprinkler* (3.1.13)

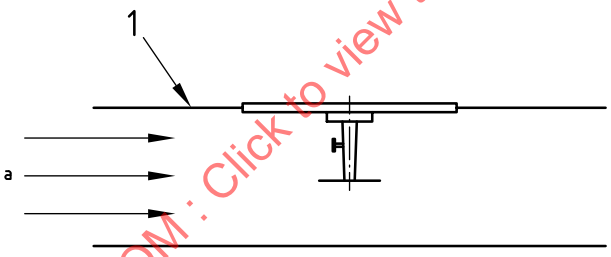
3.1.7
housing assembly
escutcheon
ornamental or protective component(s) around the hole from which the *sprinkler* (3.1.13) penetrates the plane of the ceiling or the wall

Note 1 to entry: See Figure 3.

Note 2 to entry: For the purposes of this document, housing applies to recessed and *concealed sprinklers* (3.5.2).

3.1.8
orientation A
orientation with the airflow perpendicular to both the waterway axis and the plane of the frame arms and with the heat responsive element upstream of the frame arms

Note 1 to entry: See Figure 1.



Key

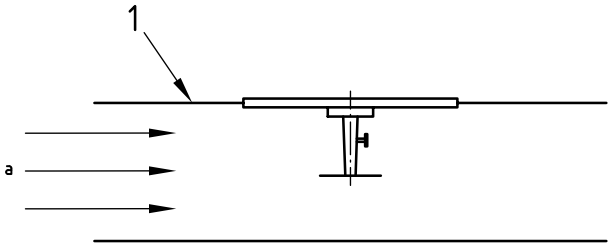
1 tunnel test section (elevation view)

[a] Airflow.

Figure 1 — Orientation A

3.1.9
orientation B
orientation with the airflow perpendicular to both the waterway axis and the plane of the frame arms and with the heat responsive element downstream of the frame arms

Note 1 to entry: See Figure 2.



Key

1 tunnel test section (elevation view)

[a] Airflow.

Figure 2 — Orientation B

3.1.10
protective covers
protective caps or straps intended to provide temporary protection for *sprinklers* (3.1.13) during shipping, handling and installation

3.1.11
response time index
RTI
measure of sprinkler sensitivity determined by Formula (1)

$$RTI = t\sqrt{u} \tag{1}$$

where

t is equal to the time constant, in seconds, of the heat-responsive element;

u is the gas velocity, in meters per second.

Note 1 to entry: The response time index is expressed in units of $(m \cdot s)^{0,5}$.

3.1.12
service load
combined force exerted on the sprinkler body by the *assembly load* (3.1.2) of the *sprinkler* (3.1.13) and the equivalent force of the rated pressure on the inlet

3.1.13
sprinkler
thermosensitive device designed to react at a predetermined temperature by automatically releasing a stream of water and distributing it in a specified pattern and quantity over a designated area

Note 1 to entry: These devices may sometimes be referred to as a sprinkler head.

3.1.14
standard orientation
orientation that produces the shortest response time with the axis of the sprinkler inlet perpendicular to the airflow

Note 1 to entry: In the case of symmetrical heat-responsive elements, standard orientation is with the airflow perpendicular to both the axis of the waterway and the plane of the frame arms; in the case of non-symmetrical heat-responsive elements, it is with the airflow perpendicular to both the waterway axis and the plane of the frame arms which produces the shortest response time.

3.2 Types of sprinklers according to type of responsive element

3.2.1
electrically activated sprinkler
EAS
sprinkler (3.1.13) that is equipped with an integral means of activation using electricity

3.2.2
sprinklers with monitoring of activation
SMA
sprinkler (3.1.13) that is equipped with an integral means of monitoring of activation using electricity

3.2.3
electrically activated sprinkler with monitoring of activation
EAS-M
sprinkler (3.1.13) that is equipped with an integral means of activation using electricity and monitoring of activation

3.2.4
fusible element sprinkler
sprinkler (3.1.13) that opens under the influence of heat by the melting of a component

3.2.5
glass bulb sprinkler
sprinkler (3.1.13) that opens under the influence of heat by the bursting of the glass bulb through pressure resulting from expansion of the fluid enclosed therein

3.3 Types of sprinklers according to type of water distribution

3.3.1
conventional sprinkler
C
sprinkler (3.1.13) giving spherical water distribution directed downward and at the ceiling for a definite protection area such that 40 % to 60 % of the total water flow is initially directed downward

3.3.2
flat spray sprinkler
F
sprinkler (3.1.13) giving water distribution directed downward for a definite protection area such that 85 % to 100 % of the total water flow is initially directed downward with a wider spray angle than expected with a *spray sprinkler* (3.3.3)

Note 1 to entry: This type of sprinkler is used in storage racks and other shallow areas in some countries.

3.3.3
spray sprinkler
S
sprinkler (3.1.13) giving paraboloid water distribution directed downward for a definite protection area such that 80 % to 100 % of the total water flow is initially directed downward

3.3.4
domestic sprinkler
D
sprinkler (3.1.13) intended to provide control of fire in domestic occupancies

3.3.5
extended coverage sprinkler
EC
sprinkler (3.1.13) with a specified area of coverage which is larger than the standard sprinkler coverage areas

3.3.5.1
extended coverage light hazard sprinkler
ECLH
sprinkler (3.1.13) having a specified area of coverage which is larger than the standard sprinkler coverage areas and intended for use in occupancies or portions of occupancies where the quantity and/or combustibility of contents is low, such as office spaces

3.3.5.2
extended coverage ordinary hazard sprinkler
ECOH
sprinkler (3.1.13) having a specified area of coverage which is larger than the standard sprinkler coverage areas and intended for use in occupancies or portions of occupancies where the quantity and/or combustibility of contents is moderate to high

3.3.5.3
extended coverage storage sprinkler
ECSS
sprinkler (3.1.13) having a specified area of coverage which is larger than the standard sprinkler coverage areas and intended to protect stockpiles of commodities in building structures, such as storage facilities

3.3.6
standard coverage storage sprinkler
SCSS
sprinkler (3.1.13) having a standard area of coverage (typically 9 m^2 maximum) and intended to protect stockpiles of commodities in building structures, such as storage facilities

3.3.7
early suppression fast response automatic sprinkler
ESFR
sprinkler (3.1.13) that is intended to provide early suppression of a fire when protecting stockpiles of commodities in building structures such as storage facilities

3.4 Types of sprinklers according to position

3.4.1
horizontal sidewall sprinkler
H
sprinkler (3.1.13) arranged such that the orifice directs the water stream horizontally towards the deflector giving a one-sided distribution pattern

3.4.2
pendent sprinkler
P
sprinkler (3.1.13) arranged such that the orifice directs the water stream downwards towards the deflector

3.4.3
vertical sidewall sprinkler
W
sprinkler (3.1.13) arranged such that the orifice directs the water stream upwards or downwards towards the deflector giving a one-sided water distribution

3.4.4
upright sprinkler
U
sprinkler (3.1.13) arranged such that the orifice directs the water stream upwards towards the deflector

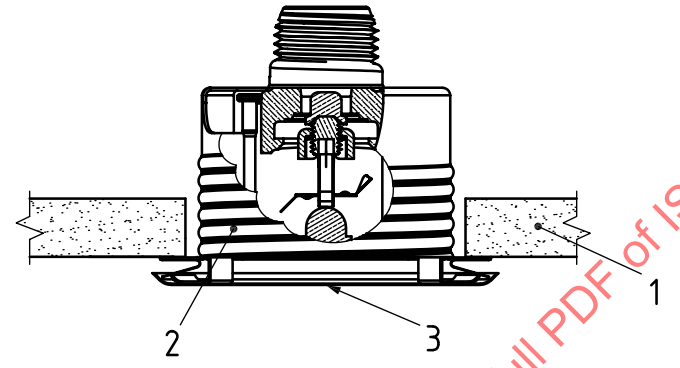
3.5 Special types of sprinklers

3.5.1
coated sprinkler
sprinkler (3.1.13) that has a factory-applied coating for corrosion protection

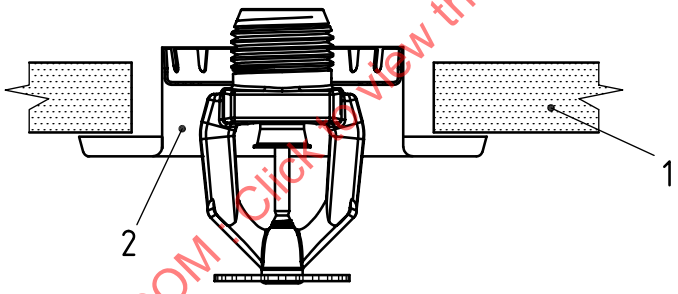
Note 1 to entry: For this document coated sprinkler does not include coatings intended for aesthetic purposes.

3.5.2
concealed sprinkler
recessed sprinkler (3.5.6) having a cover plate

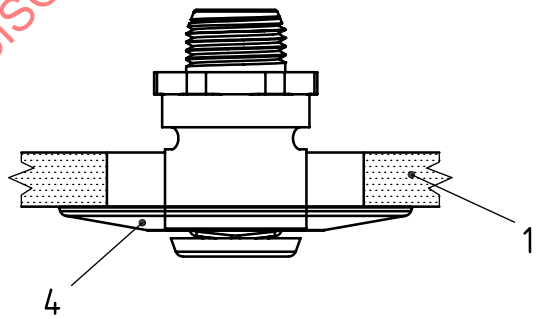
Note 1 to entry: See Figure 3 a).



a) Concealed sprinkler



b) Recessed sprinkler



c) Flush sprinkler

Key
1 ceiling
2 housing assembly
3 cover plate
4 escutcheon

Figure 3 — Flush, concealed, and recessed sprinklers

3.5.3
dry sprinkler
assembly comprising of a *sprinkler* (3.1.13) mounted at the outlet of a special extension with a seal at the inlet that prevents water from entering the extension until it is released by operation of the sprinkler

Note 1 to entry: These sprinklers may consist of pendent, upright, sidewall and other types.

3.5.4
flush sprinkler
for *pendent sprinklers* (3.4.2), all or part of the body is mounted above the lower plane of the ceiling, but all of the heat-responsive collector is below the lower plane of the ceiling; for sidewall sprinklers, the sprinkler is within the wall, but the heat-responsive collector projects into the room beyond the plane of the wall

Note 1 to entry: See Figure 3 c).

Note 2 to entry: These are not typically frame arm sprinklers.

[SOURCE: ISO 6182-1:2014, 3.5.4, modified — Notes to entry added]

3.5.5
multiple orifice sprinkler
sprinkler (3.1.13) having two or more outlet orifices arranged to distribute the water discharge in a specified pattern and quantity for a definite protection area

Note 1 to entry: Multiple orifice sprinklers are not included in the scope of this document.

3.5.6
recessed sprinkler
sprinkler (3.1.13) of which all or part of the body, other than the thread, is mounted within a recessed housing

Note 1 to entry: See Figure 3 b).

3.5.7
sprinkler with water shield
sprinkler (3.1.13), intended for use in racks or beneath open grating, which is provided with a water shield mounted above the heat-responsive element to protect it from water discharged by sprinklers at higher elevations

Note 1 to entry: Sprinklers with water shields may be a single unit that is assembled by the manufacturer or a combination of sprinkler and water shield (which in some countries are evaluated separately from the sprinkler approval) assembled on site.

3.6 Types of sprinklers according to sprinkler sensitivity

3.6.1
fast-response sprinkler
sprinkler (3.1.13) with a *response time index* (3.1.11) (RTI) ≤ 50 $(m{\cdot}s)^{0,5}$ as determined in 6.18 or for *flush* (3.5.4), *concealed* (3.5.2) and *recessed sprinklers* (3.5.6), a maximum response time as determined in 6.19

3.6.2
special-response sprinkler
sprinkler (3.1.13) with an average *response time index (RTI)* (3.1.11) of between 50 $(m{\cdot}s)^{0,5}$ and 80 $(m{\cdot}s)^{0,5}$

3.6.3
standard-response sprinkler
sprinkler (3.1.13) with a *response time index (RTI)* (3.1.11) of between 80 $(m \cdot s)^{0,5}$ and 350 $(m \cdot s)^{0,5}$ as determined in 6.18 or for *flush* (3.5.4), *concealed* (3.5.2) and *recessed sprinklers* (3.5.6), a maximum response time as determined in 6.19

4 Product consistency

4.1 Quality control programme

It shall be the responsibility of the manufacturer to implement a quality control programme to ensure that production continuously meets the requirements of this document.

4.2 Leak resistance testing

Every manufactured sprinkler shall pass a leak resistance test equivalent to a hydrostatic pressure of at least twice the rated pressure for at least 2 s.

4.3 Glass bulb integrity test

Each glass bulb sprinkler assembly shall be evaluated for glass bulb cracking, breaking, or other damage as indicated by the loss of fluid. The test shall be conducted after the leakage test.

The bubble in each glass bulb shall be examined at room ambient temperature. The sprinkler 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.

5 Product assembly

5.1 General

All sprinklers shall be designed and manufactured such that they cannot be readily adjusted, dismantled or reassembled.

NOTE This requirement does not apply to units intended for assembly/adjustment on site, e.g. combinations of sprinkler and housing assemblies/escutcheons or the assembly of the cover plate to concealed sprinklers.

5.2 Dynamic O-ring seals

The closure of the water way shall not be achieved by the use of a dynamic O-ring or similar seal that moves during operation or is in contact with a component that moves during operation.

5.3 Rated pressure

5.3.1 All sprinklers, other than storage and ESFR, shall have a rated pressure of not less than 1,2 MPa (12 bar).

5.3.2 Storage and ESFR sprinklers shall have a rated pressure of 1,2 MPa (12 bar).

5.4 Dry sprinklers

When installed with the intended fittings specified in the manufacturer's installation instructions, dry sprinklers in dry systems shall be constructed to minimize the potential to accumulate water, scale and sediment on the sprinkler inlet. The sprinkler inlet shall also be constructed so as not to substantially impact the sprinkler K-factor or pressure loss through the fitting.

5.5 Escutcheons

Escutcheons for sprinklers shall be constructed of a metallic material.

6 Requirements

6.1 General

6.1.1 Electrically activated sprinkler and monitoring of activation

6.1.1.1 Where an activation element or monitoring of activation is required for testing, electrically activated sprinklers shall comply with the requirements described herein with their integral activation element installed.

6.1.1.2 Where sprinkler operation is required as a part of a test, the sprinkler shall be operated in the intended manner using the detection and control equipment or electrical power referenced by the manufacturer as being suitable for use with the electrically activated sprinkler and sprinkler with monitoring of activation.

6.1.1.3 During fire testing, the maximum delay time between the detection of a fire to the release of the sprinkler shall be included into the test parameters.

6.1.1.4 Electrical components used to activate or monitor the sprinkler shall comply with the relevant requirements of ISO 7240.

6.1.1.5 For an electrically activated sprinkler that incorporates a glass bulb or fusible element as a secondary means of operation, the glass bulb or fusible element shall comply with the relevant requirements of this document with the electrical components attached.

6.1.2 Orifice size

6.1.2.1 All sprinklers shall be constructed with a single orifice so that a sphere of diameter 8 mm can pass through the orifice in the sprinkler, with the exceptions specified in 6.1.2.2 and 6.1.2.3.

6.1.2.2 In those countries where 6 mm or 8 mm orifice automatic sprinklers are acceptable, and the sprinklers are used together with a strainer in the system or in each sprinkler, a 5 mm sphere may be used for checking the size of the orifice.

6.1.2.3 Domestic sprinklers shall be constructed so that a sphere of diameter 5 mm can pass through the sprinkler.

6.1.3 Nominal thread sizes

Nominal thread sizes shall be in accordance with Table 1 and suitable for fittings threaded in accordance with ISO 7-1 in regions where this document is applicable. The dimensions of all threaded connections should conform to International Standards where applied or shall conform to national standards where International Standards are not applicable.

Table 1 — Nominal thread sizes

Sprinkler flow constant, *K* (l/min)/ ($bar^{1/2}$)	**Thread size** (mm)
57 ± 3	10 or 15
80 ± 4	15
115 ± 6	15 or 20
160 ± 8	15 or 20
202 ± 10	20
242 ± 12	20
323 ± 16	25
363 ± 18	25
404 ± 20	25
NOTE Dry sprinklers can have thread sizes larger than those shown in this table.	

6.2 Maximum coverage areas and spacing

6.2.1 Pendent and upright domestic, ECLH, and ECOH sprinklers shall have a square area of coverage not exceeding 37,2 m^2 with sprinkler spacing in nominal 0,5 m increments.

6.2.2 Domestic sprinklers shall be permitted to have a 4,6 m by 4,6 m spacing as described in 7.31.2

6.2.3 Sidewall domestic sprinklers, ECLH, and ECOH shall have an area of coverage not exceeding 37,2 m^2 with sprinkler spacing in nominal 0,5 m increments.

6.2.4 Pendent and upright ECSS shall have an area of coverage not exceeding 18 m^2 with sprinkler spacing in nominal 0,5 m increments.

6.3 Temperature ratings and colour coding

The marked nominal temperature rating and colour coding of sprinklers shall be in accordance with Table 2.

NOTE See 8.1 for concealed, flush, coated, and plated sprinklers.

Table 2 — Nominal temperature rating and colour coding

Glass bulb sprinklers		**Fusible element sprinklers**	
Marked nominal temperature rating °C	**Liquid colour code**	**Marked nominal temperature rating** °C	**Yoke arm colour code**
57	orange	57 to 77	uncoloured
68	red	—	—
79	yellow	80 to 107	white
93 107	green	—	—
121 141	blue	121 to 149	blue
163 182	mauve	163 to 191	red

Table 2 *(continued)*

Glass bulb sprinklers		Fusible element sprinklers	
Marked nominal temperature rating °C	**Liquid colour code**	**Marked nominal temperature rating** °C	**Yoke arm colour code**
204	black	204 to 246	green
227		260 to 302	orange
260		320 to 343	
343			

6.4 Service load and strength of sprinkler body (see 7.4)

6.4.1 The sprinkler body shall comply with the requirements of 6.4.2 or 6.4.3.

6.4.2 The sprinkler body shall not show permanent elongation of more than 0,2 % between the load-bearing points of the sprinkler body after being subjected to twice the service load as measured according to 7.4.1 or 7.4.2.

6.4.3 The sprinkler body shall not show permanent elongation of more than 50 % of the sprinkler body with the design load being applied after being subjected to twice the assembly load as measured according to 7.4.3.

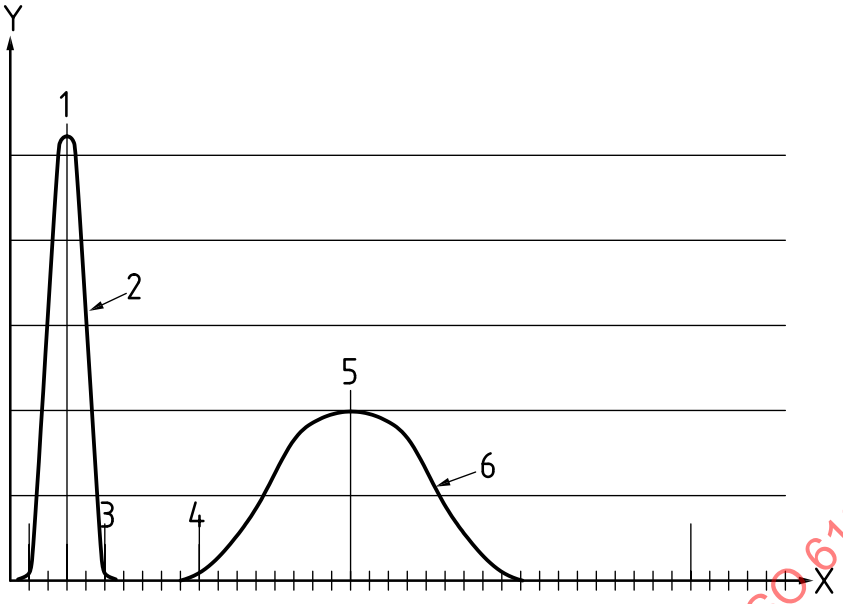
6.4.4 The manufacturer shall specify the average and upper limits of the service or assembly load. These values shall not be exceeded when tested in accordance with 7.4.1, 7.4.2, or 7.4.3 as applicable.

6.5 Strength of heat-responsive element (see 7.5)

6.5.1 Glass bulb elements

When tested in accordance with 7.5, glass bulb elements shall have a design strength lower tolerance limit (LTL) on the strength distribution curve of at least twice the upper tolerance limit (UTL) of the service load distribution curve based on calculations with a degree of confidence (y) of 0,99 for 99 % of the samples (P). Calculations will be based on normal or Gaussian distribution, except where another distribution can be shown to be more applicable due to manufacturing or design factors.

NOTE See Figure 4.



Key

X	load, strength	5	average design strength
Y	frequency	6	design strength curve
1	average service load		
2	service load curve		
3	UTL		
4	LTL		

Figure 4 — Strength curve

6.5.2 Fusible elements

A fusible heat-responsive element in the ordinary temperature range shall be designed to:

a) sustain a load of 15 times its design load corresponding to the maximum service load measured according to 7.5 for a period of 100 h when tested in accordance with 7.5.2.1

or

b) demonstrate the ability to sustain the design load when tested in accordance with 7.5.2.2

NOTE See Annex B.

6.6 Leak resistance and hydrostatic strength (see 7.6)

6.6.1 A sprinkler shall not show any sign of leakage when tested according to 7.6.1.

6.6.2 A sprinkler shall not rupture, operate, or release any parts when tested according to 7.6.3.

6.7 Thirty-day leakage resistance (see 7.7)

When tested in accordance with 7.7, sprinklers shall not leak or sustain any mechanical damage. Following completion of 7.7, the sprinklers shall meet the requirement of 6.6.1 and show no evidence of distortion or other mechanical damage.

6.8 Vacuum resistance (see 7.8)

Sprinklers shall not exhibit distortion or mechanical damage and shall meet the requirements of 6.6.1 after being subjected to the test in 7.8.

6.9 Water hammer (see 7.9)

Sprinklers shall not leak during or after the pressure surges described in 7.9. After being subjected to the test according to 7.9, they shall show no signs of mechanical damage, shall meet the requirement of 6.6.1, and shall operate when functionally tested to the requirements of 6.20 at a pressure of 0,035 MPa (0,35 bar) only.

6.10 Vibration (see 7.10)

Sprinklers shall be able to withstand the effects of vibration without deterioration when tested in accordance with 7.10. After the vibration test of 7.10, sprinklers shall show no visible deterioration and shall meet the requirements of 6.6.1 and 6.18.1, or be in accordance with 6.19 for flush, concealed and recessed sprinklers.

6.11 Deflector strength (see 7.11)

The deflector and its supporting parts shall not sustain significant damage as a result of the deflector strength test specified in 7.11.

If minor damage is noted, testing in accordance with 6.28 can be carried out to demonstrate conformance.

NOTE In most instances, visual examination of the sprinkler is sufficient to establish conformance with 6.11.

6.12 Water shield rotation (see 7.12)

Rotation of the water shield shall not alter the sprinkler service load when evaluated in accordance with 7.12.

6.13 Impact (see 7.13)

6.13.1 Sprinklers shall show no fracture or deformation and shall meet the requirements of 6.6.1 and 6.18.1 or in accordance with 6.19 for flush, concealed and recessed sprinklers after the impact test of 7.13.1. If the sprinkler is deformed during testing, water distribution testing in accordance with 6.28 shall be required.

6.13.2 The water shield of a water-shield sprinkler shall not separate or bend sufficiently to impair sprinkler function as a result of the impact test in 7.13.2.

6.14 Protective covers (see 7.14)

6.14.1 Sprinklers may be equipped with protective covers that are designed to remain in place during installation and be removed before the sprinkler system is placed in service.

6.14.2 Glass bulb sprinklers equipped with protective covers shall comply with the impact test for protective covers and marking requirements, Section 7.14 and 8.3.

6.14.3 A glass bulb sprinkler, with the protective cover installed, shall not be damaged or leak and the cover shall remain in place when tested as described in 7.14.

6.14.4 Protective covers shall be designed not to allow damage to the sprinkler and the heat sensing element during assembly of the sprinkler, installation of the sprinkler, and removal of the cover. Removal shall be possible without tools unless specified by the manufacturer.

6.15 Rough usage (see 7.15)

A sprinkler shall withstand the effects of rough usage without deterioration of its performance characteristics. After the test of 7.15, sprinklers shall comply with the leak requirement of 6.6.1 and 6.18.1, or in accordance with 6.19 for flush, concealed and recessed sprinklers.

6.16 Dry sprinkler air tightness (see 7.16)

When tested as described in 7.16.1 and 7.16.2, the connection of the extension nipple to the inlet seal assembly for a dry-type pendent or sidewall sprinkler shall not exhibit leakage at any air pressure from 0 kPa to 100 kPa (0 bar to 1 bar) when the pressure is applied externally to this connection.

6.17 Operating temperature (see 7.17)

Sprinklers shall be verified to operate within a temperature range, in accordance with Formula 2:

$$t = x \pm (0{,}035x + 0{,}62) \text{ for temperature ratings of less than 204 °C,} \quad (2)$$

or

$$t = x \pm (0{,}07x + 0{,}62) \text{ for temperature ratings of 204 °C or greater.}$$

where

t is the temperature range, rounded to the nearest 0,1 °C;

x is the marked nominal temperature rating;

NOTE See Table 2.

6.18 Sensitivity — response time index (RTI) (see 7.18)

6.18.1 Pre-exposure RTI

6.18.1.1 Standard-, special- and fast-response sprinklers shall meet the RTI limits as defined in 3.6.1 through 3.6.3 when tested in the standard orientation in accordance with 7.18.

6.18.1.2 For flush, concealed and recessed sprinklers, see 6.19.

6.18.1.3 ESFR sprinklers shall have an RTI not exceeding 36 $(m{\cdot}s)^{0,5}$ when tested in orientations A and B as described in 7.18.1.3.

An ESFR sprinkler having an RTI greater than 36 $(m{\cdot}s)^{1/2}$ but not exceeding 50 $(m{\cdot}s)^{1/2}$ shall be permitted when fire suppression can be demonstrated through additional large-scale fire tests described in 7.31.7 for the sprinklers utilizing a higher RTI heat responsive element in the as received condition.

6.18.1.4 Domestic and extended coverage sprinklers shall meet the requirements for fast response sprinklers.

6.18.2 Post-exposure RTI

After exposure to the corrosion test according to 6.26.3, 6.26.4, and 6.26.5, sprinklers shall be tested in the standard orientation in accordance with 7.18.1 for sprinklers other than ESFR sprinklers, and orientation A for ESFR sprinklers, to determine the post-exposure RTI. All post-exposure RTI values shall be calculated as in 7.18.2. The values determined shall meet one of the following:

a) none of the post-exposure RTI values shall exceed the limits referenced in 6.18.1;

b) the average RTI value shall not exceed 130 % of the average unexposed samples.

6.19 Sensitivity test of flush, concealed and recessed sprinklers (see 7.19)

6.19.1 General

Flush, concealed and recessed sprinklers shall meet the requirements of either 6.19.2 or 6.19.3.

When flush, recessed and concealed sprinklers are not identified as to response type, any of the test methods in 6.19.2 through 6.19.3 may be used.

6.19.2 Room response test (see 7.19.2)

6.19.2.1 When tested in accordance with 7.19.2, standard-response and standard-response ECOH flush, concealed and recessed sprinklers shall operate such that the mean response time and unbiased standard deviation provide computed statistical tolerance limits (see Annex F) with 95 % confidence that 99 % of the sprinklers tested do not exceed the applicable time limit described in Table 3.

6.19.2.2 When tested in accordance with 7.19.2, fast-response, domestic, fast-response ECLH and fast-response ECOH flush, concealed and recessed sprinklers shall operate within the applicable time limit described in Table 3.

Table 3 — Room sensitivity operating time requirements for flush, concealed and recessed sprinklers

Sprinkler type	Sprinkler temperature rating of 77 °C or less	Sprinkler temperature rating of 79 °C to 107 °C
Standard-response	231 s	189 c
Fast-response	75 s	75 s
Domestic	75 s	75 s
Fast-response ECLH	75 s	75 s
Standard-response ECOH	150 s	120 s
Fast-response ECOH	55 s	55 s

6.19.3 Plunge test (see 7.19.3)

6.19.3.1 When tested in accordance with 7.19.3, flush, concealed and recessed sprinklers shall operate such that the mean response time of three samples tested at each of the test conditions specified in

Table 5 does not exceed the theoretical maximum response time (t_{max}) calculated in accordance with Formula (3):

$$t_{max} = RTI * \frac{ln\left(1-\frac{\Delta T_{ea}}{\Delta T_g}\right)}{\sqrt{u}} \quad (3)$$

where

t_{max} is the maximum permitted response time, expressed in seconds;

RTI is the maximum permitted RTI taken from Table 4;

ΔT_{ea} is the temperature difference, expressed in degrees Celsius (°C), between the maximum permitted operating temperature of the sprinkler, in accordance with 6.17 and the ambient temperature;

ΔT_g is the temperature difference, expressed in degrees Celsius (°C), between the gas temperature in the test section of the tunnel, taken from Table 5, and the ambient temperature.

u is the gas velocity in the test section of the tunnel, expressed in metres per second (m/s), taken from Table 5.

6.19.4 After exposure to the corrosion test according to 6.26.3, 6.26.4, and 6.26.5, sprinklers shall be tested in accordance with 7.19. The mean time of operation after exposure shall be equal to or less than 1,30 multiple of the mean time of operation of sprinklers not subjected to the corrosion test.

Table 4 — Maximum permitted RTI

Sprinkler response	RTI $(m \cdot s)^{0,5}$
Standard	350
Special	80
Fast	50

Table 5 — Sensitivity test conditions for flush, concealed and recessed sprinklers

Test condition	Gas temperature ºC	Gas velocity m/s	Applied vacuum mm Hg[a]
1	135	2,6	0,007
2	135	3,5	0,007
3	197	2,6	0,010
4	197	3,5	0,010
5	290	2,6	0,013
6	290	3,5	0,013

[a] 1 mm Hg = 133,322 4 Pa

6.20 Lodgement (see 7.20)

When tested in accordance with 7.20, the sprinkler shall open and any lodgement of released parts shall be cleared within 10 s of release of the heat-responsive element.

6.21 Heat exposure (see 7.21)

6.21.1 Glass bulb sprinklers

There shall be no damage to the glass bulb element when the sprinkler is tested according to 7.21.1.

6.21.2 All sprinklers

Sprinklers shall withstand exposure to increased ambient temperature without evidence of weakness or failure when tested according to 7.21.2.

6.21.3 Coated sprinklers

In addition to meeting the requirement of 6.21.2 in an uncoated version, coated sprinklers shall withstand exposure to increased ambient temperatures without evidence of weakness or failure of the coating when tested according to 7.21.3.

6.22 Sprinkler coatings (see 7.22)

6.22.1 Evaporation of wax and bitumen

Waxes and bitumens used for coating sprinklers shall not contain volatile matter in quantities sufficient to cause shrinkage, hardening, cracking, or flaking of the applied coating. The loss in mass shall not exceed 5 % of that of the original sample when tested according to 7.22.1.

6.22.2 Resistance to low temperatures

All coatings used for sprinklers shall not crack or flake when subjected to low temperatures in accordance with 7.22.2.

6.23 Thermal shock for glass bulb sprinklers (see 7.23)

Glass bulb sprinklers shall not be damaged when tested according to 7.23. Following the thermal shock exposure, the sprinkler shall comply with 6.20 when tested with an inlet pressure of 0,035 MPa (0,35 bar).

6.24 Resistance to heat (see 7.24)

Open sprinklers shall be resistant to high temperatures when tested in accordance with 7.24. After exposure, the sprinkler shall not fracture or break. If visual deformation is observed on the sprinkler orifice it shall meet the requirements of 6.27. If visual deformation is observed on the sprinkler frame or deflector, it shall meet the requirements of 6.28.

6.25 Freezing test (see 7.25)

Sprinklers shall be resistant to low temperatures when tested in accordance with 7.25. After exposure, the sprinkler shall either be visibly damaged, leak subsequent to thawing at a pressure not exceeding 0,05 MPa (0,5 bar), or be undamaged. Sprinklers not visibly damaged or leaking at a pressure not exceeding 0,05 MPa (0,5 bar) shall meet the requirements of 6.6.1 and shall meet the RTI requirements of 6.18.1.

6.26 Corrosion (see 7.26)

6.26.1 Stress corrosion for copper-based alloy components (see 7.26.1)

When tested in accordance with 7.26.1, each sprinkler shall not show any cracks, signs of delamination or failure that can affect its ability to function as intended.

6.26.2 Stress corrosion for stainless steel components (see 7.26.2)

Sprinklers having components consisting of stainless steel alloys shall be subjected to 7.26.2. The stainless steel components shall not show evidence of fracture, distortion, or impending separation from the frame when tested as described in 7.26.2.

6.26.3 Sulphur dioxide/carbon dioxide corrosion (see 7.26.3)

Coated and uncoated sprinklers shall be resistant to sulphur dioxide / carbon dioxide saturated with water vapor when conditioned in accordance with 7.26.3.

Following exposure, glass bulb sprinkler samples shall either be:

a) tested at 0,035 MPa (0,35 bar) in accordance with 6.20; or

b) meet the requirements of 6.19.4 for concealed and recessed sprinklers or the requirements of 6.18.2 for other types of sprinklers.

Following exposure, half of the fusible element sprinkler samples shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with 6.20 and the remaining samples shall meet the requirements of 6.19.4 for flush, concealed and recessed sprinklers or the requirements of 6.18.2 for other types of sprinklers.

6.26.4 Hydrogen sulphide corrosion (see 7.26.4)

Coated and uncoated sprinklers shall be resistant to hydrogen sulphide saturated with water vapor when conditioned in accordance with 7.26.4.

Following exposure, glass bulb sprinkler samples shall either be:

a) tested at 0,035 MPa (0,35 bar) in accordance with 6.20; or

b) meet the requirements of 6.19.4 for flush, concealed and recessed sprinklers or the requirements of 6.18.2 for other types of sprinklers.

Following exposure, half of the fusible element sprinkler samples shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with 6.20 and the remaining samples shall meet the requirements of 6.19.4 for flush, concealed and recessed sprinklers or the requirements of 6.18.2 for other types of sprinklers.

6.26.5 Salt spray loading (see 7.26.5)

Coated and uncoated sprinklers shall be resistant to salt spray when conditioned in accordance with 7.26.5.

Following exposure, glass bulb sprinkler samples shall either be:

a) tested at 0,035 MPa (0,35 bar) in accordance with 6.20;

or

b) meet the requirements of 6.19.4 for flush, concealed and recessed sprinklers or the requirements of 6.18.2 for other types of sprinklers.

Following exposure, half of the fusible element sprinkler samples shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with 6.20 and the remaining samples shall meet the requirements of 6.19.4 for flush, concealed and recessed sprinklers or the requirements of 6.18.2 for other types of sprinklers.

6.26.6 Moist air exposure (see 7.26.6)

Sprinklers shall be resistant to moist air exposure when tested in accordance with 7.26.6. Following exposure, the sprinklers shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with 6.20.

6.26.7 Dry-type sprinkler deposit loading (see 7.26.7)

Following exposure to a carbon dioxide-sulphur dioxide atmosphere in accordance with 7.26.7.1 to 7.26.7.3, the internal components of a dry-type sprinkler shall function as intended when 0,05 MPa (0,5 bar) air pressure is applied to the sprinkler inlet and the heat responsive element is operated.

6.26.8 Dezincification of brass parts (see 7.26.8)

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

a) An average dezincification depth exceeding 100 µm; and

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

6.27 Water flow constant (see 7.27)

The flow constant, *K*, for sprinklers is determined by Formula (4):

$$K = q/\sqrt{p} \tag{4}$$

where

q is the flow rate, expressed in litres per minute.;

p is the pressure, expressed in bar.

With the exception domestic sprinklers, the flow constant, *K*, for sprinklers shall be in accordance with Table 6 when determined by the test method given in 7.27.

For domestic sprinklers, the value of the nominal flow constant, *K*, published in the manufacturer's design and installation instructions shall be verified using the test method of 7.27. Each flow constant, *K*, (calculated) shall be within ±5 % or ±3 units of the manufacturer's value, whichever is greater.

Table 6 — Flow constant requirements

Sprinkler type	Nominal flow constant, *K* (l/min)/(bar$^{1/2}$)	Tolerance for wet type	Tolerance for dry type
Spray	57	±3	±5
	80	±4	±6
	115	±6	±9
Flat	80	±4	±6
	115	±6	±9
NOTE 1(l/min)/(bar1/2) = 0,003 2 (m3/min)/(MPa1/2).			

Table 6 *(continued)*

Sprinkler type	Nominal flow constant, *K* (l/min)/(bar$^{1/2}$)	Tolerance for wet type	Tolerance for dry type
ECLH	80	±4	±6
	115	±6	±9
	160	±8	±12
	202	±10	±15
ECOH	160	±8	±12
	202	±10	±15
ECSS	242	±12	±18
	363	±18	±27
SCSS	160	±8	±12
	202	±10	±15
	242	±12	±18
	283	±14	±21
	363	±18	±27
ESFR	202	±10	±15
	242	±12	±18
	323	±16	±24
	363	±18	±27
	404	±20	± 30
NOTE 1(l/min)/(bar1/2) = 0,003 2 (m3/min)/(MPa1/2).			

6.28 Water distribution (see 7.28)

6.28.1 General

6.28.1.1 As referenced in Table 7, sprinklers tested in accordance with column 3 shall meet the applicable requirements of column 2.

6.28.1.2 Elements of integral means of activation using electricity and/or monitoring of activation should not interfere with the sprinkler's water distribution characteristics.

Table 7 — Requirements and test methods by sprinkler type

Sprinkler Type	Requirements	Test method
Pendent spray sprinkler, P Upright spray sprinkler, U Dry pendent Dry upright Flat spray, F Conventional, C	See 6.28.2.1 and 6.28.2.2	See 7.28.2.1 and 7.28.2.2
Recessed sprinkler, P Concealed sprinkler Flush pendent	See 6.28.2.1	See 7.28.2.1

Table 7 *(continued)*

Sprinkler Type	Requirements	Test method
Sidewall spray sprinkler, H Spray sprinkler, W Recessed sprinkler, H Recessed sprinkler, W Dry sidewall Flush sidewall	See 6.28.2.3	See 7.28.2.3
Domestic pendent Domestic upright	See 6.28.3	See 7.28.3.1, 7.28.3.1.1 and 7.28.3.2
Domestic sidewall	See 6.28.3	See 7.28.3.1, 7.28.3.1.2 and 7.28.3.2
Pendent extended coverage light hazard (ECLH) Upright extended coverage light hazard (ECLH)	See 6.28.4	See 7.28.4.1 and 7.28.4.3
Sidewall extended coverage light hazard (ECLH)	See 6.28.4	See 7.28.4.2 and 7.28.4.3
Pendent extended coverage ordinary hazard (ECOH) Upright extended coverage ordinary hazard (ECOH)	See 6.28.5	See 7.28.5
ESFR pendent, K-202 ESFR pendent, K-242	See 6.28.6 and 6.28.7	See 7.28.6 and 7.28.7

6.28.2 Spray, flat spray, conventional and dry sprinkler water distribution (see 7.28.2)

6.28.2.1 For other than sidewall types, the number of containers having less than 50 % of the water coverage as specified in column 2 of Table 22, shall not exceed the permitted number of containers with a lower content of water, as specified in column 6 of Table 22.

6.28.2.2 The water discharge of sprinklers downward from the deflectors shall be:

— 40 % to 60 % for conventional sprinklers,

— 85 % to 100 % for flat spray sprinklers, and

— 80 % to 100 % for spray sprinklers.

NOTE This requirement does not apply to recessed, flush, concealed, and sidewall sprinklers.

6.28.2.3 In the area between the sidewall sprinklers, the back wall shall be completely wetted from the floor up to 1,2 m below the deflector (see Figure 26).

The total quantity of water collected along the back wall shall be a minimum of 3,5 % of the total water discharged from the sprinklers during the test.

For sidewall sprinklers having a nominal K-factor of 80 (l/min)/(bar$^{1/2}$) or less, the water flow rate shall be 57 l/min for each sprinkler. The average water collection rate in the containers shall be not less than 2 mm/min and the minimum water collection rate in any individual pan shall be 1,2 mm/min.

For sidewall sprinklers having a nominal K-factor of 115 (l/min)/(bar$^{1/2}$), the water flow rate shall be 78 l/min for each sprinkler. The average water collection rate in the containers shall be not less than 2,8 mm/min and the minimum water collection rate in any individual pan shall be 1,2 mm/min.

6.28.3 Domestic sprinkler water distribution (see 7.28.3)

6.28.3.1 Horizontal surfaces

When installed in accordance with the manufacturer's design and installation instructions and tested as described in 7.28.3.1, a sprinkler shall distribute water over a horizontal surface such that the discharge density collected in any single 300 mm × 300 mm collection pan within the design area shall be at least 0,8 mm/min, except that:

a) no more than four collection pans in each quadrant shall be allowed to be at least 0,6 mm/min for upright and pendent sprinklers; and

b) no more than eight collection pans shall be allowed to be at least 0,6 mm/min for each half (split along the sprinkler centreline) of the design area for sidewall sprinklers.

6.28.3.2 Vertical surfaces

When installed in accordance with the design and installation instructions and tested as described in 7.28.3.2, a sprinkler shall distribute water over vertical surfaces as follows:

a) Walls within the coverage area shall be wetted to at least 700 mm of the ceiling with one sprinkler discharging at the specified design flow rate.

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

$$A_{col} = 0{,}2\left(\frac{l_w}{l_p}\right) \tag{5}$$

where

A_{col} is the required amount of water collected on a wall, expressed in percent;

l_w is the wall length, expressed in metres;

l_p is the total perimeter of coverage area, i.e. the length of all walls combined, expressed in metres.

6.28.4 Extended coverage light hazard sprinkler water distribution (see 7.28.4)

6.28.4.1 Upright and pendent sprinklers shall be evaluated using one quadrant of the room as shown in Figure 30 and Figure 31. Sidewall sprinkler distributions shall be measured utilizing one half of the floor area as shown in Figure 32. In all cases, a space of 25 mm shall be maintained between all walls and pans.

6.28.4.2 Not more than one pan shall have a collection less than 0,6 mm/minute and it shall not have less than 0,2 mm/minute.

6.28.4.3 The average collection of all the distribution pans for each test shall be a minimum of 1,6 mm/minute.

6.28.4.4 Sprinklers must meet all criteria when tested to the parameters shown in Table 24 and Table 25.

6.28.4.5 When installed as specified by the manufacturer and tested as described in 7.28.4.3, each extended coverage sprinkler shall wet the wall surfaces of the test area to a height within 1,5 m of the ceiling.

6.28.4.6 Coated sprinklers shall be subjected to additional distribution tests if the coating is observed to deform or deteriorate during the sensitivity-RTI test of 6.18.

6.28.5 Extended coverage ordinary hazard sprinkler water distribution (see 7.28.5)

The water collected in any individual collection pan, the average water collected for all collection pans in the distribution area, and the average water collected for collection pans in any 1,5 m^2 square area shall comply with the values specified in Table 8 with four sprinklers discharging water at the flows and distances above the collection pans specified in Table 8. The sprinklers shall be tested using the coverage areas specified by the manufacturer.

Table 8 — ECOH water distribution test parameters and requirements

Sprinkler Coverage Area (m)	Number of collection pans	Deflector to pan distance (m)	Water flow per sprinkler (l/min)	Minimum collection in any individual pan (mm/min)	Minimum average collection in any 1,5 m^2 square area (mm/min)	Minimum average collection in all pans (mm/min)
4,3 × 4,3	64	2,29	113	3,21	4,71	6,42
	64	2,29	147	4,28	6,42	8,66
	64	0,91	113	1,28	3,42	6,42
	64	0,91	147	1,28	4,71	8,66
4,9 × 4,9	100	2,29	147	3,21	4,71	6,42
	100	2,29	193	4,28	6,42	8,66
	100	0,91	147	1,28	3,42	6,42
	100	0,91	193	1,28	4,71	8,66
5,5 × 5,5	144	2,29	185	3,21	4,71	6,42
	144	2,29	246	4,28	6,42	8,66
	144	0,91	185	1,28	3,42	6,42
	144	0,91	246	1,25	4,71	8,66
6,1 × 6,1	196	2,29	227	3,21	4,71	6,42
	196	2,29	302	4,28	6,42	8,66
	196	0,91	227	1,28	3,42	6,42
	196	0,91	302	1,28	4,71	8,66

6.28.6 K202 and K242 pendent ESFR sprinkler water distribution (see 7.28.6)

When tested in accordance with 7.28.6 the sprinkler shall meet the requirements of Table 9 for K202 or Table 10 for K242.

Table 9 — ESFR sprinkler water distribution measurement K202

Number of sprinklers under the water collection system	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water collection pans m	Pressure[a,b] MPa (bar)	Minimum 16-pan average density[c] mm/min	Minimum flue space (4 pans) average density[c] mm/min	Minimum 20-pan average density[c] mm/min	Minimum non-flue 10-pan average density[c,d] mm/min	Minimum single non-flue pan density[c] mm/min
1	0	0	3,04	0,34 (3,4)	21,2	40,8	NR	NR	NR
1	0	0	4,42	0,34 (3,4)	19,6	36,3	NR	NR	NR
1	0	0	4,42	0,51 (5,1)	NR	69,4	37,1	20,4	10,6
2	3,04	0	1,27	0,34 (3,4)	24,5	NR	NR	NR	NR
2	3,04	0	3,04	0,34 (3,4)	22,0	NR	NR	NR	NR
2	0	3,04	1,27	0,34 (3,4)	23,7	NR	NR	NR	NR
2	0	3,04	3,04	0,34 (3,4)	23,3	NR	NR	NR	NR
2	3,66	0	1,27	0,34 (3,4)	18,0	NR	NR	NR	NR
2	0	3,66	1,27	0,34 (3,4)	18,4	NR	NR	NR	NR

[a] All 0,34 MPa (3,4 bar) tests are performed on a system fed from both directions (double-feed).

[b] All 0,51 MPa (5,1 bar) tests are performed on a system fed from one direction (single-feed), except for the two-sprinklers, single-pipe tests which are performed on a double-feed system.

[c] NR = No requirement.

[d] Average of the ten non-flue pans with the lowest water collection.

Table 9 *(continued)*

Number of sprinklers under the water collection system	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water collection pans m	Pressure[a,b] MPa (bar)	Minimum 16-pan average density[c] mm/min	Minimum flue space (4 pans) average density[c] mm/min	Minimum 20-pan average density[c] mm/min	Minimum non-flue 10-pan average density[c,d] mm/min	Minimum single non-flue pan density[c] mm/min
2	3,04	0	1,27	0,51 (5,1)	NR	NR	31,4	24,5	8,2
2	0	3,04	1,27	0,51 (5,1)	NR	NR	31,4	24,5	8,2
4	3,04	3,04	1,27	0,34 (3,4)	27,7	NR	NR	NR	NR
4	3,04	3,04	3,04	0,34 (3,4)	35,1	NR	NR	NR	NR
4	2,44	3,6	1,27	0,34 (3,4)	26,9	NR	NR	NR	NR
4	3,04	3,04	1,27	0,51 (5,1)	NR	NR	29,0	24,5	15,1

[a] All 0,34 MPa (3,4 bar) tests are performed on a system fed from both directions (double-feed).

[b] All 0,51 MPa (5,1 bar) tests are performed on a system fed from one direction (single-feed), except for the two-sprinklers, single-pipe tests which are performed on a double-feed system.

[c] NR = No requirement.

[d] Average of the ten non-flue pans with the lowest water collection.

Table 10 — ESFR sprinkler water distribution measurement K242

Number of sprinklers under the water collection system	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water collection pans m	Pressure[a,b] MPa (bar)	Minimum 16-pan average density[c] mm/min	Minimum flue space (4 pans) average density[c] mm/min	Minimum 20-pan average density[c] mm/min	Minimum non-flue 10-pan average density[c,d] mm/min	Minimum single non-flue pan density[c] mm/min
1	0	0	3,04	0,24 (2,4)	21,2	40,8	NR	NR	NR
1	0	0	4,42	0,24 (2,4)	19,6	36,3	NR	NR	NR
1	0	0	4,42	0,36 (3,6)	NR	69,4	37,1	20,4	10,6
2	3,04	0	1,27	0,24 (2,4)	24,5	NR	NR	NR	NR
2	3,04	0	3,04	0,24 (2,4)	22,0	NR	NR	NR	NR
2	0	3,04	1,27	0,24 (2,4)	23,7	NR	NR	NR	NR
2	0	3,04	3,04	0,24 (2,4)	23,3	NR	NR	NR	NR
2	3,66	0	1,27	0,24 (2,4)	18,0	NR	NR	NR	NR
2	0	3,66	1,27	0,24 (2,4)	18,4	NR	NR	NR	NR

[a] All 0,24 MPa (2,4 bar) tests are performed on a system fed from both directions (double-feed).

[b] All 0,36 MPa (3,6 bar) tests are performed on a system fed from one direction (single-feed), except for the two-sprinklers, single-pipe tests which are performed on a double-feed system.

[c] NR = No requirement.

[d] Average of the ten non-flue pans with the lowest water collection.

Table 10 *(continued)*

Number of sprinklers under the water collection system	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water collection pans m	Pressure[a,b] MPa (bar)	Minimum 16-pan average density[c] mm/min	Minimum flue space (4 pans) average density[c] mm/min	Minimum 20-pan average density[c] mm/min	Minimum non-flue 10-pan average density[c,d] mm/min	Minimum single non-flue pan density[c] mm/min
2	3,04	0	1,27	0,36 (3,6)	NR	NR	31,4	24,5	8,2
2	0	3,04	1,27	0,36 (3,6)	NR	NR	31,4	24,5	8,2
4	3,04	3,04	1,27	0,36 (2,6)	27,7	NR	NR	NR	NR
4	3,04	3,04	3,04	0,24 (2,4)	35,1	NR	NR	NR	NR
4	2,44	3,6	1,27	0,24 (2,4)	26,9	NR	NR	NR	NR
4	3,04	3,04	1,27	0,36 (3,6)	NR	NR	29,0	24,5	15,1

[a] All 0,24 MPa (2,4 bar) tests are performed on a system fed from both directions (double-feed).

[b] All 0,36 MPa (3,6 bar) tests are performed on a system fed from one direction (single-feed), except for the two-sprinklers, single-pipe tests which are performed on a double-feed system.

[c] NR = No requirement.

[d] Average of the ten non-flue pans with the lowest water collection.

6.28.7 Thrust force measurements for K202 and K242 pendent ESFR sprinklers (see 7.28.7)

When tested in accordance with 7.28.7, sprinklers shall meet the minimum thrust force requirements shown in Table 11 or Table 12, as appropriate.

Table 11 — Thrust K202

Pressure for sprinklers MPa (bar)	Direction of feed flow	Ceiling clearance to thrust plate m	Minimum required thrust kPa (mbar)
0,34 (3,4)	Double	1,2	0,071 (0,71)
0,36 (3,6)	Double	2,1	0,044 (0,44)
0,51 (5,1)	Single	2,1	0,10 (1,00)

Table 12 — Thrust K242

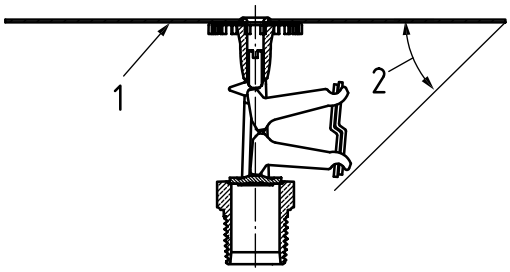
Pressure for sprinklers MPa (bar)	Direction of feed flow	Ceiling clearance to thrust plate m	Minimum required thrust kPa (mbar)
0,24 (2,4)	Double	1,2	0,071 (0,71)
0,24 (2,4)	Double	2,1	0,044 (0,44)
0,36 (3,4)	Single	2,1	0,10 (1,00)

6.29 Lateral discharge (see 7.29)

Sprinklers, other than flat or conventional, shall not prevent the operation of adjacent sprinklers when tested in accordance with 7.29.

6.30 Water shield angle of protection (see 7.30)

Water shields where fitted shall provide an angle of protection of 45° or less in accordance with 7.30. See Figure 5.



Key

1 water shield

2 angle of protection

Figure 5 — Angle of protection

6.31 Fire performance (see 7.31)

6.31.1 General

As outlined in Table 13, sprinklers tested in accordance with column 3 shall meet the applicable requirements of column 2.

Table 13 — Fire test requirements and test methods by sprinkler type

Sprinkler type	Requirements	Test method
Spray sprinkler, pendent Spray sprinkler, upright Dry spray sprinkler, pendent Dry spray sprinkler, upright Flush pendent Recessed sprinkler, pendent Concealed sprinkler, pendent	See 6.31.2	See 7.31.2
Domestic pendent Domestic upright Domestic sidewall	See 6.31.3	See 7.31.3
Pendent extended coverage light hazard (ECLH) Upright extended coverage light hazard (ECLH) Sidewall extended coverage light hazard (ECLH)	see 6.31.4	see 7.31.4
Pendent extended coverage ordinary hazard (ECOH) Upright extended coverage ordinary hazard (ECOH)	see 6.31.5	see 7.31.5
ESFR pendent, K-202 ESFR pendent, K-242	see 6.31.6	see 7.31.6

Table 13 *(continued)*

Sprinkler type	Requirements	Test method
Standard coverage storage sprinkler, pendent, all K-factors Standard coverage storage sprinkler, upright, all K-factors Extended coverage storage sprinkler, pendent, all K-factors Extended coverage storage sprinkler, upright, all K-factors ESFR pendent, all other K-factors ESFR upright, all K-factors	see 6.31.7	see 7.31.7

6.31.2 Spray sprinkler fire performance (see 7.31.2)

6.31.2.1 All nominal K-factor sprinklers of 80 (l/min)/(bar$^{1/2}$) and 115 (l/min)/(bar$^{1/2}$), except sidewall, flat spray, and conventional sprinklers, shall control crib fires when tested according to 7.31.2. For dry-type sprinklers, the shortest length manufactured shall be used for this test.

6.31.2.2 The air temperature at the locations of the thermocouples shall be reduced to less than 275 °C above ambient temperature within the first 5 min of water application.

6.31.2.3 The mean air temperature at the thermocouples shall not exceed 275 °C above ambient temperature for any continuous 3 min period within the remaining test time.

6.31.2.4 The average temperature for the time interval between the time at which the ceiling temperature falls below a temperature of 275 °C above initial ambient and the time at the end of the test shall be computed by comparing the area under the curve determined by the recorded ceiling temperatures with the area beneath a straight line drawn at the temperature point 275 °C above the initial ambient. The area beneath the curve of the recorded ceiling temperatures shall be the lesser of the two areas.

6.31.2.5 The loss in mass of the crib shall not exceed 20 %.

6.31.3 Domestic sprinkler fire performance (see 7.31.3)

6.31.3.1 When fire-tested as described in 7.31.3, sprinklers shall meet the following requirements:

a) Maximum temperature for 76 mm below the ceiling shall not exceed 315 °C.

b) Maximum temperature for 1,6 m above the floor shall not exceed 93 °C.

c) Temperature at the location described in item b) shall not exceed 54 °C for more than any continuous 2-min period.

d) Maximum ceiling material temperature for 6,0 mm behind the finished ceiling surface shall not exceed 260 °C.

e) A maximum of two sprinklers shall operate.

f) The third sprinkler at the doorway shall not operate.

NOTE See Figure 43 (pendent or upright sprinklers) or Figure 44 and Figure 45 (sidewall sprinklers) for temperature measuring locations.

6.31.4 Extended coverage light hazard sprinkler fire performance (see 7.31.4)

When tested as described in 7.31.4, an extended coverage sprinkler shall limit the average loss of weight of three wood cribs to not more than 35 %.

6.31.5 Extended coverage ordinary hazard sprinkler fire performance (See 7.31.5)

6.31.5.1 When tested as described in 7.31.5, water discharged from the sprinkler shall:

a) Not result in the operation of more than the number of sprinklers specified in Table 14 within 45 minutes of the start of the test.

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

c) The water flow rate for sidewall sprinkler spacing other than those described in Table 14 shall not be less than a flow correlating to an 8 mm/min discharge density.

Table 14 — Extended coverage ordinary hazard sprinkler fire test conditions and criteria

Sprinkler coverage area m	Water flow per sprinkler l/min	Maximum number of sprinklers to permitted operate
6,1 by 6,1	303	5
5,5 by 5,5	247	5
4,9 by 4,9	196	6
4,3 by 4,3	150	8

6.31.6 Nominal K-202 and K-242 pendent ESFR fire performance (see 7.31.6)

Nominal K-202 and K-242 pendent ESFR sprinklers shall meet the minimum average densities shown in Table 15 or Table 16 when measured in accordance with 7.31.6.

Table 15 — ADD measurements K202

Number of sprinklers over the ADD apparatus	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water collection pans m	Freeburn convective heat release kW	Pressure MPa (bar)	Direction of feed flow	Minimum 16-pan average ADD mm/min	Minimum flue space (4 pans) average[a] mm/min
1	0	0	4,57	1 318	0,34 (3,4)	Double	19,1	60,3
1	0	0	4,57	2 636	0,34 (3,4)	Double	9,7	20,4
2	3,66	0	1,22	2 636	0,34 (3,4)	Single	11,8	NR
2	0	3,66	1,22	2 636	0,34 (3,4)	Double	14,2	NR

[a] NR = No requirement.

Table 15 *(continued)*

Number of sprinklers over the ADD apparatus	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water collection pans m	Freeburn convective heat release kW	Pressure MPa (bar)	Direction of feed flow	Minimum 16-pan average ADD mm/min	Minimum flue space (4 pans) average[a] mm/min
4	2,44	3,66	1,22	2 636	0,34 (3,4)	Double	26,1	NR

[a] NR = No requirement.

Table 16 — ADD measurement K242

Number of sprinklers over the ADD apparatus	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water collection pans m	Freeburn convective heat release kW	Pressure MPa (bar)	Direction of feed flow	Minimum 16-pan average ADD mm/min	Minimum flue space (4 pans) average[a] mm/min
1	0	0	4,57	1 318	0,24 (2,4)	Double	19,1	60,3
1	0	0	4,57	2 636	0,24 (2,4)	Double	9,7	20,4
2	3,66	0	1,22	2 636	0,24 (2,4)	Single	11,8	NR
2	0	3,66	1,22	2 636	0,24 (2,4)	Double	14,2	NR
4	2,44	3,66	1,22	2 636	0,24 (2,4)	Double	26,1	NR

[a] NR = No requirement.

6.31.7 Standard coverage storage, extended coverage storage and ESFR (Other than K202 & K242 Pendent) sprinkler fire test performance (see 7.31.7)

6.31.7.1 When subjected to large-scale fire testing described in 7.31.7, standard coverage storage extended coverage storage and ESFR (other than K202 & K242 pendent) sprinklers shall comply with the requirements in Table 17.

Table 17 — Storage sprinkler fire performance evaluation criteria

Criteria to be evaluated	Test requirements
Maximum number of sprinklers permitted to operate	For any test, not more than 67 % of the number of sprinklers required to be included in the hydraulic calculation for a sprinkler system design as specified in the manufacturer's installation and design parameter instructions.
Maximum 1 minute average steel temperature, °C	538
Fire spread	No sustained combustion at either end of the main test array length and none at any of the outer edges of the target array.

6.31.7.2 Regardless of the number of sprinklers that operate during the worst-case fire test, the number of sprinklers required to be included in the hydraulic calculation for a sprinkler system design as

specified in the manufacturer's installation and design parameter instructions shall be no less than one of the following:

1) Twelve sprinklers for standard coverage storage sprinklers.

2) Eight sprinklers for extended-coverage storage sprinklers based on a spacing of 3,7 m × 3,7 m.

3) Six sprinklers for extended-coverage storage sprinklers based on a spacing of 4,3 m × 4,3 m.

6.31.7.3 During any of the tests, no sprinklers located on the outside perimeter of the installed sprinkler system shall operate.

6.32 Electrical characteristics

6.32.1 Signals such as starting current shall cause activation of a sprinkler during a specified response time and their acceptable limits shall be specified in a sprinkler datasheet.

6.32.2 Monitoring signals such as electrical monitoring current shall not cause activation of a sprinkler during the operational process for an unlimited amount of time.

6.32.3 Wires and cables shall not be torn away from the sprinkler under a force equal to the weight of the sprinkler.

7 Test methods

7.1 General

Before testing, precise drawings of parts and the assembly shall be submitted together with the appropriate specifications (using SI units). Tests shall be conducted at a room temperature of (20 ± 5) ºC, unless other temperatures are indicated. Sprinklers shall be tested with all the components required by their design and installation.

Unless otherwise stated, the tolerances shall be in accordance with Annex C.

7.2 Preliminary examination

The construction shall be examined to ensure that it is in accordance with Clauses 4 and 5.

7.3 Visual examination

Before testing, sprinklers shall be examined visually with respect to the following:

a) marking;

b) conformance of the sprinklers with the manufacturer's drawings and specification;

c) obvious defects.

7.4 Service load and strength of sprinkler body test (see 6.4)

7.4.1 Test option 1

7.4.1.1 The service load shall be measured on a minimum of 10 sprinklers by securely installing each sprinkler, at room temperature, in a tensile/compression test machine and applying the equivalent of a hydraulic pressure equal to the rated pressure at the inlet.

7.4.1.1.1 Alternatively, the service load may be determined by measuring the assembly load and adding a calculated or measured value of the force equivalent to a hydrostatic pressure equal to the rated pressure at the inlet.

7.4.1.2 An indicator capable of reading deflection to an accuracy of 0,001 mm shall be used to measure any change in length of the sprinkler between the load-bearing points of the sprinkler body. Movement of the sprinkler shank thread in the threaded bushing of the test machine shall be avoided or taken into account.

7.4.1.3 Release hydraulic pressure, if applied, and remove the heat-responsive element of the sprinkler by a suitable method. When the sprinkler is at room temperature, make a second measurement using the indicator.

7.4.1.4 Apply an increasing mechanical load to the sprinkler, at a rate not exceeding 500 N/min, until the indicator reading at the deflector end of the sprinkler returns to the initial value achieved under hydrostatic load. Record the mechanical load necessary to achieve this as the service load.

7.4.1.5 Increase the applied load progressively at a rate not exceeding 500 N/min until twice the average service load has been applied. Maintain this load for (15 ± 5) s.

7.4.1.6 Remove the load and compare the permanent elongation with the requirement of 6.4.2.

7.4.2 Test option 2

7.4.2.1 A minimum of 10 samples shall be individually mounted into a solid fixture and the pipcap/seat, spring, and frame shall be marked for orientation purposes to record the original assembled position. A dial indicator shall be located on the bottom of the sprinkler, through the waterway, and in contact with the bottom of the pipcap/seat. The indicator gage shall be indexed to zero reading.

7.4.2.2 The glass bulb element shall be fractured and removed using pliers or another mechanical device. The compression screw shall then be removed from the sprinkler. The components (spring and pipcap/seat) shall be reassembled in the waterway. A hydraulic ram (or other device) shall be set with a load cell on the top of the sprinkler with an extended ram through the setscrew hole and in contact with the pipcap/seat. A load shall then be applied to the pipcap/seat so as to compress the spring to its original position and held for 10 min. After which, the load that the cell is reporting shall be recorded and is considered the assembly load. After the reading is taken, apply additional load to the pipcap/seat to verify that the spring is not in the flat position.

7.4.2.3 Springs used in this test shall have been preloaded to the nominal assembly load.

7.4.2.4 If this test methodology is used to calculate the assembly load, then preloaded springs shall be used in the production of the sprinklers.

7.4.3 Test option 3

7.4.3.1 The assembly load shall be measured on a minimum of 10 sprinklers by securely installing each sprinkler at room temperature in a tensile/compression test machine.

7.4.3.2 An indicator capable of reading deflection to an accuracy of 0,001 mm shall be used to make the first measurement of any change in length of the sprinkler between the loadbearing points of the sprinkler body. Movement of the sprinkler shank thread in the threaded bushing of the test machine shall be avoided or taken into account.

7.4.3.3 Remove the heat-responsive element of the sprinkler by a suitable method. When the sprinkler is at room temperature, make a second measurement using the indicator.

7.4.3.4 Mechanical load shall be applied progressively to the sprinkler at a rate not exceeding 500 N/min until the indicator reading at the first measurement point of the sprinkler returns to the initial value achieved. Record the mechanical load necessary to achieve this as the assembly load.

7.4.3.5 Increase the load progressively at a rate not exceeding 500 N/min until twice the average of the assembly load has been applied. Maintain this load for (15 ± 5) s.

7.4.3.6 Remove the load and take a third measurement. Compare the permanent elongation with the requirement of 6.4.3.

NOTE An amount of change in the length of the sprinkler body while applying its assembly load will be the difference between the first and second measurements. The amount of permanent elongation will be the difference between the second and third measurements.

7.5 Strength of heat-responsive element test (see 6.5)

7.5.1 Glass bulbs

7.5.1.1 At least 55 glass bulbs of each bulb type shall be positioned individually in a test fixture using the sprinkler seating parts. Each bulb shall then be subjected to a uniformly increasing force at a rate of (250 ± 25) N/s in the test machine until the glass bulb fails.

7.5.1.2 Each test shall be conducted with the bulb mounted in new seating parts. The seating parts may be reinforced externally or manufactured from hardened steel (Rockwell Hardness C44 ±6) in accordance with the specifications of the sprinkler manufacturer to prevent collapse, but in a manner which does not interfere with bulb failure. Record the crush force for each bulb.

7.5.1.3 Using the lowest 50 measured bulb strength results, calculate the average strength and the lower tolerance limit (LTL) for bulb strength in accordance with Annex A. Using the values of service load recorded in 7.4, calculate the upper tolerance limit (UTL) for the sprinkler release element service load in accordance with Annex A. Verify conformance with 6.5.1.

7.5.2 Fusible elements

7.5.2.1 Determine conformance with the requirements of 6.5.2(a) by subjecting at least 10 samples to 15 times the maximum design load for 100 h. Abnormal failures, those not related to evaluation of the fusible material, shall not be used; however, valid results from at least 10 samples shall be obtained.

7.5.2.2 Determine conformance with the requirements of 6.5.2(b) by subjecting fusible heat responsive elements to loads in excess of the maximum design load, L_d, which will produce failure within and after 1 000 h. At least 10 samples shall be subjected to different loads up to 15 times the maximum design load.

Abnormal failures shall be rejected; however, valid results from at least 10 samples shall be obtained. Plot a full logarithmic regression curve using the method of least squares, and from this, calculate the load at 1 h, L_0, and the load at 1 000 h, L_M. The paired values for L_0 and L_M shall satisfy Formula (6).

$$L_d \leq 1{,}02 L_M^2 / L_0 \quad (6)$$

where

L_d is the maximum design load;

L_M is the load at 1 000 h;

L_0 is the load at 1 h.

NOTE See Annex B for the derivation of this formula.

7.6 Leak resistance and hydrostatic strength tests (see 6.6)

7.6.1 Twenty sprinklers shall be tested. They shall be subjected to a water pressure equal to two times the rated pressure but not less than 3,0 MPa (30 bar).

7.6.2 Increase the pressure from 0 MPa (0 bar) to the value noted above at a rate of (0,1 ± 0,03) MPa/s [(1 ± 0,3) bar/s], maintain the pressure for a period of 3 min and then allow it to fall to 0 MPa (0 bar). After the pressure has dropped to 0 MPa (0 bar), increase it to 0,05 MPa (0,5 bar) within not more than 5 s. Maintain this pressure for 15 s and then increase it to 1 MPa (10 bar) at a rate of increase of (0,1 ± 0,03) MPa/s [(1 ± 0,25) bar/s], and maintain it for 15 s. Each sprinkler shall meet the requirement of 6.6.1.

7.6.3 Following the test of 7.6.1 and 7.6.2, the 20 sprinklers shall be subject to a water pressure equal to 4 times the rated pressure. Fill the sprinkler inlet with water at (20 ± 5) °C and vent it of air. Increase the pressure to four times the rated pressure at a rate not exceeding 0,1 MPa/s (1 bar/s). Maintain at four times the rated pressure for 1 min. The sprinkler shall meet the requirements of 6.6.2.

7.7 Thirty-day leakage test (see 6.7)

Five sprinklers shall be installed on a water-filled test line maintained under a constant pressure of 1,67 times the rated pressure for 30 days at an ambient temperature of (20 ± 5) ºC.

The sprinklers shall be inspected visually at least weekly for leakage. Following the 30-day period, all samples shall meet the leak resistance requirement specified in 6.6.1 and show no evidence of distortion or other mechanical damage.

7.8 Vacuum test (see 6.8)

Three sprinklers shall be subjected to a gradually increasing vacuum of up to 460 mm Hg applied to a sprinkler inlet for 1 min at an ambient temperature of (20 ± 5) °C. Following this test, each sample shall be examined to verify that no distortion or mechanical damage has occurred and then shall meet the leak resistance requirement specified in 6.6.1.

NOTE Millimetres of mercury is a deprecated unit. 1 mm Hg = 133,322 4 Pa.

7.9 Water hammer test (see 6.9)

Five sprinklers shall be connected to the test equipment. After purging the air from the sprinklers and the test equipment, 100 000 cycles of pressure varying from (0,4 ± 0,05) MPa [(4 ± 0,5) bar] to twice the rated pressure but not less than (3,0 ± 0,1) MPa [(30 ± 1) bar] shall be generated. The pressure shall be

raised at a minimum rate of 4 MPa/s (40 bar/s) where no more than 60 cycles of pressure per minute shall be generated. The pressure shall be measured electronically with a pressure transducer.

Visually examine each sprinkler for leakage during the test. After the test, each sprinkler shall meet the leak resistance requirements of 6.6.1 and the functional requirement of 6.20 at a pressure of 0,035 MPa (0,35 bar) only.

7.10 Vibration test (see 6.10)

7.10.1 Five sprinklers shall be fixed vertically to a vibration table and subjected to sinusoidal vibrations. The direction of vibration shall be along the axis of the connecting thread. When dry sprinklers are tested, they shall be of the longest manufactured length.

7.10.2 The sprinklers shall be vibrated continuously from 5 Hz to 40 Hz at a maximum rate of 5 min/octave and an amplitude of 1 mm (1/2 peak-to-peak value). If one or more resonant points are detected, the sprinklers, after coming to 40 Hz, shall be vibrated at each of these resonant frequencies for 120 h per number of resonances. If no resonances are detected, the vibration from 5 Hz to 40 Hz shall be continued for 120 h.

7.10.3 After vibration, each sprinkler shall be subjected to the leak resistance requirement of 6.6.1 and the function requirement of 6.20 at a pressure of 0,035 MPa (0,35 bar) only.

7.11 Deflector strength test (see 6.11)

In order to check the strength of the deflector, 3 sprinklers shall be submitted to the function test in each normal mounting position at a pressure not less than the rated pressure. The water shall be allowed to flow at a residual pressure not less than the rated pressure for a period of 30 min.

7.12 Water shield rotation test (see 6.12)

7.12.1 The water shield on each of three sprinklers shall not rotate with an applied torque of up to 4,0 N·m. The torque shall be applied slowly and smoothly.

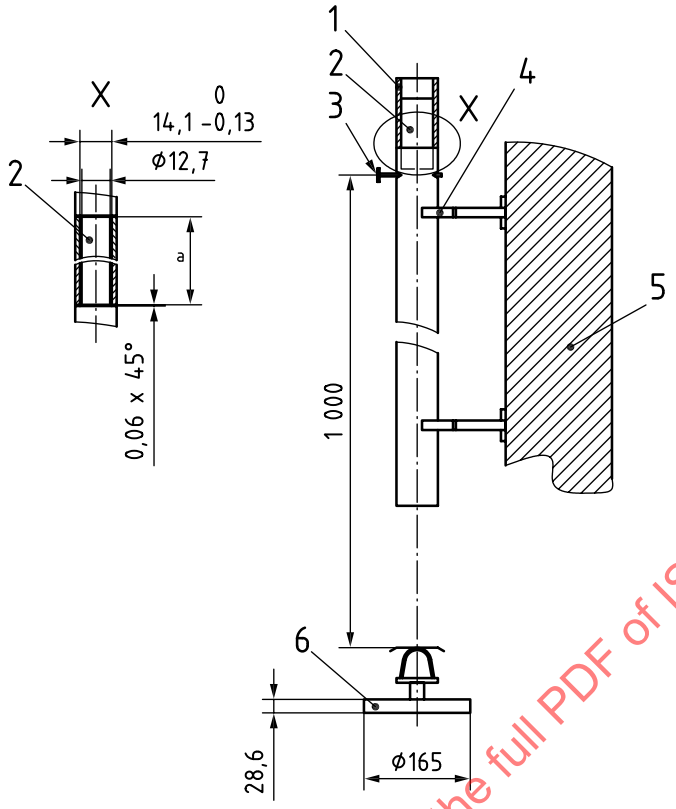
7.12.2 If the water shield rotates at a torque less than 4,0 N·m, the shield shall be rotated 360° and the sprinkler then examined for a change in service load. If visual observation of the shield rotation indicates a change in service load, five samples shall have their shields rotated two revolutions and the average service load determined. The average service load shall not change more than ±10 %.

7.13 Impact (see 6.13)

7.13.1 Five sprinklers, other than dry type, shall be impact-tested by dropping a mass onto the deflector end of the sprinkler along the axial centreline of the waterway. Sprinklers provided with protective covers, which are intended for removal only after completion of the sprinkler installation, shall be impact tested with the caps in place. The mass equivalent to that of a sprinkler shall be dropped from a height of 1 m (see Figure 6). In a sprinkler with water shield, the dropped weight shall be equivalent to the weight of the test sprinkler without the water shield. The dropped weight shall be prevented from impacting more than once upon each sample. After the impact test, each sprinkler shall meet the requirements of 6.13.1.

7.13.2 The integrity of a water shield attached to a sprinkler shall be evaluated by dropping an assembled sprinkler from a height of 1 m onto a concrete surface such that the water shield impacts the floor at an angle of approximately 45° (see 6.13.2).

Dimensions in millimetres



Key

1 cold-drawn seamless steel tubing
2 mass
3 latching pin
4 adjustable brackets (2)
5 rigid support
6 sprinkler support
a Length to be determined (length of required mass).

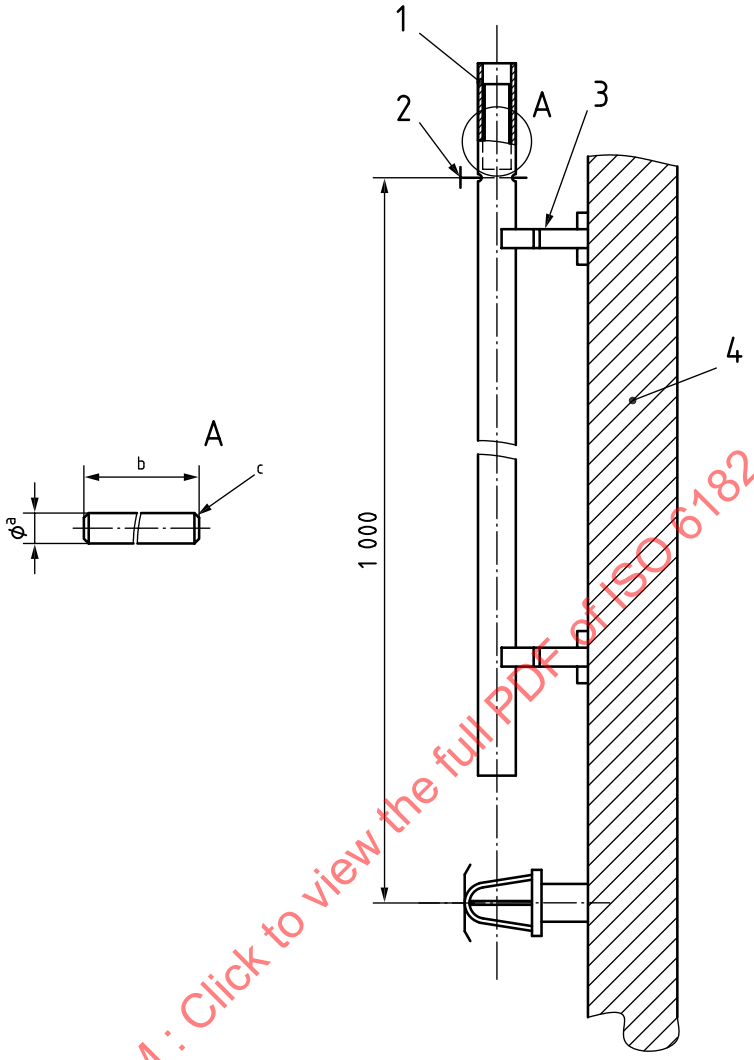
Figure 6 — Impact test apparatus

7.14 Protective cover impact test for glass bulb sprinklers (see 6.14)

Five sample sprinklers with their protective covers are to be mounted in the horizontal position (see Figure 7) and impacted with a cylindrical mass equivalent to the mass of the sprinkler to the nearest 15-gram increment from a height of one meter onto the geometric centre of the heat responsive element. Five additional samples are to be tested with the impact applied to the opposite side of the sprinkler if the cover is designed to provide unsymmetrical protection. If the heat responsive element extends beyond the perimeter of the sprinkler deflector, an additional five sample sprinklers are to be mounted in the vertical position and impacted with the same cylindrical mass from a height of one meter onto the geometric centre of the heat responsive element. The mass shall be prevented from impacting more than once upon each sample.

Following the impact, each sprinkler shall be visually examined and there shall be no evidence of cracks, breaks, or any other damage to the heat responsive element. Each sample sprinkler shall comply with the leak resistance requirements of 6.6.1 and then shall meet the requirements of 6.18.1 in the standard orientation only.

Dimensions in millimetres



Key

1 mass (see Detail A)
2 latching pin
3 adjustable brackets
4 rigid support
a 12,70-mm-diameter AISI C1018 cold finished steel.
b Length to be determined (function of required mass).
c Break corner, 0,06 mm × 45°.

Figure 7 — Impact test apparatus for protective covers

7.15 Rough usage test (see 6.15)

Five sample sprinklers are to be tested. The sprinklers shall be permitted to be tested with a protective cover in place if the cover is intended to be removed from the sprinkler after the sprinkler is installed, and reference to this removal requirement is made in the manufacturer's design and installation instructions.

NOTE Dry sprinklers are not required to be subjected to this test. In addition, concealed sprinklers are tested without their cover plate assembly.

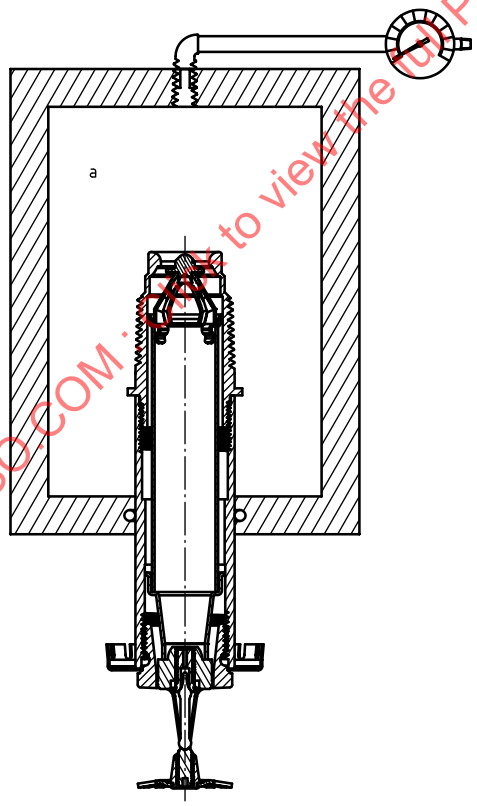
Five samples are to be individually placed in a vinyl-lined right hexagonal prism-shaped drum designed to provide a tumbling action. The drum is to have an axis rotation of 250 mm. The distance between opposite sides shall be 300 mm. For each test, one sample and five 38-mm hardwood cubes are to be placed in the drum. The drum shall be rotated at 1 rev/s for 3 min. The sample shall be removed from the drum, examined for signs of damage, and then subjected to the leakage resistance test (see 6.6.1) and to the RTI requirements of 6.18.1, or in accordance with 6.19 for flush, recessed and concealed sprinklers.

7.16 Dry sprinkler air tightness test (see 6.16)

7.16.1 Five samples are to be individually tested. The assembly shall be installed in an air leakage test fixture in such a manner that the extension nipple connection to the inlet seal assembly can be fully pressurized with air.

NOTE See Figure 8.

7.16.2 The assembly shall be immersed in water and orientated so that air bubbles indicating leakage past the extension nipple and inlet seal assembly connection point are allowed to freely escape from internal waterway of the dry sprinkler assembly. The air pressure applied to the connection point is then to be increased from 0 to 100 kPa (0 to 1 bar) within 30 seconds and then held at 100 kPa (1 bar) for 30 seconds. Observations shall be made for leakage as evidenced by any air bubbles escaping from the internal portion of the dry sprinkler assembly.



Key

a Pressurized with air.

Figure 8 — Dry sprinkler air tightness test apparatus (typical)

7.17 Operating temperature tests (see 6.17)

7.17.1 Liquid test

Ten sprinklers shall be heated from a temperature of (20 ± 5) °C to a temperature of (20 $^{+2}_{0}$) °C below their nominal operating temperature. The rate of increase in temperature shall not exceed 20 °C/min and the temperature shall be maintained for 10 min. The temperature shall then be increased at a rate of (0,5 ± 0,1) °C/min until the sprinkler operates.

The nominal operating temperature shall be ascertained with equipment having an accuracy of ±0,25 % of the nominal temperature rating.

The test shall be conducted in a liquid bath. Sprinklers having nominal operating temperatures of ≤80 °C shall be tested in a bath of demineralized water. Sprinklers with higher rated elements shall be tested in a bath of glycerine, vegetable oil or synthetic oil.

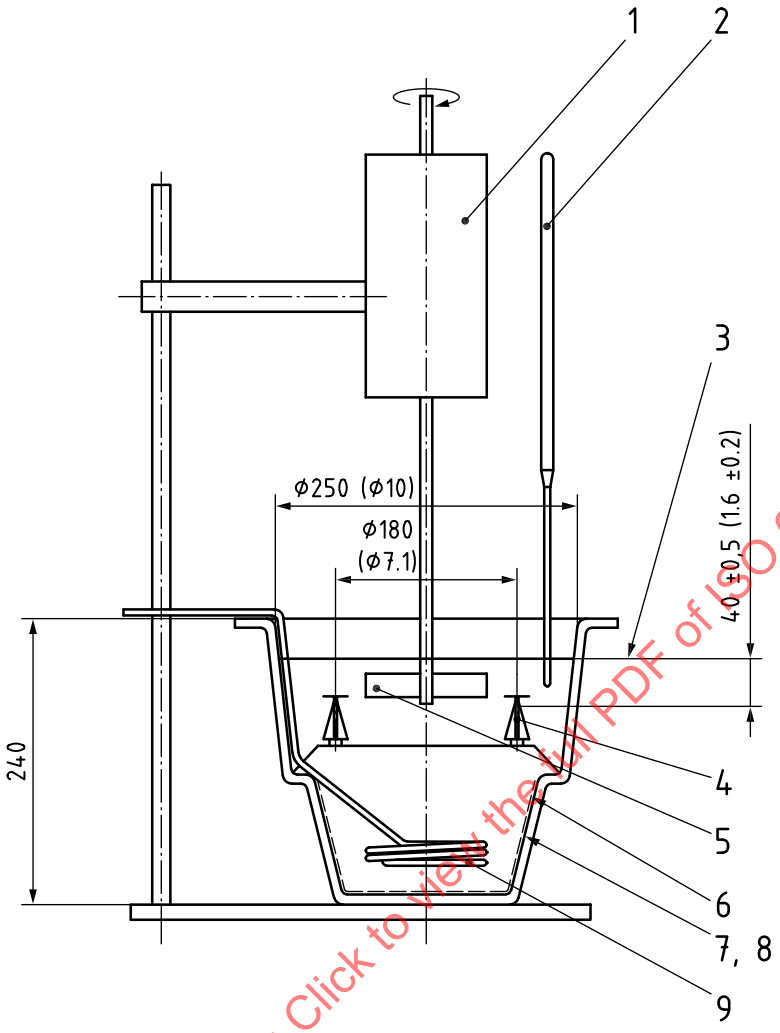
The sprinklers shall be located in the liquid bath in a vertical position and totally immersed under a liquid cover of at least 5 mm. The test zone is located at a distance, below the liquid surface level with the geometric centre of the glass bulb or fusible element. The test zone shall not be less than 35 mm below the liquid surface level. The temperature deviation within the test zone shall be within ±0,25 °C.

NOTE It is preferred to have the test zone at (40 ± 5) mm below the liquid surface level.

Any rupture of a glass bulb within the prescribed temperature range constitutes an operation. Partial or complete operation of any heat-responsive element within the prescribed temperature range shall constitute an operation. Partial fracture of any glass bulb or incomplete operation of any heat-responsive element shall necessitate verification of function through an additional 50 samples being tested in accordance with 7.17.2.

An example of a standardized liquid bath is shown in Figure 9. A laboratory temperature measuring device, calibrated to a depth of 40 mm immersion, shall be used to determine temperatures of liquids in bath tests and the operating temperature. The bulb of the thermometer shall be held level with the sprinkler operating parts by a support member. To control the temperature in the thermal bath, a PT100 IEC 60751 resistance thermometer or equivalent may be used.

Dimensions in millimetres



Key

1 agitator motor (150 rpm)
2 thermometer calibrated for 40 mm immersion and either PT100 or thermocouple
3 liquid level
4 ring to support sprinklers
5 double wing agitator (100 mm × 20 mm)
6 mesh screen
7 standard glass vessel
8 desiccators, Ø250, liquid volume, approx. 7 l
9 immersion heater

Figure 9 — Example of a liquid bath test apparatus

7.17.2 Air test

Fifty previously untested sprinklers shall be placed on their threaded inlets in a programmable oven circulating air at ambient temperature. The temperature in the oven shall be steadily raised to (11,1 ± 1,1) °C below the nominal temperature rating of the sprinklers over a 20 min period. Once this temperature is reached, the oven shall be maintained at a constant temperature for a period of at least 20 minutes. The temperature shall then be raised at a constant rate of (0,5 ± 0,3) °C per minute until all sprinklers operate. Partial fracture of a glass bulb or partial operation of a fusible element, i.e. strutting, shall be deemed a failure.

It is not necessary to meet the operating temperature limits of 6.17 in this test.

Where SMA samples are tested, they shall be connected to a measuring device capable of measuring the signal from the sprinkler. The time from activation of the sprinkler to the moment of record of change of electrical parameters shall not exceed the time specified in the sprinkler datasheet.

7.18 Sensitivity test — response time index (RTI) (see 6.18)

7.18.1 Plunge test

7.18.1.1 Subject 10 sprinklers in each nominal temperature rating to the plunge test described in 7.18.1.4. Calculate the RTI as described in 7.18.2.

7.18.1.2 Sprinklers other than ESFR types shall be tested in the standard orientation.

7.18.1.3 For ESFR sprinklers, 5 samples each shall be test in orientations A and B. For sprinklers with symmetrical heat responsive elements and frames, orientation A is the same as orientation B, so such sprinklers shall be tested in standard orientation.

7.18.1.4 After exposure to the corrosion test according to 6.26.3, 6.26.4 and 6.26.5, sprinklers shall be tested in the standard orientation to determine post-exposure RTI.

7.18.1.5 Conduct the plunge tests using a brass sprinkler mount. Apply 1 wrap to 1,5 wraps of PTFE sealant tape to the sprinkler threads of the sprinkler under test. Screw the sprinkler into a mount to a torque of (15 ± 3) N·m. Mount each sprinkler on a tunnel test section cover and maintain the sprinkler and cover at ambient temperature for a period of no less than 30 min.

Test all sprinklers with the inlet end of each sample connected to a source of pressure at (0,035 ± 0,005) MPa [(0,35 ± 0,05) bar].

A timer accurate to ±0,01 s with suitable measuring devices to sense the time between when the sprinkler is plunged into the tunnel and the time it operates shall be utilized to obtain the response time.

A tunnel shall be used with airflow and temperature conditions at the test section (sprinkler location) selected from the appropriate range of the conditions given in Table 18 to minimize radiation exchange between the sensing element and the boundaries confining the flow. The test section of the apparatus shall be designed to limit radiation effects to within ±3 % of calculated RTI values.

NOTE Minimized radiation effects can be achieved using an uninsulated test section constructed of 1,5 mm thick stainless steel 500 mm in length with a cross section measuring at least 150 mm × 300 mm.

Tunnel conditions shall be selected to limit maximum anticipated equipment error to 3 %.

The range of permissible tunnel operating conditions is given in Table 18. The selected operating condition shall be maintained for the duration of the test with the tolerances as specified by footnote a to Table 18.

NOTE A suggested method for determining radiation effects is by conducting comparative plunge tests on a blackened (high emissivity) metallic test specimen and polished (low emissivity) metallic test specimen.

Table 18 — Range of plunge test conditions at test section (sprinkler location)

Marked nominal temperature rating °C	Air temperature ranges			Velocity ranges[a]		
	Standard-response sprinklers °C	Special-response sprinklers °C	Fast-response sprinklers °C	Standard-response sprinklers m/s	Special-response sprinklers m/s	Fast-response sprinklers m/s
57 to 77	191 to 203	129 to 141	129 to 141	2,4 to 2,6	2,4 to 2,6	2,4 to 2,6
79 to 107	282 to 300	191 to 203	191 to 203	2,4 to 2,6	2,4 to 2,6	2,4 to 2,6
121 to 149	382 to 432	282 to 300	282 to 300	2,4 to 2,6	2,4 to 2,6	2,4 to 2,6
163 to 191	382 to 432	382 to 432	382 to 432	3,4 to 3,6	2,4 to 2,6	2,4 to 2,6

[a] Where results are shown to be equivalent, testing laboratories may use other conditions.

7.18.2 Response time index (RTI) calculation

The RTI shall be determined in accordance with Formula (7):

$$RTI = \frac{-t_r \sqrt{u}}{ln\left(1 - \frac{\Delta T_{ea}}{\Delta T_g}\right)} \tag{7}$$

where

t_r is the response time of the sprinkler, expressed in seconds;

u is the actual air velocity in the test section of the tunnel from Table 18, expressed in meters per second;

ΔT_{ea} is the mean liquid bath operating temperature of the sprinkler minus the ambient temperature, expressed in degree Celsius;

ΔT_g is the actual air temperature in the test section minus the ambient temperature, in degree Celsius;

ln is the natural logarithm (natural log).

7.19 Sensitivity test for flush, concealed and recessed sprinklers (see 6.19)

7.19.1 General

Sprinklers undergoing the room response test shall be tested in accordance with 7.19.2. Sprinklers undergoing the plunge test shall be tested in accordance with 7.19.3.

7.19.2 Room response test

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

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

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

c) For pendent flush, concealed and recessed sprinklers incorporating frame arms with symmetrical heat-responsive elements, 10 samples are to be orientated with the frame arms in a plane parallel to the direction of the fire source. The samples are to be installed in their intended position at the ceiling.

d) For sidewall flush, concealed and recessed sprinklers, 10 samples are to be installed in their intended position with the deflector located 102 mm below the ceiling. If the intended installation position is greater than 152 mm below the ceiling, 10 additional samples shall be tested at the maximum distance below the ceiling.

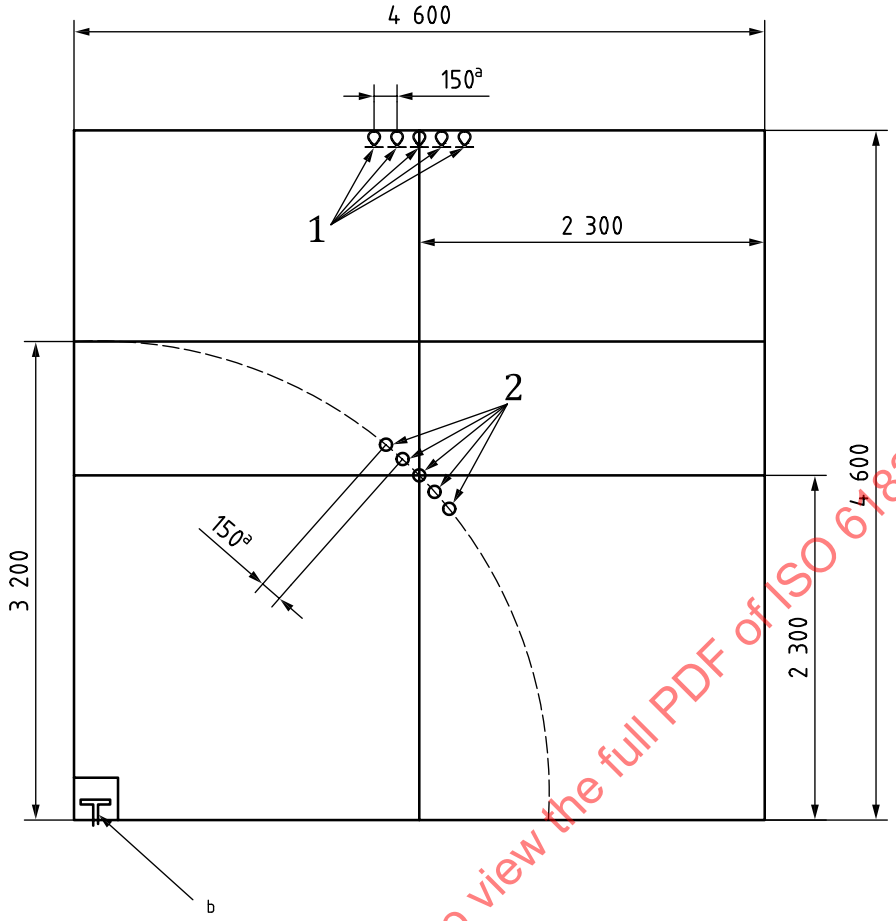
7.19.2.2 At least 10 samples each of flush, concealed and recessed sprinklers shall be tested in groups of five in a nominal 2,4 m high closed room and subjected to the heat from a 300 mm × 300 mm × 300 mm sand burner (see Figure 14) located on the floor in one corner of the room. The sprinklers shall be located 150 mm apart as described in Figure 10, Figure 11, or Figure 12 for the applicable type of flush, concealed or recessed sprinkler described in Table 19. Each sprinkler shall be filled with water at (20 ± 5) °C either with no pressure or with the inlet connected to a source of pressure at 0,05 MPa (0,5 bar). The sprinklers shall be installed in the maximum recessed position. Concealed and recessed sprinklers with vented housing units shall be installed and tested in a manner that will not inhibit airflow through the housing assembly/escutcheon. Concealed and recessed sprinklers with vented housing units which are specified for use in ceilings not permitting airflow shall be installed and tested with the openings blocked. For the evaluation of dry sprinklers, the shortest length manufactured shall be used.

NOTE See 9.2 g).

Table 19 — Room sensitivity test parameters for flush, concealed and recessed sprinklers

Sprinkler type	Test room configuration	Gas flow for sprinkler temperature rating of 77 °C or less m^3/h	Gas flow for sprinkler temperature rating of 79 °C to 107 °C m^3/h	Starting ambient temperature for sprinkler temperature rating of 77 °C or less °C	Starting ambient temperature for sprinkler temperature rating of 79 °C to 107 °C °C
Standard-response	7.19.1	9,6	25,9	31 ± 1	49 ± 2
Fast-response	7.19.2	14,2	17	31 ± 1	49 ± 2
Domestic	7.19.2	14,2	14,2	31 ± 1	31 ± 1
Fast-response ECLH	7.19.3	14,2	17	31 ± 1	49 ± 2
Standard-response ECOH	7.19.3	9,6	25,9	31 ± 1	49 ± 2
Fast-response ECOH	7.19.3	14,2	17	31 ± 1	49 ± 2

Dimensions in millimetres



Key

1 sidewall sprinkler locations

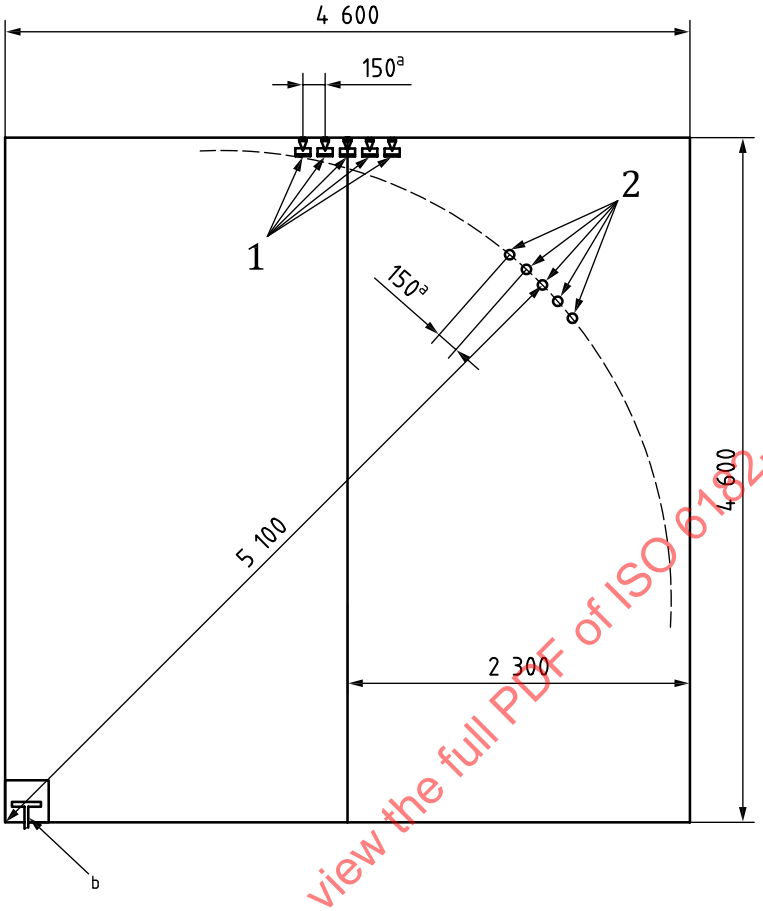
2 pendent sprinkler locations

a Typical dimension.

b For sand burner detail, see Figure 14.

Figure 10 — Plan view of room sensitivity test for standard-response flush, concealed and recessed sprinklers

Dimensions in millimetres

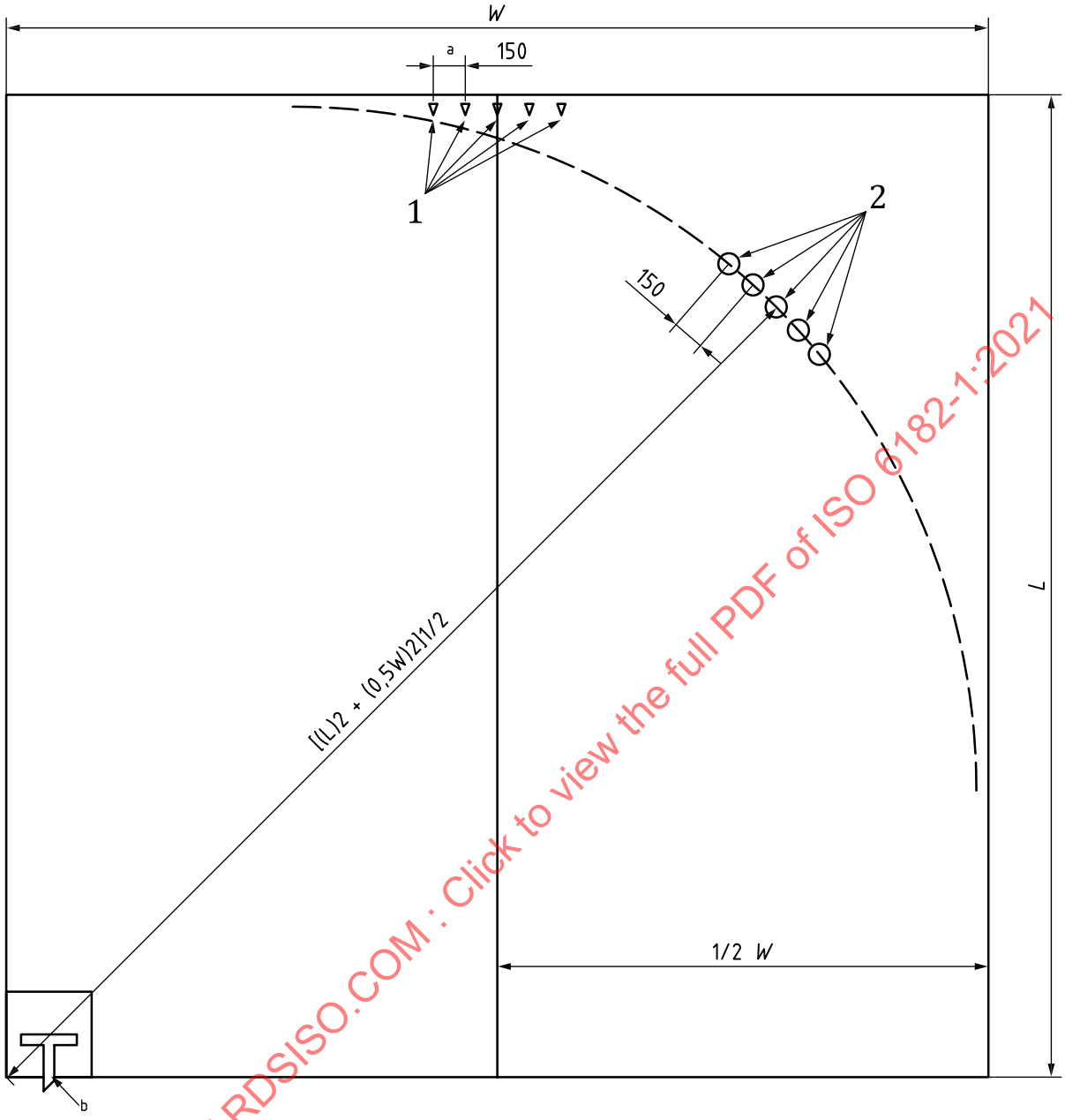


Key

1 sidewall sprinkler locations
2 pendent sprinkler locations
[a] Typical dimension.
[b] Sand burner detail.

Figure 11 — Plan view of room sensitivity test for fast-response and domestic flush, concealed and recessed sprinklers

Dimensions in millimetres



Key

1 sidewall sprinkler locations

2 pendent sprinkler locations

[a] Typical dimension.

[b] Sand burner detail.

Figure 12 — Plan view of room sensitivity test for fast-response ECLH, standard-response ECOH and fast-response ECOH flush, concealed and recessed sprinklers

7.19.2.3 The test room shall be constructed of nominal 12-mm-thick plywood. The ceiling shall be constructed of nominal 12-mm-thick gypsum wallboard or similar ceiling material. A non-combustible wall covering may be installed in the corner of the room with the sand burner.

7.19.2.4 A flow of natural gas or methane shall be established through the sand burner for the applicable type of flush, concealed or recessed sprinkler described in Table 19.

7.19.2.4.1 Gases with a higher heat content may be used provided the heat output obtained is made equivalent by adjusting the flow rate.

7.19.2.5 The room response test shall be started when the ambient temperature measured in the centre of the room 254 mm below the ceiling is as referenced for the applicable type of flush, concealed or recessed sprinkler described in Table 19 and the operating time of each sprinkler shall be recorded.

7.19.3 Plunge test

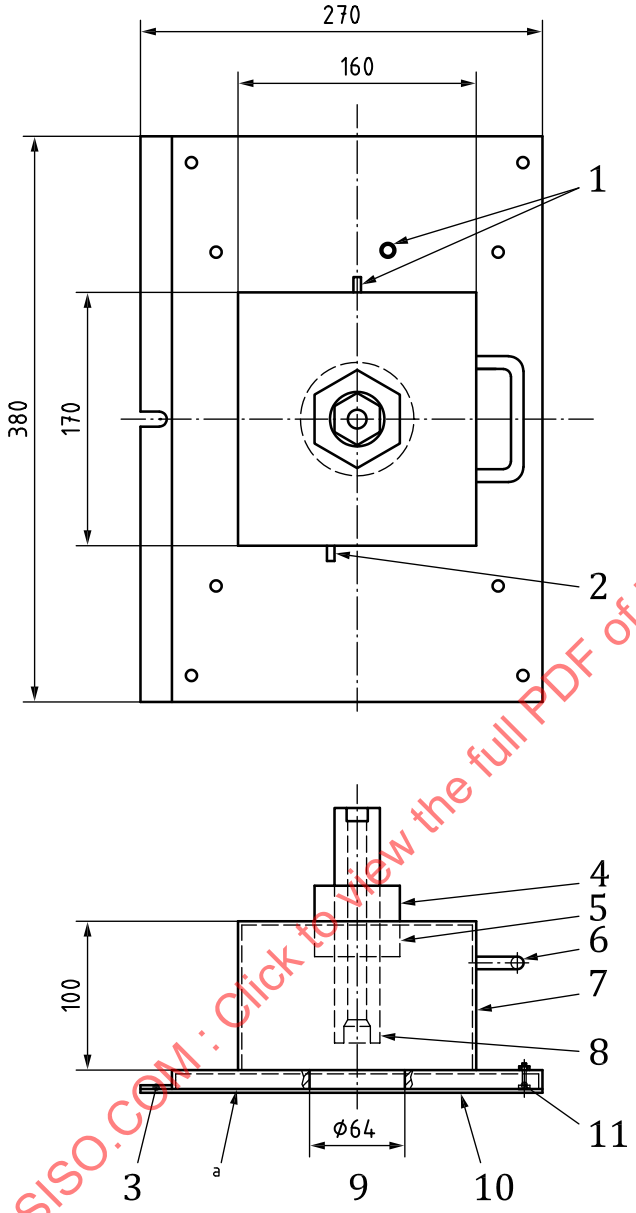
7.19.3.1 Using maximum RTI values and test conditions from Tables 4 and 5 calculate the maximum permitted response times in accordance with 6.26.3. For standard response sprinklers, use all test conditions of Table 5. For fast response sprinklers, use only test conditions 1 through 4 of Table 5. For calculations that return valid results, three samples shall be tested at the corresponding test conditions. Calculations that return an invalid result shall be disregarded.

Each sprinkler under test shall have 1 to 1,5 wraps of PTFE sealant tape applied to the sprinkler threads. Each sample shall be screwed into the test plate (see Figure 13) to a torque of (15 ± 3) N·m and maintained at ambient temperature for a period of not less than 30 min. The sprinkler shall be installed in the test plate such that the sprinkler's heat-sensitive element is at the minimum protrusion (as permitted by the sprinkler design) into the plunge tunnel laminar gas stream.

A timer accurate to ±0,01 s with suitable measuring devices to sense the time between when the sprinkler is plunged into the tunnel and the time it operates shall be utilized to obtain the response time. Unless the sprinkler design prevents it, a vacuum (as noted in Table 5) shall be applied to the upper enclosure of the test plate as soon as the sprinkler is plunged into the gas stream and shall be maintained throughout the test.

Record the operating time of each sprinkler.

Dimensions in millimetres



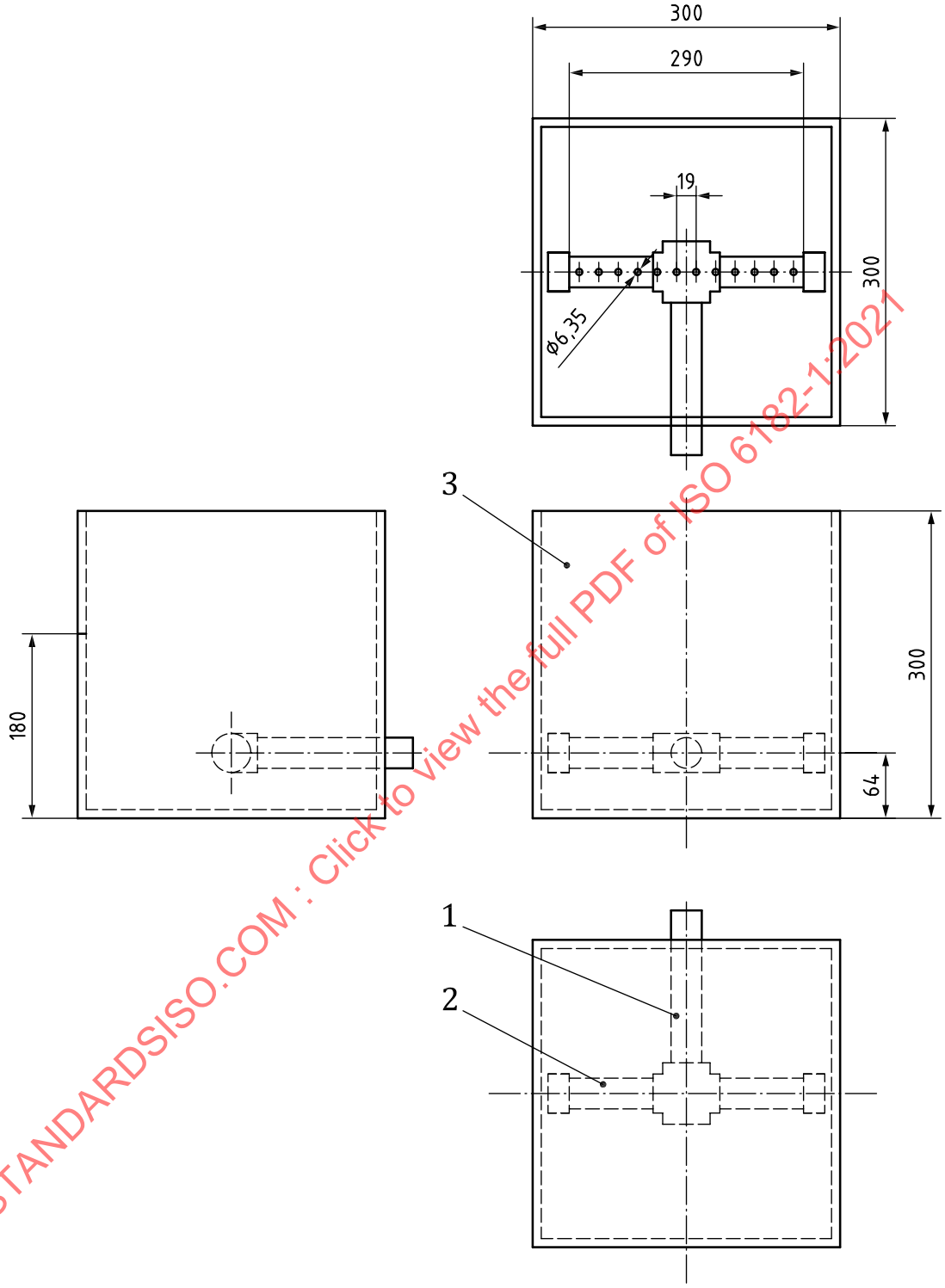
Key

1	differential pressure ports	7	0,40 mm thick s/s enclosure
2	vacuum port	8	Ø32 mm thread rod × 146 mm long (thread one end for air hose fitting, other end for sprinkler)
3	steel frame (3,038 mm ± 0,20 mm)	9	sprinkler installation hole in Marinite®
4	jam nut to lock in position	10	2,5-mm-thick × 25,4-mm-wide gasket (four sides)
5	jam nut welded to inside of enclosure steel frame and flange of enclosure body	11	pan head screws countersunk in Marinite®
6	handle	a	Marinite® 19 mm.

NOTE Marinite is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

Figure 13 — Example of dynamic heating test plate for concealed and recessed sprinklers

Dimensions in millimetres



Key

1 nominal pipe Ø 25 mm

2 nominal pipe Ø 40 mm

3 sand

NOTE Sand burner materials consist of a steel plate box (welded), steel piping and fittings with 12 holes 6,35 mm in diameter, and mason grade sand.

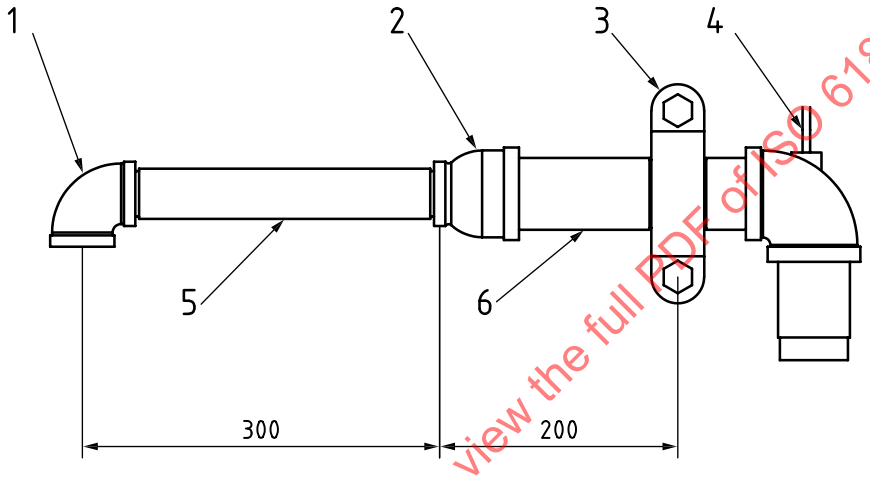
Figure 14 — Details of sand burner

7.20 Lodgement test (see 6.20)

7.20.1 Automatic sprinklers and dry-type automatic sprinklers in the shortest length of any temperature rating are to be individually tested. Each sample shall be installed in its intended installation position on a rigid piping arrangement and supplied with flowing water. Tests are to be conducted using a single-feed (Figure 15 or Figure 16) and a double-feed (Figure 17) water supply arrangement. The test pressures and number of samples tested at each pressure using each water supply configuration are specified in Table 20. Each sample shall be operated by exposing the heat responsive element to a uniform application of heat. The service pressure and the action of the operating parts, when releasing, are to be observed to determine conformance with these requirements.

7.20.2 The flowing pressure shall be at least 75% of the initial operating pressure.

Dimensions in millimetres

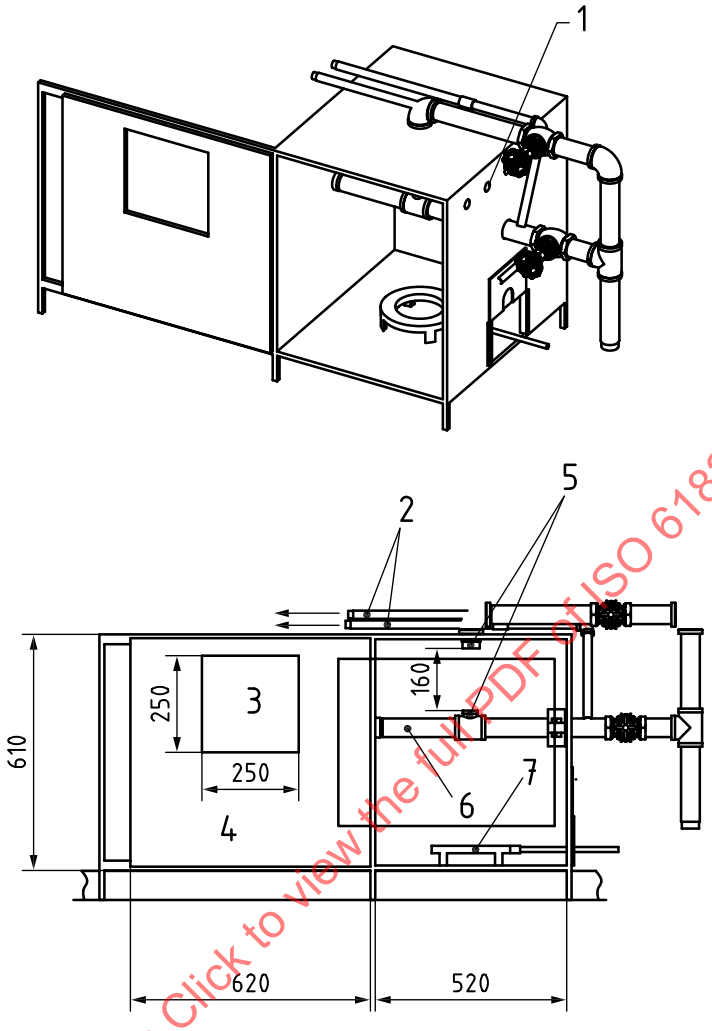


Key

1 32 mm nominal elbow (outlet as required)
2 32 mm × 50 mm nominal reducer
3 50 mm nominal grooved coupling
4 bleed line
5 32 mm nominal steel pipe
6 50 mm nominal steel pipe

Figure 15 — Typical single-feed lodgement test arrangement

Dimensions in millimetres

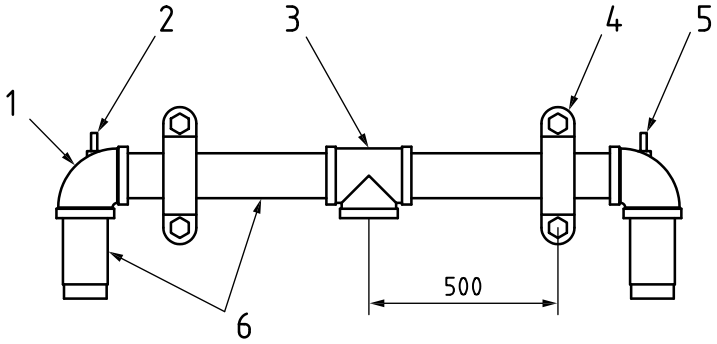


Key

1 oven air vents
2 gauge pipe
3 window
4 door
5 threaded connection to sprinklers
6 water discharge
7 heat source

Figure 16 — Typical function test oven

Dimensions in millimetres



Key

1 50 mm nominal elbow
2 bleed line
3 50 mm nominal tee coupling (outlet as required)
4 50 mm nominal grooved coupling (typical)
5 bleed line
6 50 mm nominal steel pipe (typical)

Figure 17 — Typical double-feed lodgement test arrangement

Table 20 — Lodgement test pressures and number of test samples

Test pressure[c]		Water supply arrangement	Number of test samples[d]
MPa	bar		
0,035 or 0,05	0,35 or 0,5[a]	Single Feed	5
0,035 or 0,05	0,35 or 0,5[a]	Double Feed	5
0,17	1,7	Single Feed	5
0,17	1,7	Double Feed	5
0,35	3,5	Single Feed	5
0,35	3,5	Double Feed	5
0,52	5,2	Single Feed	5
0,52	5,2	Double Feed	5
0,69	6,9	Single Feed	5
0,69	6,9	Double Feed	5
0,86	8,6	Single Feed	5
0,86	8,6	Double Feed	5
1,0	10	Single Feed	5
1,0	10	Double Feed	5
1,2	12	Single Feed	5
1,2	12	Double Feed	5
Incremental 0,17[b]	Incremental 1,7[b]	Single Feed	5 at each pressure
Incremental 0,17[b]	Incremental 1,7[b]	Double Feed	5 at each pressure

[a] For dry upright sprinklers, the starting test pressure is 0,09 MPa (0,9 bar).

[b] If the sprinkler is rated for a pressure of greater than 1,2 MPa (12 bar), sprinklers are to be tested in 0,17 MPa (1,7 bar) increments from 1,37 MPa (13,7 bar) to the rated pressure.

[c] Mandatory test pressures include 0,035 MPa or 0,05 MPa (0,35 bar or 0,5 bar), 0,35 MPa (3,5 bar), and the rated pressure.

[d] Testing using each temperature rating can be required in some countries.

7.20.3 To determine that the internal parts of a dry sprinkler do not restrict the intended flow rate, a flow meter shall be connected to the water supply piping. Prior to operation of the test samples in 7.20.1,

an operated sample that has demonstrated acceptable K-factor results in the water flow constant test, 7.27, shall be installed in the operational test fixture. Water shall be flowed at each of the pressures noted in 7.20.1 and the K-factor at each pressure shall be recorded. Dry-type sprinkler samples are then to be tested as described in 7.20.1. After sprinkler operation, the flow at each pressure specified in 7.20.1 shall be recorded. The discharge coefficient K-factor is then to be calculated as specified in 7.27. The K-factor value shall be within 5 % of previously tested K-factor samples.

7.20.4 Lodgement is considered to have occurred when one or more of the released parts lodges in the deflector frame assembly.

7.21 Heat exposure test (see 6.21)

7.21.1 Glass bulb sprinklers (see 6.21.1)

Four glass bulb sprinklers having nominal release temperatures of ≤80 °C shall be heated in a water bath (preferably distilled water) from (20 ± 5) °C to (20 ± 2) °C below their nominal operating temperature. The rate of increase in temperature shall not exceed 20 °C/min. A suitable fluid shall be used for higher-rated release elements.

This temperature shall then be increased at a rate of 1 °C/min to the temperature at which the gas bubble dissolves, or to a temperature 5 °C lower than the lower limit of the tolerance range of the operating temperature, whichever is lower. Remove the sprinkler from the liquid bath and allow it to cool in air until the gas bubble has formed again. During the cooling period, the pointed end of the glass bulb (seal end) shall be pointing downwards. This test shall be performed four times on each of four sprinklers.

7.21.2 All sprinklers (see 6.21.2)

Twelve uncoated sprinklers shall be exposed for a period of 90 days to a high ambient temperature that is 11 °C below the nominal rating or at the temperature given in Table 21, whichever is lower, but not less than 49 °C. After exposure, four of the sprinklers shall be subjected to the requirements of 6.6.1 and 6.18.2, four sprinklers to the requirements of 6.20 [two at 0,035 MPa (0,35 bar) and two at 1 MPa (10 bar)], and four sprinklers to the requirements of 6.17. If a sprinkler fails a test, eight additional sprinklers shall be tested as described above and subjected to the test in which the failure was recorded. All eight sprinklers shall pass the test.

7.21.3 Coated sprinklers (see 6.21.3)

In addition to the test exposure of 7.21.2 in an uncoated version, 12 coated sprinklers shall be exposed to the test of 7.21.2 using the temperatures given in column 3 of Table 21 for wax coated sprinklers and column 2 for all other coatings.

The test shall be conducted for 90 days. After the 90-day exposure, four of the sprinklers shall be subjected to the requirements of 6.6.1, four sprinklers to the requirements of 6.27 [two at 0,035 MPa (0,35 bar) and two at 1 MPa (10 bar)], and four sprinklers to the requirements of 6.17. If a sprinkler fails a test, eight additional sprinklers shall be tested as described above and subjected to the test in which the failure was recorded. All eight sprinklers shall pass the test.

Table 21 — Test temperatures for sprinklers

Marked nominal temperature rating °C	Test temperature °C	Wax-coated sprinkler test temperature °C
57 to 60	49	38
61 to 77	52	38
78 to 107	79	66
108 to 149	121	66
150 to 191	149	N/A
192 to 246	191	N/A
247 to 302	246	N/A
303 to 343	302	N/A

7.22 Sprinkler coatings (see 6.22)

7.22.1 Evaporation of wax and bitumen test (see 6.22.1)

A 50 cm^3 sample of wax or bitumen shall be placed in a metal or glass cylindrical container having a flat bottom, an internal diameter of 55 mm, and an internal height of 35 mm. The container, without lid, shall be placed in an automatically controlled electric, constant-ambient temperature oven with air circulation. The temperature in the oven shall be controlled at 16 °C below the nominal release temperature of the sprinkler, but at not less than 50 °C. The sample shall be weighed before and after a 90-day exposure to determine any loss of volatile matter; the sample shall meet the requirements of 6.22.1.

7.22.2 Low temperature test (see 6.22.2)

Five sprinklers, coated by normal production methods, whether with wax, bitumen, or a metallic coating, shall be subjected to a temperature of –10 °C for a period of 24 h. On removal from the low temperature cabinet, the sprinklers shall be allowed to return to normal ambient temperature for at least 30 min before examination of the coating to the requirements of 6.22.2.

7.23 Thermal shock test for glass bulb sprinklers (see 6.23)

7.23.1 Before starting the test, condition at least five sprinklers at (20 ± 5) °C for at least 30 min.

7.23.2 Sprinklers having nominal operating temperatures less than or equal to 80 °C shall be tested in a bath of de-mineralized water. Sprinklers with higher rated elements shall be tested in a bath of suitable fluid. The temperature of the bath shall be (10 ± 0,5) °C below the lower limit of the tolerance range of the operating temperature of the sprinklers. After 5 min, remove the sprinklers from the bath and immerse them immediately in another bath of liquid (demineralized water), with the bulb seal downwards, at a temperature of (10 ± 0,5) °C. Then test the sprinklers in accordance with 6.20 at 0,035 MPa (0,35 bar).

7.24 Resistance to heat test (see 6.24)

One sprinkler body shall be heated in an oven at 650 °C ± 10 °C or 770 °C ± 10 °C for a period of 15 min, with the sprinkler in on its inlet thread. The sprinkler body shall then be removed, holding it by the threaded inlet, and shall be promptly immersed in a water bath at a temperature of approximately 15 °C.

7.25 Freezing (see 6.25)

Five samples shall be individually attached to one end of a 100-mm length of 25-mm nominal diameter steel pipe using an appropriate fitting. A pipe coupling shall be attached to the opposite end of each pipe. Each assembly shall then be filled to capacity with water and sealed using a pipe plug. The assemblies shall be exposed to a temperature of (-30 ± 5) °C for a period of 24 h. After exposure, the sprinklers shall be allowed to thaw at room temperature and shall be hydrostatically tested at 0,05 MPa (0,5 bar) for 15 seconds. Sprinklers which do not leak shall be tested according to 6.6.1 and 6.18.1.

7.26 Corrosion tests (see 6.26)

7.26.1 Stress corrosion test for copper-based alloy components (see 6.26.1)

Five sprinklers without any plating or coating shall be subjected to the following aqueous ammonia test. The inlet of each sample shall be sealed with a nonreactive cap.

EXAMPLE A plastic cap.

Degrease the samples to be tested and then expose them for 10 days to a moist ammonia-air mixture in a glass container.

An aqueous ammonia solution, having a density of 0,94 g/cm^3, shall be maintained in the bottom of the container, approximately 40 mm below the bottom of the samples. A volume of aqueous ammonia solution corresponding to 0,01 ml/cm^3 of the volume of the container will give approximately the following atmospheric concentrations: 35 % ammonia, 5 % water vapor, and 60 % air.

The moist ammonia–air mixture shall be maintained as closely as possible at atmospheric pressure, with the temperature maintained at (34 ± 2) °C. Provision shall be made for venting the chamber via a capillary tube to avoid the increase of pressure. Specimens shall be shielded from dripping condensate. The glass container shall be placed in an enclosure which shall be heated uniformly to prevent condensate on the test samples.

After exposure, rinse and dry the sprinklers, and conduct a detailed examination. If a crack, delamination, or failure of any operating part is observed, the sprinkler(s) shall be subjected to a leak resistance test at rated pressure for 1 min and to the function test at 0,035 MPa (0,35 bar) only. See 6.6.1 and 6.20.

Sprinklers showing cracking, delamination or failure of any non-operating part shall not show evidence of separation of permanently attached parts when subjected to a flowing pressure equal to the rated pressure for 30 min.

7.26.2 Stress corrosion for stainless steel components (see 6.26.2)

7.26.2.1 Stainless steel components shall be tested for resistance to stress corrosion as described in 7.26.2.2 to 7.26.2.5 and in accordance with ASTM C36. For use in normal atmospheres, four sets of uncoated or unplated stainless steel components and four previously untested sprinklers shall be degreased and then exposed to a boiling magnesium chloride solution for a period of $(150\ ^{12}_{0})$ h. For use in corrosive atmospheres, four sets of stainless steel components and four previously untested sprinklers shall be degreased and then exposed to a boiling magnesium chloride solution for a period of $(500\ ^{12}_{0})$ h. Special fixtures or elevated temperature operating elements can be employed to simulate assembly loading on parts, where appropriate and necessary.

7.26.2.2 Samples are to be placed in a flask fitted with a wet condenser. The flask shall be filled approximately one-half full with a nominal 44 % by weight magnesium chloride solution, placed on a thermostatically-controlled electrically-heated mantle, and maintained at a boiling temperature of (150 ± 2) °C.

7.26.2.3 Following exposure, the samples shall be removed and rinsed in potable water. Following a 2- to 4-day drying period, visual examination of the samples shall be made.

7.26.2.4 The stainless steel components that show no evidence of cracking, delamination, or degradation shall not need further testing. Stainless steel components that show evidence of stress corrosion shall be permitted to be reassembled and subjected to the tests in 7.26.2.5.

7.26.2.5 The sprinklers tested shall not weep or leak at, or below, 1,2 MPa (12,1 bar) when hydrostatically tested for one min. Subsequently, half of the samples shall exhibit positive operation and release of all operating parts when tested in accordance with the functional test at 0,05 MPa (0,5 bar). The remaining samples shall not show evidence of separation of permanently attached parts when subjected to the water flow at rated pressure for 30 min.

7.26.3 Sulphur dioxide/carbon dioxide corrosion test (see 6.26.3)

Subject eight sprinklers to the following moist sulphur dioxide/carbon dioxide corrosion test. Fill the inlet of each sample with deionized water and seal it with a non-reactive cap.

EXAMPLE A plastic cap.

Use test equipment consisting of a vessel made of non-reactive material, with a lid of such a shape as to prevent condensate dripping on the sprinklers. Regulate the heating of the vessel so as to maintain the temperature inside the vessel at (25 ± 3) °C. Shield specimens from dripping condensate.

Suspend the sprinklers to be tested in their normal mounting position under the lid inside the vessel. Sulphur dioxide and carbon dioxide are to be supplied to the test chamber from commercial cylinders. Introduce an amount of sulphur dioxide equivalent to 1 % of the volume of the test chamber, and an equal volume of carbon dioxide, into the chamber each working day. Maintain a small amount of potable or de-mineralized water at the bottom of the chamber.

Conduct the test for a period of 10 days. After a total of 10 days, remove the samples from the container and allow them to dry for 1 day to 5 days at a temperature not exceeding 35 °C with a relative humidity no greater than 70 %.

After the drying period, the samples shall be tested as described in 6.26.3.

7.26.4 Hydrogen sulphide corrosion test (see 6.26.4)

Subject eight sprinklers to the following moist hydrogen sulphide corrosion test. Fill the inlet of each sample with deionized water and seal it with a non-reactive cap.

EXAMPLE A plastic cap.

Use test equipment consisting of a vessel made of non-reactive material, with a lid of such a shape as to prevent condensate dripping on the sprinklers. Regulate the heating of the vessel so as to maintain the temperature inside the vessel at (25 ± 3) °C. Shield specimens from dripping condensate.

Suspend the sprinklers to be tested in their normal mounting position under the lid inside the vessel. Hydrogen sulphide shall be supplied to the test chamber from a commercial cylinder. Introduce an amount of hydrogen sulphide equivalent to 1 % of the volume of the test chamber into the chamber each working day. Maintain a small amount of water at the bottom of the chamber.

Conduct the test for a period of 10 days. After a total of 10 days, remove the samples from the container and allow them to dry for 1 day to 5 days at a temperature not exceeding 35 °C with a relative humidity no greater than 70 %.

After the drying period, the samples shall be tested in accordance with 6.26.4.

7.26.5 Salt spray loading test (see 6.26.5)

7.26.5.1 Sprinklers for normal atmospheres

Ten sprinklers shall be exposed to a salt spray within a fog chamber. For evaluation of dry type sprinklers, the shortest length manufactured shall be used. The inlet of each sample shall be filled with water and sealed with a nonreactive cap.

EXAMPLE A plastic cap.

During the corrosive exposure, the inlet thread orifice shall be sealed by a nonreactive cap after the sprinklers have been filled with deionized water. The salt solution shall be a 20 %-by-mass sodium chloride solution in deionized water. The pH shall 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. Suitable means of controlling the atmosphere in the chamber shall be provided. The specimens shall 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, in which the exposure zone shall be maintained at a temperature of (35 ± 2) ˚C. Salt solution shall be supplied from a recirculating reservoir through air-aspirating nozzles, at a pressure of between 0,07 MPa (0,7 bar) and 0,17 MPa (1,7 bar). Salt solution runoff from exposed samples shall be collected and shall not return to the reservoir for recirculation. Specimens shall be shielded from dripping condensate.

Fog shall be collected from at least 2 points in the exposure zone to determine the rate of application and salt concentration. The fog shall be such that for each 80 cm^2 of collection area 1 ml to 2 ml of solution shall be collected per hour over a 16 h period and the salt concentration shall be (20 ± 1) % by mass.

The sprinklers shall withstand exposure to the salt spray for a period of 10 days. After this period, the sprinklers shall be removed from the fog chamber and allowed to dry for 4 days to 7 days at a temperature not exceeding (20 ± 5) °C in an atmosphere having a relative humidity not greater than 70 %. After the drying period, the samples shall be tested in accordance with 6.26.5.

7.26.5.2 Sprinklers for corrosive atmospheres

Sprinklers intended to be used in corrosive atmospheres shall be subjected to the tests specified in 7.26.5.1, except that the duration of the salt spray exposure shall be extended from 10 days to 30 days.

7.26.6 Moist air exposure (see 6.27.6)

Five sprinklers shall be exposed to a high temperature-humidity atmosphere consisting of a relative humidity of (98 ± 2) % and a temperature of (94 ± 2) °C. For evaluation of dry-type sprinklers, the shortest length manufactured shall be used.

The sprinklers shall be installed on a pipe manifold containing deionized water. The entire manifold shall be placed in the high temperature-humidity enclosure for 90 days. After this period, the sprinklers shall be removed from the high temperature-humidity enclosure and allowed to dry for 4 days to 7 days at a relative humidity not greater than 70 %. Following the drying period, five sprinklers shall meet the functional requirements of 6.20.1 at a pressure of 0,035 MPa (0,35 bar) only.

At the manufacturer's option, additional samples can be furnished for this test to provide early evidence of failure. The additional samples may be removed from the test chamber at 30-day intervals for testing.

7.26.7 Dry-type sprinkler deposit loading test (see 6.26.7)

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

7.26.7.2 The samples are to be exposed to a moist carbon dioxide-sulphur dioxide air mixture in a closed chamber maintained at (35 ± 2) °C for a period of 30 days. The samples are to be supported in a manner to permit the internal and external sprinkler parts to be exposed to the gases, such as by placing test samples on polymeric light diffuser trays with nominal 13 mm × 13 mm openings. All test samples shall be supported at only one elevation level within the chamber. On 5 days out of every 7 days, an amount of carbon dioxide equivalent to 1,0 % of the volume of the chamber, plus an amount of sulphur dioxide equivalent to 1,0 % of the volume, are to be introduced. Prior to each introduction of gas, the remaining gas-air mixture from the previous day shall be thoroughly purged from the chamber. On the 2 days out of every 7 days that this does not occur, the chamber is to remain closed and no purging or introduction of gas shall be provided. A small amount of water (10 ml/0,003 m^3 of chamber volume) shall be maintained at the bottom of the chamber for humidity. This water shall be replaced weekly.

7.26.7.3 After the carbon dioxide-sulphur dioxide exposure, the samples are to be dried at (49 ± 3) °C in an automatically controlled, circulating-type, constant-temperature oven for not less than 24 h or more than 72 h. Each sample is then to be stored at (21 ± 3) °C for at least 4 h prior to installation onto piping in the pendent position and supplied with air at a service pressure of 0,05 MPa (0,5 bar). Each sprinkler is then to be activated by exposing the heat-responsive element to a uniform application of heat or by removing the heat-responsive element if it is degraded by the moist carbon dioxide-sulphur dioxide exposure. The water seal assembly and other internal parts shall clear the waterway as intended.

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

7.26.8 Dezincification of brass components (see 6.26.8)

A test solution shall be prepared by dissolving 12,7 g of copper (II) chloride dihydrate ($CuCl_2 2H_20$) in distilled water and then making up the volume to 1 000 ml. Fresh solution shall be used for each test.

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

Each test piece shall 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.

Each test piece shall 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 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 $\pm^{50}_{10}$) ml of the copper (II) chloride solution is required per 100 mm^2 of exposed surface of the test piece.

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

Microscopic examination of the test piece shall 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 shall be sectioned at right angles to the exposed test surface, and the remaining thermoset resin attached to the section that shall 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 shall be ground and polished for microscopic examination. The total length of section through the exposed surface is not to be less than 5 mm. If the dimensions of the test piece make this impossible, the section shall be taken to provide the maximum possible total length.

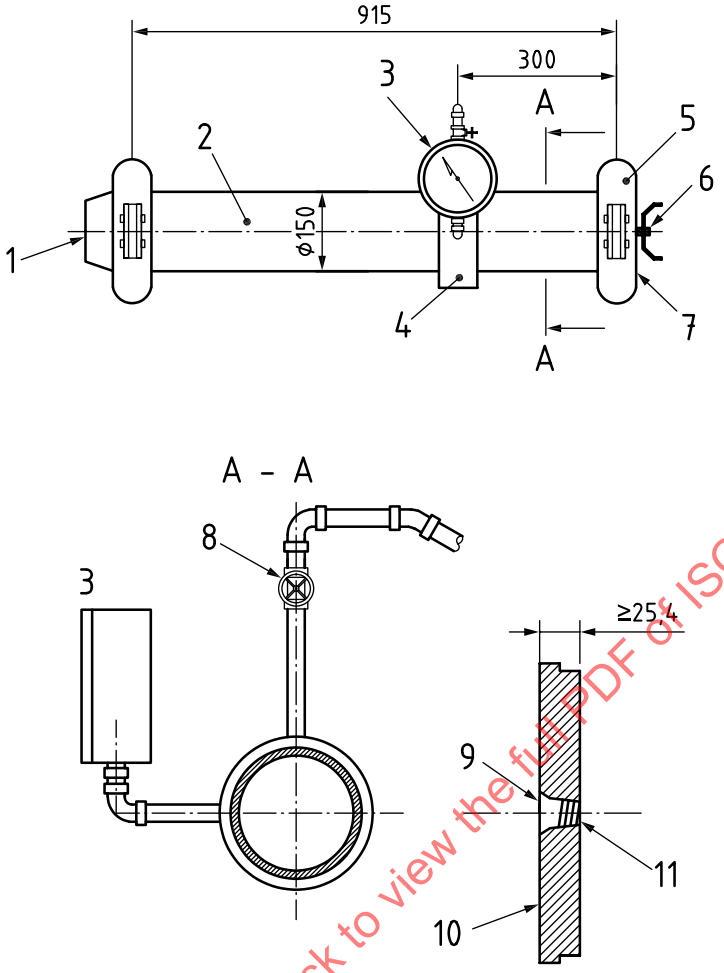
The dezincification depth measurements are to be made at five evenly spaced locations and the average calculated. The dezincification depth shall be measured from the post exposed test surface and is not to include the sample edge. The maximum dezincification shall be recorded and the average depth calculated.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

7.27 Water flow constant (see 6.27)

The sprinkler shall be mounted with a pressure gauge on a supply pipe, an example of which is shown in Figure 18. Four sprinklers shall be tested. The frame arms and deflector of sprinklers shall be removed to facilitate testing. The water flow shall be measured at pressures of 0,10 MPa to 1,0 MPa (1,0 bar to 10 bar) at intervals of 0,1 MPa (1 bar). In one series of tests, the pressure shall be increased to each interval, and, in the other series, the pressure shall be decreased from 1,0 MPa (10 bar) to each interval. The K-factor shall be calculated for each flowing pressure and the K-factor shall be averaged for each series of readings. Each calculated K-factor and the average K-factor for each series shall be within the limits specified in 6.27. During the test, pressures shall be corrected for differences in height between the gauge and the outlet orifice of the sprinkler.

Dry type sprinklers of the shortest and longest lengths manufactured shall be tested.

Dimensions in millimetres



Key

1	water source inlet	7	grooved end cap
2	pipe	8	valve for air relief
3	pressure gauge	9	inlet of tapped hole with generous radius
4	piezometer ring	10	flat surface of end cap
5	flexible coupling (typical)	11	appropriate tapped hole
6	sprinkler		

Figure 18 — Example of a water flow test apparatus

7.28 Water distribution tests (see 6.28)

7.28.1 General

Water distribution tests shall be in accordance with 7.28.2 through 7.28.6. If sprinklers are EAS type, they shall be activated using electricity prior to any water distribution tests.

7.28.2 Spray, flat spray, conventional and dry sprinklers (see 6.28.2)

7.28.2.1 Spray upright, pendent, flat, and conventional (including dry)

In a test chamber of minimum dimensions 7 m × 7 m, install four sprinklers of the same type and orifice size, arranged in a square, on piping prepared for this purpose. The arrangements of the piping and

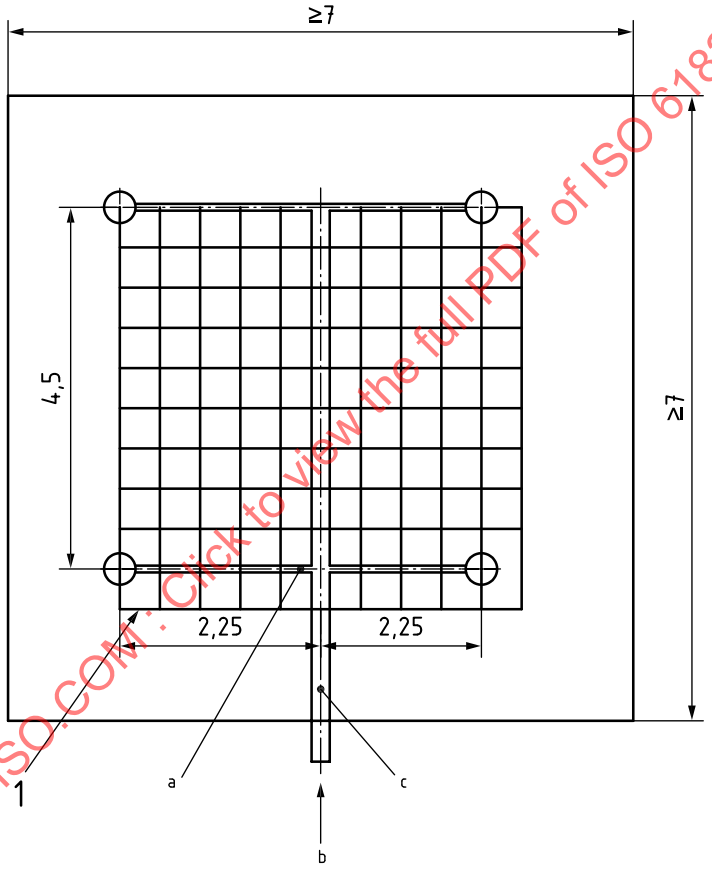
containers are shown in Figure 19 through Figure 22. The yoke arms of the sprinklers shall be parallel to the supply pipes. Dry-type sprinklers of the shortest manufactured length shall be tested.

The distance between the ceiling and the deflector of upright sprinklers shall be 50 mm. In the case of pendent sprinklers, the distance shall be 275 mm.

Flush, concealed, and recessed sprinklers shall be mounted in the maximum recessed position in a false ceiling of dimensions of not less than 6 m × 6 m and arranged symmetrically in the test chamber. The sprinklers shall be fitted directly into the horizontal pipe work by means of a tee or elbow fitting or a nominal 25 mm pipe nipple exceeding 150 mm in length with a reduced fitting.

The size of the surface to be covered and the density of coverage for each of the three nominal sizes shall be in accordance with Table 22.

Dimensions in millimetres



Key

1 collecting pans (0,5 m x 0,5 m)

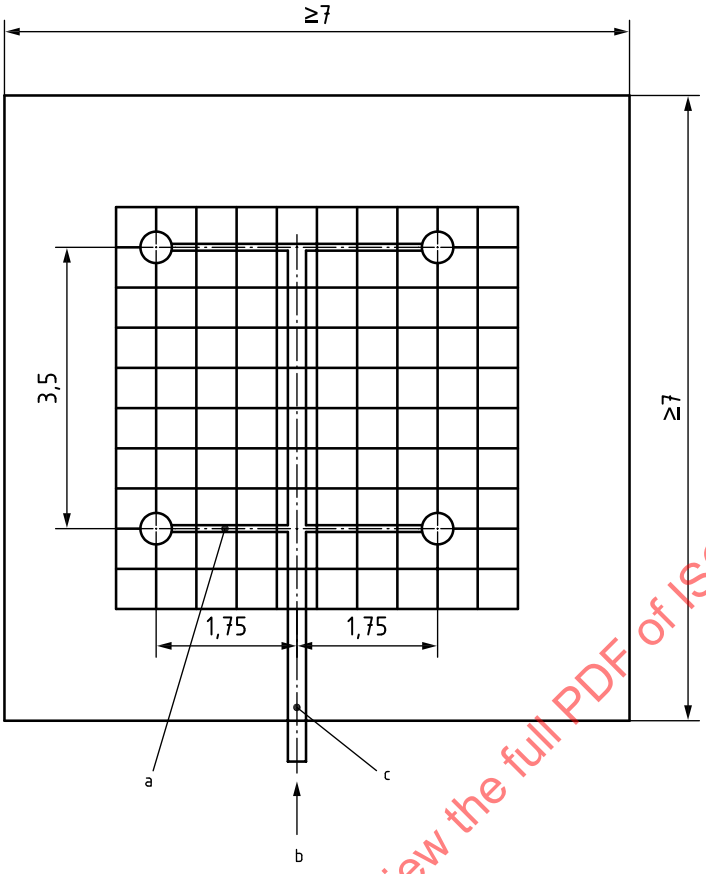
a Nominal bore is 25 mm.

b Water flow.

c Nominal bore is 65 mm.

Figure 19 — Layout of water distribution collection room — measured area: 20,25 m^2

Dimensions in metres



Key

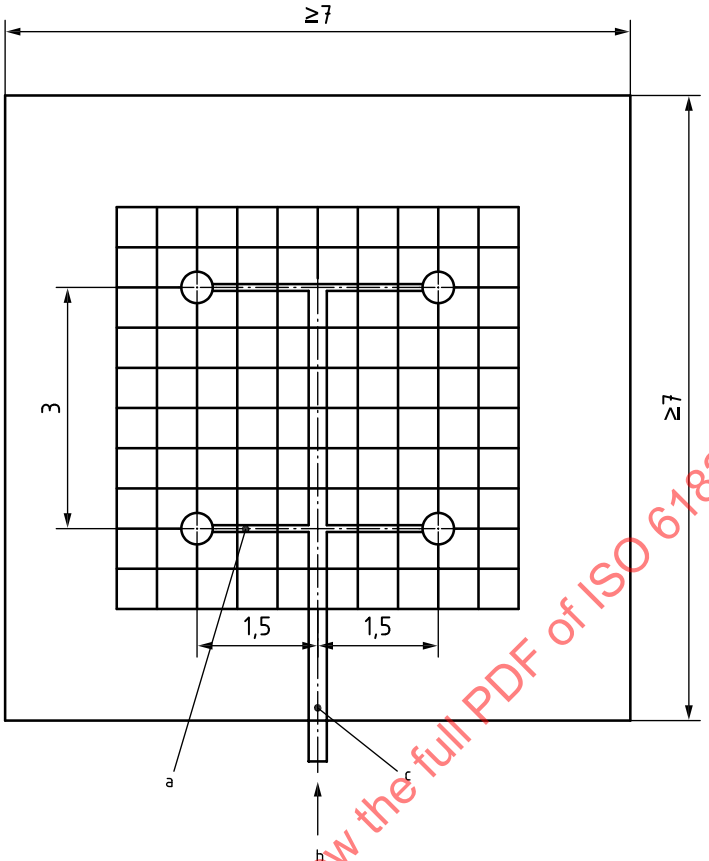
a Nominal bore is 25 mm.

b Water flow.

c BS 1387 medium tube of nominal bore 65 mm.

Figure 20 — Layout of water distribution collection room — measured area: 12,25 m^2

Dimensions in millimetres



Key

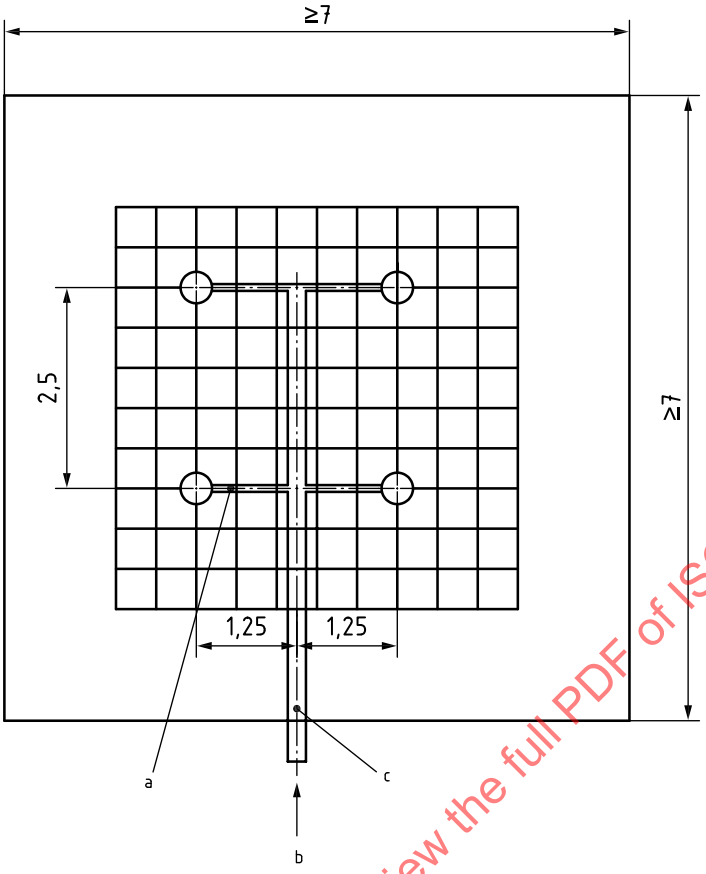
a Nominal bore is 25 mm.

b Water flow.

c BS 1387 medium tube of nominal bore 65 mm.

Figure 21 — Layout of water distribution collection room — measured area: 9 m^2

Dimensions in metres



Key

a Nominal bore is 25 mm.

b Water flow.

c BS 1387 medium tube of nominal bore 65 mm.

Figure 22 — Layout of water distribution collection room — measured area: 6,25 m^2

The water distribution in the protected area between the four sprinklers shall be measured by means of square containers measuring 500 mm on a side. The distance between the ceiling and the upper edge of the measuring containers shall be 2,7 m. The measuring containers shall be positioned centrally in the room, beneath the four sprinklers. The number of containers in which the quantity of water is less than 50 % of the water coverage given in Table 22 shall not exceed the value specified in column 6 of Table 22.

Test flat spray sprinklers additionally with a distance of (0,3 ± 0,025) m between the deflector and the upper edge of the measuring containers. The water shall be collected for at least 3 min.

Table 22 — Water distribution

Flow constant, K (l/min)/(bar)½	Water coverage mm/min	Flow rate per sprinkler l/min	Protected area m^2	Sprinkler spacing m	Permitted number of containers with a lower content of water
57	2,5	50,6	20,25	4,5	8
80	5,0	61,3	12,25	3,5	5
	15,0	135,0	9,00	3,0	4
115	10,0	90,0	9,00	3,0	4
	30,0	187,5	6,25	2,5	3

7.28.2.2 Water distribution above and below the deflector

Sprinklers, except flat spray, recessed and concealed sprinklers, shall be installed horizontally in a test apparatus, the features of which are shown in Figure 23. Flat spray sprinkler arrangement is shown in Figure 24.

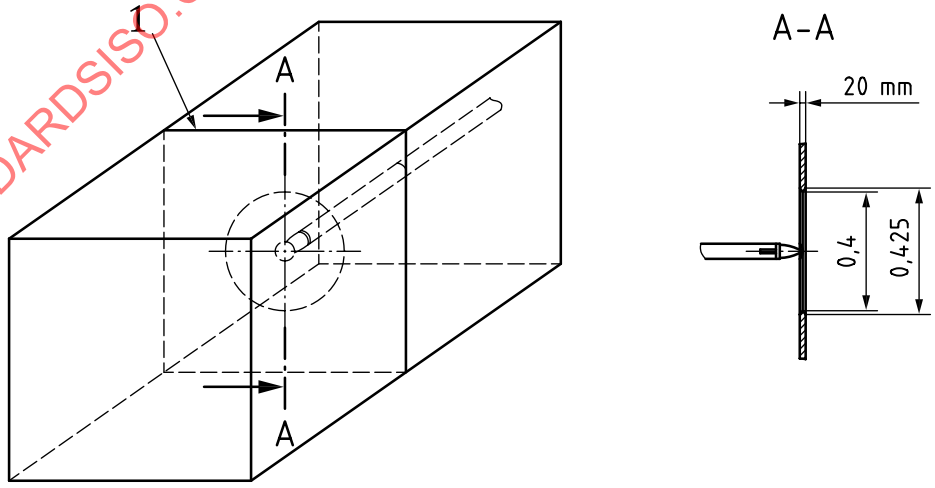
The deflector shall be positioned within the apparatus such that a theoretical dividing line between the two collecting volumes intersects a point on the axis of the sprinkler where the water spray is travelling substantially parallel to the plane of the partition.

The sprinklers shall be tested at the flow conditions given in Table 23.

Table 23 — Flow condition

Flow constant, K (l/min)/bar½	Water flow rate l/min½
57	50,6
80	61,3
115	90,0

Dimensions in millimetres

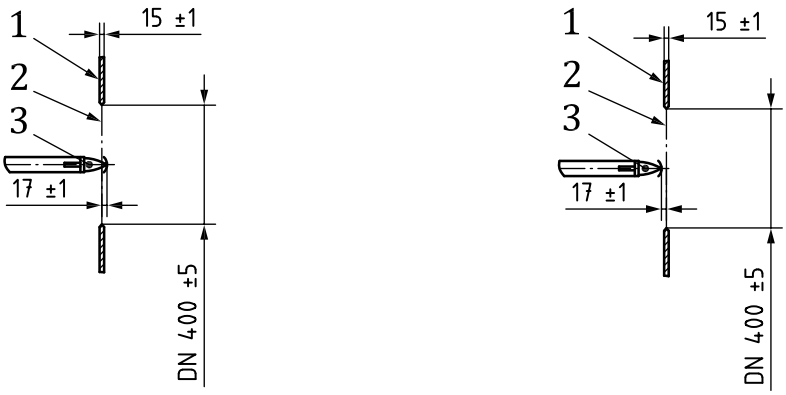


Key

1 partition

Figure 23 — Apparatus for determining water distribution above and below the deflectors except flat spray sprinklers

Dimensions in millimetres



a) Flat spray sprinkler: pendent **b) Flat spray sprinkler: upright**

Key

1 partition
2 circular hole
3 sprinkler

Figure 24 — Apparatus for determining water distribution above and below the deflectors for flat spray sprinklers

7.28.2.3 Sidewall sprinklers, H & W (including dry)

In a test chamber of minimum dimensions 7 m × 7 m, install two sidewall sprinklers of the same type and orifice size arranged along one wall and 3 m apart, on piping prepared for this purpose. The arrangement of piping, sprinklers, and 500 mm square containers is shown in Figure 25 and Figure 26.

The distance between the ceiling and the deflector of each sprinkler shall be 100 mm (see Figure 26).

The water distribution in the designated area between the two sidewall sprinklers shall be measured by means of 36 square measuring containers each side of which is 500 mm. The distance between the ceiling and the upper edge of the containers shall be 2,14 m.

The 36 measuring containers shall be positioned centrally between and below the two sprinklers as shown in Figure 25 and Figure 26. The first line of the array of 36 containers shall be placed parallel to and displaced by 600 mm from the wall behind the sprinklers.

An additional line of six measuring containers shall be placed on the floor adjacent to the wall between the two sidewall sprinklers to collect the water impinging on the wall. The wall surface shall be covered with a non-porous material. The water shall be directed from the non-porous material into the line of containers on the floor adjacent to the wall.

NOTE See Figure 26.

The pans along the back wall are to be provided with a shield/cover located within 50 mm of the wall so that the water collected in the pans is primarily from the water impinging on the back wall.

The total quantity of water collected in these containers shall be a minimum of 3,5 % of the total water discharged from the sprinklers during the test.

For sidewall sprinklers having a nominal K-factor of 80 (l/min)/(bar$^{1/2}$) or less, the water flow rate shall be 57 l/mm for each sprinkler. The average water collection rate in the containers shall be not less than 2 mm/min and the minimum water collection rate in any individual pan shall be 1,2 mm/min.

For sidewall sprinklers having a nominal K-factor of 115 (l/min)/(bar½), the water flow rate shall be 78 l/mm for each sprinkler. The average water collection rate in the containers shall be not less than 2,8 mm/min and the minimum water collection rate in any individual pan shall be 1,2 mm/min.

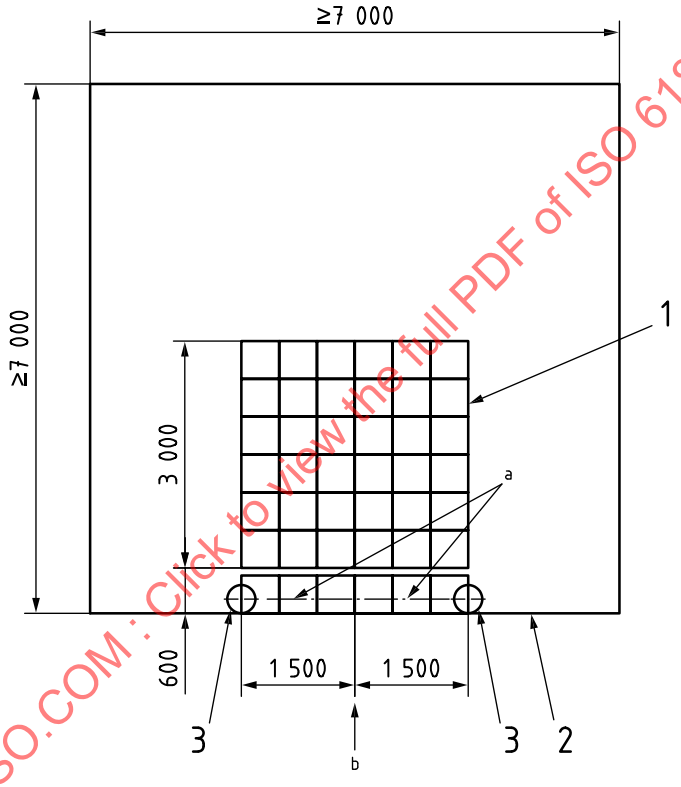
Water shall be discharged for 10 min during this test.

The sidewall sprinklers shall wet a curvilinear area above the containers on the smooth back wall behind the sprinkler.

NOTE See Figure 26.

The entire area shall be completely wetted within the curvilinear shape. The apex of the curvilinear shape shall be a maximum of 1,22 m below each sprinkler deflector.

Dimensions in millimetres

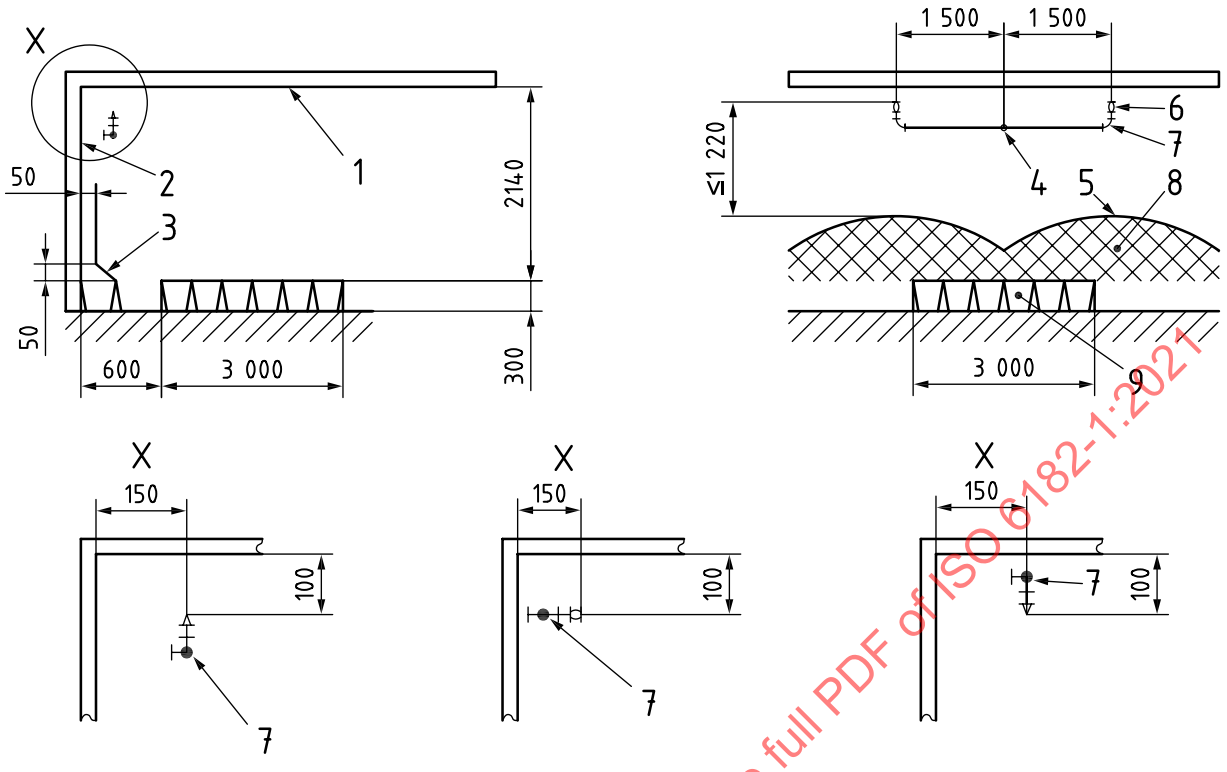


Key

1 500 mm square container (typical)
2 back wall
3 sprinkler
a Nominal pipe diameter is 25 mm.
b Water flow.

Figure 25 — Plan view of sidewall distribution collection room

Dimensions in millimetres



a) Upright **b) Horizontal** **c) Pendent**

Key

1 ceiling
2 back wall
3 baffle
4 tee
5 back wall water contact line
6 sprinkler (2 required)
7 90° reducer elbow (2 required)
8 wetted area
9 measuring containers

Figure 26 — Sidewall sprinkler installation for water distribution test

7.28.3 Domestic sprinklers (see 6.28.3)

7.28.3.1 Horizontal surface water distribution

Tests are to be conducted on an individual sprinkler using design flow rates specified in the manufacturer's design and installation instructions that simulate one sprinkler in a system operating. For sprinklers having a pressure rating greater than 1,2 MPa (12 bar), tests shall be conducted using flows corresponding to a pressure of 0,5 MPa (5 bar) less than the rated pressure at the maximum coverage area. The water distribution test shall be conducted for 20 min.

Dry type sprinklers of the shortest manufactured length shall be tested. If the K-factor for the longest length deviates by more than 5 % from the shortest length, then the longest length shall also be tested.

An open sprinkler shall be installed in its intended position in a pipe fitting having a 25 mm inlet and an outlet the same size as the sprinkler inlet, and shall be supplied with water through 25 mm piping. The

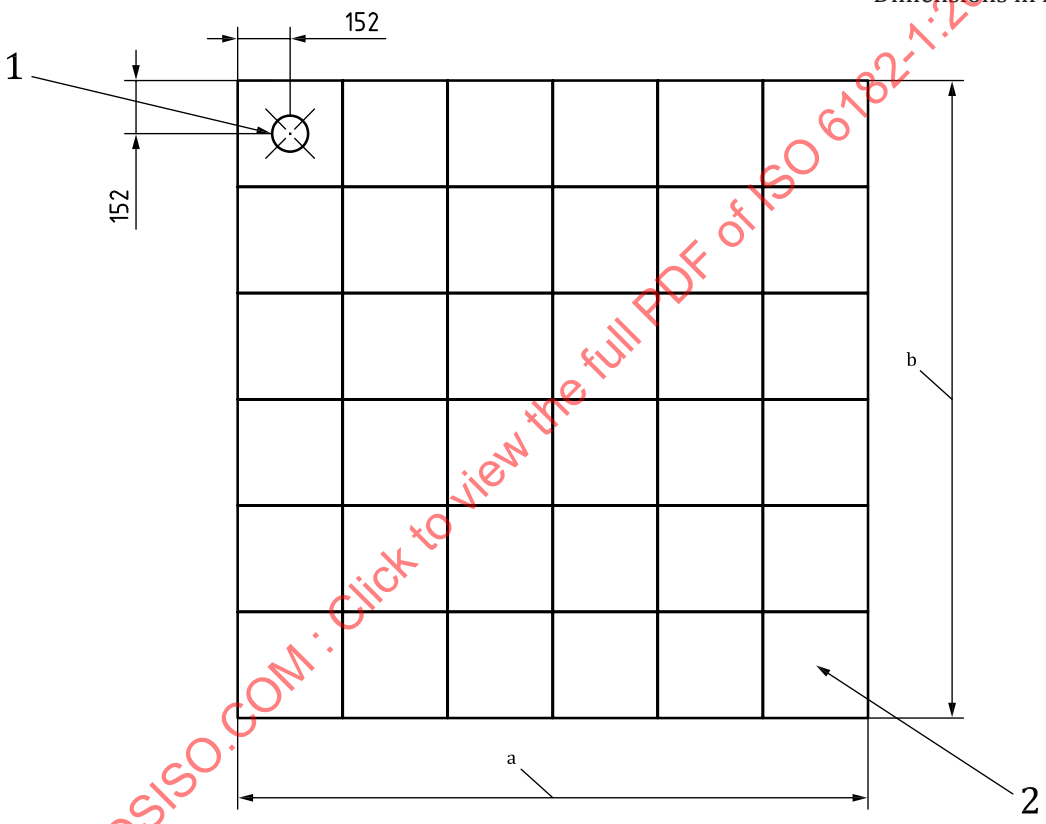
sprinkler deflector shall be located in its intended position as specified in the manufacturer's design and installation instructions. A pendent or upright sprinkler shall be tested after being rotated 90° about its vertical axis after being tested as initially installed.

7.28.3.1.1 Upright and pendent domestic sprinkler

Collector pans measuring 300 mm by 300 mm are to be placed on the floor in one quadrant of the sprinkler's discharge pattern; see Figure 27. The tops of the pans are to be 2,4 m below the ceiling.

The specified water flow rate shall be established and the test shall be conducted for 20 min. At the completion of water flow, the water collected is measured to verify conformance with the requirements of 6.28.3.1 with the sprinkler as installed and after being rotated 90°.

Dimensions in millimetres



Key

1 sprinkler
2 collector pans, 300 mm × 300 mm
a w_c, coverage width (m)
b l_c, coverage length (m)

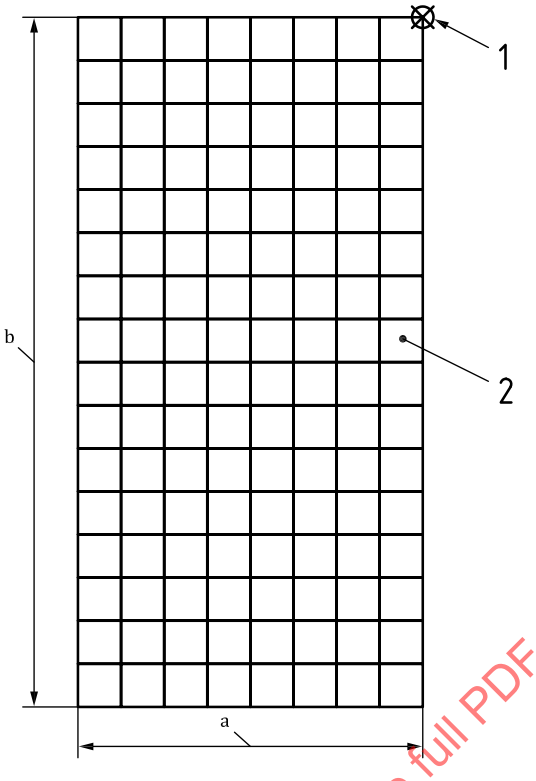
Figure 27 — Water collection for upright, pendent, recessed pendent, and ceiling sprinklers

7.28.3.1.2 Sidewall domestic sprinkler

Collector pans measuring 300 mm by 300 mm are to be placed as shown in Figure 28. The tops of the pans are to be 2 m below the ceiling.

The specified water flow rate shall be established and the test shall be conducted for 20 min. At the completion of water flow, the water collected shall be measured to verify conformance with the requirements in 6.28.3.1.

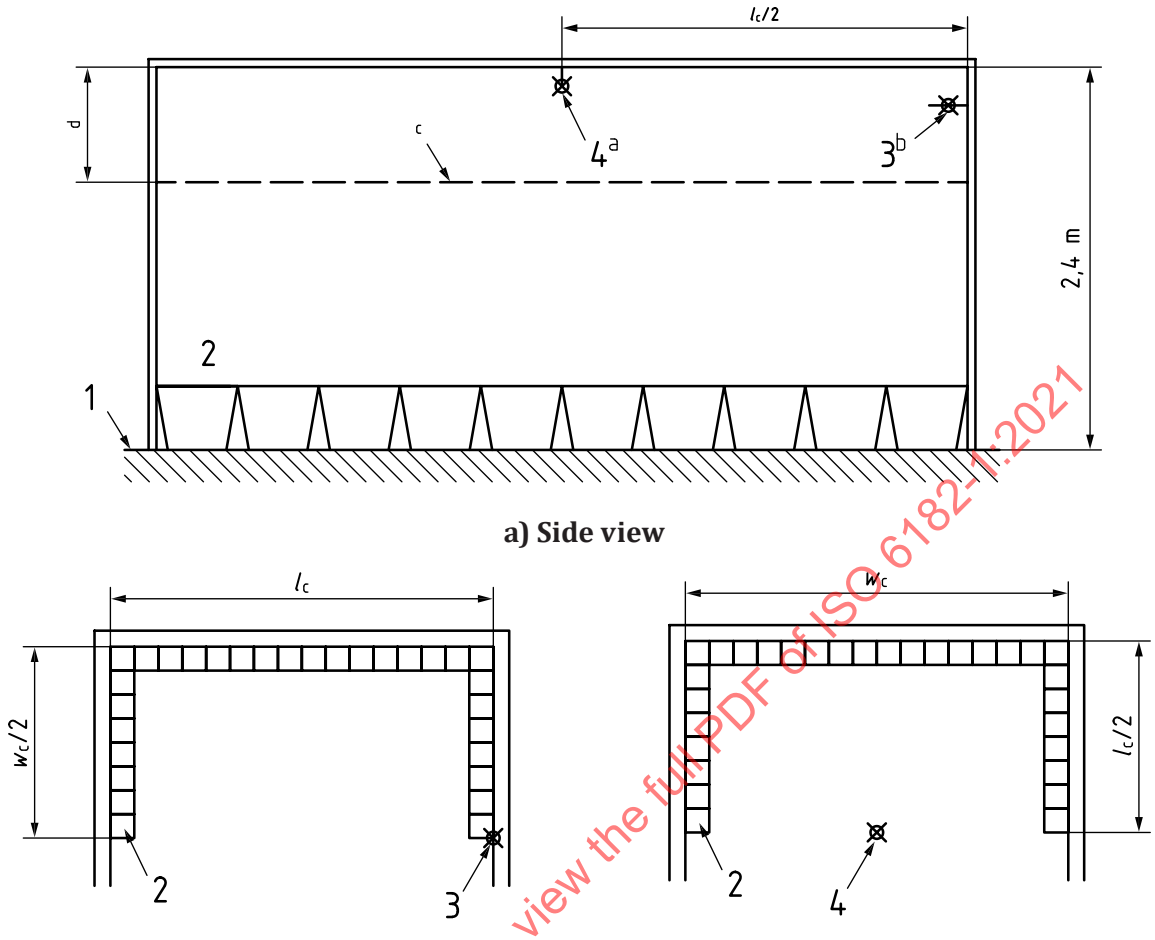
Dimensions in millimetres



Key

1 sidewall sprinkler
2 collector pans, 300 mm × 300 mm
a w_c, coverage width (m)
b l_c, coverage length (m)

Figure 28 — Water collection for sidewall sprinklers



a) Side view

b) Collection pans for sidewall sprinklers (plan view)

c) Collection pans for upright or pendent sprinklers (plan view)

Key

1 floor
2 collector pans
3 sidewall sprinkler
4 pendent or upright sprinkler
w_c coverage width (m)
l_c coverage length (m)
a For upright or pendent sprinkler only.
b For sidewall sprinkler only.
c Maximum wall wetting distance from ceiling.
d 0,7 m.

Figure 29 — Water collection

7.28.3.2 Vertical surface

Tests are to be conducted on an individual sprinkler using design flow rates specified in the manufacturer's design and installation instructions that simulate one sprinkler in a system operating. For sprinklers having a pressure rating greater than 1,2 MPa (12 bar), tests shall be conducted using flows corresponding to a pressure of 0,5 MPa (5 bar) less than the rated pressure at the maximum coverage area. Each water distribution test shall be conducted for a minimum of 10 min.

An open domestic sprinkler shall be installed in its intended position in a pipe fitting having a 25 mm inlet and an outlet the same size as the sprinkler inlet, and shall be supplied with water through 25 mm piping. The sprinkler deflector shall be located in its intended position as specified in the installation instructions. A pendent or upright sprinkler shall be tested at a 90° rotation after being tested as initially installed.

Collector pans are to be used to determine that at least 5 % of the sprinkler flow is discharged onto each wall; see Figure 29. The walls of the test room are to be nonporous or have a nonporous covering so that water impinging on the walls can be collected and measured.

The collector pans measure 300 mm × 300 mm and are placed on the floor against the walls for the length and width of specified coverage. The tops of the pans are located 2 m below the ceiling. Means shall be provided to prevent sprinkler discharge from directly entering the pans; see Figure 29.

Dry type sprinklers of the shortest manufactured length shall be tested. If the K-factor for the longest length deviates by more than 5 % from the shortest length, then the longest length shall also be tested.

The specified water flow rate shall be established and the test shall be conducted for 10 min. At the completion of the test, the water collected and the height of wall wetting is measured to determine conformance with the requirements in 6.28.3.2.

7.28.4 Extended coverage light hazard sprinklers (see 6.28.4)

7.28.4.1 Extended coverage light hazard upright and pendent sprinklers

In a test chamber of minimum dimensions 7 m × 7 m, install one sprinkler on piping prepared for this purpose. The dimensions of the ceiling shall not be less than the measured area of coverage.

The sprinklers shall be fitted directly into the horizontal pipe work by means of tee or elbow fittings or a nominal 25 mm pipe nipple exceeding 150 mm in length with a reducing fitting. The yoke arms of the sprinklers shall be parallel to the supply pipes.

Dry type sprinklers of the shortest manufactured length shall be tested.

The distance between the ceiling and the deflector of the sprinkler shall be 100 mm. In cases where adjustment of the distance between the deflector and the ceiling is possible, (i.e., concealed, flush, and recessed sprinklers), distribution tests shall be conducted at both extremes of deflector position.

Upright and pendent sprinklers shall be evaluated by collecting water in one quadrant of the room as shown in Figure 30 and Figure 31. The collection pans are to be positioned 25 mm from adjacent walls.

Tests shall be conducted in each nominal room size at the corresponding nominal flow rate given in Table 24.

The water distribution in the protected area shall be measured by means of square collection pans 500 mm on a side. The distance between the ceiling and the upper edge of the pans shall be 2,2 m.

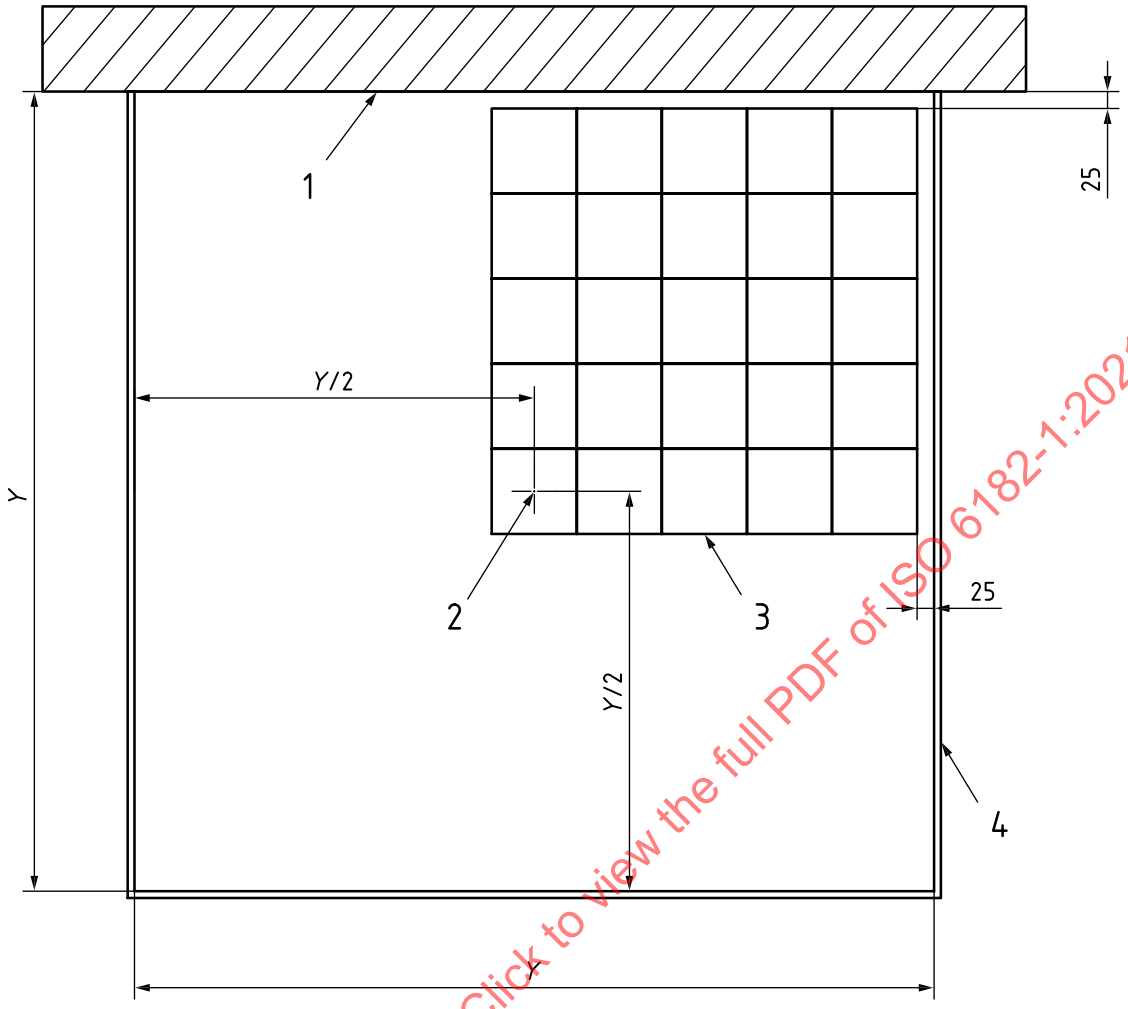
The water shall be collected for at least 10 minutes.

The wall wetting test (7.28.4.3) may be performed concurrently with this test.

Table 24 — Distribution testing parameters for upright and pendent ECLH sprinklers

Nominal flow constant, *K* l/m[bar]^{0,5}	**Nominal room dimensions** [width × length] m × m	**Nominal flow rate** l/min
80	5,0 × 5,0	100
80	5,5 × 5,5	125
80	6,0 × 6,0	150
115	5,0 × 5,0	100
115	5,5 × 5,5	125
115	6,0 × 6,0	150
160	5,0 × 5,0	115
160	5,5 × 5,5	125
160	6,0 × 6,0	150
202	5,0 × 5,0	140
202	5,5 × 5,5	140
202	6,0 × 6,0	150

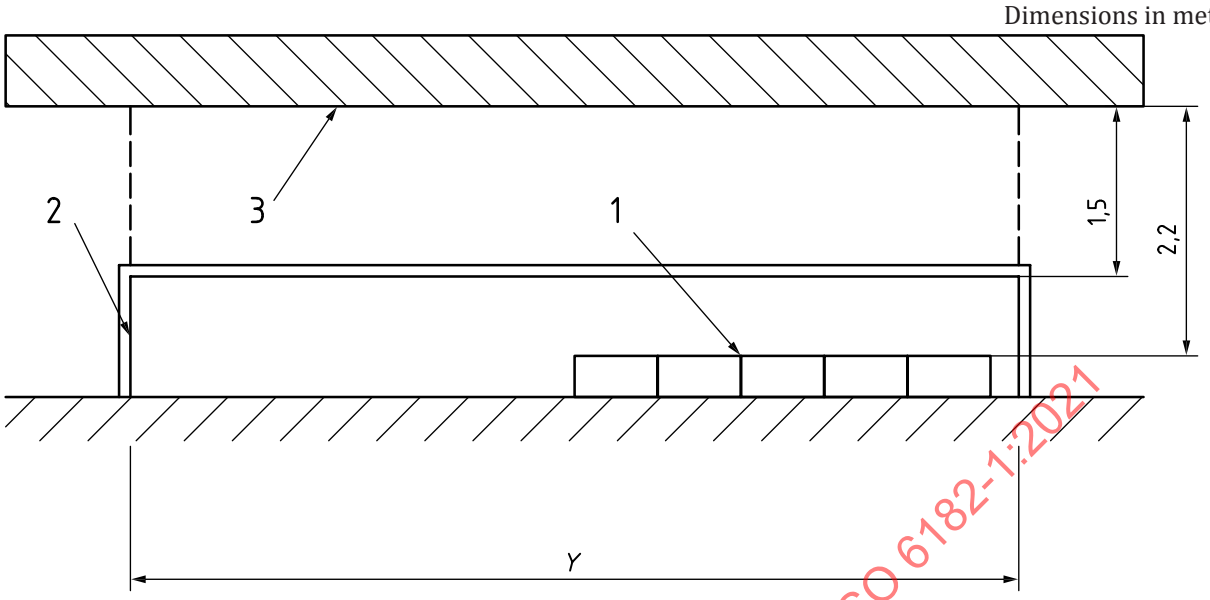
Dimensions in millimetres



Key

1 test chamber wall
2 sprinkler locations
3 collection pans
4 open framework supporting paper wall
Y room length/width

Figure 30 — Water distribution and wall wetting test setup for ECLH upright and pendent sprinklers plan view



Key

1 collection pans
2 open framework supporting paper wall
3 test chamber ceiling
Y room width

Figure 31 — Water distribution and wall wetting test setup for ECLH upright and pendent sprinklers elevation view

7.28.4.2 Extended coverage light hazard sidewall sprinklers

In a test chamber of minimum dimensions 7 m x 9 m, install one sprinkler in a wall on piping prepared for this purpose. The wall shall not be less than 2,4 m high and 5,5 m in length. The dimensions of the ceiling shall not be less than the measured area of coverage.

The sprinkler shall be fitted directly into the horizontal pipe work by means of tee or elbow fittings or a nominal 25 mm pipe nipple exceeding 150 mm in length with a reducing fitting.

Dry type sprinklers of the shortest manufactured length shall be tested.

The sprinkler shall be tested with ceiling-to-distribution-plate distances of 100 mm and 300 mm. In cases where adjustment of the distance between the deflector and the ceiling is possible, (i.e., concealed, flush, and recessed sprinklers), distribution tests shall be conducted at both extremes of deflector position.

Sidewall sprinklers shall be evaluated by collecting water in one half of the room as shown in Figure 32. The collection pans are to be positioned 25 mm from adjacent walls.

Tests shall be conducted in each nominal room size at the corresponding nominal flow rate given in Table 25.

The water distribution in the protected area shall be measured by means of square collection pans 500 mm on a side. The distance between the ceiling and the upper edge of the pans shall be 2,2 m. The water shall be collected for at least 6 min.

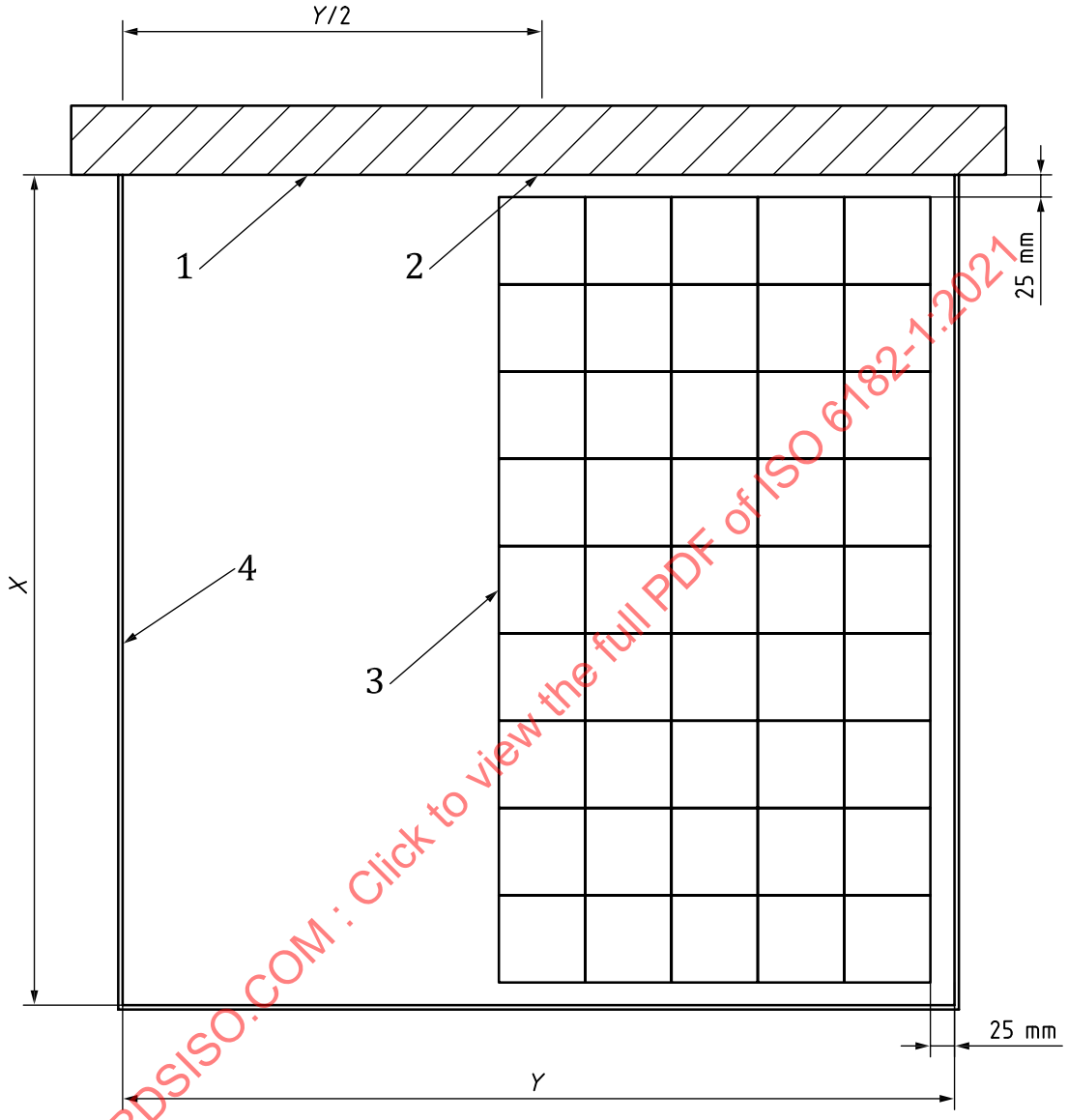
The wall wetting test (7.28.4.3) may be performed concurrently with this test.

Table 25 — Distribution testing parameters for sidewall sprinklers

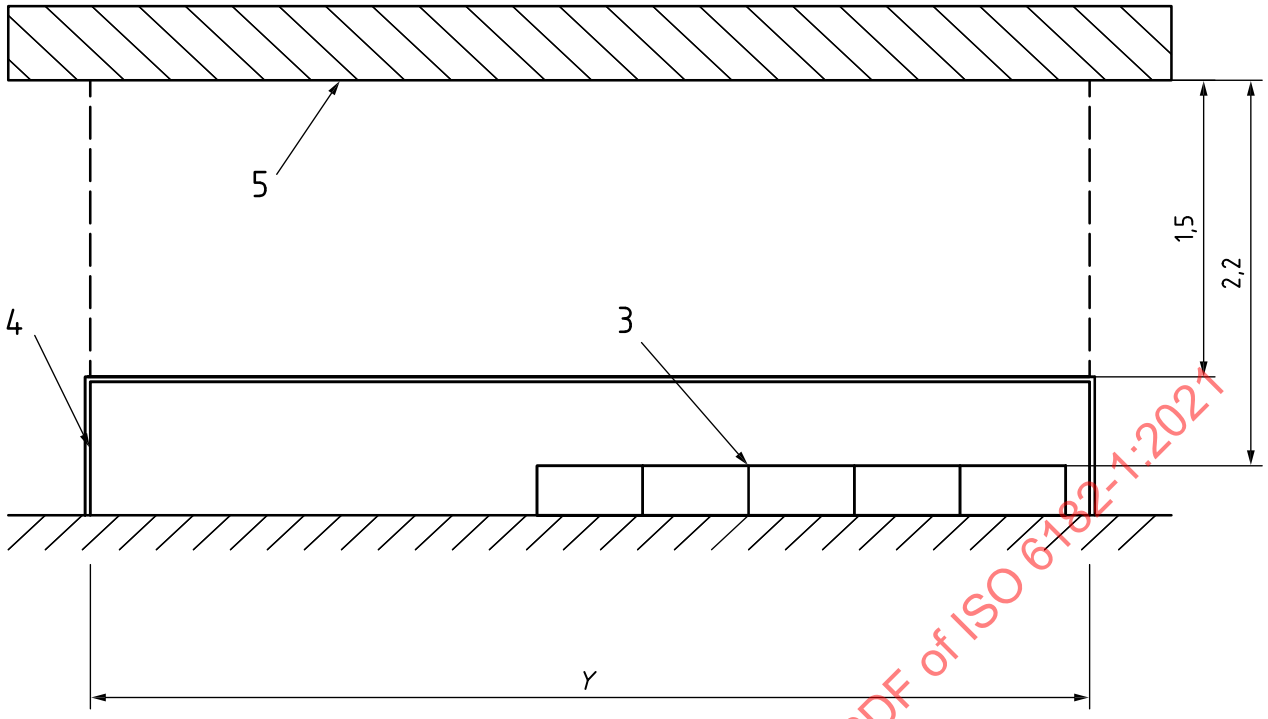
Nominal flow constant, *K* l/m[bar]^{0,5}	**Nominal room dimensions** [width × length] m × m	**Nominal flow rate** l/min
80	5,0 × 5,0	100
80	5,0 × 5,5	115
80	5,0 × 6,0	125
115	5,0 × 5,0	120
115	5,0 × 5,5	135
115	5,0 × 6,0	150
115	5,0 × 6,5	165
115	5,0 × 7,0	180

Dimensions in metres

Dimensions in metres



a) Plan view



b) Elevation view

Key

1 test chamber wall
2 sprinkler locations
3 collection pans
4 open framework supporting paper wall
5 test chamber ceiling
X room length
Y room width

Figure 32 — Water distribution and wall wetting test setup for ECLH sidewall sprinklers

7.28.4.3 Wall wetting test for extended coverage light hazard sprinklers (see 6.31.5)

The wall wetting tests shall be conducted in a test chamber large enough to contain a room of the maximum size permitted for the sprinkler type and orifice size (see Table 24 for upright and pendent sprinklers and Table 25 for sidewall sprinklers). An open framework supporting a paper wall shall be erected in the chamber to simulate a room of the appropriate size as shown in Figure 30 and Figure 31 or Figure 32, as applicable.

Upright and pendent sprinklers shall be tested with a ceiling-to-distribution-plate distance of 100 mm. Sidewall sprinklers shall be tested with ceiling-to-distribution-plate distances of 100 mm and 300 mm. In cases where adjustment of the distance between the deflector and the ceiling is possible, (i.e. concealed, flush, and recessed sprinklers), distribution tests shall be conducted at both extremes of deflector position.

Dry type sprinklers of the shortest manufactured length shall be tested. Tests shall be conducted in each nominal room size at the corresponding nominal flow rate given in Table 24 or 7.28.4. Each test shall be conducted for 6 min. After the test duration, each wall of the room shall be examined to verify conformance with 6.28.4.

This test may be conducted concurrently with the water distribution test (7.28.4.1 or 7.28.4.2).

7.28.5 Extended coverage ordinary hazard sprinklers (see 6.28.5)

Four open sprinklers are to be installed in their intended position (upright or pendent) in the 38 mm × 38 mm × 19 mm tees, each supplied with water through two 38 mm diameter pipes with sprinklers placed at the corners of spacings specified by the manufacturer. The upright and pendent sprinkler deflectors are to be located 178 mm below flat ceiling and frame arms, parallel to the piping on which it is installed. For dry type sprinklers, the minimum length to be produced shall be tested. A ceiling mounted sprinkler type shall be installed as specified by the manufacturer.

Collection pans, having dimensions of 305 mm, are to be centred below the sprinklers at distances below the sprinkler deflectors as specified in Table 8.

Water shall be discharged for 10 minutes. The amount collected in each pan shall be measured, and the density in gallons per minute per mm/min calculated.

7.28.6 K202 and K242 pendent ESFR sprinklers (see 6.28.6)

Test three samples, or sets of samples, to the requirements given in Tables 9 and 10, as appropriate. Operate all samples by applying a heat source to remove the heat-sensitive element. The sprinkler test area shall be designed as shown in Figure 33 through Figure 38. Construct the water-collection apparatus in accordance with the specifications given in Figure 39. Locate the test apparatus in a room of sufficient volume so as to minimize the entrainment of additional water spray. Prevent any drafts or other air movement from entering, or leaving, the test area.

Cover the water-collection system, Figure 39, until the required pressure has been obtained. At that time, quickly remove the cover in such a manner as to not cause water collected on top of the cover to be deposited into the collection pans. Conduct this test for a period of 5 min. At the conclusion of the test, immediately place the cover over the collection pans to prevent any further water from being collected in the pans. The top surface of collection pans shall be greater than 1 000 mm above solid floor surface.

Dimensions in metres

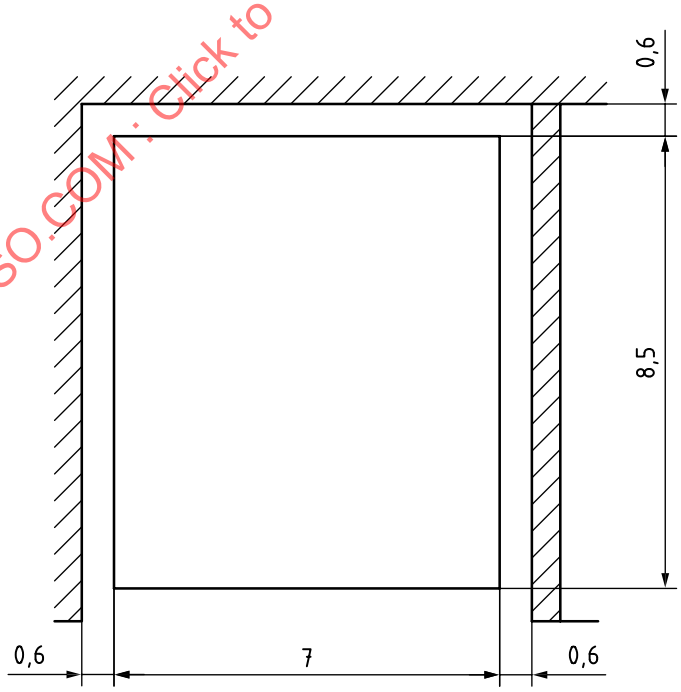
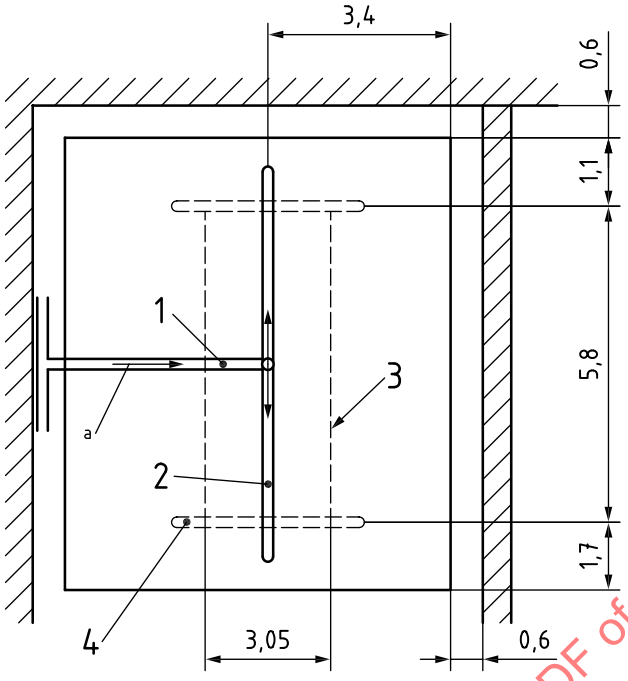


Figure 33 — Minimum dimensions of the water distribution collection apparatus

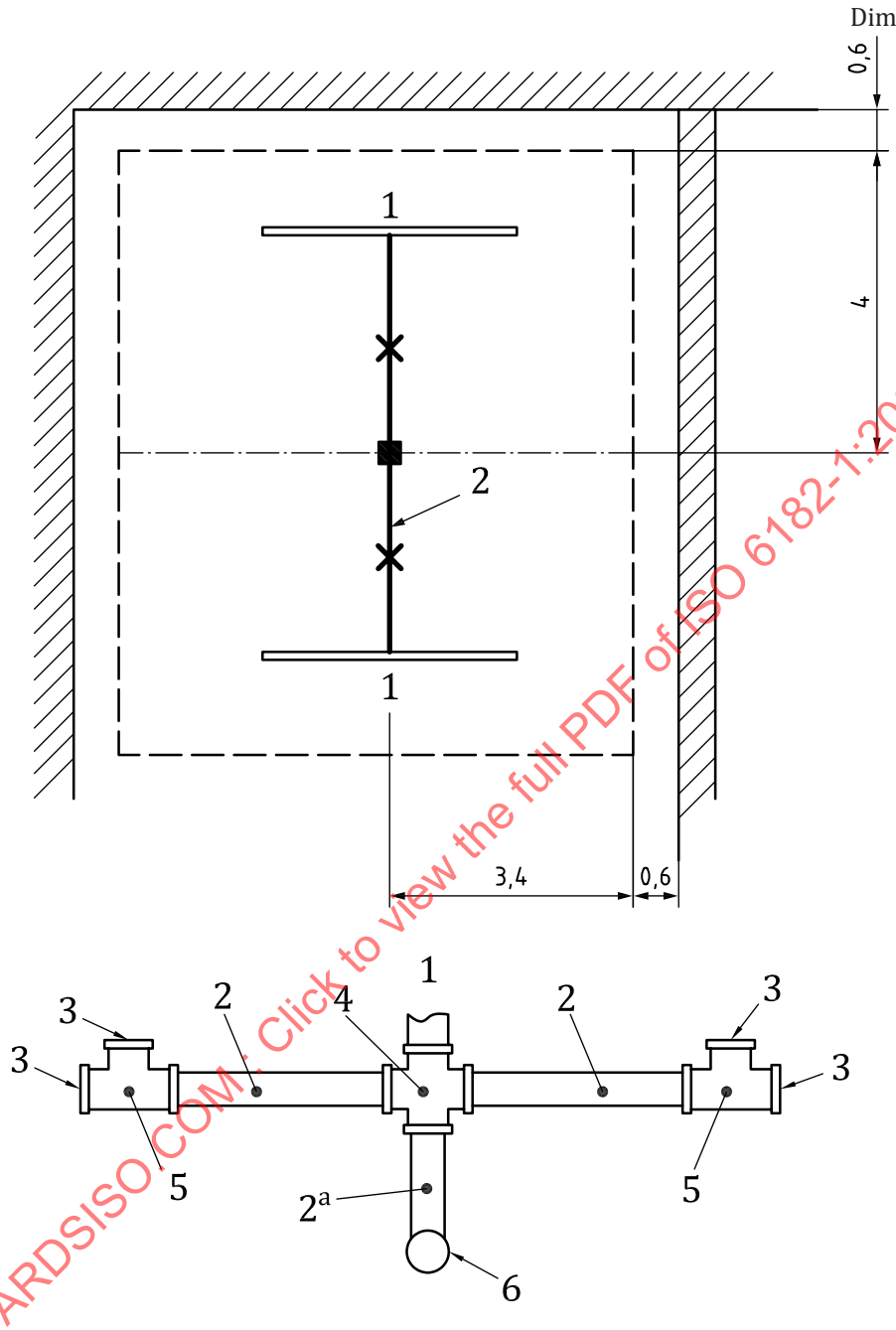
Dimensions in metres



Key

1 pipe [Ø 100 nom. (mm)]
2 pipe [Ø 75 nom. (mm)]
3 sprinkler pipe (Ø 50 mm)
4 manifold under ceiling (Ø 50 mm)
a Water flow.
---- Indicates piping located below the ceiling (see Figure 35 and Figures 36 - 38).

Figure 34 — Overhead piping configuration for water-distribution-collection apparatus

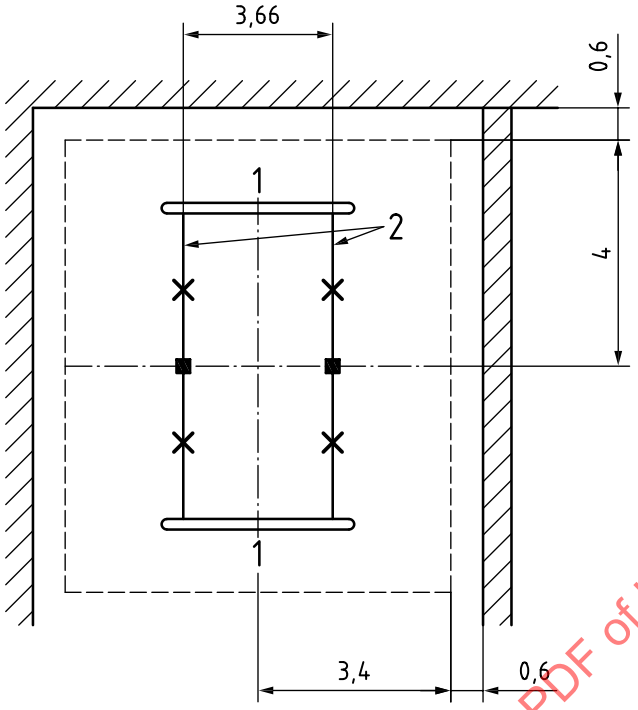


Key

1	pipe manifold
2	pipe [Ø 50 nom. (mm)]
3	pipe plug
4	threaded cross [50 × 50 × 50 (mm)]
5	threaded tee [50 × 50 × 50 (mm)]
6	nominal feed line from above the ceiling with reducer [Ø 75 (mm)]
■	sprinkler location — one sprinkler test
X	sprinkler location — two sprinkler test
a	300 mm minimum length.

Figure 35 — Single sprinkler piping configuration for the water-distribution-collection apparatus

Dimensions in metres



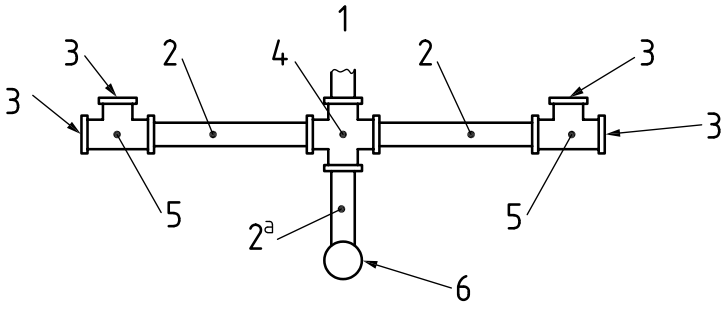
Key

■	sprinkler location — two sprinkler test
X	sprinkler location — four sprinkler test
1	pipe manifold
2	pipe [Ø 50 nom. (mm)]
3	pipe plug
4	threaded cross [50 × 50 × 50 × 50 (mm)]
5	threaded tee [50 × 50 × 50 (mm)]
6	nominal feed line from above the ceiling with reducer [Ø 75 (mm)]

NOTE See Table 2 for pipe spacing.

Figure 36 — Multiple sprinkler piping configuration for the water-distribution-collection apparatus

Dimensions in millimetres



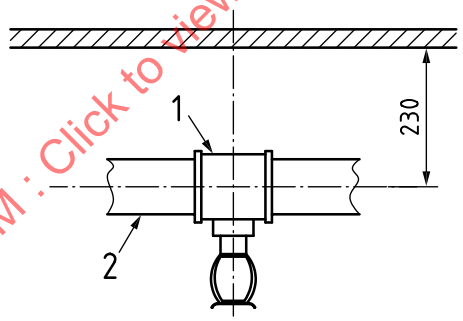
Key

1	pipe manifold
2	pipe [Ø 50 nom.]
3	pipe plug
4	threaded cross (50 × 50 × 50 × 50)
5	threaded tee (50 × 50 × 50)
6	nominal feed line from above the ceiling with reducer (Ø 75)
a	300 mm minimum length.

NOTE See Table 2 for pipe spacing.

Figure 37 — Multiple sprinkler piping configuration for the water-distribution-collection apparatus

Dimensions in millimetres



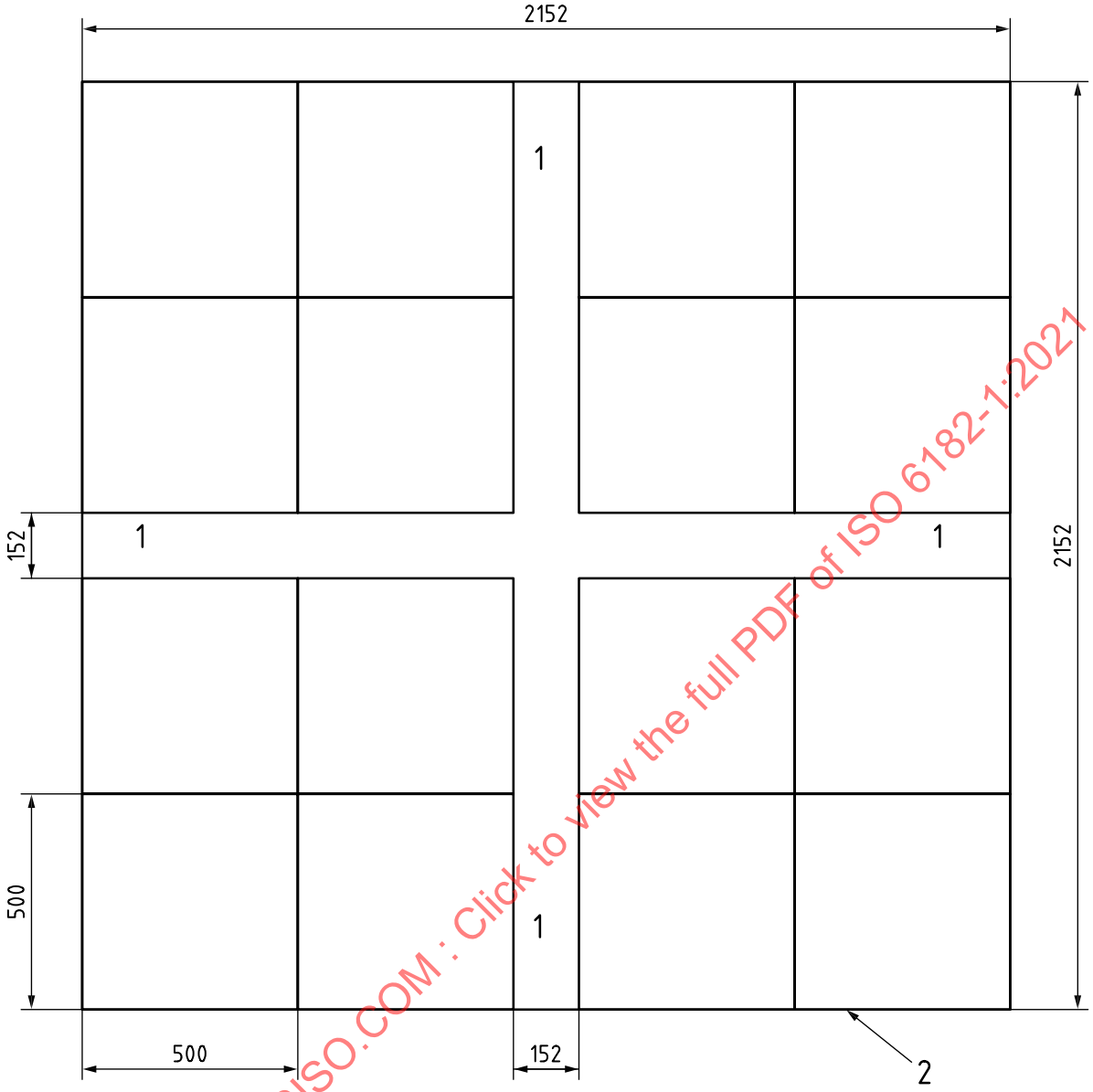
Key

1 threaded pipe

2 pipe [Ø 50 nom.]

Figure 38 — Multiple sprinkler piping configuration for the water-distribution-collection apparatus

Dimensions in millimetres



Key

1 flue space collection pan

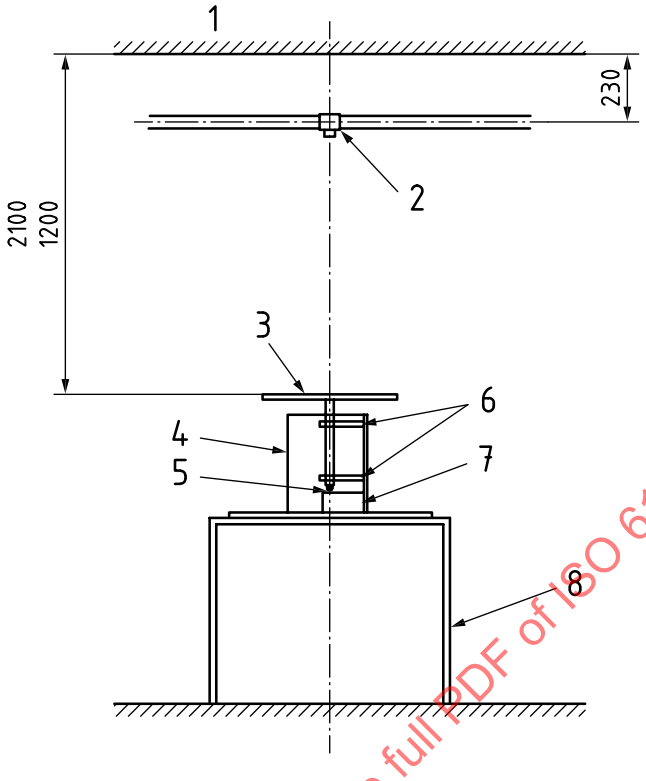
2 square collection pan

Figure 39 — Collection pan assembly for water distribution collection apparatus

7.28.7 Thrust force test (see 6.28.7)

Install the sprinkler in the thrust force apparatus as shown in Figure 40. Measure and record the thrust at the pressures specified in Tables 11 and 12, as appropriate. Repeat the test two more times with different sprinklers.

Dimensions in millimetres



Key

1 suspended ceiling
2 threaded tee (50 × 50 × 50)
3 thrust plate (Ø 343 ± 1)
4 waterproof casing
5 stainless steel ball
6 slide ball bearing
7 load cell transducer
8 platform

Figure 40 — Thrust force measurement test apparatus

7.29 Lateral discharge test (see 6.29)

7.29.1 General

The lateral discharge test shall be applied to all sprinkler types other than flat or conventional sprinklers.

While discharging water at a service pressure of 0,52 MPa (5,2 bar) less than the rated pressure, an open sprinkler shall not prevent the operation of a 57 °C to 77 °C temperature rated automatic sprinkler of the same type and response located at the distance specified in Table 26 and described in 7.29.2 or 7.29.3.

7.29.2 Upright and pendent sprinklers

7.29.2.1 An upright or pendent automatic sprinkler of the type noted in Table 26 having a nominal release temperature of 57 °C to 77 °C shall be installed on piping at a distance (centre-to-centre) specified

in Table 26 from a second open sprinkler of the same type. The sprinklers shall be on separate parallel pipelines.

7.29.3 Sidewall sprinklers

For sidewall sprinklers, an automatic and open sprinkler are to be installed on the same pipe line with the sprinklers located at a distance apart as specified in Table 26, to discharge water perpendicular to the pipe line. The test shall be conducted with the sprinklers located at distances specified in Table 26 below a flat ceiling and 152 mm away from a back wall.

7.29.4 Exposure to heat and flame

Water shall be discharged from the open sprinkler at a service pressure of 0,52 MPa (5,2 bar) less than the rated pressure. Under this condition, the automatic sprinkler shall be exposed to the heat and flame from a 305 mm^2 pan, 102 mm deep, containing 0,47 l of heptane and 0,47 l of water, with the top of the pan located 152 mm below the heat-responsive element of the automatic sprinkler. Observations are to be made for operation of the automatic sprinkler. The test shall be conducted at each of the deflector to ceiling distances specified for each type of sprinkler listed in Table 26. Recessed sprinklers can be tested in the recessed condition in lieu of 102 mm below ceiling.

7.29.5 Consumption of heptane

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

Table 26 — Lateral discharge test parameters

Sprinkler type	Distance between sprinkler m	Distance from ceiling mm
Standard spray pendent	1,83	150 and 560
Standard spray upright	1,83	150 and 560
Standard spray sidewall	1,83	150 and 300
ECLH and ECOH, pendent and upright	2,4 or minimum distance specified by installation instructions	150
Extended coverage sidewall	2,4 or minimum distance specified by installation instructions	102 and 300
Domestic pendent	2,4 or minimum distance specified by installation instructions	102
Domestic upright	2,4 or minimum distance specified by installation instructions	102
Domestic sidewall	2,4 or minimum distance specified by installation instructions	102 and 300
SCSS	1,83	300
ECSS	2,4 or minimum distance specified by installation instructions	300
ESFR	1,83	355

7.30 Water shield angle of protection (see 6.30)

Determine the angle of protection according to 6.30 by measuring the angle between the plane of the water shield at its outer edge to the extremity of any fusible element or glass bulb, with any lever mechanisms rotated to give the largest subtended angle (see Figure 5).

For a link and lever sprinkler, this is the outermost and lowest edge of the link or lever measured with the link and lever assembly rotated to 90° to the frame arm plane.

For a centre strut or glass bulb sprinkler, if a line drawn to the edge of the lower seat of the bulb, rather than to the extremity of the bulb, produces a larger angle, then that larger angle shall be the angle of protection for that sprinkler.

7.31 Fire performance (see 6.31)

7.31.1 General

7.31.1.1 Fire performance tests shall be in accordance with 7.31.2 through 7.31.7.

7.31.1.2 Electrically activated sprinklers shall be operated in the intended manner using the detection and control equipment referenced by the manufacturer as being suitable for use with the electrically activated sprinkler and sprinkler with monitoring of activation, and the maximum delay time between the detection of a fire to the release of the sprinkler shall be included into the test parameters of the fire tests.

7.31.2 Spray sprinkler fire performance

7.31.2.1 Fire test assembly

7.31.2.2 The test shall be conducted using cribs of sawn lengths of *Pinus sylvestris* (pine) or *Picea excelsa* (spruce).

Each crib shall contain two lengths of nominal dimensions 100 mm × 150 mm × 2 400 mm, 13 lengths of nominal dimensions 100 mm × 100 mm × 1 200 mm, and 28 lengths of nominal dimensions 50 mm × 100 mm × 1 200 mm. The average moisture content of the wood shall be between 6 % and 14 % (see Figure 41).

The timber specified above shall be layered by being evenly spaced from each other and forming a square crib, 1 200 mm × 1 200 mm in area and 600 mm high, supported in turn by the two 2 400-mm-long, 100 mm × 150 mm stringers. The total mass of the timber in the crib shall be determined and recorded.

The crib stringers shall be supported by a steel framework of channel iron mounted on adjustable pipe supports. The framework shall be sufficiently large to span the steel pan described in 7.31.2.4.

Dimensions in millimetres

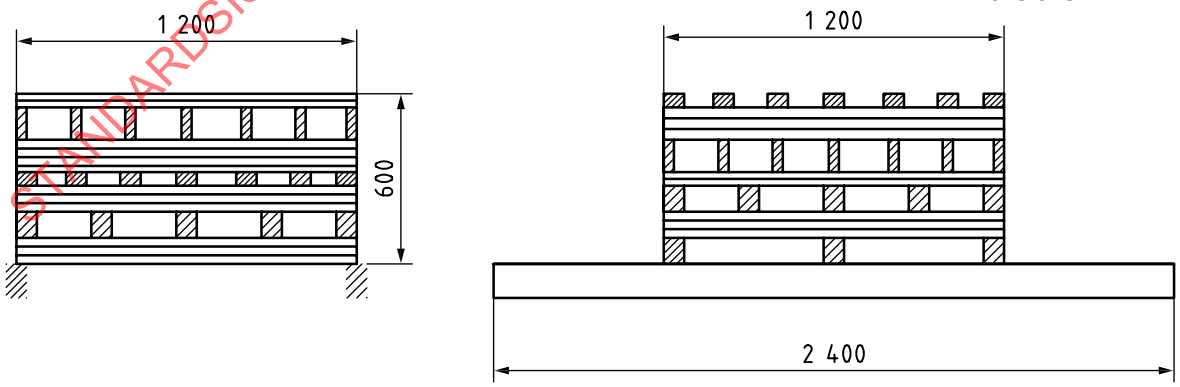


Figure 41 — Test crib

7.31.2.3 A supply of *n*-heptane or equivalent fuel, sufficient for 30 min, and a nozzle shall be incorporated in the assembly as shown in Figure 42. The spray shall form a hollow cone having an angle of approximately 75° when atomizing the fuel at a rate of 0,063 l/s. To prevent flameout, an igniter shall be located next to the nozzle. This may be a cylindrical container partially filled with heptane.

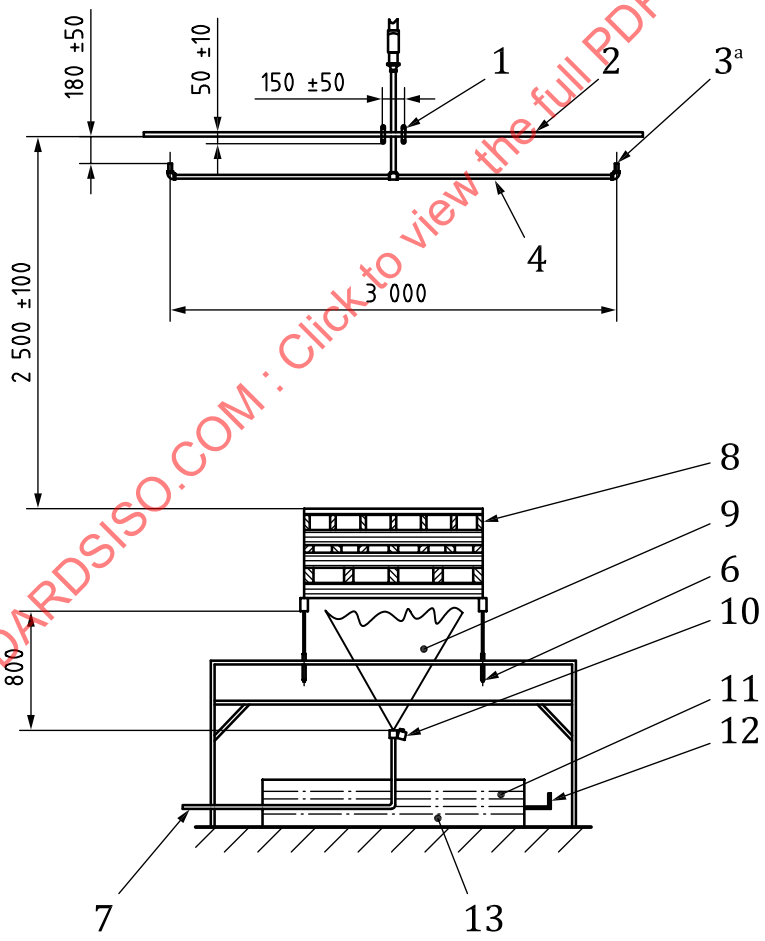
NOTE A suitable nozzle is available commercially. See ISO/TC 21 for details.

7.31.2.4 The steel pan shall be 1 800 mm × 2 400 mm × 300 mm (depth), constructed of steel plate not less than 5,4 mm thick. The upper corners shall be reinforced by a continuous steel band. The pan shall be liquid tight and, prior to the test, shall be filled with water to a depth of 100 mm. The pan shall be provided with means of drainage to maintain the water level at 100 mm.

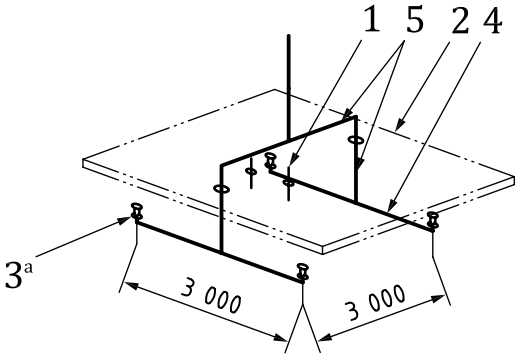
7.31.2.5 Sprinkler installation

Four open sprinklers of the same type and orifice size shall be placed under an unobstructed portion of ceiling having a minimum area of 5 000 mm × 5 000 mm. The sprinklers shall be mounted in a square configuration, using balanced piping (see Figure 42), with 3 000 mm between the sprinklers on each side. The ceiling shall be located (2 500 ± 100) mm above the top of the crib. The distance between the deflectors of upright sprinklers and the ceiling shall be (180 ± 50) mm and (250 ± 50) mm for pendent sprinklers. Closed sprinklers with a nominal temperature rating of 77 °C or less can be used provided that they operate within 70 s of ignition.

Dimensions in millimetres



a) Elevation view



b) Isometric view

Key

1	thermocouples	8	crib
2	ceiling	9	*n*-heptane flames
3	sprinkler	10	igniter
4	25 mm pipe	11	water
5	40 mm pipe	12	overflow pipe
6	adjustable pipe support	13	steel pan
7	fuel supply piping		

[a] Four sprinklers, spaced in a square configuration, with 3 000 mm between the sprinklers on each side.

Figure 42 — Crib fire test

Flush, concealed, and recessed sprinklers shall be mounted in the maximum recessed position in a false ceiling of dimensions not less than 6 m × 6 m and arranged symmetrically in the test chamber.

Two thermocouples, spaced 150 mm apart, shall be located 50 mm below the ceiling, at the centre of the square formed by the sprinklers. The tips of the thermocouples shall be turned upwards to avoid the formation of water droplets.

Sprinkler frame arms shall be oriented parallel to the piping.

7.31.2.6 Test room

The test room shall be a ventilated, draught-free enclosure and shall have a minimum floor area of not less than 100 m^2 with no floor dimension less than 10 m. The ceiling height shall be sufficient to accommodate the assembly as shown in Figure 42. The total air inlet area to the test room shall be not less than 1 m^2. Provision shall be made, either by venting or by the dimensions of the test room, to evacuate or dissipate smoke.

7.31.2.7 Procedure

Two tests, each of 30 min duration, shall be conducted. For each test, a new wood crib, placed in the centre of the test room, shall be fed for 30 min with *n*-heptane maintained at a temperature between 5 °C and 25 °C. Continuous combustion of the *n*-heptane shall be ensured by means of a pilot flame or igniter placed within 50 mm of the spray nozzle.

The total flow rate to the four sprinklers having a nominal *K*-factor of 80 (l/min)/(bar$^{1/2}$) shall be $\left(230^{+9}_{0}\right)$ l /min for the first test and $\left(380^{+15}_{0}\right)$ l/min for the second test.

The total flow rate to the four sprinklers having a nominal *K*-factor of 115 (l/min)/(bar$^{1/2}$) shall be $\left(320^{+12}_{0}\right)$ l/min for the first test and $\left(530^{+21}_{0}\right)$ l/min for the second test.

The fuel flow shall be started and the torch ignited immediately. When the torch is ignited, the test timer and temperature-measuring equipment shall be started.

For open sprinklers, water application shall be started after a minimum free-burning time of 1 min or after a ceiling temperature of 760 °C is achieved, whichever occurs later.

After the 30 min period, the test shall be stopped and the crib fully extinguished within 1 min. The crib shall then be oven-dried and weighed.

If the wood crib cannot be oven-dried, it shall be dried for 1 week in a sheltered area. The value of the crib mass measured before the test (6 % to 12 % moisture content) and after drying shall be corrected to the value at 0 % moisture before calculations are performed to determine conformance with the mass loss requirement (see 6.31.2).

7.31.3 Domestic sprinkler fire performance (see 6.31.3)

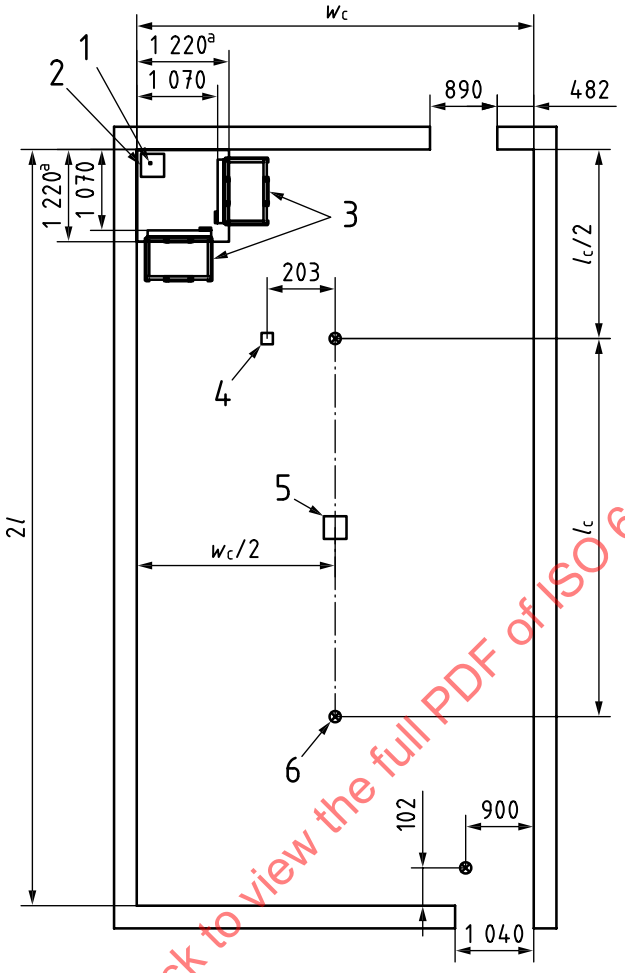
7.31.3.1 Sprinklers in each temperature rating are to be subjected to the tests specified in 7.31.3.2 to 7.31.3.22. Dry type sprinklers of the shortest manufactured length shall be tested. If the K-factor for the longest length deviates by more than 5 % from the shortest length, then the longest length shall also be tested.

7.31.3.2 The test room dimensions for upright, pendent, flush, recessed, and concealed sprinklers shall be the sprinkler coverage width by twice the sprinkler coverage length. The test room dimensions for sidewall sprinklers shall be the sprinkler coverage length by 1,5 times the sprinkler coverage width plus 2,7 m. The room shall have a 2,4 m high ceiling. For each test, new acoustical panels shall be installed in the 1,2 m × 1,2 m area directly over the fire source.

7.31.3.3 The test room ceiling shall be covered with cellulosic acoustical panels or gypsum board, attached to furring strips. The acoustical panels shall measure 600 mm × 1 200 mm × 12,7 mm thick, shall have a density of (216 ± 24) kg/m^3, and shall have a maximum flame spread index rating of 25.

7.31.3.4 The test room shall have provision for ventilation through two door openings on opposite test room walls. Each opening shall be 2,2 m high, which provides for a 200 mm lintel above the openings. The door widths shall be as specified in Figure 43 to Figure 45.

Dimensions in millimetres

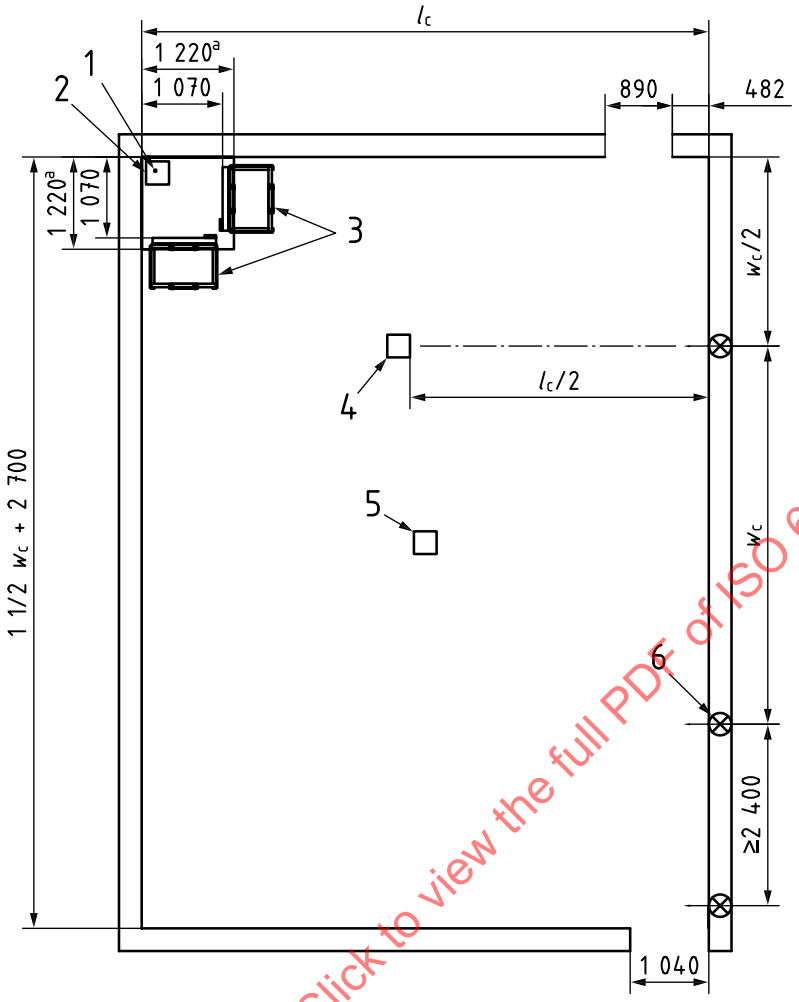


Key

1	thermocouples, 6 mm above ceiling and 254 mm diagonally from the corner	4	thermocouple, 76 mm below ceiling and 1 600 mm above the floor
2	wood crib	5	thermocouple, 76 mm below ceiling (room centre)
3	simulated furniture	6	sprinkler (typical)
[a]	Douglas fir plywood.		
w_c	coverage width		
l_c	coverage length		

Figure 43 — Fire test arrangement for pendent and upright sprinklers

Dimensions in millimetres

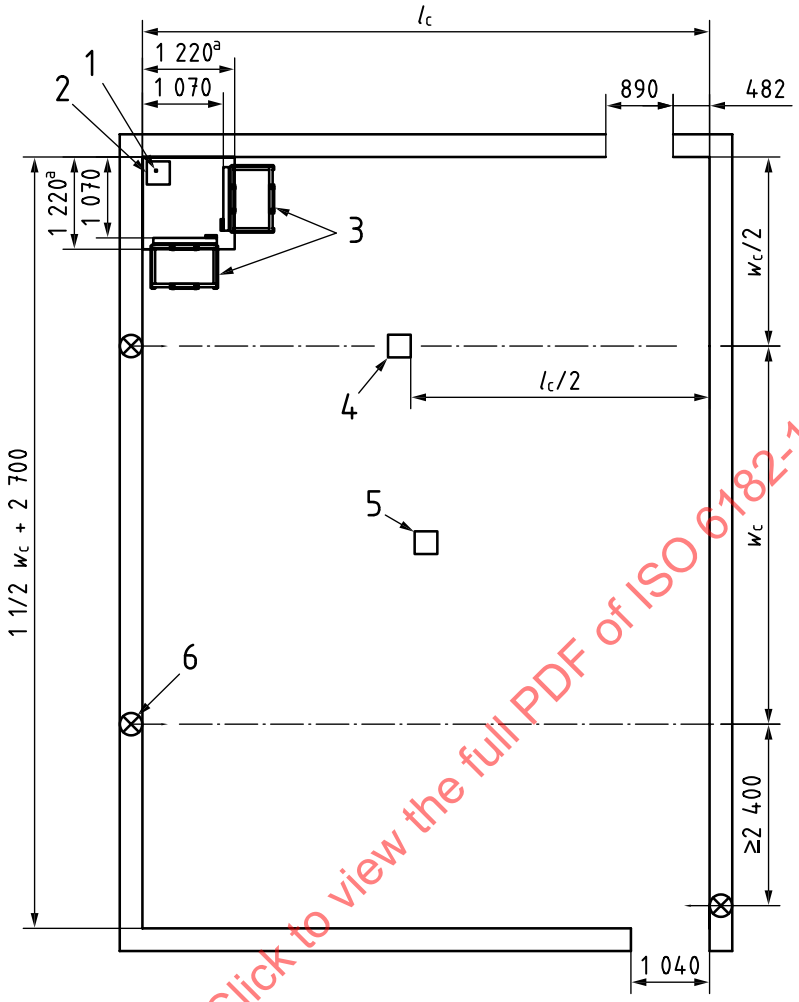


Key

1	thermocouples, 6 mm above ceiling and 254 mm diagonally from the corner	4	thermocouple, 76 mm below ceiling and 1 600 mm above the floor
2	wood crib	5	thermocouple, 76 mm below ceiling (room centre)
3	simulated furniture	6	sidewall sprinkler (typical)
a	Douglas fir plywood.		
w_c	coverage width		
l_c	coverage length		

Figure 44 — Fire test arrangement 1 for sidewall sprinkler

Dimensions in millimetres



Key

1	thermocouples, 6 mm above ceiling and 254 mm diagonally from the corner	4	thermocouple, 76 mm below ceiling and 1 600 mm above the floor
2	wood crib	5	thermocouple, 76 mm below ceiling (room centre)
3	simulated furniture	6	sidewall sprinkler (typical)
[a]	Douglas fir plywood.		
w_c	coverage width		
l_c	coverage length		

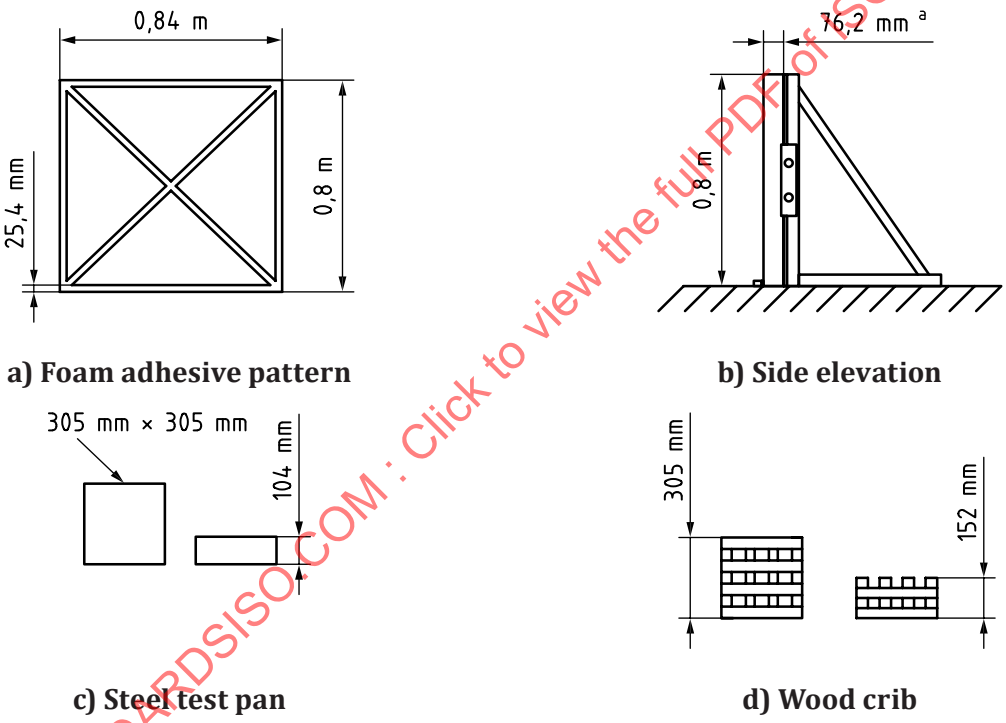
Figure 45 — Fire test arrangement 2 for sidewall sprinkler

7.31.3.5 Douglas fir 3-ply panels measuring 1,2 m × 2,4 m shall be placed on two of the test room walls extending out 1,2 m from a common corner. The panels shall be approximately 6,4 mm thick. The plywood panels shall be conditioned at (21 ± 3) °C and (50 ± 10) % relative humidity for at least 72 h prior to the test. They shall be placed on the walls by being attached to 12,7 mm thick wood furring strips. The Douglas fir plywood panels shall have the burning characteristic properties specified in Table 27.

Table 27 — Test methods

Property	Test method	Range
Flame spread index	UL 723	130 ± 30
Critical heat flux	ISO 5660-1	15 ± 3 kW/m^2
Thermal response parameter	ISO 5660-1	220 ± 50 kW·(s$^{1/2}$) m^2

7.31.3.6 The fire source is to consist of a wood crib and simulated furniture. The wood crib is ignited with a pan of heptane and the simulated furniture is ignited using two 150 mm long by 6,4 mm diameter cotton wicks soaked in heptane (see Figure 43 for pendent or upright sprinklers and Figure 44 and Figure 45 for sidewall sprinklers) for placement of the fire source. See Figure 46 for details of the fuel package.



a) Foam adhesive pattern

b) Side elevation

c) Steel test pan

d) Wood crib

Key

a Thick foam pad.

Figure 46 — Fire test crib and simulated furniture fuel package

7.31.3.7 The heptane shall be commercial grade with the following distillation characteristics:

— minimum initial boiling point: 88 °C;

— maximum dry point: 100 °C;

— specific gravity, 15,6 °C/15,6 °C: 0,68 – 0,73.

7.31.3.8 The wood crib is to weigh 2,5 kg to 3,2 kg and shall be dimensioned 305 mm × 305 mm × 152 mm high. The crib is to consist of four alternate layers of four trade size 38,1 mm × 38,1 mm kiln-dried spruce

or fir lumber 305 mm long. The alternate layers of the lumber are to be placed at right angles to the adjacent layers. The individual wood members in each layer are to be evenly spaced along the length of the previous layer of wood members and stapled.

7.31.3.9 After the wood crib is assembled, it shall be conditioned at a temperature of (104 ± 5) °C for not less than 24 h or more than 72 h. Following the conditioning, the crib shall be placed in a plastic bag and stored at room temperature for at least 4 h before being used in a test. The wood crib shall be placed on top of a nominal 300 mm × 200 mm × 100 mm high, 6 mm thick, steel test pan positioned on the floor in a corner of the test enclosure. The wood crib shall be positioned 5 mm from each wall.

7.31.3.10 The simulated furniture is to consist of two 76 mm thick uncovered pure polypropylene oxide polyol, polyether foam cushions having a density of 27,2 kg/m^3 to 30,4 kg/m^3 measuring 810 mm × 760 mm. The polyether foam shall have the following burning characteristic properties, average of five samples, when tested in accordance with ISO 5660-1 at a 30 kW/m^2 heat flux:

— peak heat release rate (HRR): (345 ± 85) kW/m^2;

— heat of combustion: (22 ± 3) kJ/g

7.31.3.11 Each foam cushion shall be glued to a 840 mm × 790 mm × 12,7 mm thick plywood backing using an aerosol urethane foam adhesive. The foam pad is glued to the plywood backing leaving a 12,7 mm space on both sides and a 25 mm space along the bottom. The foam cushion and plywood backing assembly shall be conditioned at (21 ± 2,8) °C and (50 ± 10) % relative humidity for at least 24 h prior to test. The foam and plywood backing assembly shall be placed in a steel frame to provide support for holding each assembly in the vertical orientation. The entire fire test package shall be placed on top of a nominal 6 mm thick cement board sheathing or equivalent non-combustible sheathing material having dimensions of 1,2 m × 1,2 m. For each test, new or dried sheathing shall be used.

7.31.3.12 Three sprinklers are to be installed in the test room for each fire test. Two are to be installed at their maximum length and width coverage dimensions, and the third shall be installed near the doorway farthest from the fire; see Figure 43 to Figure 45. Pendent and upright sprinklers are to be installed with their deflectors located 76 mm below the ceiling unless another distance is specified in the installation instructions. A pendent sprinkler also intended to be installed as a recessed sprinkler shall be tested in the most recessed position in lieu of 76 mm below the ceiling. Flush and concealed sprinklers are to be installed in their intended location as specified in the manufacturer's installation instructions. Sidewall sprinklers are to be installed with their deflectors located 100 mm below the ceiling and at the maximum distance below the ceiling as specified in the installation instructions if the maximum exceeds 152 mm below the ceiling.

NOTE See 7.31.3.13 for sprinkler pipe sizes.

The third sprinkler in near the door shall have the same heat-responsive element and temperature rating as the other sprinklers within the room. For pendent, upright, flush recessed pendent and concealed pendent sprinklers, the third sprinkler shall be located 51 mm below the ceiling. For sidewall sprinklers, the third sprinkler shall be located 102 mm below the ceiling.

7.31.3.13 Sprinklers are to be installed in pipe fittings having a 25 mm inlet and an outlet the same size as the sprinkler inlet and are to be supplied with water through 25 mm piping. Pendent, upright, flush, recessed pendent and concealed sprinklers are to be tested in two orientations. One test shall be conducted such that the sprinkler frame arms or deflector pins are parallel to the short wall and a second test shall be conducted with the sprinkler frame arms or deflector pins rotated 90°.

7.31.3.14 Recessed and concealed sprinklers having vented housing assemblies are to be installed in the most recessed position and tested in a manner that does not inhibit airflow through the housing assembly (unblocked) and tested in a manner that does inhibit airflow through the escutcheons (blocked) by placing a 200 mm thick R-25 fibreglass, or equivalent, insulating batt entirely around and over the portion of the sprinkler that is located above the ceiling or behind the wall.

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

7.31.3.16 The temperatures at each thermocouple location shall be continuously recorded during the test using 0,8 mm diameter chromel-alumel thermocouples or thermocouples providing equivalent temperature measuring results. The thermocouples shall be shielded from impingement of water from the sprinklers.

7.31.3.17 The wood crib shall be ignited with a pan of heptane and the simulated furniture shall be ignited with two 150 mm long by 6,4 mm diameter cotton wicks soaked in heptane. One half litre of water and 0,25 l of heptane shall be placed in the pan directly below the wood crib. The heptane in the pan located beneath the crib shall be ignited and the heptane-soaked cotton wicks shall be ignited immediately following the heptane pan ignition.

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

7.31.3.19 The fire test shall be conducted for 30 min after the ignition of the wood crib, unless after 10 min, all the combustibles are extinguished or only the wood crib is sustaining combustion at which point the test shall be terminated. The water flow rate for the test shall be the minimum specified in the manufacturer's installation instructions for each sprinkler coverage area tested and not less than the flow values specified in Table 28. In addition, the water flow rate shall be the same for single and multiple operating sprinklers.

Table 28 — Minimum rated sprinkler flow rates

Upright, pendent, recessed pendent, flush, and concealed sprinklers		Sidewall sprinklers[a]	
Spacing m	Minimum flow l/min	Spacing m	Minimum flow l/min
3,7 × 3,7	28	3,7 × 3,7	28
4,3 × 4,3	37	4,3 × 4,3	37
4,6 × 4,6	45	4,6 × 4,6	45
4,9 × 4,9	49	4,9 × 4,9	49
5,5 × 5,5	62	5,5 × 5,5	62
6,1 × 6,1	76	6,1 × 6,1	76
		4,9 × 5,5	55
		4,9 × 6,1	61
		5,5 × 6,1	69

[a] The minimum rated flow for a sidewall sprinkler spacing other than those specified in this table shall not be less than a flow correlating to a 2 mm/min discharge density.

7.31.3.20 Pendent or upright sprinklers shall be subjected to the fire test arrangement shown in Figure 43, and sidewall sprinklers shall be subjected to both fire test arrangements shown in Figure 44 and Figure 45.

7.31.3.21 When sprinkler coverage areas exceed 3,6 m × 3,6 m, and the sprinkler has not been investigated for a 3,6 m × 3,6 m area using the same or a lesser flow rate as the next larger rated coverage area, the tests specified in 7.31.3.1 to 7.31.3.21 shall be repeated in a room size corresponding to a 3,6 m × 3,6 m coverage area, using a water flow rate corresponding to the minimum flow rate required for the next larger coverage area.

7.31.3.22 For sprinklers having a pressure rating greater than 1,2 MPa (12 bar), tests are to be conducted at the maximum rated spacing using a flow corresponding to a pressure of 0,5 MPa (5 bar) less than the rated pressure.

7.31.4 Extended coverage light hazard sprinkler fire performance (see 6.31.4)

7.31.4.1 For upright or pendent sprinklers, the fire tests are to be conducted in a room having the dimensions of 6 m × 6 m using a nominal flow of 147 l/min. For sidewall sprinklers, the fire tests are to be conducted in a room having the largest dimensions for the nominal flow constant as shown in Table 24 using the nominal flow for the room size. In addition, for sprinklers having a pressure rating greater than 1,2 MPa (12 bar), tests are to be conducted at the maximum spacing using a flow corresponding to a pressure of 0,5 MPa (5 bar) less than the rated pressure.

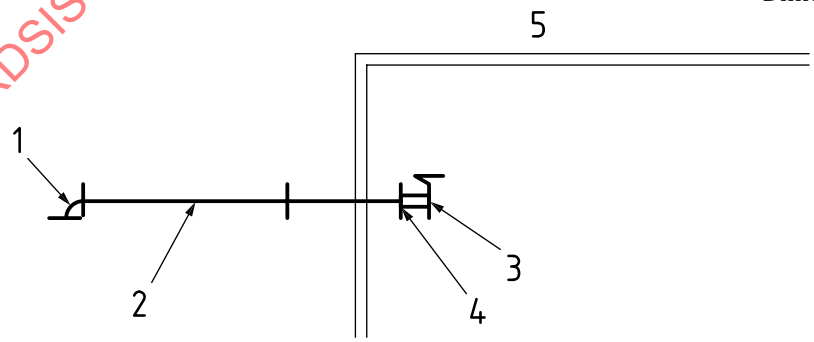
7.31.4.2 Recessed or concealed sprinklers with vented housings/escutcheons are to be installed in a manner that does not inhibit air flow through the housing/escutcheon (unblocked).

7.31.4.3 Sprinklers other than sidewall types are to be installed in their intended installation position with the deflector 250 mm below the ceiling, unless specifically designed for other positions (such as concealed, flush or recessed) (see Figure 47 and Figure 48).

7.31.4.4 For a sidewall sprinkler, two series of tests are to be conducted; one series with the sprinkler installed 100 mm below the ceiling and a second series with the sprinkler installed 300 mm below the ceiling. The base of a horizontal type sprinkler shall be installed adjacent to the wall. The deflector of an upright or pendent type sidewall sprinkler shall be mounted at the minimum clearance to the wall. A sidewall type sprinkler shall be installed using a 250 mm long, 25 mm nominal diameter pipe nipple with a reducing coupling installed with its axis perpendicular to the wall (see Figure 47 and Figure 48).

7.31.4.5 Water distribution measurements, for the purposes of determining the crib fire locations only, are to be conducted in an enclosed room with an open sprinkler discharging water at the minimum flow rate and maximum area of coverage as specified in Table 24 or Table 25, as appropriate. Water collection pans that are 300 mm × 300 mm and 300 mm deep are to be located on the floor of the enclosed room in the areas of the eleven crib locations as shown in see Figure 49. The distribution data are to be recorded and used in determining the specific positions of the wood cribs as required for the second and third fire tests in the fire test series.

Dimensions in millimetres



Key

1 25 mm × 25 mm 90 °EL
2 25 mm nominal pipe 250 mm long
3 25 mm × 12 mm reducing coupling
4 sprinkler
5 ceiling assembly

Figure 47 — Piping arrangements for the fire tests of sidewall sprinklers