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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

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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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 5, *Fixed firefighting systems using water*.

This third edition cancels and replaces the second edition (ISO 6182-1:2004), of which it constitutes a minor revision.

ISO 6182 consists of the following parts, under the general title *Fire protection — Automatic sprinkler systems*:

— *Part 1: Requirements and test methods for sprinklers*

— *Part 2: Requirements and test methods for wet alarm valves, retard chambers and water motor alarms*

— *Part 3: Requirements and test methods for dry pipe valves*

— *Part 4: Requirements and test methods for quick-opening devices*

— *Part 5: Requirements and test methods for deluge valves*

— *Part 6: Requirements and test methods for check valves*

— *Part 7: Requirements and test methods for early suppression fast response (ESFR) sprinklers*

— *Part 8: Requirements and test methods for pre-action dry alarm valves*

— *Part 9: Requirements and test methods for water mist nozzles*

— *Part 10: Requirements and test methods for domestic sprinklers*

— *Part 11: Requirements and test methods for pipe hangers*

— *Part 12: Requirements and test methods for grooved-end components for steel pipe systems*

Fire protection — Automatic sprinkler systems —

Part 1: Requirements and test methods for sprinklers

1 Scope

This part of ISO 6182 specifies performance and marking requirements and test methods for conventional, spray, flat spray, and sidewall sprinklers. It is not applicable to sprinklers having multiple orifices.

NOTE The requirements for early suppression fast response (ESFR) sprinklers are in ISO 6182-7; the requirements for domestic sprinklers are in ISO 6182-10; and the requirements for extended coverage (EC) sprinklers are under development.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7-1:1994, *Pipe threads where pressure-tight joints are made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 49, *Malleable cast iron fittings threaded to ISO 7-1*

ISO 65, *Carbon steel tubes suitable for screwing in accordance with ISO 7-1*

3 Terms and definitions

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

3.1 General

3.1.1
assembly load
force exerted on the sprinkler body excluding hydrostatic pressure

3.1.2
average design strength
glass bulb supplier's specified and assured lowest average axial design strength of any batch of 50 bulbs

3.1.3
design load
force exerted on the release element at the service load of the sprinkler

3.1.4
housing assembly/escutcheon
ornamental or protective component(s) around the hole from which the sprinkler penetrates the plane of the ceiling or the wall

Note 1 to entry: See Figure 1.

Note 2 to entry: For the purposes of this part of ISO 6182, housing applies to recessed and concealed sprinklers.

3.1.5
response time index
RTI
measure of sprinkler sensitivity

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

where

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

u is the gas velocity, expressed in meters per second.

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

3.1.6
service load
combined force exerted on the sprinkler body by the assembly load of the sprinkler and the equivalent force of the rated pressure on the inlet

3.1.7
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

3.1.8
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 sprinkler according to type of heat-responsive element

3.2.1
fusible element sprinkler
sprinkler that opens under the influence of heat by the melting of a component

3.2.2
glass bulb sprinkler
sprinkler 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 sprinkler according to type of water distribution

3.3.1
conventional sprinkler
C
sprinkler 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 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

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

3.3.3
sidewall sprinkler
W
sprinkler giving a one-sided water distribution over a definite protection area

3.3.4
spray sprinkler
S
sprinkler 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

3.4 Types of sprinkler according to position

3.4.1
horizontal sprinkler
H
sprinkler arranged such that the water stream is directed horizontally against the distribution plate

3.4.2
pendent sprinkler
P
sprinkler arranged such that the water stream is directed downwards against the distribution plate

3.4.3
upright sprinkler
U
sprinkler arranged such that the water stream is directed upwards against the distribution plate

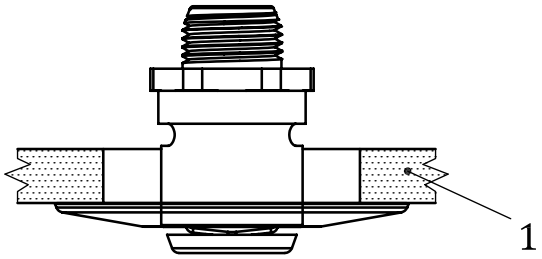
3.5 Special types of sprinkler

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

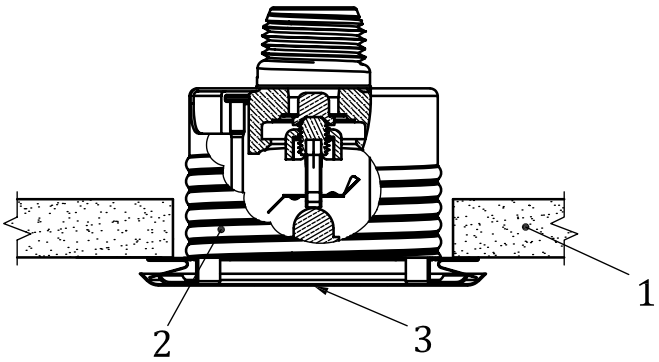
Note 1 to entry: For this part of ISO 6182, coated sprinkler does not include coatings intended for aesthetic purposes.

3.5.2
concealed sprinkler
recessed sprinkler having a cover plate

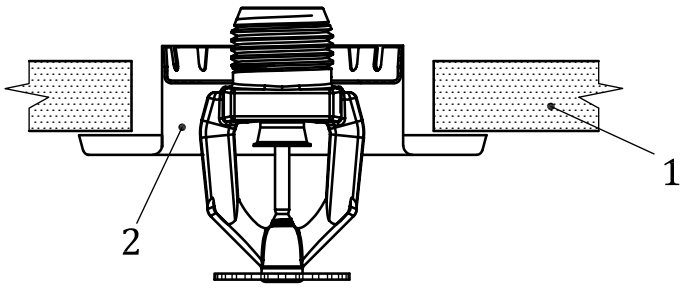
Note 1 to entry: See Figure 1.



a) Flush



b) Concealed



c) Recessed

Key

1 ceiling
2 housing assembly
3 cover plate

Figure 1 — Flushed, concealed, and recessed sprinklers

3.5.3
dry sprinkler
assembly comprising of a sprinkler 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, sidewall, or other types.

3.5.4
flush sprinkler
for pendent sprinklers, 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 1.

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

3.5.5
multiple orifice sprinkler
MO
sprinkler 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 excluded from this part of ISO 6182 in the scope.

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

Note 1 to entry: See Figure 1.

3.5.7
sprinkler with water shield
sprinkler, 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 sprinkler according to sprinkler sensitivity

3.6.1
fast-response sprinkler
sprinkler having a response time index (RTI) ≤50 $(m \cdot s)^{0,5}$ as determined in 6.14 or for concealed and recessed sprinklers, a maximum response time of 75 s as determined in 6.25

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

3.6.3
standard-response sprinkler
sprinkler having a response time index (RTI) of between 80 $(m \cdot s)^{0,5}$ and 350 $(m \cdot s)^{0,5}$ or for concealed and recessed sprinklers, a maximum response time as determined in 6.25

4 Product consistency

4.1 Quality control program

It shall be the responsibility of the manufacturer to implement a quality control program to ensure that production continuously meets the requirements of this part of ISO 6182.

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.

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 if 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 if 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 waterway shall not be achieved by the use of a dynamic O-ring or similar seal. (An O-ring or similar seal moves during operation or is in contact with a component that moves during operation.)

5.3 Rated pressure

Sprinklers shall have a rated pressure of not less than 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 not to substantially impact the sprinkler *K*-factor or pressure loss through the fitting.

6 Requirements

6.1 Dimensions

6.1.1 Orifice size

6.1.1.1 All sprinklers shall be constructed so that a sphere of diameter 8 mm can pass through each water passage in the sprinkler, with the exceptions specified in 6.1.1.2.

6.1.1.2 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 each water passage.

In those countries where sprinklers having multiple water passages are acceptable, and the sprinklers are used together with a strainer in the system or in each sprinkler, a 3 mm sphere may be used for checking the size of each water passage.

6.1.2 Nominal thread sizes

Nominal thread sizes shall be suitable for fittings threaded in accordance with ISO 7-1. 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.

6.2 Temperature ratings and colour coding

The marked nominal temperature rating and colour coding of the sprinkler shall be in accordance with Table 1.

Table 1 — 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
204, 227, 260, 343	black	204 to 246	green
		260 to 302, 320 to 343	orange

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

6.3 Operating temperature (see 7.4)

Sprinklers shall be verified to operate within a temperature range of

$$t = x \pm (0{,}035x + 0{,}62)\ °C$$

where

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

x is the marked nominal temperature rating (see Table 1).

6.4 Water flow and distribution

6.4.1 Water flow constant (see 7.5)

The flow constant, *K,* for sprinklers is given by the formula:

$$K = \frac{q}{\sqrt{10p}}$$

where

p is the pressure, expressed in megapascals (MPa);

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

The *K*-factor for sprinklers, according to this part of ISO 6182, shall be in accordance with Table 2 when determined by the test method given in 7.5.

6.4.2 Water distribution (see 7.6)

6.4.2.1 When tested in accordance with 7.6, the sprinkler shall meet the following applicable requirements.

For other than sidewall types, the number of containers having less than 50 % of the water coverage, as specified in Column 2 of Table 5, shall not exceed the permitted number of containers with a lower content of water, as specified in Column 6 of Table 5.

6.4.2.2 Sidewall sprinklers must meet the following requirements.

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 11).

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)/(bar½) 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)/(bar½), 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.

6.4.2.3 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.

Exception: this requirement does not apply to recessed, flush, concealed, and sidewall sprinklers.

Table 2 — Flow constant requirements

Flow constant ***K*** (l/min)/(bar½)	**Flow constant** ***K* for dry sprinklers** (l/min)/(bar½)
57 ± 3	57 ± 5
80 ± 4	80 ± 6
115 ± 6	115 ± 9

NOTE 1 (l/min)/(bar½) = 0,003 2 (m^3/min)/(MPa½).

6.5 Function (see 7.7)

6.5.1 Lodgement (see 7.7.1)

When tested in accordance with 7.7.1, the sprinkler shall open and any lodgement of released parts shall be cleared within 60 s of release of the heat-responsive element.

If lodgement occurs at any pressure level and test arrangement, 25 additional sprinklers shall be tested in that arrangement and at that pressure. The total number of sprinklers in which lodgement occurs shall not exceed one out of the 30 sprinklers tested at that pressure and in that arrangement.

6.5.2 Deflector strength (see 7.7.2)

The deflector and its supporting parts shall not sustain significant damage as a result of the deflector strength test specified in 7.7.2.

If minor damage is noted, testing in accordance with 6.4.2 can be done to demonstrate compliance.

NOTE In most instances, visual examination of the sprinkler will be sufficient to establish conformance with 6.5.2.

6.6 Service load and strength of sprinkler body (see 7.8)

6.6.1 The sprinkler body shall comply with the requirements of 6.6.1.1 or 6.6.1.2.

6.6.1.1 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 7.8.1 or 7.8.2.

6.6.1.2 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 7.8.3.

6.6.2 The manufacturer shall specify the average and upper limits of the service or assembly load.

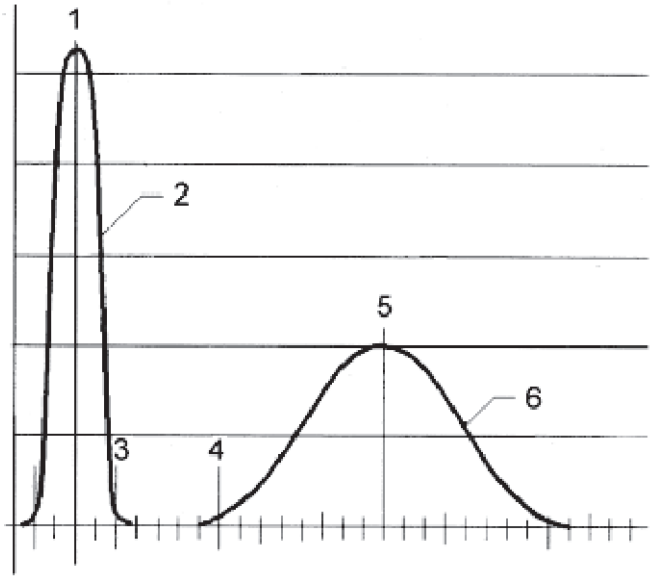
6.7 Strength of heat-responsive element (see 7.9)

6.7.1 When tested in accordance with 7.9.1, glass bulb elements shall

a) have an average design strength of at least six times the average service load and

b) 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 (γ) of 0,99 for 99 % of samples (P), based on normal or Gaussian distribution,

except where another distribution can be shown to be more applicable due to manufacturing or design factors (see Figure 2).



Key

1 average service load
2 service load curve
3 UTL
4 LTL
5 average design strength
6 design strength curve

Figure 2 — Strength curve

6.7.2 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 7.8 for a period of 100 h when tested in accordance with 7.9.2.1 or

b) demonstrate the ability to sustain the design load when tested in accordance with 7.9.2.2 (see Annex A).

6.8 Leak resistance and hydrostatic strength (see 7.10)

6.8.1 A sprinkler shall not show any sign of leakage when tested according to 7.10.1.

6.8.2 A sprinkler shall not rupture, operate, or release any parts when tested according to 7.10.2.

6.9 Heat exposure (see 7.11)

6.9.1 Glass bulb sprinklers

There shall be no damage to the glass bulb element when the sprinkler is tested according to 7.11.1.

6.9.2 Uncoated sprinklers

Sprinklers shall withstand exposure to increased ambient temperature without evidence of weakness or failure when tested according to 7.11.2.

6.9.3 Coated sprinklers

In addition to meeting the requirement of 6.9.2 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 7.11.3.

6.10 Thermal shock for glass bulb sprinklers (see 7.12)

Glass bulb sprinklers shall not be damaged when tested according to 7.12. Following the thermal shock exposure, the sprinkler shall comply with 6.5.1 when tested with an inlet pressure of 0,035 MPa (0,35 bar).

6.11 Corrosion (see 7.13)

6.11.1 Stress corrosion for copper-based alloy components (see 7.13.1)

When tested in accordance with 7.13.1, each sprinkler shall not show any cracks, signs of delamination, or failure that can affect its ability to function as intended.

6.11.2 Sulfur dioxide/carbon dioxide corrosion (see 7.13.2)

NOTE In some countries, this test is not mandatory.

Coated and uncoated sprinklers shall be resistant to sulfur dioxide/carbon dioxide saturated with water vapour when conditioned in accordance with 7.13.2.

Following exposure, glass bulb sprinkler samples shall either be

a) tested at 0,035 MPa (0,35 bar) in accordance with 6.5.1 or

b) meet the requirements of 6.25 for concealed and recessed sprinklers or the requirements of 6.14.2 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 6.5.1 and the remaining samples shall meet the requirements of 6.25 for concealed and recessed sprinklers or the requirements of 6.14.2 for other types of sprinklers.

6.11.3 Hydrogen sulfide corrosion (see 7.13.3)

NOTE In some countries, this test is not mandatory.

Coated and uncoated sprinklers shall be resistant to hydrogen sulfide saturated with water vapour when conditioned in accordance with 7.13.3.

Following exposure, glass bulb sprinkler samples shall either be

a) tested at 0,035 MPa (0,35 bar) in accordance with 6.5.1 or

b) meet the requirements of 6.25 for concealed and recessed sprinklers or the requirements of 6.14.2 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 6.5.1 and the remaining samples shall meet the requirements of 6.25 for concealed and recessed sprinklers or the requirements of 6.14.2 for other types of sprinklers.

6.11.4 Salt spray loading (see 7.13.4)

NOTE In some countries, the salt spray corrosion test (6.11.6) is conducted instead of the salt spray loading test.

Coated and uncoated sprinklers shall be resistant to salt spray when conditioned in accordance with 7.13.4.

Following exposure, glass bulb sprinkler samples shall either be

a) tested at 0,035 MPa (0,35 bar) in accordance with 6.5.1 or

b) meet the requirements of 6.25 for concealed and recessed sprinklers or the requirements of 6.14.2 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 6.5.1 and the remaining samples shall meet the requirements of 6.25 for concealed and recessed sprinklers or the requirements of 6.14.2 for other types of sprinklers.

6.11.5 Moist air exposure (see 7.13.5)

Sprinklers shall be resistant to moist air exposure when tested in accordance with 7.13.5. Following exposure, the sprinklers shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with 6.5.1.

6.11.6 Salt spray corrosion (see 7.13.6)

NOTE In some countries, the salt spray loading test (6.11.4) is conducted instead of the salt spray corrosion test.

Coated and uncoated sprinklers shall be resistant to salt spray when conditioned in accordance with 7.13.6.

Following exposure, glass bulb sprinkler samples shall either be

a) tested at 0,035 MPa (0,35 bar) in accordance with 6.5.1 or

b) meet the requirements of 6.25 for concealed and recessed sprinklers or the requirements of 6.14.2 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 6.5.1 and the remaining samples shall meet the requirements of 6.25 for concealed and recessed sprinklers or the requirements of 6.14.2 for other types of sprinklers.

6.12 Coated sprinklers (see 7.14)

6.12.1 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 7.14.1.

6.12.2 Resistance to low temperatures

All coatings used for sprinklers shall not crack or flake when subjected to low temperatures in accordance with 7.14.2.

6.13 Water hammer (see 7.15)

Sprinklers shall not leak during or after the pressure surges described in 7.15. After being subjected to the test according to 7.15, they shall show no signs of mechanical damage, shall meet the requirement of 6.8.1, and shall operate when functionally tested to the requirements of 6.5.1 at a pressure of 0,035 MPa (0,35 bar) only.

6.14 Dynamic heating (see 7.16)

6.14.1 Standard orientation

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 7.16.

For concealed and recessed sprinklers, see 6.25. Maximum and minimum RTI values for fast- and standard-response sprinklers shall fall within the limits of the appropriate category. Special-response sprinklers shall have an average RTI value of between 50 and 80, with no value less than 40 or more than 100.

6.14.2 Post-exposure RTI

After exposure to the corrosion test according to 6.11.2, 6.11.3, 6.11.4, and 6.11.6, sprinklers shall be tested in the standard orientation in accordance with 7.16.1 to determine the post-exposure RTI. All post-exposure RTI values shall be calculated as in 7.16.2. The values determined shall meet one of the following:

a) none of the post-exposure RTI values shall exceed the limits referenced in 6.14.1;

b) the average RTI value shall not exceed 130 % of the pre-exposure average value.

6.15 Resistance to heat (see 7.17)

Open sprinklers shall be resistant to high temperatures when tested in accordance with 7.17. After exposure, the sprinkler shall not fracture or break. If visual deformation is observed on the sprinkler orifice, it shall meet the requirements of 6.4.1. If visual deformation is observed on the sprinkler frame or deflector, it shall meet the requirements of 6.4.2.

6.16 Vibration (see 7.18)

Sprinklers shall be able to withstand the effects of vibration without deterioration when tested in accordance with 7.18. After the vibration test of 7.18, sprinklers shall show no visible deterioration and shall meet the requirements of 6.8.1 and 6.14.1.

6.17 Impact (see 7.19)

6.17.1 Sprinklers shall show no fracture or deformation and shall meet the requirements of 6.8.1 and 6.14.1 after the impact test of 7.19.1. If the sprinkler is deformed during testing, water distribution testing in accordance with 6.4.2 shall be required.

6.17.2 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 7.19.2.

6.18 Rough usage (see 7.20)

A sprinkler shall withstand the effects of rough usage without deterioration of its performance characteristics. Following 3 min of tumbling as described in 7.20, the sprinkler shall comply with the

leak requirement of 6.8.1 and the requirement of 6.14.1, or in accordance with 6.25, the requirement for recessed and concealed sprinklers.

6.19 Crib fire performance (see 7.21)

NOTE In some countries, this test is not mandatory.

6.19.1 All nominal *K*-factor sprinklers of 80 (l/min)/(bar½) and 115 (l/min)/(bar½), except sidewall, flat spray, and conventional sprinklers, shall control crib fires when tested according to 7.21. For dry-type sprinklers, the shortest length manufactured shall be used for this test.

6.19.2 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.

6.19.3 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.

6.19.4 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.

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

6.20 Lateral discharge (see 7.22)

Upright and pendent spray sprinklers and sidewall sprinklers shall not prevent the operation of adjacent sprinklers when tested in accordance with 7.22.

6.21 Thirty-day leakage resistance (see 7.23)

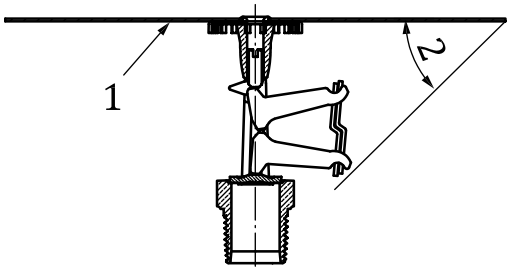
When tested in accordance with 7.23, sprinklers shall not leak or sustain any mechanical damage. Following exposure, the sprinklers shall meet the requirement of 6.8.1.

6.22 Vacuum resistance (see 7.24)

Sprinklers shall not exhibit distortion or mechanical damage and shall meet the leakage requirements of 6.8.1 after being subjected to the test in 7.24.

6.23 Water shield angle of protection (see 7.25)

Water shields shall provide an angle of protection of 45° or less in accordance with 7.25. See Figure 3.



Key

1 water shield

2 angle of protection

Figure 3 — Angle of protection

6.24 Water shield rotation (see 7.26)

Rotation of the water shield shall not alter the sprinkler service load when evaluated in accordance with 7.26.

6.25 Thermal response of concealed and recessed sprinklers (see 7.27)

6.25.1 Standard-response concealed and recessed sprinklers shall meet the requirements of either 6.25.2 or 6.25.4. Fast-response concealed and recessed sprinklers shall meet the requirements of either 6.25.3 or 6.25.4.

NOTE In some countries, recessed and concealed sprinklers are not identified as to response type. In this case, any of the test methods in 6.25.2 through 6.25.4 can be used.

6.25.2 When tested in accordance with 7.27.1 through 7.27.5, standard-response concealed and recessed sprinklers shall operate such that the mean response time and unbiased standard deviation provide computed statistical tolerance limits (see Annex B) with 95 % confidence that 99 % of the sprinklers tested do not exceed the following statistical tolerance limits:

a) 3 min, 51 s (3,85 min) for sprinklers having a temperature rating not exceeding 77 °C;

b) 3 min, 9 s (3,15 min) for sprinklers having a temperature rating of between 80 °C and 107 °C.

6.25.3 When tested in accordance with 7.27.1 through 7.27.5, fast-response concealed and recessed sprinklers shall operate within 75 s or less.

6.25.4 When tested in accordance with 7.27.6 and 7.27.7, concealed and recessed sprinklers shall operate such that the mean response time of three samples tested at each of the noted test conditions does not exceed the theoretical maximum response time calculated utilizing the following information:

a) RTI according to Table 3;

b) gas temperature and velocity according to Table 4 — for standard and special response, utilize test conditions 1 to 9; for fast response, utilize test conditions 1 to 6;

c) upper permitted temperature limit of the sprinkler in accordance with 6.3;

d) ambient temperature during testing.

Table 3 — Maximum permitted RTI

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

Table 4 — Dynamic heating test apparatus conditions for concealed and recessed sprinklers

Test condition	Gas temperature °C	Gas velocity m/s	Applied vacuum mm Hg[a]
1	128	1,0	0,007
2	128	2,6	0,007
3	128	3,5	0,007
4	197	1,0	0,010
5	197	2,6	0,010
6	197	3,5	0,010
7	290	1,0	0,013
8	290	2,6	0,013
9	290	3,5	0,013

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

6.25.5 After exposure to the corrosion test according to 6.11.2, 6.11.3, and 6.11.4, sprinklers shall be tested in accordance with 7.27. The mean time of operation for each exposure time shall be equal to or less than a 1,30 multiple of the mean time of sprinklers not subjected to the corrosion test.

6.26 Freezing test (see 7.28)

Sprinklers shall be resistant to low temperatures when tested in accordance with 7.28. 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 6.8.1 and shall meet the RTI requirements of 6.14.1.

6.27 Dry-type sprinkler deposit loading (see 7.29)

NOTE In some countries, this test is not mandatory.

Following exposure to a carbon dioxide-sulfur dioxide atmosphere in accordance with 7.29.1 through 7.29.3, 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 is operated.

6.28 Dry sprinkler air tightness (see 7.30)

When tested as described in 7.30.1 and 7.30.2, 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.

NOTE In some countries, this test is not mandatory, although the construction of the connection of the extension nipple to the inlet seal must be airtight.

6.29 Protective covers (see 7.31)

NOTE In some countries, it is required to use the protective covers as described in this clause.

6.29.1 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.

6.29.2 Glass bulb sprinklers equipped with protective covers shall comply with the impact test for protective covers and marking requirements (see 7.31 and 8.3).

6.29.3 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 7.31.

6.29.4 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.

6.30 Dezincification of brass parts (see 7.32)

NOTE In some countries, this test is not mandatory.

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

a) an average dezincification depth exceeding 100 µm;

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

6.31 Stress corrosion — magnesium chloride (see 7.33)

NOTE In some countries, this test is not mandatory.

Sprinklers having components consisting of stainless steel alloys shall be subjected to the test in 7.33. The stainless steel components shall not show evidence of fracture, distortion, or impending separation from the frame when tested as described in 7.33.

7 Test methods

7.1 General

The following tests shall be conducted for each type of sprinkler. 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) °C, unless other temperatures are indicated. Sprinklers shall be tested with all the components required by their design and installation.

Unless otherwise stated, the tolerances given in Annex C shall apply.

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 Operating temperature test (see 6.3)

7.4.1 Test of static operation

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 carried out 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.

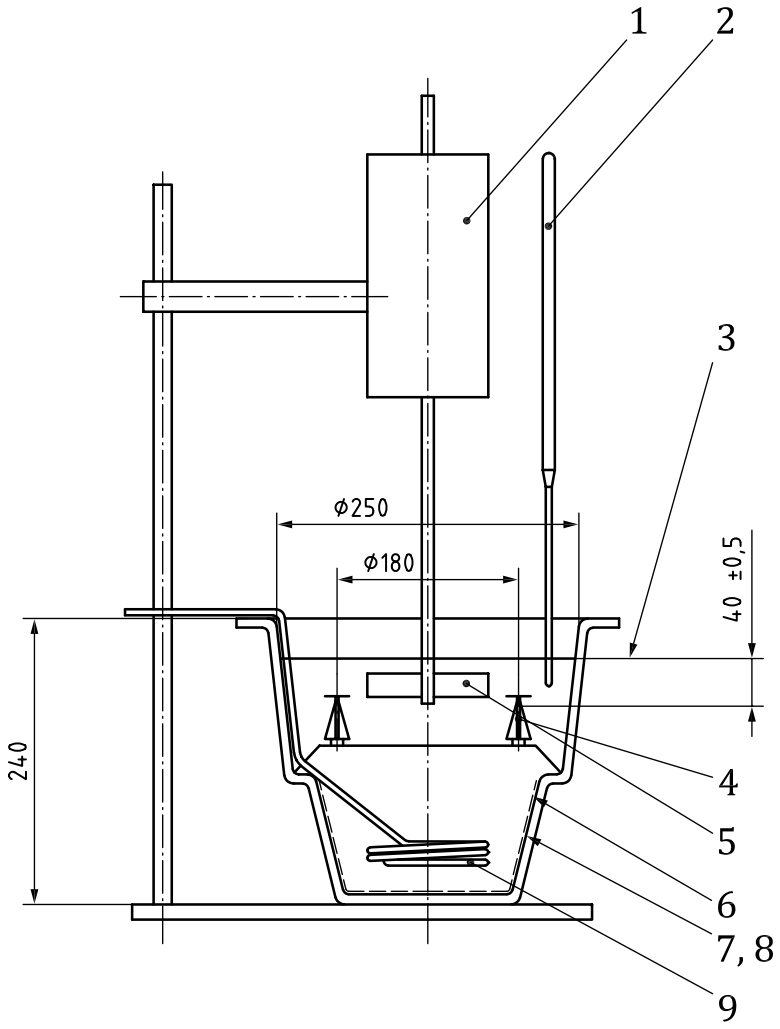
The sprinklers shall be located in the liquid bath in a vertical position and totally immersed under a liquid cover of at least 5 mm. The test zone is located at a distance, below the liquid surface level with the geometric center of the glass bulb or fusible element. The test zone shall not be less 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 7.4.2.

An example of a standardized liquid bath is shown in Figure 4. 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 PT 100 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 4 — Example of a liquid bath test apparatus

7.4.2 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 constant temperature for a period of at least 20 min. The temperature shall then be raised at a constant rate of 0,5 °C ± 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.

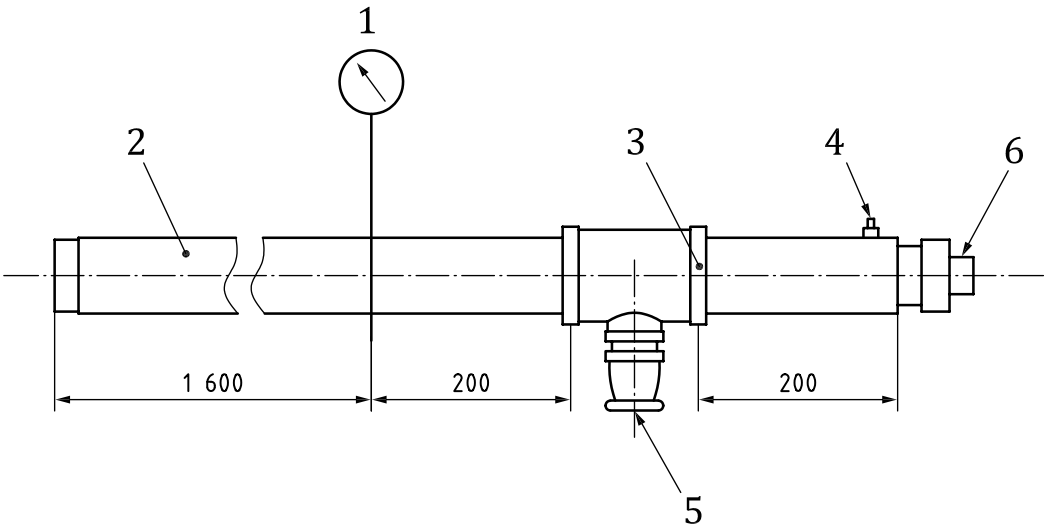
NOTE It is not necessary to meet the operating temperature limits of 6.3 in this test.

7.5 Water flow constant (see 6.4.1)

The sprinkler shall be mounted with a pressure gauge on a supply pipe, an example of which is shown in Figure 5. 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 (1,0 bar) to 0,52 MPa (5,2 bar) less than the rated pressure 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 0,52 MPa (5,2 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 6.4.1. 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 pressure gauge
2 steel tube, nominal internal diameter 40 mm, medium mass (in accordance with ISO 65)
3 fitting, 10 mm, 15 mm, 20 mm, 25 mm, or 32 mm (in accordance with ISO 49)
4 air bleed valve
5 sprinkler
6 plug or cap with fitting for G or E connection

NOTE Accuracy: pressure gauge ±2 %; weighing machine ±1 %.

Figure 5 — Example of a water flow test apparatus

7.6 Water distribution tests (see 6.4.2)

7.6.1 Sprinklers other than sidewall types (see 6.4.2.1)

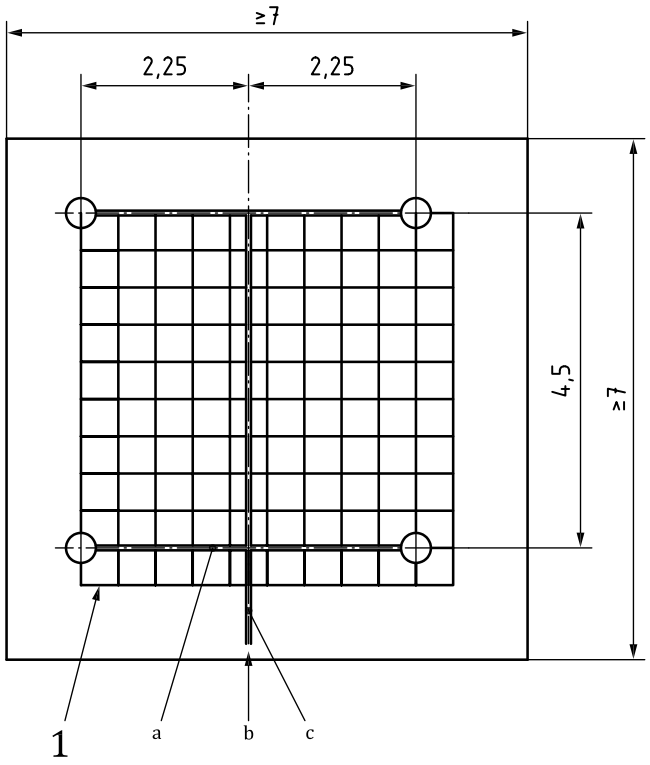
In a test chamber of minimum dimensions 7 m × 7 m, install four sprinklers of the same type and orifice size, arranged in a square, on piping prepared for this purpose. The arrangements of the piping and containers are shown in Figures 6 to 9. The yoke arms of the sprinklers shall be parallel to the 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 "T" 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 5.

Dimensions in metres



Key

1 collecting pans (0,5 m × 0,5 m)

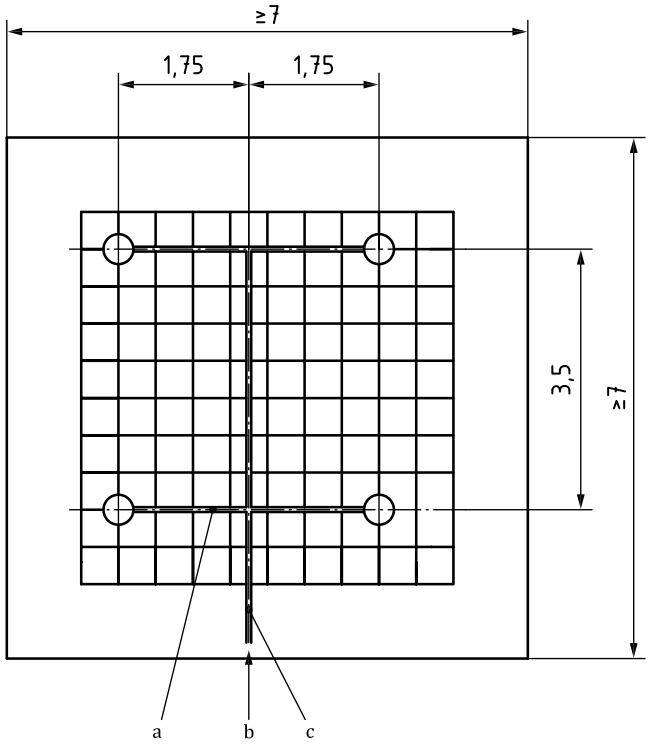
a Nominal bore is 25 mm.

b Water flow.

c Nominal bore is 65 mm.

Figure 6 — Layout of water distribution collection room — measured area: 20,25 m^2

Dimensions in metres



Key

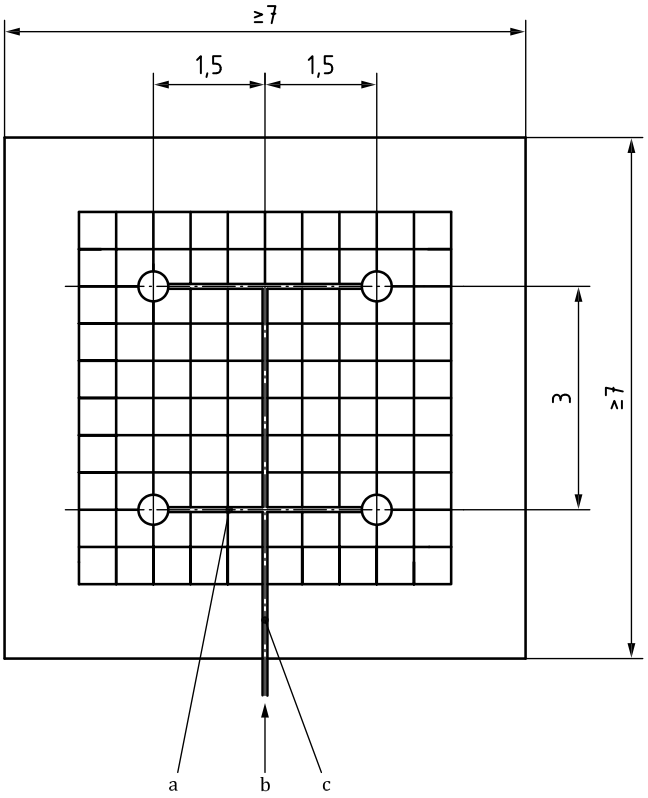
a Nominal bore is 25 mm.

b Water flow.

c BS 1387 medium tube of nominal bore 65 mm.

Figure 7 — Layout of water distribution collection room — measured area: 12,25 m^2

Dimensions in metres



Key

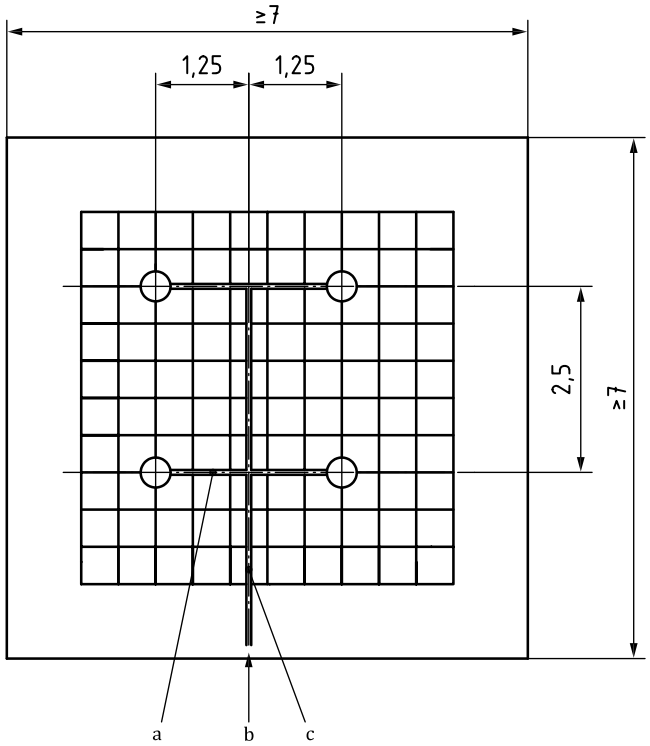
a Nominal bore is 25 mm.

b Water flow.

c BS 1387 medium tube of nominal bore 65 mm.

Figure 8 — 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 9 — Layout of water distribution collection room — measured area: 6,25 m²

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 5 shall not exceed the value specified in Column 6 of Table 5.

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 5 — Water distribution

Nominal *K*-factor (l/min)/(bar½)	**Water coverage** mm/min	**Flow rate per sprinkler** l/min	**Protected area** m²	**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

7.6.2 Sidewall sprinklers (see 6.4.2.2)

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 Figures 10 and 11.

The distance between the ceiling and the deflector of each sprinkler shall be 100 mm (see Figure 11).

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 Figures 10 and 11. 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. (See Figure 11.)

A baffle shall be placed over this line of containers to prevent direct impingement of water from sprinklers.

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.

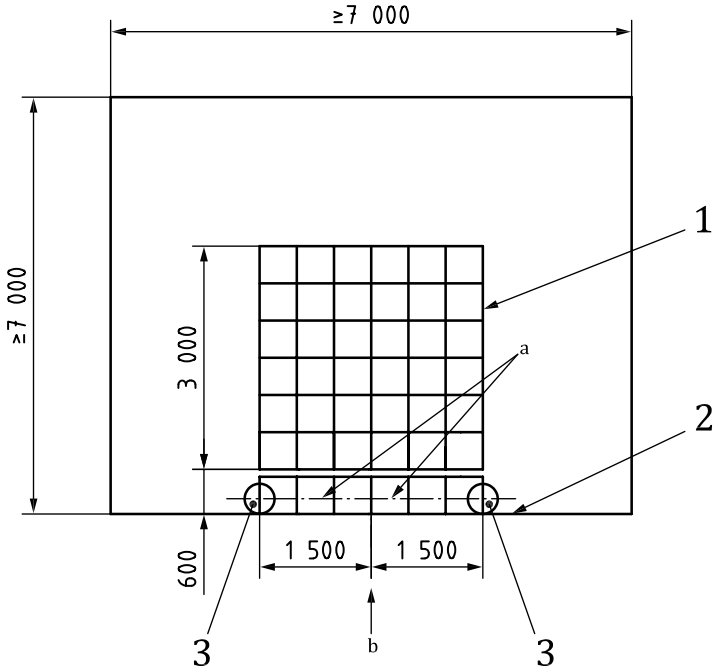
For sidewall sprinklers having a nominal *K*-factor of 80 (l/min)/(bar$^{1/2}$) or less, the water flow rate shall be 57 l/mm for each sprinkler. The average water collection rate in the containers shall be not less than 2 mm/min and the minimum water collection rate in any individual pan shall be 1,2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

For sidewall sprinklers having a nominal *K*-factor of 115 (l/min)/(bar$^{1/2}$), 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 is to 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 (see Figure 11). 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

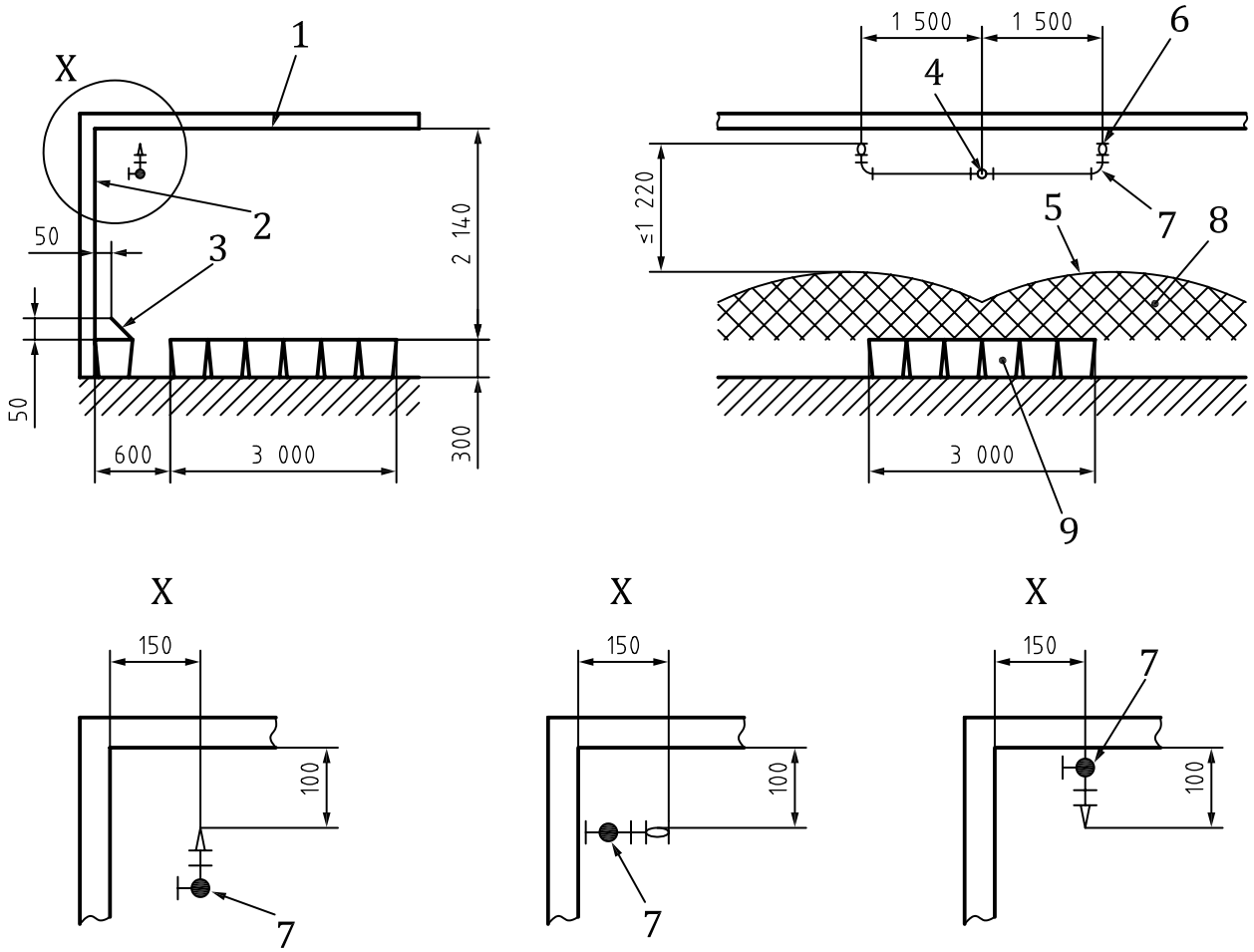


Key

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

Figure 10 — 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 (two required)
7 90° reducer elbow (two required)
8 wetted area
9 500 mm square containers

NOTE Nominal pipe diameter is 25 mm.

Figure 11 — Sidewall sprinkler installation for water distribution test

7.6.3 Water distribution above and below the deflector

Sprinklers, except flat spray, shall be installed horizontally in a test apparatus, the features of which are shown in Figure 12. Flat spray sprinkler arrangement is shown in Figure 13.

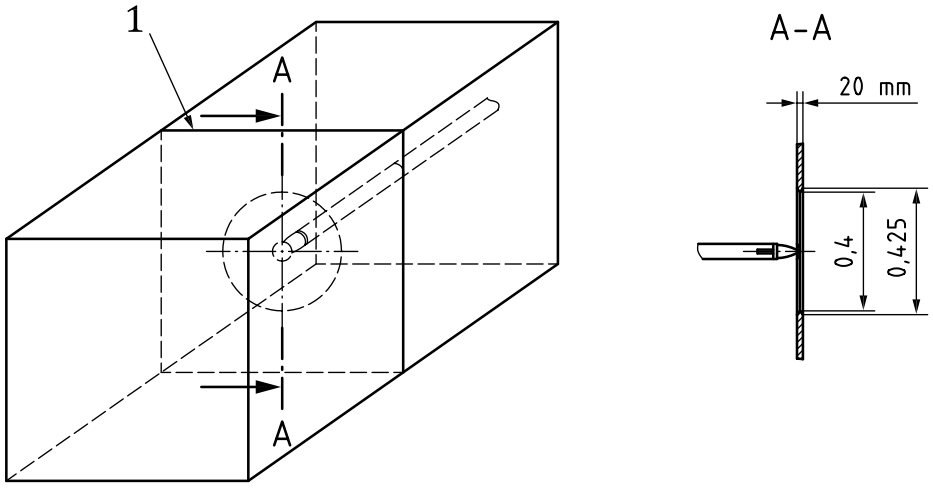
The deflector shall be positioned within the apparatus such that a theoretical dividing line between the two collecting volumes intersects a point on the axis of the sprinkler where the water spray is travelling substantially parallel to the plane of the partition.

The sprinklers shall be tested at the flow conditions given in Table 6.

Table 6 — Flow condition

Nominal *K*-factor (l/min)/(bar½)	**Water flow rate** l/min½
57	50,6
80	61,3
115	90,0

Dimensions in metres



Key

1 partition

Figure 12 — 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

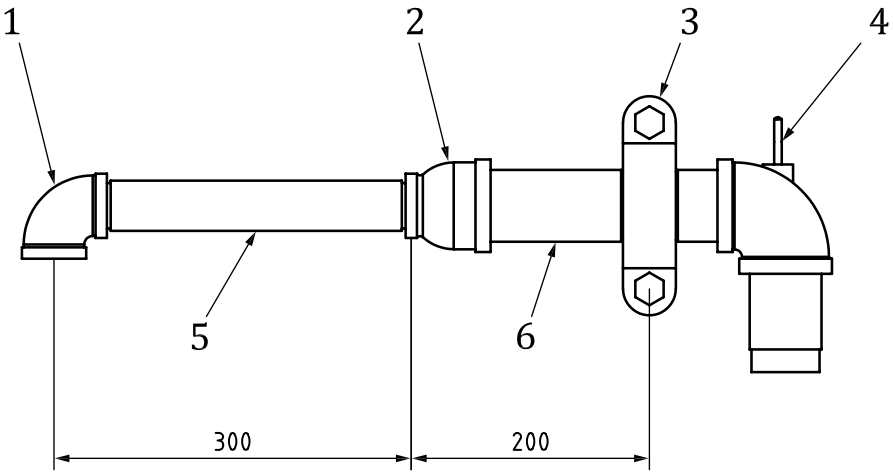
Figure 13 — Apparatus for determining water distribution above and below the deflectors for flat spray sprinklers

7.7 Functional test (see 6.5)

7.7.1 Lodgement test (see 6.5.1)

7.7.1.1 Automatic sprinklers and dry-type automatic sprinklers in the shortest length of any temperature rating are to be individually tested. Each sample is to be installed in its intended installation position on a rigid piping arrangement and supplied with flowing water. Tests are to be conducted using a single-feed (Figure 14 or 15) and a double-feed (Figure 16) water supply arrangement. The test pressures and number of samples tested at each pressure using each water supply configuration are specified in Table 7. Each sample is to 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 compliance with these requirements.

Dimensions in millimetres

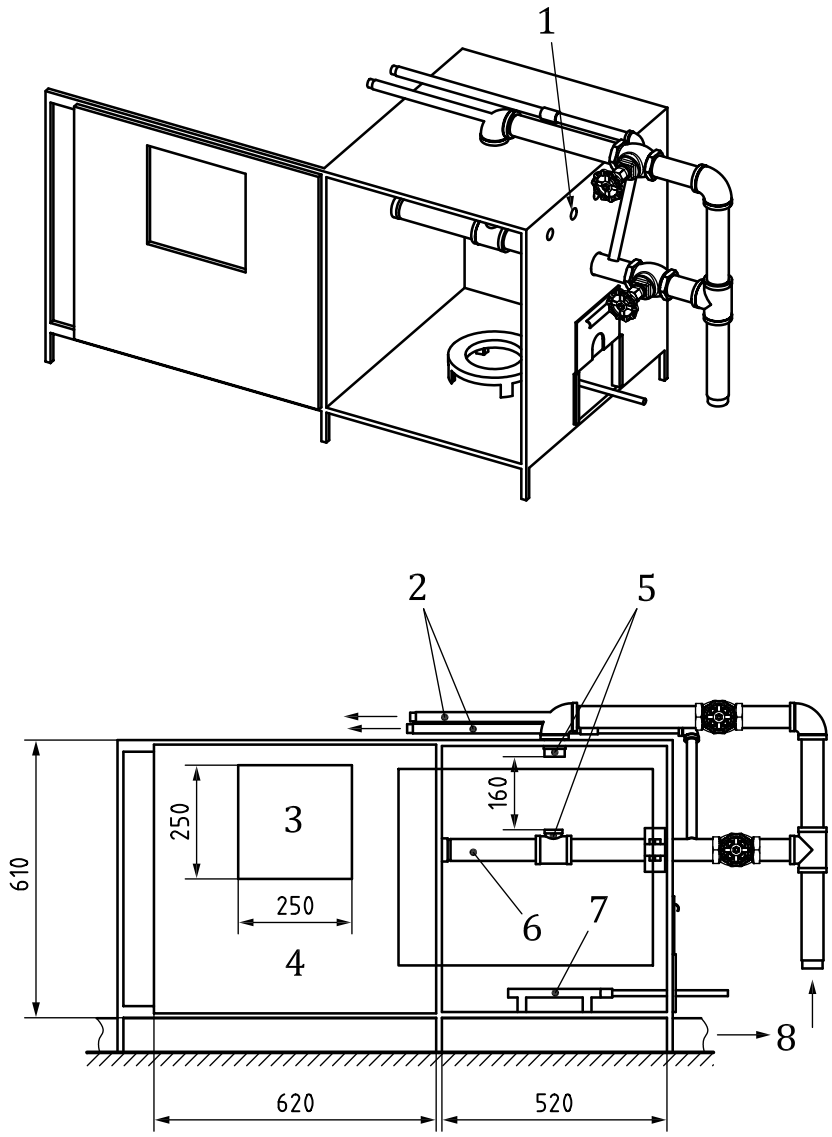


Key

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 14 — Typical single-feed lodgement test arrangement

Dimensions in millimetres

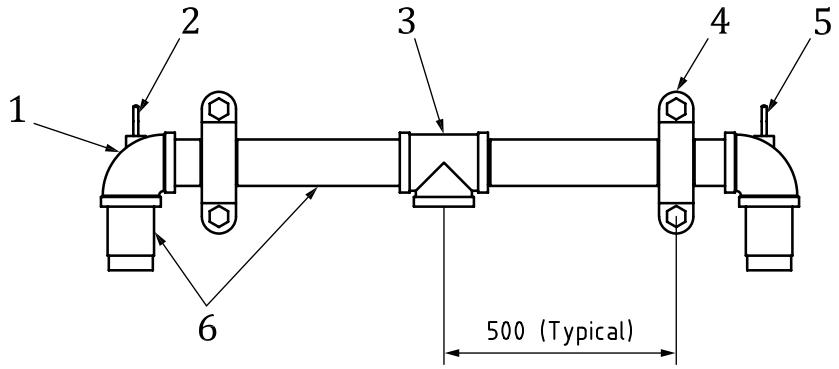


Key

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

Figure 15 — 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 16 — Typical double-feed lodgement test arrangement

Table 7 — 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

[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 may be required in some countries.

Table 7 *(continued)*

Test pressure[c]		Water supply arrangement	Number of test samples[d]
MPa	bar		
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 may be required in some countries.

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

7.7.1.2 To determine that the internal parts of a dry sprinkler do not restrict the intended flow rate, a flow meter is to be connected to the water supply piping. Prior to operation of the test samples in 7.7.1, an operated sample that has demonstrated acceptable *K*-factor results in the water flow constant test, 7.5, shall be installed in the operational test fixture. Water is to be flowed at each of the pressures noted in 7.7.1.1 and the *K*-factor at each pressure is to be recorded. Dry-type sprinkler samples are to be tested as described in 7.7.1. After sprinkler operation, the flow at each pressure specified in 7.7.1.1 is to be recorded. The discharge coefficient *K*-factor is then to be calculated as specified in 7.5. The *K*-factor value shall be within 5 % of previously tested *K*-factor samples.

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

7.7.2 Deflector strength test (see 6.5.2)

In order to check the strength of the deflector, three 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.

7.8 Service load and strength of sprinkler body test (see 6.6)

7.8.1 Test option 1

7.8.1.1 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.

7.8.1.1.1 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.

7.8.1.2 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.

7.8.1.3 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.

7.8.1.3.1 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.

7.8.1.3.2 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.

7.8.1.3.3 Remove the load and compare the permanent elongation with the requirement of 6.6.1.

7.8.2 Test option 2

A minimum of 10 samples shall be individually mounted into a solid fixture and the pipcap/seat, spring, and frame for orientation purposes shall be marked 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.

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.

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

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

7.8.3 Test option 3

7.8.3.1 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.

7.8.3.2 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 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.

7.8.3.3 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.

7.8.3.4 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.

7.8.3.5 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.

7.8.3.6 Remove the load and take a third measurement. Compare the permanent elongation with the requirement of 6.6.1.2.

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.

7.9 Strength of heat-responsive element test (see 6.7)

7.9.1 Glass bulbs

7.9.1.1 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.

7.9.1.2 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.

7.9.1.3 Using the lowest 50 measured bulb strength results, calculate the average strength and the lower tolerance limit (LTL) for bulb strength (see Annex D). Using the values of service load recorded in 7.8, calculate the upper tolerance limit (UTL) for the sprinkler release element service load (see Annex D). Verify compliance with 6.7.1.

7.9.2 Fusible elements

7.9.2.1 Determine compliance with the requirements of 6.7.2 (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, at least 10 valid samples shall be obtained.

7.9.2.2 Determine compliance with the requirements of 6.7.2 (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 (see Annex A). At least 10 samples shall be subjected to different loads up to 15 times the maximum design load. Abnormal failures shall be rejected; however, at least 10 valid 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, where

$$L_d \leq 1{,}02 L_M^2 / L_0$$

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.

7.9.2.3 The tests of 7.9.2.1 and 7.9.2.2 shall be conducted at an ambient temperature of (20 ± 3) °C.

7.10 Leak resistance and hydrostatic strength tests (see 6.8)

7.10.1 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).

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. After the pressure

has dropped to 0, 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 6.8.1.

7.10.2 Following the test of 7.10.1, the 20 sprinklers shall be subject to a water pressure equal to four 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 6.8.2.

NOTE In some countries, the hydrostatic strength test in 7.10.2 is not mandatory.

7.11 Heat exposure test (see 6.9)

7.11.1 Glass bulb sprinklers (see 6.9.1)

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 the four sprinklers.

7.11.2 Uncoated sprinklers (see 6.9.2)

Twelve uncoated sprinklers shall be exposed for a period of 90 d to a high ambient temperature that is 11 °C below the nominal rating or at the temperature given in Table 8, whichever is lower, but not less than 49 °C. After exposure, four of the sprinklers shall be subjected to the requirements of 6.8.1 and 6.14.2, four sprinklers to the requirements of 6.5.1 [two at 0,035 MPa (0,35 bar) and two at 1 MPa (10 bar)], and four sprinklers to the requirements of 6.3. 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.

7.11.3 Coated sprinklers (see 6.9.3)

In addition to the test exposure of 7.11.2 in an uncoated version, 12 coated sprinklers shall be exposed to the test of 7.11.2 using the temperatures given in Column 3 of Table 8 for wax-coated sprinklers and Column 2 for all other coatings.

The test shall be conducted for 90 d. After the 90 d exposure, four of the sprinklers shall be subjected to the requirements of 6.8.1, four sprinklers to the requirements of 6.5.1 [two at 0,035 MPa (0,35 bar) and two at 1 MPa (10 bar)], and four sprinklers to the requirements of 6.3. 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 8 — 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

7.12 Thermal shock test for glass bulb sprinklers (see 6.10)

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

7.12.2 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 (de-mineralized water), with the bulb seal downwards, at a temperature of (10 ± 0,5) °C. Then test the sprinklers in accordance with 6.5.1 at 0,035 MPa (0,35 bar).

7.13 Corrosion tests (see 6.11)

7.13.1 Stress corrosion test for copper-based alloy components (see 6.11.1)

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 (e.g. plastic) cap.

Degrease the samples to be tested and then expose them for 10 d 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 build up 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 sample.

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 6.8 and 6.5.1.

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 of rated pressure for 30 min.

7.13.2 Sulfur dioxide/carbon dioxide corrosion test (see 6.11.2)

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, e.g. plastic.

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. Sulfur dioxide and carbon dioxide are to be supplied to the test chamber from commercial cylinders. Introduce an amount of sulfur 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 d. After a total of 10 d, remove the samples from the container and allow them to dry for 1 d to 5 d 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 6.11.2.

7.13.3 Hydrogen sulfide corrosion test (see 6.11.3)

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

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 sulfide is to be supplied to the test chamber from a commercial cylinder. Introduce an amount of hydrogen sulfide 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 d. After a total of 10 d, remove the samples from the container and allow them to dry for 1 d to 5 d 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 6.11.3.

7.13.4 Salt spray loading test (see 6.11.4)

7.13.4.1 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 non-reactive (e.g. plastic) cap.

During the corrosive exposure, the inlet thread orifice shall be sealed by a non-reactive 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. The temperature shall be recorded at least once per day, at least 7 h apart (except weekends and holidays when the chamber normally would not be opened). 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 two 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 d. After this period, the sprinklers shall be removed from the fog chamber and allowed to dry for 4 d to 7 d 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 6.11.4.

7.13.4.2 Sprinklers for corrosive atmospheres

Sprinklers intended to be used in corrosive atmospheres shall be subjected to the tests specified in 7.13.4.1, except that the duration of the salt spray exposure shall be extended from 10 d to 30 d.

7.13.5 Moist air exposure (see 6.11.5)

Five sprinklers shall be exposed to a high temperature-humidity atmosphere consisting of a relative humidity of 98 % ± 2 % and a temperature of 94 °C ± 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 is to be placed in the high temperature-humidity enclosure for 90 d. After this period, the sprinklers shall be removed from the high temperature-humidity enclosure and allowed to dry for 4 d to 7 d at a relative humidity not greater than 70 %. Following the drying period, five sprinklers shall meet the functional requirements of 6.5.1 at a pressure of 0,035 MPa (0,35 bar) only.

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

7.13.6 Salt spray corrosion test (see 6.11.6)

7.13.6.1 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 non-reactive (e.g. plastic) cap.

During the corrosive exposure, the inlet thread orifice shall be sealed by a non-reactive cap after the sprinklers have been filled with deionized water. The salt solution shall be a 5 % by mass sodium chloride solution in distilled 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. The temperature shall be recorded at least once per day, at least 7 h apart. 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 two 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 (5 ± 1) % by mass.

The sprinklers shall withstand exposure to the salt spray for a period of 10 d. After this period, the sprinklers shall be removed from the fog chamber and allowed to dry for 4 d to 7 d 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 6.11.6.

7.13.6.2 Sprinklers for corrosive atmospheres

Sprinklers intended to be used in corrosive atmospheres shall be subjected to the tests specified in 7.13.6.1, except that the duration of the salt spray exposure shall be extended from 10 d to 30 d.

7.14 Tests for sprinkler coatings

7.14.1 Evaporation of wax and bitumen test (see 6.12.1)

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 d exposure to determine any loss of volatile matter; the sample shall meet the requirements of 6.12.1.

7.14.2 Low temperature test (see 6.12.2)

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 6.12.2.

7.15 Water hammer test (see 6.13)

7.15.1 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 maximum rate of 10 MPa/s (100 bar/s) with no more than 60 cycles of pressure per minute. The pressure shall be measured electronically with a pressure transducer.

7.15.2 Visually examine each sprinkler for leakage during the test. After the test, each sprinkler shall meet the leak resistance requirements of 6.8.1 and the functional requirement of 6.5.1 at a pressure of 0,035 MPa (0,35 bar) only.

7.16 Dynamic heating test (see 6.14)

7.16.1 Plunge test

Subject 10 sprinklers in each nominal temperature rating to the plunge test in the standard orientation. Calculate the RTI as described in 7.16.2.

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.

At least 25 ml of water, conditioned to ambient temperature, shall be introduced into the sprinkler inlet prior to testing. 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].

NOTE In some countries, the water at the inlet is not required to perform the test.

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 9 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.

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

The range of permissible tunnel operating conditions is given in Table 9. The selected operating condition shall be maintained for the duration of the test with the tolerances as specified by footnotes a and b to Table 9.

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

Marked nominal temperature rating °C	Air temperature ranges[a]			Velocity ranges[b]		
	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] The selected air temperature shall be known and maintained constant within the test section throughout the test to an accuracy of ±1 °C for the air temperature range of 129 °C to 141 °C within the test section and within ±2 °C for all other air temperatures.

[b] The selected air velocity shall be known and maintained constant throughout the test to an accuracy of ±0,03 m/s for velocities of 2,4 m/s to 2,6 m/s and ±0,04 m/s for velocities of 3,4 m/s to 3,6 m/s.

7.16.2 RTI value calculation

The formula used to determine the RTI value is as follows:

$$\mathrm{RTI} = \frac{-t_r \sqrt{u}}{\ln(1 - \Delta T_{ea} / \Delta T_g)}$$

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 4, 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 (see 7.16.1);

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

7.17 Heat resistance test (see 6.15)

One sprinkler body shall be heated in an oven at 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.

NOTE In some countries, 650 °C is used instead of 770 °C for this test.

7.18 Vibration test (see 6.16)

7.18.1 Five sprinklers shall be fixed vertically to a vibration table and subjected at room temperature 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.

7.18.2 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.

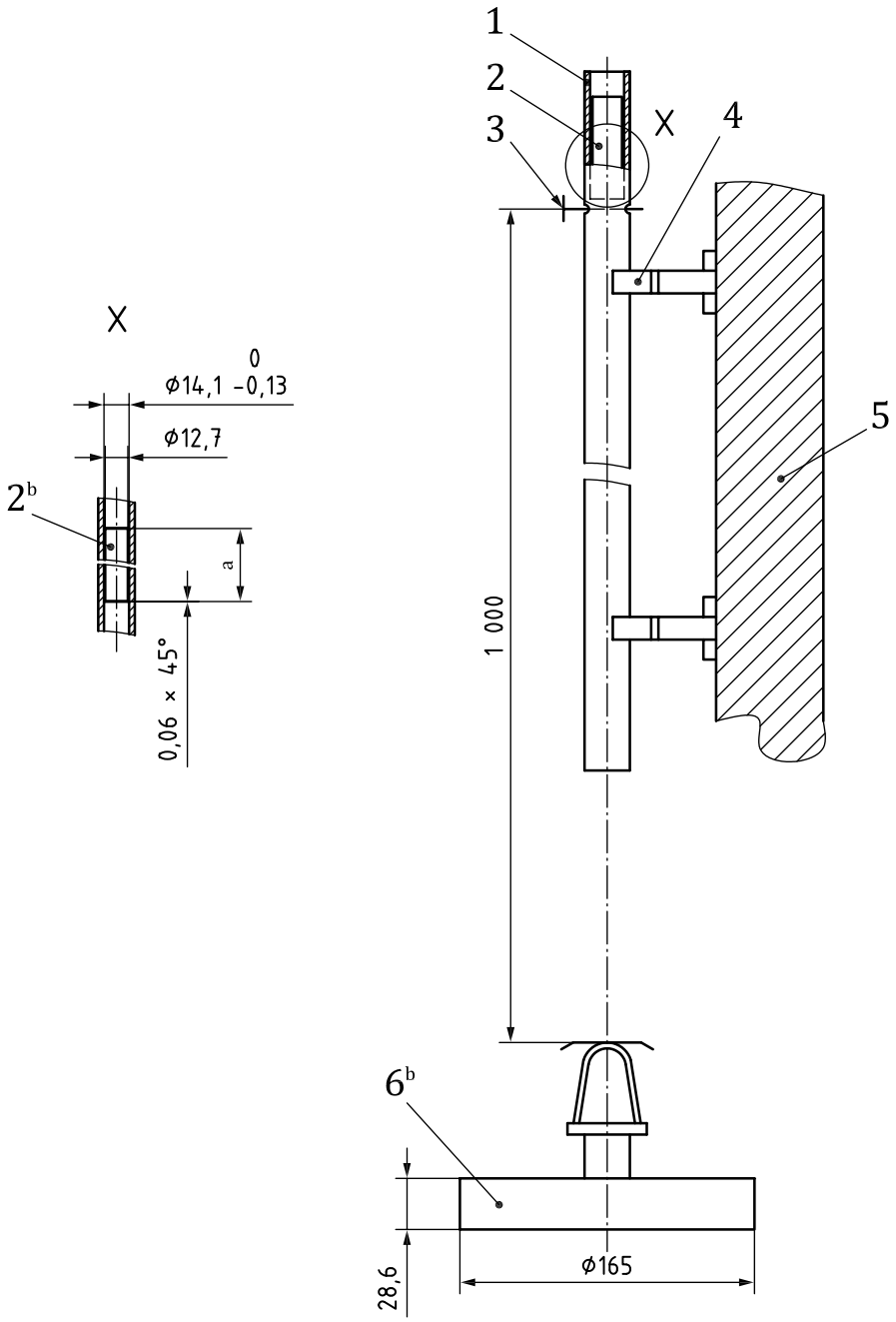
7.18.3 After vibration, each sprinkler shall be subjected to the leak resistance requirement of 6.8.1 and the function requirement of 6.5.1 at a pressure of 0,035 MPa (0,35 bar) only.

7.19 Impact test (see 6.17)

7.19.1 Five sprinklers, other than dry type, shall be impact tested by dropping a mass onto the deflector end of the sprinkler along the axial centerline 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 covers in place. The mass equivalent to that of a sprinkler shall be dropped from a height of 1 m (see Figure 17). 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 6.17.1.

7.19.2 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 6.17.2).

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).
b Cold finished steel.

Figure 17 — Impact test apparatus

7.20 Rough usage test (see 6.18)

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.

EXCEPTION Dry sprinklers are not required to be subjected to this test. In addition, concealed sprinklers are tested without their coverplate 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 is to be 300 mm. For each test, one sample and five 38 mm hardwood cubes are to be placed in the drum. The drum is to be rotated at 1 rev/s for 3 min. The sample is to be removed from the drum, examined for signs of damage, and then subjected to the leakage resistance test in 6.8.1 and to the RTI requirements of 6.14.1 or in accordance with 6.25.1 for recessed and concealed sprinklers.

7.21 Crib fire test (see 6.19)

7.21.1 Fire test assembly

7.21.1.1 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 18).

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 7.21.1.3.

Dimensions in millimetres

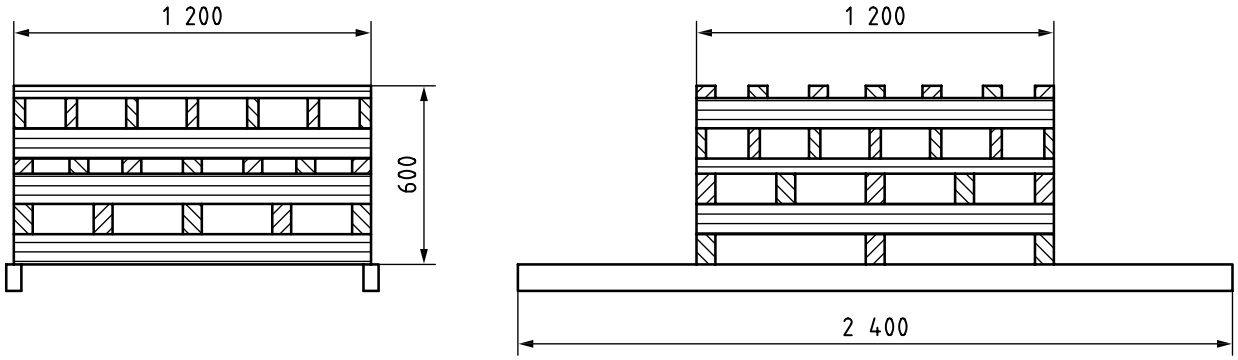


Figure 18 — Test crib

7.21.1.2 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 19. 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. Details can be obtained from ISO/TC 21.

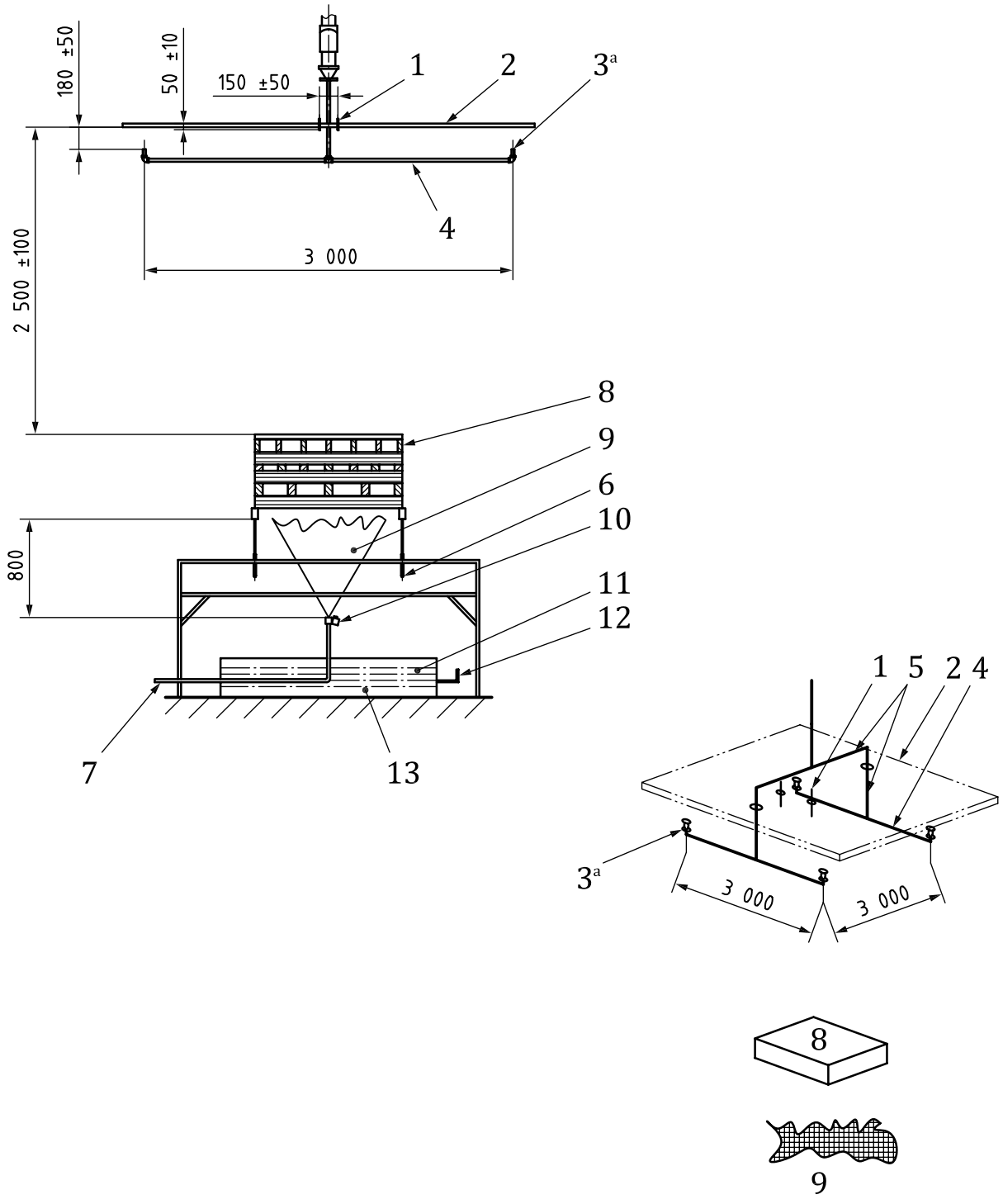
7.21.1.3 The steel pan shall be 1 800 mm × 2 400 mm × 300 mm (depth), constructed of steel plate not less than 5,4 mm thick. The upper corners shall be reinforced by a continuous steel band. The pan shall be liquidtight and, prior to the test, shall be filled with water to a depth of 100 mm. The pan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

7.21.2 Sprinkler installation

7.21.2.1 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 19), 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.

NOTE Closed sprinklers with a nominal temperature rating of 77 °C or less may be used provided that they operate within 70 s of ignition.

Dimensions in millimetres



Key

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

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

Figure 19 — Crib fire test

7.21.2.2 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.

7.21.2.3 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.

7.21.2.4 Sprinkler frame arms shall be oriented parallel to the piping.

7.21.3 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 19. 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.

7.21.4 Procedure

7.21.4.1 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.

7.21.4.2 The total flow rate to the four sprinklers having a nominal *K*-factor of 80 (l/min)/(bar½) 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)/(bar½) 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.

7.21.4.3 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.

7.21.4.4 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 w 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 compliance with the mass loss requirement (see 6.19).

7.22 Lateral discharge test (see 6.20)

7.22.1 General

While discharging water at a service pressure of 0,52 MPa (5,2 bar) less than the rated pressure, an open upright or pendent spray sprinkler shall not prevent the operation of a 57 °C to 77 °C temperature-rated automatic sprinkler of the same type and response located 1,83 m distant on an adjacent pipeline in the same horizontal plane.

7.22.2 Upright and pendent sprinklers

7.22.2.1 An upright or pendent spray automatic sprinkler having a nominal release temperature of 57 °C to 77 °C shall be installed on piping 1,83 m distant (centre-to-centre) from a second open sprinkler of the same type. The sprinklers shall be on separate parallel pipelines with the frame arms parallel to the pipe and the sprinkler deflectors located 560 mm below a flat ceiling. Water shall be discharged from the open sprinkler at a service pressure of 0,52 MPa (5,2 bar) less than the rated pressure. After water flow is established, the automatic sprinkler shall be exposed to the heat and flame from a 305 mm square pan 102 mm deep containing 0,47 l of heptane. The top of the pan shall be located 152 mm below the heat-responsive element.

7.22.2.2 Locate the sprinkler deflectors 152 mm below the flat ceiling and repeat both tests.

7.22.3 Sidewall sprinklers

For sidewall sprinklers, an automatic and open sprinkler are to be installed on the same pipeline with the sprinklers located 1,8 m apart, or the minimum distance between sprinklers as specified in the installation instructions, to discharge water perpendicular to the pipeline. One test is to be conducted with the sprinklers located 152 mm below a flat ceiling and 152 mm away from a back wall. The second test is to be conducted with the sprinklers located 305 mm below a flat ceiling and 152 mm away from a back wall.

7.22.4 Exposure to heat and flame

Water is to 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 is to 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.

7.22.5 Consumption of heptane

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

7.23 Thirty-day leakage test (see 6.21)

7.23.1 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 d at an ambient temperature of (20 ± 5) °C.

7.23.2 The sprinklers shall be inspected visually at least weekly for leakage. Following the 30 d period, all samples shall meet the leak resistance requirement specified in 6.8.1 and show no evidence of distortion or other mechanical damage.

7.24 Vacuum test (see 6.22)

Three sprinklers shall be subjected to a gradually increasing vacuum of up to 460 mm Hg[1)] 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 6.8.1.

1) Millimeters of mercury. This is a deprecated unit. 1 mm Hg = 133,322 4 Pa.

7.25 Water shield angle of protection (see 6.23)

Verify the angle of protection according to 6.23; measure 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 3).

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.

7.26 Water shield rotation test (see 6.24)

7.26.1 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.

7.26.2 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 %.

7.27 Thermal response of concealed and recessed sprinklers test (see 6.25)

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

a) For pendent 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 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.

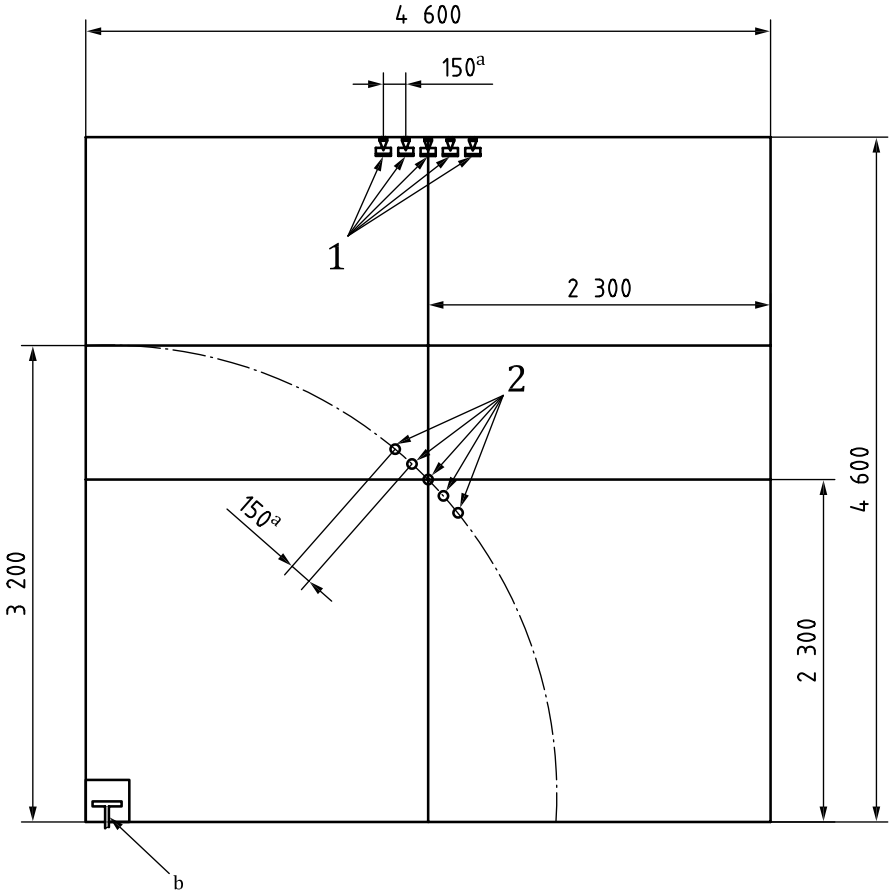
c) For pendent concealed and recessed sprinklers incorporating frame arms with symmetrical heat-responsive elements, 10 samples are to be orientated with the frame arms in a plane parallel to the direction of the fire source. The samples are to be installed in their intended position at the ceiling.

d) For sidewall 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.

7.27.2 At least 10 samples each of concealed and recessed sprinklers shall be tested in groups of five in a nominal 4,6 m × 4,6 m × 2,4 m high closed room and subjected to the heat from a sand burner (see Figure 23) located on the floor in one corner of the room with the sprinklers located 15 cm apart as described in Figure 20 for standard-response sprinklers and Figure 21 for fast-response sprinklers. 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 For concealed and recessed sprinklers with vented housings, the manufacturer's installation manual shall state whether the sprinklers are allowed to be installed in ceilings not permitting airflow through the housing.

Dimensions in millimetres



Key

1 sidewall sprinkler locations

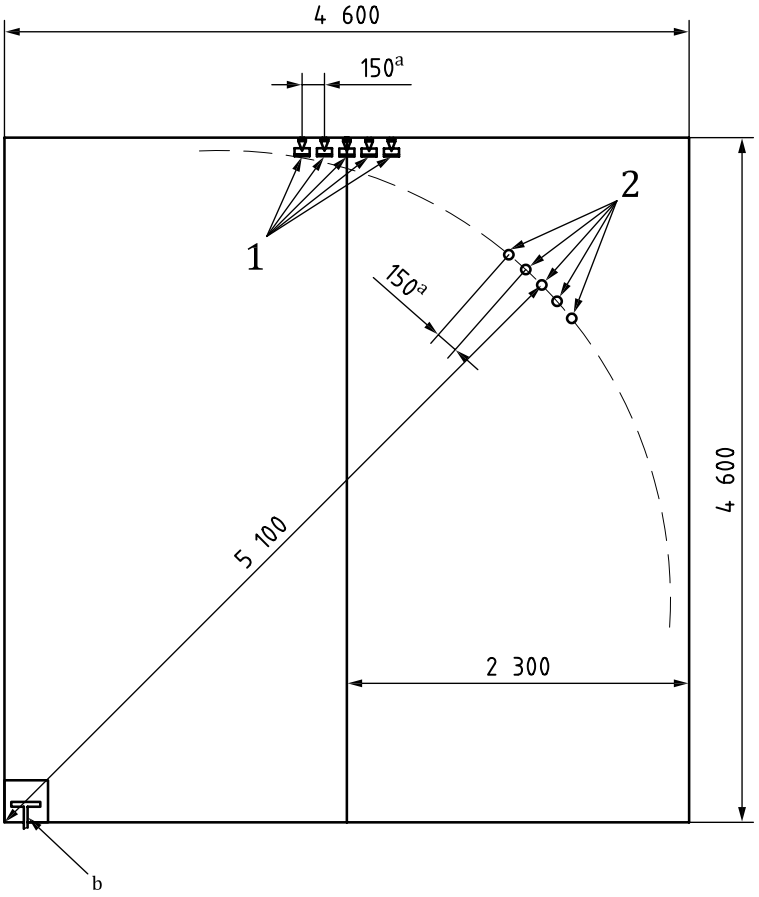
2 pendent sprinkler locations

a Typical dimension.

b For sand burner detail, see Figure 23.

Figure 20 — Plan view of room heat test for standard-response concealed and recessed sprinklers

Dimensions in millimetres



Key

1 sidewall sprinkler locations

2 pendent sprinkler locations

a Typical dimension.

b Sand burner detail.

Figure 21 — Plan view of room heat test for fast-response concealed and recessed sprinklers

7.27.3 The test room shall be constructed of nominal 1,2-cm-thick plywood. The ceiling shall be constructed of nominal 1,2-cm-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.

7.27.4 A flow of natural gas or methane shall be established through the sand burner as follows:

a) 9,6 m^3/h for standard-response sprinklers having a temperature rating of 77 °C or less;

b) 26 m^3/h for standard-response sprinklers having a temperature rating of 79 °C to 107 °C;

c) 14,2 m^3/h for fast-response sprinklers having a temperature rating of 77 °C or less;

d) 17 m^3/h for fast-response sprinklers having a temperature rating of 79 °C to 107 °C.

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

7.27.5 The response test shall be started when the ambient temperature measured in the centre of the room 254 mm below the ceiling is

a) (31 ± 1) °C for sprinklers having a temperature rating not exceeding 77 °C; or

b) (49 ± 1,7) °C for sprinklers having a temperature rating between 79 °C and 107 °C.

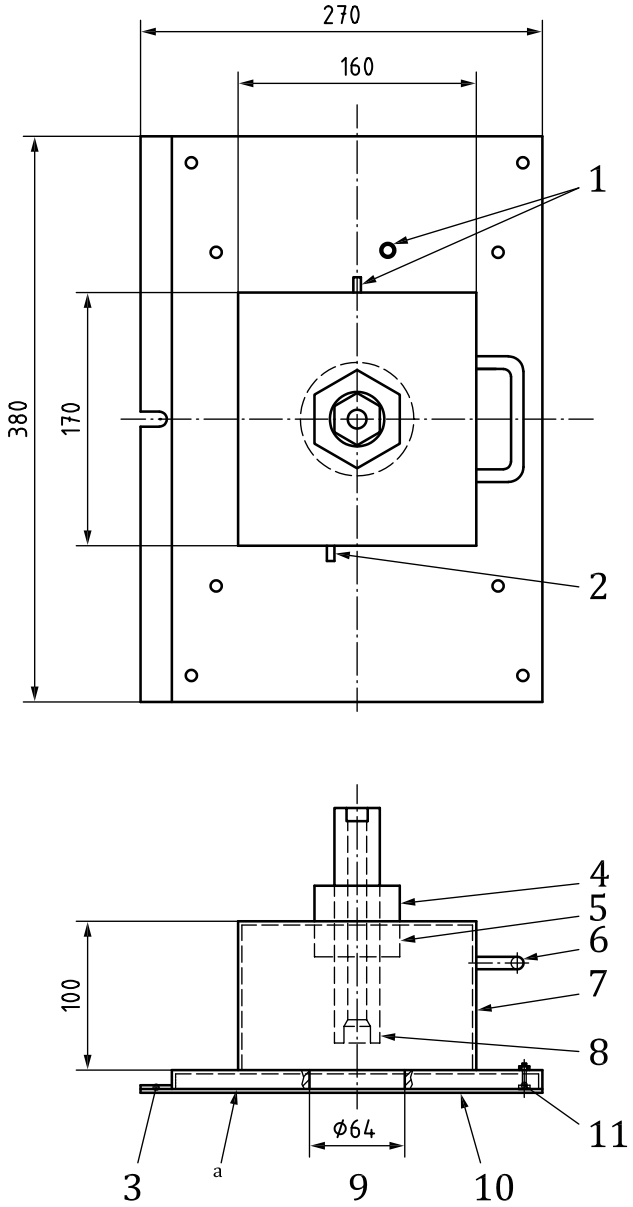
The operating time of each sprinkler is to be recorded.

7.27.6 Three samples shall be tested at each of the test conditions and orientations determined from the calculations obtained according to 6.25.4. Each sprinkler under test shall have 1 wrap to 1,5 wraps of PTFE sealant tape applied to the sprinkler threads. Each sample shall be screwed into the test plate (see Figure 22) to a torque of (15 ± 3) N·m and maintained in a conditioning chamber to allow the sprinkler and test plate to reach ambient temperature for a period of not less than 30 min. The sprinkler shall be installed such that the sprinkler's heat-sensitive element is at the minimum protrusion (as permitted by the sprinkler design) into the dynamic heating apparatus laminar gas stream. The orientations according to Table 4 shall be based on the sprinkler as if it were not concealed or recessed.

7.27.7 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. As soon as the sprinkler is plunged into the dynamic heating apparatus, the applied vacuum (as noted in Table 4) shall be applied and maintained throughout the remainder of the testing.

Record the operating time of each sprinkler.

Dimensions in millimetres



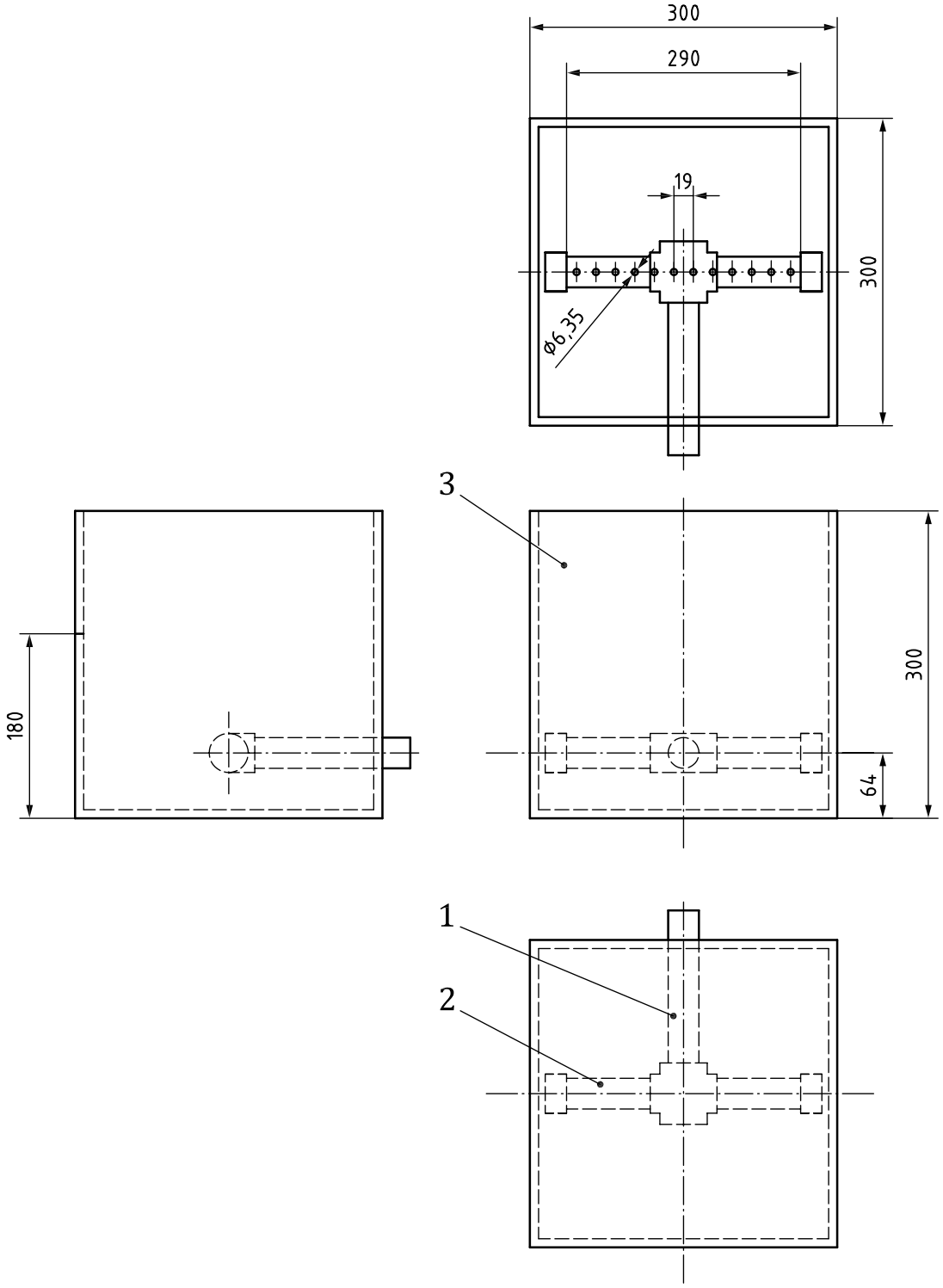
Key

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	11	pan head screws countersunk in Marinite® used to fasten Marinite® steel frame and flange of enclosure body
6	handle	a	Marinite® 1,9cm.

Figure 22 — Example of dynamic heating test plate for concealed and recessed sprinklers [2)]

2) 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.

Dimensions in millimetres



Key

1 nominal pipe Ø25 mm

2 nominal pipe Ø40 mm

3 sand

NOTE Materials: steel plate box, welded; steel piping and fittings, with 12 6,35 holes; and mason grade sand.

Figure 23 — Details of sand burner

7.28 Freezing test (see 6.26)

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 s. Sprinklers which do not leak shall be tested according to 6.8.1 and 6.14.2.

7.29 Dry-type sprinkler deposit loading test (see 6.27)

7.29.1 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 is to be exposed with the sprinkler in the vertical position with the inlet up and the second group with the sprinkler inlet down.

7.29.2 The samples are to be exposed to a moist carbon dioxide-sulfur dioxide air mixture in a closed chamber maintained at (35 ± 2) °C for a period of 30 d. 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 d out of every 7 d, an amount of carbon dioxide equivalent to 1,0 % of the volume of the chamber, plus an amount of sulfur dioxide equivalent to 1,0 % of the volume, are to be introduced. Prior to each introduction of gas, the remaining gas-air mixture from the previous day is to be thoroughly purged from the chamber. On the 2 d out of every 7 d that this does not occur, the chamber is to remain closed and no purging or introduction of gas is to be provided. A small amount of water (10 ml/0,003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity. This water is to be replaced weekly.

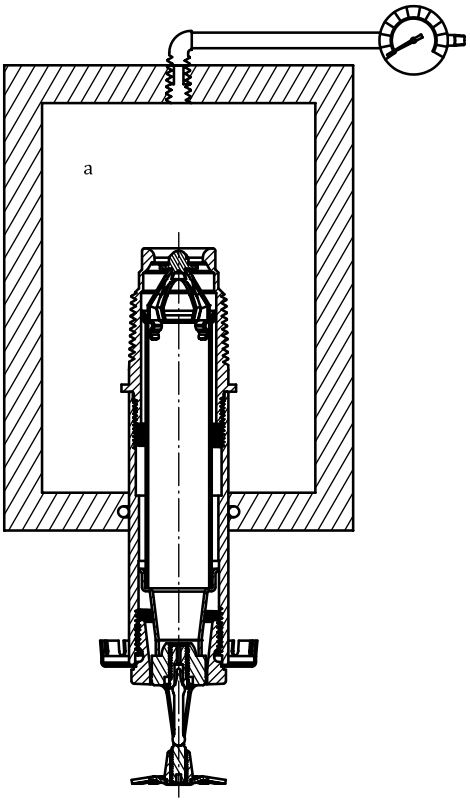
7.29.3 After the carbon dioxide-sulfur dioxide exposure, the samples are to be dried at (49 ± 3) °C in an automatically controlled, circulating-type, constant-temperature oven for not less than 24 h or more than 72 h. Each sample is then to be stored at (21 ± 3) °C for at least 4 h prior to installation 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-sulfur dioxide exposure. The water seal assembly and other internal parts shall clear the waterway as intended.

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

7.30 Dry sprinkler air tightness test (see 6.28)

7.30.1 Five samples are to be individually tested. The assembly is to be installed in an air leakage test fixture in such a manner that the extension nipple connection to the inlet seal assembly can be fully pressurized with air. See Figure 24.

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



Key

a Pressurized with air.

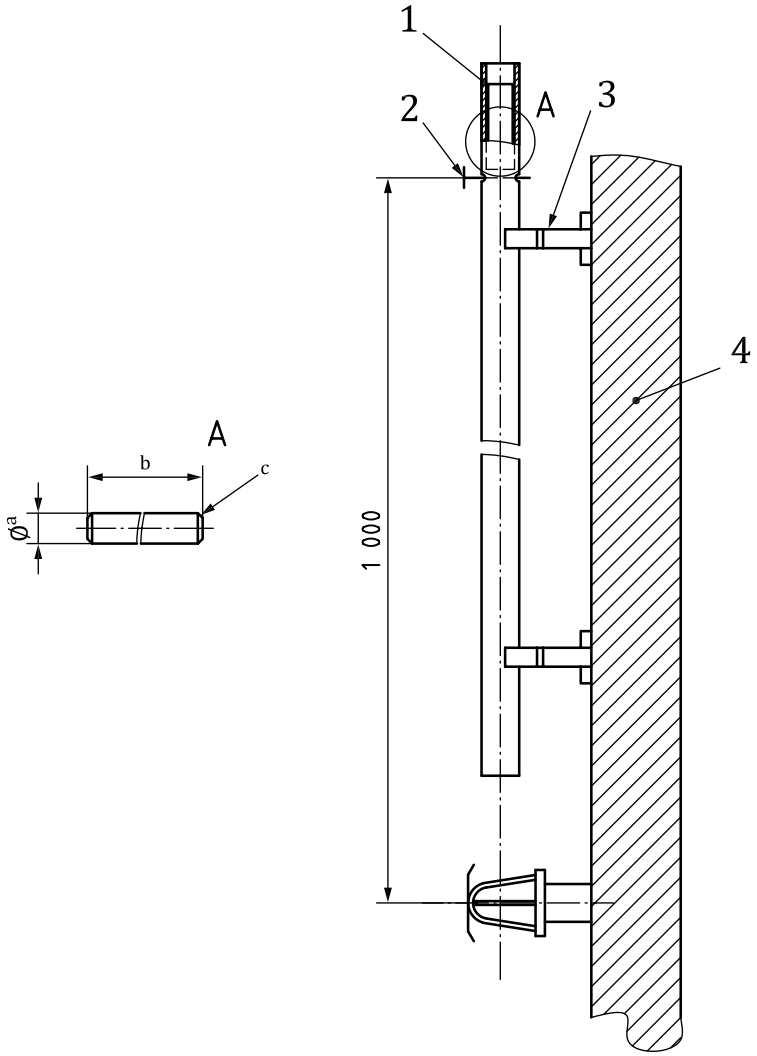
Figure 24 — Dry sprinkler air tightness test apparatus (typical)

7.31 Protective cover impact test for glass bulb sprinklers (see 6.29)

7.31.1 Five sample sprinklers with their protective covers are to be mounted in the horizontal position (see Figure 25) and impacted with a cylindrical mass equivalent to the mass of the sprinkler to the nearest 15 g increment from a height of 1 m 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 1 m onto the geometric centre of the heat-responsive element. The mass is to be prevented from impacting more than once upon each sample.

7.31.2 Following the impact, each sprinkler is to be visually examined and there shall be no evidence of cracks, breaks, or any other damage to the heat-responsive element. Each sample sprinkler shall comply with the leak resistance requirements of 6.8.1 and then shall meet the requirements of 6.14.1 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 weight).
c Break corner, 0,06 mm × 45°.

Figure 25 — Impact test apparatus for protective covers

7.32 Dezincification of brass parts test (see 6.30)

7.32.1 Reagent

A test solution is to 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 is to be used for each test.

7.32.2 Pieces

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

7.32.3 Method

Each test piece is to be placed in the middle of the beaker containing the copper (II) chloride solution so that the test surface is vertical and at least 15 mm 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 a non-metallic compound. A total of 250 ml (+50, –10) 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 is to be placed in the thermostatically controlled oven or oil bath with the temperature maintained at (75 ± 2) °C. The test piece is to be exposed continuously for 144 h. At the end of this period, they are to be removed from the beaker, washed in water, rinsed in the ethanol, and allowed to dry.

Microscopic examination of the test piece is to be conducted as soon as possible after the exposure. If the test pieces are stored before microscopic examination, they are to be kept in a desiccator. Each test piece is to be sectioned at right angles to the exposed test surface and the remaining thermoset resin attached to the section that is to be removed. The cross-sectioned piece is then to be re-embedded in a thermoset resin having minimal shrinkage, and the area to be viewed is to be ground and polished for microscopic examination. The total length of section through the exposed surface is not to be less than 5 mm. If the dimensions of the test piece make this impossible, the section is to 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 is to be measured from the post exposed test surface and is not to include the sample edge. The maximum dezincification is to be recorded and the average depth calculated. Magnification is to be used to provide the greatest accuracy of measurement.

7.33 Stress corrosion — magnesium chloride test (see 6.31)

7.33.1 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 as described below, and in accordance with ASTM G36. Special fixtures or elevated temperature operating elements may be employed to simulate assembly loading on parts, where appropriate and necessary.

7.33.2 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 42 % by weight magnesium chloride solution, placed on a thermostatically controlled electrically heated mantle, and maintained at a boiling temperature of 150 °C ± 2 °C.

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

7.33.4 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 7.33.5.

7.33.5 The sprinklers tested shall not weep or leak at, or below, 1,2 MPa (12,1 bar) when hydrostatically tested for 1 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.

8 Marking

8.1 Sprinklers

8.1.1 Each sprinkler shall be permanently marked on a non-operating part as follows:

a) manufacturer's factory identification (if the manufacturer has more than one sprinkler manufacturing facility);

b) nominal year of manufacture, which may include the last 3 mo of the preceding year and the first 6 mo of the following year;

c) nominal operating temperature, the range of which shall be colour coded on the sprinkler to identify the nominal rating. The colour code shall be visible on the yoke arms holding the distribution plate for fusible element sprinklers and shall be indicated by the colour of the liquid in glass bulbs. All sprinklers shall be stamped, cast, engraved, or colour coded in such a way that the nominal temperature rating is recognizable even if the sprinkler has operated. This shall be in accordance with Table 1.

8.1.2 In addition to the requirements of 8.1, each sprinkler shall be permanently marked on a non-operating part with either 8.1.2.1 or 8.1.2.2.

8.1.2.1 A sprinkler identification number (SIN) shall be used. All sprinklers shall be permanently marked with a one- or two- character manufacturer symbol, followed by up to four numbers, so as to identify a unique model of sprinkler for every change in orifice size or orifice shape, deflector characteristic, thermal sensitivity, and pressure rating. The manufacturer symbol shall be registered with the International Fire Sprinkler Association.

NOTE The International Fire Sprinkler Association maintains a registry of manufacturer symbols at www.sprinklerworld.org.

8.1.2.2 The following items must be marked as indicated in 8.1.2:

a) trademark or manufacturer's name;

b) abbreviation of the type of sprinkler and the mounting position (see 8.1.3);

c) the nominal flow constant;

d) the pressure rating if other than 1,2 MPa (12 bar).

8.1.3 The following abbreviations, or combinations thereof, shall be marked, as applicable, on a non-operating part of the sprinkler where required by 8.1.2.2.

CUP	conventional upright or pendent sprinkler
FR	fast-response sprinkler
IR	special- (intermediate-) response sprinkler
FU	flat spray upright sprinkler
FP	flat spray pendent sprinkler
SU or SSU	spray upright sprinkler
SP or SSP	spray pendent sprinkler
WP	sidewall pendent sprinkler
WU	sidewall upright sprinkler
WUP	sidewall upright or pendent sprinkler
WH	sidewall horizontal sprinkler

No additional markings are required for the following sprinklers:

a) concealed;

b) flush;

c) recessed;

d) dry upright;

e) dry pendent;

f) water shield.

8.1.4 For deflectors of non-horizontal sidewall sprinklers, there shall be a clear indication of their intended orientation, relative to the direction of flow. If an arrow is employed, it shall be accompanied by the word “flow”. Horizontal sidewall sprinklers shall include the word “top” on the deflector to indicate their orientation.

8.1.5 Coated, plated, concealed, and flush fusible link sprinklers are not required to be colour coded.

8.1.6 Sprinklers using glass bulbs from more than one supplier shall have permanently coded marking on a non-operating part of the sprinkler identifying the individual supplier of the glass bulb used in that specific sprinkler.

8.2 Sprinkler housings and concealed-sprinkler cover plates

8.2.1 Recessed housing assemblies/escutcheons and concealed-sprinkler cover plates shall be marked for use with the corresponding sprinklers, unless the housing is a non-removable part of the sprinkler.

8.2.2 Concealed-sprinkler cover plates shall be permanently marked with the words “Do not paint” on the exterior surface.

8.3 Protective covers

Protective covers shall be orange in colour and shall be marked to indicate that the cover must be removed before the sprinkler system is placed in service. The marking shall be placed on the cover so it is visible after sprinkler installation (see 7.31).

9 Manufacturer's installation instructions

9.1 The manufacturer's installation instructions shall be available.

9.2 Those instructions shall include the following where applicable:

a) flow constant;

b) response type;

c) rated pressure;

d) minimum distance between sprinklers when the minimum distance exceeds 1,8 m;

e) installation position;

f) maximum and minimum distances of sprinkler deflector from ceiling and/or wall;

g) venting requirements for recessed and concealed sprinklers;

h) sprinkler identification in accordance with 8.1.2;

i) manufacturer-approved installation tool(s);

j) a statement requiring removal of protective cover;

k) a statement indicating use in corrosive environments.

9.3 In addition, the manufacturer's installation instructions for dry sprinklers shall include information on the appropriate types and sizes of fittings that are compatible with the sprinkler (see 5.4).

Annex A
(informative)

Analysis of the strength test for release elements

A.1 The formula given in 7.9.2 is based on the intention of providing fusible elements that are not susceptible to failure caused by creep stresses during a reasonable period of service. As such, the duration of 876 600 h (100 y) was selected only as a statistical value with an ample safety factor. No other significance is intended, as many other factors govern the useful life of a sprinkler.

A.2 Loads causing failure by creep, and not by an unnecessarily high initial distortion stress, are applied and the times noted. The given requirement then approximates the extrapolation of the full logarithmic regression curve by means of the following analysis.

A.3 The observed data are used to determine, by means of the method of least squares, the load at 1 h, L_O, and the load at 1 000 h, L_M. One way of stating this is that, when plotted on full logarithmic paper, the slope of the line determined by L_M and L_O shall be greater than or equal to the slope determined by the maximum design load at 100 y, L_d, and L_O, or

$$(\ln L_M - \ln L_o) / \ln 1\,000 \geq (\ln L_d - \ln L_o) / \ln 876\,600$$

This is then reduced as follows:

$$\ln L_M \geq (\ln L_d - \ln L_O)\frac{\ln 1\,000}{\ln 876\,600} + \ln L_O$$

$$\geq 0{,}504\,8\,(\ln L_d - \ln L_O) + \ln L_O$$

$$\geq 0{,}504\,8 \ln L_d + 0{,}495\,2 \ln L_O$$

With an error of approximately 1 %, the formula may be approximated by

$$\ln L_M \geq 0{,}5\,(\ln L_d + \ln L_O)$$

or, compensating for errors,

$$L_M \geq 0{,}99\,(L_d + L_O)^{0{,}5} \text{ or } L_M \geq 1{,}02 L_d{}^2 / L_O$$

Annex B
(informative)

Statistical tolerance limits

B.1 The calculation method for determining compliance with the tolerance limit requirements specified in 6.25 is described below.

B.2 Record the sample operation time in decimal form.

B.3 Calculate the mean and unbiased standard deviation. The sample unbiased standard deviation (s) is calculated from the formula:

$$s = \left[\sum_{i-1}^{n} (x_i - x)^2 / (n-1) \right]^{0,5}$$

where

x is the sample mean operation time;

x_i is the individual operation time of each sample tested;

n is the number of samples tested.

B.4 Determine K, where K is a factor selected from Table B.1.

B.5 Complete the steps in the comparison with the requirements specified in 6.25 in accordance with Table B.1.

B.6 The statistical tolerance limits were derived from thermal response tests performed using a commercially available sprinkler having an RTI of approximately 350 $(m \cdot s)^{0,5}$.

Table B.1 — Table for *K*, factors for one-sided tolerance limits for normal distributions

n	*K* for response test of ceiling-type sprinklers [including concealed, flush, and recessed (see 6.25)] Y=0,95 P=0,99 (99 % of samples)
10	3,981
11	3,852
12	3,747
13	3,659
14	3,585
15	3,520
16	3,463
17	3,415
18	3,370

Table B.1 *(continued)*

n	*K* for response test of ceiling-type sprinklers [including concealed, flush, and recessed (see 6.25)] Y=0,95 P=0,99 (99 % of samples)
19	3,331
20	3,295
21	3,262
22	3,233
23	3,206
24	3,181
25	3,158
30	3,064
35	2,994
40	2,941
45	2,897
50	2,863

Table B.2 — Tolerance limit worksheet for response test of ceiling-type sprinklers [including concealed and recessed (see 6.25)]

Operation times			
Minutes: seconds	Minutes (decimal)	Minutes: seconds	Minutes (decimal)

X is the mean sample sprinkler operating time, expressed in minutes;

S is the sample unbiased standard deviation, expressed in minutes;

n is the sample size;

K is the factor from Table B.1 for Y= 0,95 and *P* = 0,99;

TL_{tol} is the tolerance limit = X + *K S*, expressed in minutes.

Sample data is acceptable if

*L*tol ≤ 3,85 min for sprinklers having a temperature rating not exceeding 77 °C, or

*L*tol ≤ 3,15 mm for sprinklers having a temperature rating between 79 °C and 107 °C

Annex C
(normative)

Tolerances

C.1 Unless otherwise stated, the tolerances given in Table C.1 shall apply.

Table C.1 — Tolerances

Parameter	Tolerance	
Angle	±2°	
Frequency (Hz)	±5 % of value	
Length	±2 % of value	
Volume	±5 % of value	
Pressure	±3 % of value	
Temperature	±5 % of value	
Time	+5 0	seconds
	+0,1 0	minutes
	+0,1 0	hours
	+0,25 0	days

Annex D
(normative)

Tolerance limit calculation methods for strength distribution

D.1 General

The calculation methods for determining compliance with the tolerance limit requirements specified in 6.7.1 is described in D.2 to D.4.

D.2 Unbiased standard deviation

The sample unbiased standard deviation is calculated from the formula:

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

where

$\overline{X}$ is the sample mean;

X_i is the individual value of each sample tested;

n is the number of samples tested;

S is the unbiased sample standard deviation.

D.3 Determination of constant

Determine K, where K is a factor selected from Table D.1.

D.4 Calculation parameters

To complete the comparison with the requirements specified in 6.7.1, the following calculation parameters are required.

$\overline{X}_1$ [mean bulb strength, lb (kg)]

$\overline{S}_1$ (sample unbiased standard deviation for $\overline{X}_1$)

$\overline{X}_2$ [mean assembly load, lb (kg)]

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

K_1 (bulb strength factor from Table A.1 for Γ = 0,99 and P = 0,99)

K_2 (assembly load factor from Table A.1 for Γ = 0,99 and P = 0,99)

UTL (upper tolerance limit for sprinkler assembly load = $\overline{X}_2 + K_2 S_2$)

LTL (lower tolerance limit for bulb strength = $\overline{X}_1 - K_1 S_1$)

Sample data is acceptable if LTL > 2UTL.

Table D.1 — *K*-factors for one-sided tolerance limits for normal distributions

N	***K*** Strength of heat-responsive element test for frangible bulb types (see 6.7.1) Γ = 0,99 p = 0,99 (99% of samples)
10	5,075
11	4,828
12	4,633
13	4,472
14	4,336
15	4,224
16	4,124
17	4,038
18	3,961
19	3,893
20	3,832
21	3,776
22	3,727
23	3,680
24	3,638
25	3,601
30	3,446
35	3,334

Table D.1 *(continued)*

N	***K*** Strength of heat-responsive element test for frangible bulb types (see 6.7.1) $\Gamma = 0{,}99$ $p = 0{,}99$ (99% of samples)
40	3,250
45	3,181
50	3,124

Table D.2 — Example worksheet for strength of heat-responsive element test for frangible bulb types (see 6.7.1)

Sample bulb strength values N	**Sprinkler assembly load values** N

Bibliography

[1] ISO 6182-7, *Fire protection — Automatic sprinkler systems — Part 7: Requirements and test methods for early suppression fast response (ESFR) sprinklers*

[2] ISO 6182-10, *Fire protection — Automatic sprinkler systems — Part 10: Requirements and test methods for domestic sprinklers*

[3] IEC 60751, *Industrial platinum resistance thermometers and platinum temperature sensors*

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