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Second edition

FIRE PROTECTION - AUTOMATIC SPRINKLER SYSTEMS PART 1: REQUIREMENTS AND TEST METHODS FOR SPRINKLERS

(This English version is for reference only)

HA NOI - 2007

Foreword

TCVN 6305-1:2007 replaces TCVN 6305-1:1997 (ISO 6182-1:1993).

TCVN 6305-1:2007 was identical to ISO 6182-1:2004.

TCVN 6305-1:2007 was prepared by Technical Committee TCVN/TC 21 Fire protection equipments, proposed by Directorate for Standards, Metrology and Quality, issued by Ministry of Science & Technology.

TCVN 6305 (ISO 6182:2004) consists of the 5 parts, under the general title Fire protection — Automatic sprinkler systems:

- TCVN 6305-1:2007 (ISO 6182-1:2004) - Part 1: Requirements and test methods for sprinklers;
- TCVN 6305-2:2007 (ISO 6182-2:2004) - Part 2: Requirements and test methods for wet alarm valves, retard chambers and water motor alarms;
- TCVN 6305-3:2007 (ISO 6182-3:2004) - Part 3: Requirements and test methods for dry pipe valves;
- TCVN 6305-7:2006 (ISO 6182-7:2004) - Part 7: Requirements and test methods for early suppression fast response (ESFR) sprinklers;
- TCVN 6305-11:2006 (ISO 6182-11:2004) - Part 11: Requirements and test methods for pipe hangers.

Second edition

Fire protection — Automatic sprinkler systems

Part 1: Requirements and test methods for sprinklers

1 Scope

This standard 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.

2 Normative references

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

TCVN 7705 (ISO 49), Malleable cast iron fittings threaded to ISO 7-1

ISO 7-1:1982, Pipe threads where pressure-tight joints are made on the threads — Part 1: Dimensions, tolerances and designation

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

PPP-B-640D: 1969, Federal Specification for Boxes, Fiberboard, Corrugated, Triple-wall

3 Terms and definitions

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

3.1 General

3.1.1 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

3.1.2 Conductivity factor *C*

Measure of the conductance between the sprinkler's heat-responsive element and the fitting

NOTE The conductivity factor is expressed in units of $(m/s)^{0,5}$.

3.1.3 Response time index

RTI measure of sprinkler sensitivity

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

where

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

u is the gas velocity, expressed in metres per second

NOTE 1 The response time index is expressed in units of $(m.s)^{0,5}$.

NOTE 2 RTI can be used in combination with the conductivity factor (*C*) to predict the response of a sprinkler in fire environments defined in terms of gas temperature and velocity versus time.

3.1.4 Standard orientation

Orientation that produces the shortest response time with the axis of the sprinkler inlet perpendicular to the air flow

NOTE In the case of symmetrical heat-responsive elements, standard orientation is with the air flow 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 air flow perpendicular to both the waterway axis and the plane of the frame arms which produces the shortest response time.

3.1.5 Worst-case orientation

“Response” orientation that produces the longest response time with the axis of the sprinkler inlet perpendicular to the air flow

3.1.6 Assembly load

Force exerted on the sprinkler body at 0 MPa (0 bar) hydraulic pressure at the inlet

3.1.7 Design load

Force exerted on the release element at the service load of the sprinkler.

3.1.8 Service load

Combined force exerted on the sprinkler body by the assembly load of the sprinkler and the equivalent force of a 1,2 MPa (12 bar) hydraulic pressure of the inlet.

3.1.9 Average design strength

“Axial” glass bulb supplier's specified and assured lowest average design strength of any batch of 50 bulbs

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 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

3.3.3 Flat spray sprinkler, F

Sprinkler giving paraboloid water distribution directed downward for a definite protection area, such that 60 % to 80 % of the total water flow is initially directed downward

3.3.4 Sidewall sprinkler, W

Sprinkler giving a one-sided (half-paraboloid) water distribution over a definite protection area

3.4 Types of sprinkler according to position

3.4.1 Upright sprinkler, U

Sprinkler arranged such that the water stream is directed upwards 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 Horizontal sprinkler, H

Sprinkler arranged such that the water stream is directed horizontally against the distribution plate

3.5 Special types of sprinkler

3.5.1 Dry upright sprinkler

Unit comprising an upright installed sprinkler mounted at the outlet of a special riser extension with a seal at the inlet end that prevents water from entering the riser until it is released by operation of the sprinkler

3.5.2 Dry pendent sprinkler

Unit comprising a pendent installed sprinkler mounted at the outlet of a special drop extension with a seal at the inlet end that prevents water from entering the drop until it is released by operation of the sprinkler

3.5.3 Flush sprinkler

Sprinkler of which all or part of the body, including the shank thread, is mounted above the lower plane of the ceiling, but part or all of whose heat-responsive element is below the lower plane of the ceiling

3.5.4 Recessed sprinkler

Sprinkler of which all or part of the body, other than the shank thread, is mounted within recessed housing

3.5.5 Concealed sprinkler

Recessed sprinkler having a cover plate

3.5.6 On/off sprinkler, o/o

Sprinkler that repeatedly opens under the influence of heat and closes if a heat-sensitive element cools to a predetermined temperature

3.5.7 Multiple-orifice pendent sprinkler, MO

Sprinkler having two or more outlet orifices arranged to distribute the water discharge downward in a specified pattern and quantity for a definite protection area

3.5.8 Coated sprinkler

Sprinkler that has a factory-applied coating for corrosion protection

3.5.9 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

3.5.10 Extended-coverage sprinkler

Sprinkler having a specified area of coverage larger than that of a conventional, spray, flat spray or sidewall sprinkler

3.6 Types of sprinkler according to sprinkler sensitivity

3.6.1 Fast-response sprinkler

Sprinkler having a response time index (RTI) $\leq 50\ (m.s)^{0.5}$ and a conductivity factor (C) of $\leq 1{,}0\ (m/s)^{0.5.}$

See Figure 1.

3.6.2 Special-response sprinkler

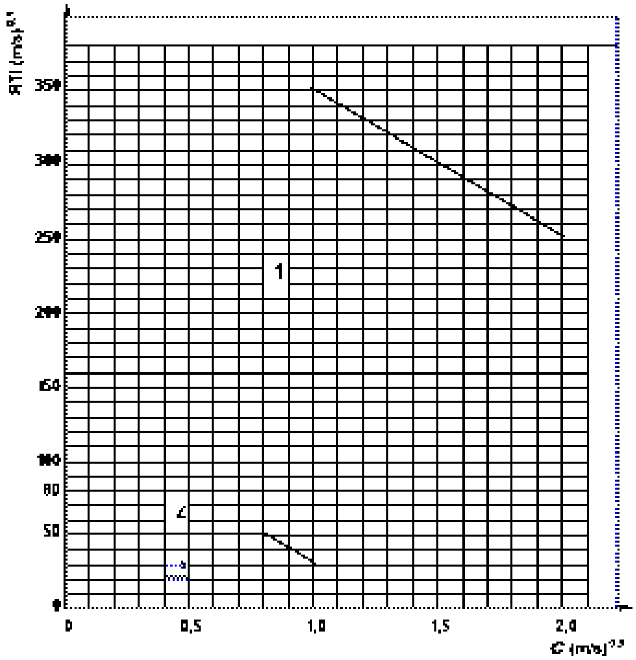
Sprinkler having an average response time index (RTI) of between 50 (m.s)0.5 and 80 (m.s)0.5 and a conductivity (C) factor of $\leq 1{,}0\ (m/s)^{0.5}$

See Figure 1.

3.6.3 Standard-response sprinkler

Sprinkler having a response time index (RTI) of between 80 $(m.s)^{0.5}$ and 350 $(m.s)^{0,5}$ and a conductivity (C) factor not exceeding 2,0 $(m/s)^{0.5}$

See Figure 1.



Key

1 Standard-response sprinklers

2 Special-response sprinklers

3 Fast-response sprinklers

Figure 1 — RTI and *C* limits for standard orientation

4 Product consistency

4.1 Quality control programme

It shall be the responsibility of the manufacturer to implement a quality control programme to ensure that production continuously meets the requirements of this standard in the same manner as the originally tested samples.

4.2 Leak resistance testing

Every manufactured sprinkler shall pass a leak resistance test equivalent to a hydrostatic pressure of at least 3 MPa (30 bar) for at least 2 s.

5 Product assembly

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

6 Requirements

6.1 Dimensions

Sprinkler dimensions shall be in accordance with Table 1.

Table 1 — Dimensional requirements

Nominal diameter of orifice mm	**Nominal thread size** inches
10	3/8
15	1/2
20	3/4

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 some countries, sprinklers having orifices of nominal diameters 6 mm, 8 mm or 9 mm, or sprinklers having multiple water passages, are acceptable.

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

6.1.2.1 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

6.1.2.2 In some countries, the use of 1/2-in threads for sprinklers having orifices of nominal diameters 6 mm, 8 mm, 9 mm, 10 mm and 20 mm is acceptable.

6.1.2.3 Special sprinklers such as dry and flush sprinklers may have larger thread sizes**.**

6.2 Nominal operating temperature (see 7.7.1)

6.2.1 The nominal operating temperature of glass bulb sprinklers shall be in accordance with Table 2.

6.2.2 The nominal operating temperatures of all other sprinklers shall be specified in advance by the manufacturer and verified in accordance with 6.3, and shall be determined according to 7.7.1. Nominal operating temperature ranges for these sprinklers shall be in accordance with Table 2.

6.2.3 The nominal operating temperature to be marked on the sprinkler shall be that determined when the sprinkler is tested according to 7.7.1, taking into account the requirement of 6.3.

6.3 Operating temperature (see 7.7.1)

Sprinklers shall operate within a temperature range of

$$I \pm (0.035I + 0.62)\ ^{\circ}C$$

where I is the nominal operating temperature.

Table 2 — Nominal operating temperatures

Glass bulb sprinklers	
Nom. operating temperature, *I* °C	**Liquid colour code**
57	orange
68	red
79	yellow
93	green
107	green
121	blue
141	blue
163	mauve
182	mauve
204	black
227	black
260	black
343	black
Fusible element sprinklers	
Nom. operating temperature range *I* °C	**Yoke arm colour code**
57 to 77	uncoloured
80 to 107	white
121 to 149	blue
163 to 191	red
204 to 246	green
260 to 302	orange
320 to 343	orange

6.4 Water flow and distribution

6.4.1 Flow constant (see 7.11)

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

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

where

p is the pressure, expressed in megapascals;

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

K-factor for sprinklers according to this standard shall be in accordance with Table 3 when determined by the test method given in 7.11.

Table 3 — Flow constant

Nominal diameter of orifice mm	*K*	***K* for dry sprinklers**
10	57 ± 3	57 ± 5
15	80 ± 4	80 ± 6
20	115 ± 6	115 ± 9

6.4.2 Water distribution (see 7.12)

To demonstrate the required coverage of the protected area allotted to it, the sprinkler shall pass the test according to 7.12.

6.5 Function (see 7.6)

6.5.1 When tested in accordance with 7.6.1 to 7.6.5, the sprinkler shall open and, within 5 s of the release of the heat-responsive element, shall operate satisfactorily in accordance with 6.4.1. Any lodgement of released parts shall be cleared within 60 s of release of the heat-responsive element for standard response sprinklers and within 10 s for special- and fast-response sprinklers; otherwise, the sprinkler shall then comply with 6.4.2.

6.5.2 The deflector and its supporting parts shall not sustain significant damage as a result of the functional test specified in 7.6.6 and shall be in accordance with 6.4.2.

NOTE In most instances, visual examination of the sprinkler will be sufficient to establish conformance with 6.5.1 and 6.5.2.

6.5.3 An on/off sprinkler shall switch between the fully off and fully on positions. No intermediate, partially on, position is acceptable. After initial operation, leakage not exceeding 20 ml/min is acceptable in the off position (see 7.27.10).

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

6.6.1 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 7.4.

6.6.2 The manufacturer shall specify the average and the upper limit of the service load.

6.7 Strength of heat-responsive element (see 7.10)

6.7.1 When tested in accordance with 7.10.1, glass bulb elements shall

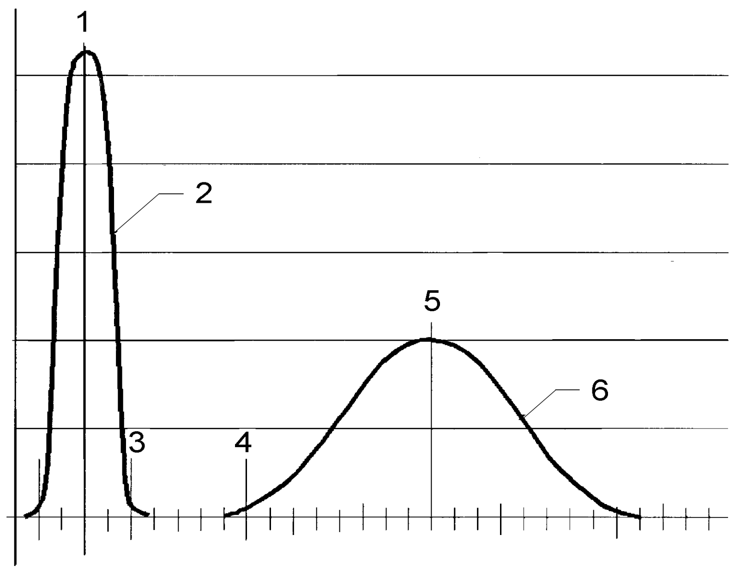
a) have an average design strength of at least six times the average service load, and

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 (*y*) of 0.99 for 99 % of samples (*P*), based on normal or Gaussian distribution except where other distribution can be shown to be more applicable owing to manufacturing of design factors (see Figure 2).

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 7.4 for a period of 100 h when tested in accordance with 7.10.2.1, or

b) demonstrate the ability to sustain the design load when tested in accordance with 7.10.2.2.



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

6.8 Leak resistance and hydrostatic strength (see 7.5)

6.8.1 A sprinkler shall not show any sign of leakage when tested according to 7.5.1.

6.8.2 A sprinkler shall not rupture, operate or release any parts when tested according to 7.5.2.

6.9 Heat exposure (see 7.8)

6.9.1 Glass bulb sprinklers

There shall be no damage to the glass bulb element when the sprinkler is tested according to 7.8.1.

6.9.2 Uncoated sprinklers

Sprinklers shall withstand exposure to increased ambient temperature without evidence of weakness or failure when tested according to 7.8.2.

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 7.8.3.

6.10 Thermal shock (see 7.9)

Glass bulb sprinklers shall not be damaged when tested according to 7.9. Proper operation shall not be considered damage.

6.11 Corrosion

6.11.1 Stress corrosion (see 7.13.1)

When tested in accordance with 7.13.1, each sprinkler shall show no cracks, delaminations or failures which could affect its ability to satisfy other requirements.

6.11.2 Sulfur dioxide corrosion (see 7.13.2)

Coated and uncoated sprinklers shall be resistant to sulfur dioxide saturated with water vapour when conditioned in accordance with 7.13.2. Following exposure, the sprinklers shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with 6.5.1 and shall meet the dynamic heating requirements of 6.14.3 or 6.24 for concealed, flush or recessed sprinklers.

6.11.3 Salt spray corrosion (see 7.13.3)

Coated and uncoated sprinklers shall be resistant to salt spray when conditioned in accordance with 7.13.3. Following exposure, the sprinklers shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with 6.5.1 and shall meet the dynamic heating requirements of 6.14.3 or 6.24 for concealed, flush or recessed sprinklers.

6.11.4 Moist air exposure (see 7.13.4)

Sprinklers shall be resistant to moist air exposure when tested in accordance with 7.13.4. Following exposure, the sprinklers shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with 6.5.1 and shall meet the dynamic heating requirements of 6.14.3 or 6.24 for concealed, flush or recessed sprinklers.

6.12 Coated sprinklers (see 7.8.3)

6.12.1 Exposure to increased ambient temperature

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 by the method specified in 7.8.3.

6.12.2 Evaporation of wax and bitumen (see 7.14.1)

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.

6.12.3 Resistance to low temperatures (see 7.14.2)

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

6.12.4 Resistance to high temperature

Coated sprinklers shall meet the requirement of 6.9.3.

6.13 Water hammer (see 7.16)

Sprinklers shall not leak during or after the pressure surges described in 7.16. After being subjected to the test according to 7.16, 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 7.7.2)

6.14.1 Standard orientation

Standard-, special- and fast-response sprinklers shall meet the RTI and *C* limits shown in Figure 1, when tested in the standard orientation in accordance with 7.7.2. Worst-case orientation can usually be determined by visual inspection. Maximum and minimum RTI values calculated using *C* for fast- and standard-response sprinklers shall fall within the limits of the appropriate category shown in Figure 1. Special-response sprinklers shall have an average RTI value, calculated using *C*, of between 50 and 80, with no value less than 40 or more than 100.

6.14.2 Offset orientation

When tested at an angular offset in accordance with 7.7.2.1.1 to 7.7.2.1.4, each value of RTI, calculated using *C*, shall not exceed 600 % or 250 %, whichever is less, of the average RTI in the standard orientation.

6.14.3 Post-exposure RTI

After exposure to the corrosion test according to 6.11.2, 6.11.3 and 6.11.4, sprinklers shall be tested in the standard orientation in accordance with 7.7.2.1 to determine the post-exposure RTI. None of the post- exposure RTI value shall exceed the limits shown in Figure 1 for the appropriate category. In addition, the average RTI value shall not exceed 130 % of the pre-exposure average value. All post-exposure RTI values shall be calculated as in 7.7.2.3 using the pre-exposure conductivity factor (*C*).

6.15 Resistance to heat (see 7.15)

Open sprinklers shall be resistant to high temperatures when tested in accordance with 7.15. After exposure, the sprinkler shall not show visual deformation or breakage.

6.16 Resistance to vibration (see 7.17)

Sprinklers shall be able to withstand the effects of vibration without deterioration when tested in accordance with 7.17. After the vibration test of 7.17, sprinklers shall show no visible deterioration, 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.

6.17 Resistance to impact (see 7.18)

6.17.1 Conventional, spray, and water-shield sprinklers shall have the strength adequate to withstand impacts associated with handling, transport and installation without deterioration of performance or reliability. After the impact test of 7.18.1, these sprinklers shall show no fracture or deformation, 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.

6.17.2 The water shield of a water-shield sprinkler shall not shear off or bend sufficiently to impair sprinkler function as a result of the impact test given in 7.18.2.

6.18 Crib fire performance (see 7.19)

6.18.1 All 15 mm and 20 mm nominal orifice sprinklers, except sidewall, flat spray and conventional sprinklers, shall control crib fires when tested according to 7.19. For example, for dry type sprinklers, the shortest length manufactured shall be used for this test.

6.18.2 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.

6.18.3 The mean air temperature at the thermocouples shall not exceed 275 °C above ambient temperature for any continuous three-minute period within the remaining test time.

6.18.4 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.

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

6.19 Lateral discharge (see 7.20)

Upright and pendent spray sprinklers shall not prevent the operation of adjacent sprinklers when tested in accordance with 7.20.

6.20 Thirty-day leakage resistance (see 7.21)

Sprinklers shall not leak or sustain distortion or other mechanical damage when subjected to 2 MPa (20 bar) water pressure for 30 days. During this exposure and following exposure, the sprinklers shall satisfy the requirements of 7.21.

6.21 Vacuum resistance (see 7.22)

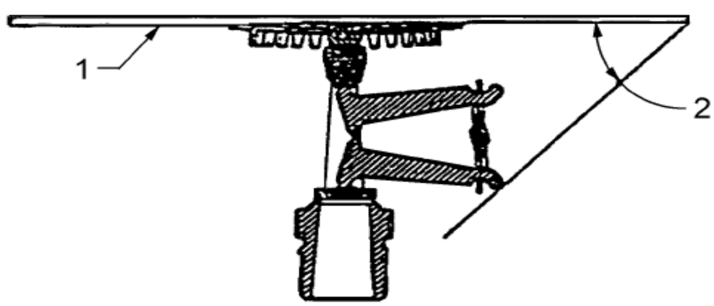
Sprinklers shall not exhibit distortion, mechanical damage or leakage after being subjected to the test given in 7.22.

6.22 Water shield angle of protection (see 7.23)

Water shields shall provide an angle of protection of 45° or less for the heat-responsive element against direct impingement or run-off of water from the shield caused by discharge from sprinklers at higher elevations (see Figure 3). Compliance with this requirement shall be determined in accordance with 7.23.

6.23 Water shield rotation (see 7.24)

Rotation of the water shield shall not alter the sprinkler service load when evaluated in accordance with 7.24.



Key

1 water shield

2 angle of protection

Figure 3 — Angle of protection

6.24 Thermal response of concealed, flush and recessed sprinklers (see 7.25)

6.24.1 Concealed, flush and recessed sprinklers shall meet the requirements of either 6.24.2 or 6.24.3.

6.24.2 When tested in accordance with 7.25.1, concealed, flush, and recessed sprinklers shall operate such that the mean response time of three samples tested at the noted test conditions does not exceed the theoretical maximum response time calculated utilizing the following information:

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 79 °C and 107 °C.

6.24.3 When tested in accordance with 7.25.2, concealed, flush 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) RTI and *C* values according to Table 4;

b) gas temperature and velocity according to Table 5 — 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. See Annex E for sample calculations.

Table 4 — Maximum permitted RTI and *C* combinations

Sprinkler response	RTI $(m.s)^{0,5}$	*C* $(m/s)^{0,5}$	Offset angle (^{o})
Standard	350	1.0	0
Standard	250	2.0	0
Standard	600	5.0	15
Special	80	1.0	0
Special	200	2.5	20
Fast	50	0.8	0
Fast	30	1.0	0
Fast	125	2.0	25

Table 5 — Dynamic heating test apparatus conditions for concealed, flush and recessed sprinklers

Test condition	Gas temperature ^{o}C	Gas velocity m/s	Applied vacuum Pa (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] Millimetres of mercury. Use of this unit is deprecated. 1 mm Hg = 133.3224 Pa.

6.25 Operational cycling of on/off sprinklers (see 7.26)

6.25.1 An on/off sprinkler cycle consists of operation from the closed position to the fully open position and return to the closed position. It shall not be acceptable for an on/off sprinkler to remain in a partially open position. Following 1000 cycles of operation the sprinkler shall comply with 6.8.1, except that leakage not exceeding 20 ml/min is acceptable.

6.25.2 An on/off sprinkler shall operate as intended for 1 000 cycles when tested according to 7.26.1, after being immersed for 14 d in distilled water at a temperature of between 95 °C and 100 °C. Visual observation is usually adequate for determining compliance.

6.25.3 An on/off sprinkler shall show no evidence of clogging when subjected to 1 000 cycles according to 7.26.1 and using water contaminated in accordance with 7.26.2. Immediately following completion of 1 000 cycles, the sprinkler shall comply with the requirement of 6.8.1, except that leakage not exceeding 20 ml/min is acceptable.

6.26 Piled stock fire test for on/off sprinklers (see 7.27)

When tested according to 7.27, an on/off sprinkler shall

a) limit the loss in mass of corrugated cartons (see 7.27.6 to 7.27.8), within 45 min of the start of the test, to not more than 50 %,

b) cause the ceiling temperature of each thermocouple to be reduced to a value less than 295 °C above ambient within 5 min after start of water discharge,

c) cause

1) the ceiling temperature of each thermocouple to not exceed 295 °C above ambient for more than three consecutive minutes, and

2) the average temperature to not exceed 295 °C above ambient from the time the temperature initially falls below 295 °C above ambient to the end of the test, and

d) not remain in an intermediate position, visual observation usually being adequate to determine compliance.

6.27 High temperature exposure for on/off sprinklers (see 7.28)

After being conditioned according to 7.28.1, the change in the average discharge coefficient of an on/off sprinkler shall not exceed 10 % when compared with sprinklers that have not been conditioned.

6.28 Resistance to low temperatures (see 7.29)

Sprinklers shall be resistant to low temperatures when tested according to 7.29. After exposure, the sprinkler may either be visibly damaged, may leak subsequent to thawing or may be undamaged. Sprinklers not visibly damaged shall be subject to 6.8 and shall meet the requirements of 6.3.1.

7 Test methods

7.1 General

The following tests shall be carried out 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 carried out 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. A suggested test programme is illustrated in Figure 4 for guidance.

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

7.2 Preliminary examination

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

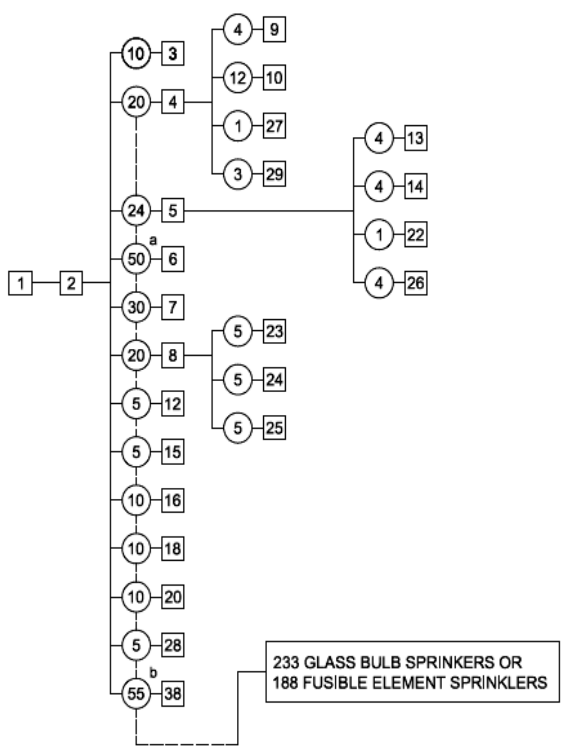
7.3 Visual examination

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

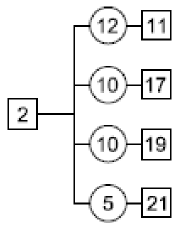
a) marking;

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

c) obvious defects.

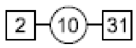


a) Test programme for sprinklers of one orifice size and temperature range

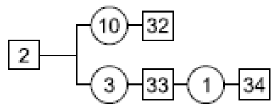


b) Sprinklers for corrosive atmosphere including coated sprinklers

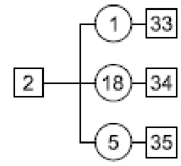
c) Water-shield sprinkler



d) Concealed, flush, or recessed sprinklers



e) Extended coverage sprinkler



f) On/off sprinklers

Key

☐ test programme number

◯ number of sprinklers required

Test programme number

1 preliminary examination (7.2)
2 visual examination (7.3)
3 strength of body (7.4)
4 leak resistance and hydrostatic strength (7.5)
5 functional test (7.6)
6 operating temperature (7.7)
7 dynamic heating (7.7.2)
8 conductivity factor (7.7.2.2)
9 heat exposure (7.8.1)
10 heat exposure (7.8.2)
11 heat exposure, coated (7.8.3)
12 thermal shock (7.9)
13 water flow (7.11)
14 water distribution (7.12)
15 stress corrosion (7.13.1)
16 sulfur dioxide corrosion (7.13.2)
17 sulfur dioxide corrosion, coated (7.13.2)
18 salt spray (7.13.3)
19 salt spray, coated (7.13.3.2)
20 moist air (7.13.4)
21 low temperature, coated (7.14.2)
22 heat resistance (7.15)
23 water hammer (7.16)
24 vibration (7.17)
25 impact (7.18)
26 crib fire test (7.19)
27 lateral discharge (7.20)
28 thirty-day leakage (7.21)
29 vacuum test (7.22)
30 water shield rotation (7.24)
31 thermal response; concealed, flush, recessed (7.24)
32 thermal response; extended coverage (7.25)
33 fire test, extended coverage (7.26)
34 wall wetting (7.27)
35 operational cycling, on/off sprinklers (7.26)
36 piled stock fire test; on/off sprinklers (7.27)
37 high-temperature exposure; on/off sprinklers (7.28)
38 strength of release element (7.9)

[a] Requires 50 glass bulb sprinklers or 10 fusible element sprinklers.

[b] Requires 55 glass bulb sprinklers or 10 fusible element sprinklers. Additional sprinklers and tests are required for b) to f).

Figure 4 — Sprinkler test programmes

7.4 Service load and body strength test (see 6.6)

7.4.1 The service load shall be measured on a minimum of ten sprinklers by securely installing each sprinkler, at room temperature, in a tensile/compression test machine and applying the equivalent of a hydraulic pressure of 1,2 MPa (12 bar) at the inlet.

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 of 1.2 MPa (12 bar) at the inlet.

7.4.2 An indicator capable of reading deflection to an accuracy of 0.01 mm shall be used to measure any change in length of the sprinkler between the load bearing points of the sprinkler body. Movement of the sprinkler shank thread in the threaded bushing of the test machine shall be avoided or taken into account.

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

7.4.3.1 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.

7.4.3.2 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.

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

7.5 Leak resistance and hydrostatic strength test (see 6.8)

7.5.1 Twenty sprinklers shall be subjected to a water pressure of 3 MPa (30 bar).

Increase the pressure from 0 MPa to 3 MPa (0 bar to 30 bar) at a rate of (0,1 ± 0.03) MPa/s [(1 ± 0.3) bar/s], maintain the pressure at 3 MPa (30 bar) 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.

7.5.2 Following the test of 7.5.1, the twenty sprinklers shall be subjected to a water pressure of 4.8 MPa (48 bar). Fill the sprinkler inlet with water at (20 ± 5) °C and vent it of air. Increase the pressure to 4.8 MPa (48 bar) at a rate not exceeding 2.0 MPa/min (20 bar/min). Maintain at 4.8

MPa (48 bar) for 1 min. The sprinkler shall meet the requirements of 6.8.2.

7.6 Functional test (see 6.5.1)

7.6.1 Sprinklers having nominal release temperatures of less than 78 °C, including dry sprinklers that can be accommodated in the test equipment, shall be heated in an oven. While being heated, they shall be subjected to each of the water pressures specified in 7.6.3 applied to their inlet. The oven is shown in Figure 5. The temperature of the oven shall be increased to (400 ± 20) °C within 3 min, local to the sprinkler.

7.6.2 Sprinklers having higher nominal release temperatures and dry sprinklers shall be heated using a suitable heat source. Heating shall continue until the sprinkler has operated.

7.6.3 Eight sprinklers shall be tested in each normal mounting position and at each of the following pressures (a total of 24 sprinklers):

- 0.035 MPa (0.35 bar) for all sprinklers other than dry upright sprinklers, or 0.50 MPa (0,5 bar) for dry upright sprinklers only;
- 0.35 MPa (3.5 bar);
- 1.2 MPa (12.0 bar).

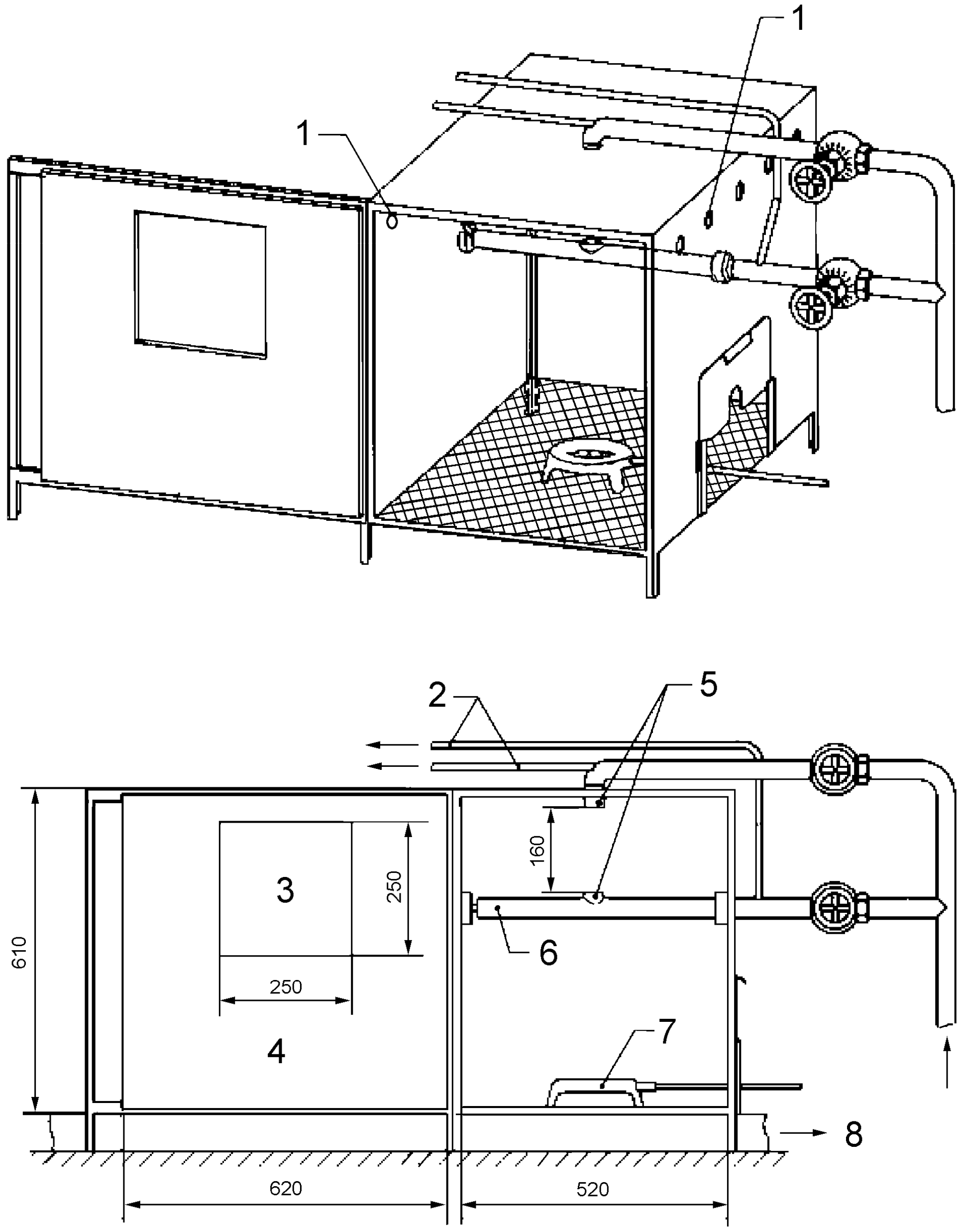
The flowing pressure shall be at least 75 % of the initial operating pressure. The oven temperature shall be measured local to the sprinkler.

7.6.4 If lodgement occurs at any pressure level and mounting position, 24 more sprinklers shall be tested in that mounting position and at that pressure. The total number of sprinklers in which lodgement occurs shall not exceed one out of the 32 sprinklers tested at that pressure and in that mounting position.

7.6.5 Lodgement is considered to have occurred when one or more of the released parts lodge in the deflector frame assembly such as to cause failure to meet the water distribution requirement of 6.4.2 after the period of time specified in 6.5.1.

7.6.6 In order to check the strength of the deflector, three sprinklers shall be submitted to the functional test in each normal mounting position at a pressure of 1.2 MPa (12 bar). The water shall be allowed to flow at a running pressure of 1.2 MPa (12 bar) for a period of 15 min.

Dimensions in millimetres



Key

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

Figure 5 — Typical functional test oven

7.7 Operating temperature test (see 6.3)

7.7.1 Test of static operation

Fifty glass bulb sprinklers or ten fusible element sprinklers shall be heated from a temperature of (20 ± 5)^0 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.

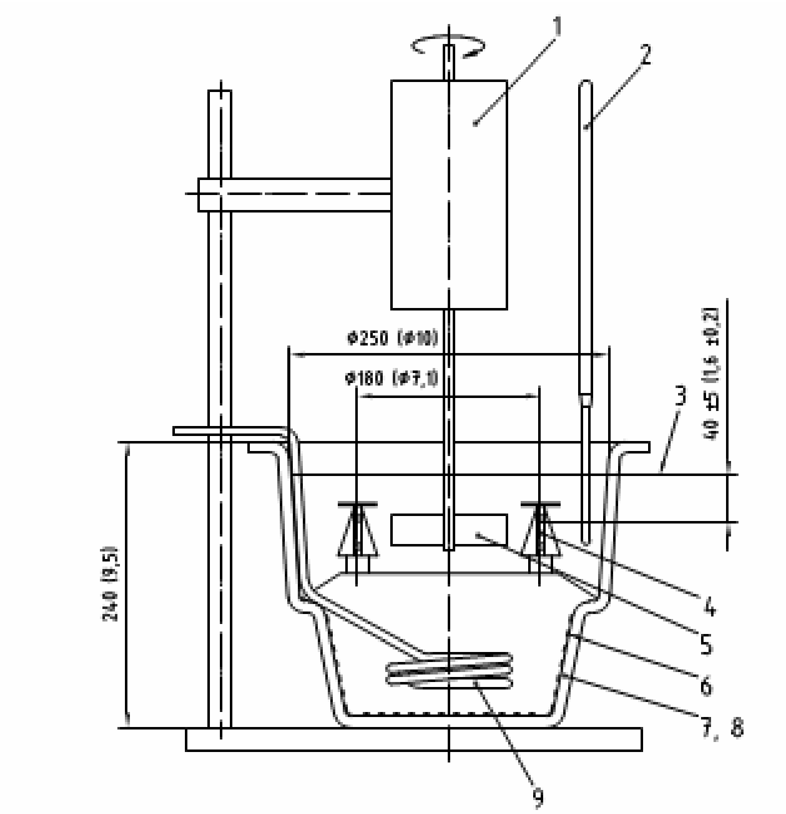
The nominal operating temperature shall be ascertained with equipment having an accuracy of ± 0,25 % of the nominal temperature rating.

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.

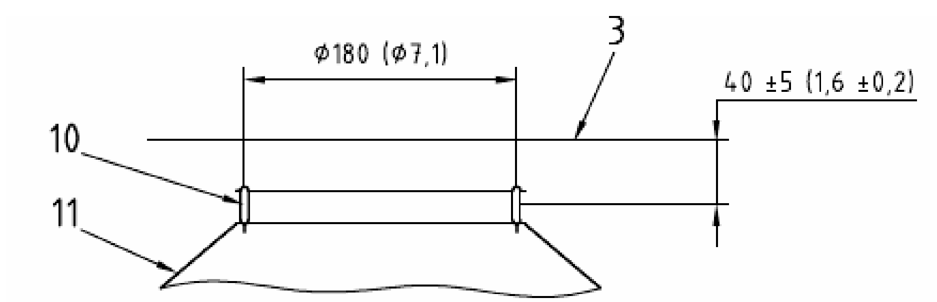
The sprinklers shall be located in the liquid bath in a vertical position and totally immersed under a liquid cover of (5^{3}_{0})mm. The test zone is located at a distance, below the liquid surface, level with the geometric centre of the glass bulb or fusible element. The test zone shall be at, if possible, but not less than, (40 ± 5) mm below the liquid surface level. The temperature deviation within the test zone shall be within ± 0.25 °C.

Any rupture of a glass bulb within the prescribed temperature rate constitutes an operation. Partial fracture of a glass bulb which does not result in sprinkler operation shall necessitate an additional functional test (see 6.5.1).

An example of a standardized liquid bath is shown in Figure 6. 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 DIN EN 60751 thermocouple may be used.



a) Setup for 10 to 15 spinklers



b) Ring support for 50 glass bulb sprintlers

Key

1 speed agitator, 150 r/min

2 thermometer calibrated for 40 mm [1,6] immersion and PT-100

3 liquid level

4 ring to support 10 sprinklers, 3/4″, or 15 sprinklers, 1/2″

5 1 double wing 100 mm × 20 mm [3,9 × 8]

6 mesh screen

7 standard glass vessel

8 dessiccator, ∅250 [10], liquid volume, approx. 7 l

9 immersion heater

10 glass bulbs

11 ring to support 50 glass bulbs

Figure 6 — Liquid bath

7.7.2 Dynamic heating test (see 6.14)

7.7.2.1 Plunge test

7.7.2.1.1 Using a single temperature rating, ten plunge tests shall be performed at the standard and worst-case orientations. Ten additional samples shall be plunge-tested at the offset orientation as specified in 7.7.2.1.2 to 7.7.2.1.4. The RTI shall be calculated according to 7.7.2.3 and 7.7.2.4 for each orientation, respectively. For all remaining temperature ratings, 10 samples of each temperature rating shall be tested in the standard orientation.

The plunge tests shall be conducted using a brass sprinkler mount designed such that the mount or water temperature rise (as measured by a thermocouple heatsinked and embedded in the mount not more than 8 mm radially outward from the root diameter of the internal thread or by a thermocouple located in the water at the centre of the sprinkler inlet) does not exceed 2 °C for the duration of an individual plunge test up to a response time of 55 s. If the response time is greater than 55 s, then the mount or water temperature in degrees Celsius shall not increase more than 0,036 times the response time in seconds for the duration of an individual plunge test.

The sprinkler under test shall have one wrap to 1.5 wraps of PTFE sealant tape applied to the sprinkler threads. It shall be screwed into a mount to a torque of (15 ± 3) Nm. Each sprinkler shall be mounted on a tunnel test section cover and maintained in a conditioning chamber to allow the sprinkler and cover to reach ambient temperature for a period of not less than 30 min.

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

All sprinklers shall be tested with the inlet end of each sample connected to a source of pressure at 0.05 MPa (0.5 bar).

For evaluation of dry type sprinklers, the shortest length manufactured shall be used.

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 air flow and temperature conditions at the test section (sprinkler location) selected from the appropriate range of the conditions given in Table 6. 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 6. 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 6.

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

Air temperature ranges [a]				Velocity ranges [b]		
Nominal operating temperatures °C	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	1.65 to 1.85
79 to 107	282 to 300	191 to 203	191 to 203	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
121 to 149	382 to 432	282 to 300	282 to 300	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
163 to 191	382 to 432	382 to 432	382 to 432	3.4 to 3.6	2.4 to 2.6	1.65 to 1.85

[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 1,65 m/s to 1,85 m/s and 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.

7.7.2.1.2 Standard response sprinklers shall be tested at an angular offset of 15° from the worst-case orientation.

7.7.2.1.3 Special response sprinklers shall be tested at an angular offset of 20° from the worst-case orientation.

7.7.2.1.4 Fast-response sprinklers shall be tested at an angular offset of 25° from the worst-case orientation.

7.7.2.1.5 RTI is calculated as described in 7.7.2.3 and 7.7.2.4 for the appropriate orientation.

7.7.2.1.6 If a single sprinkler design is submitted in multiple temperature ratings, the worst case of orientation and the *C*-factor shall be determined by testing one temperature rating only.

7.7.2.2 Determination of conductivity factor (*C*)

7.7.2.2.1 General

The conductivity factor (*C*) shall be determined using the prolonged plunge test (see 7.7.2.2.2) or the prolonged exposure ramp test (see 7.7.2.2.3).

7.7.2.2.2 Prolonged plunge test

The prolonged plunge test is an iterative process to determine *C* and may require up to twenty sprinkler samples. A new sprinkler sample must be used for each test in this section even if the sample does not operate during the prolonged plunge test.

The sprinkler under test shall have 1 to 1.5 wraps of PTFE sealant tape applied to the sprinkler threads. It shall be screwed into a mount to a torque of (15 ± 3) Nm. Each sprinkler is to be mounted on a tunnel test section cover and maintained in a conditioning chamber to allow the sprinkler and cover to reach ambient temperature for a period of not less than 30 min.

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

All sprinklers shall be tested with the inlet end of each sample connected to a source of pressure at 0,05 MPa (0.5 bar).

Dry sprinklers of the shortest length manufactured shall be tested.

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.

The mount temperature shall be maintained at (20 ± 0.5) °C for the duration of each test. The air velocity in the tunnel test section at the sprinkler location shall be maintained with ± 2 % of the selected velocity. Air temperature shall be selected and maintained during the test as specified in Table 7.

The range of permissible tunnel operating conditions is given in Table 7. The selected operating condition shall be maintained for the duration of the test with the tolerances as specified in Table 7.

Table 7 — Range of test conditions for conductivity factor (*C*) determination at test section (sprinkler location)

Temperatures in degrees Celsius (°C)

Nominal operating temperature	Air temperature	Maximum variation of air temperature during test from selected temperatures
57	85 to 91	± 1.0
58 to 77	124 to 130	± 1.5
79 to 107	193 to 201	± 3.0
121 to 149	287 to 295	± 4.5
163 to 191	402 to 412	± 6.0

To determine *C*, the sprinkler is immersed in the test stream at various air velocities for a maximum of 15 min. Velocities are chosen such that actuation is bracketed between two successive test velocities. That is, two velocities must be established such that at the lower velocity (u_L) actuation does not occur in the 15-min test interval. At the next higher velocity (u_H), actuation must occur within the 15-min time limit. If the sprinkler does not operate at the highest velocity, select an air temperature from Table 7 for the next higher temperature range.

If *C* is determined to be less than 0,5 $(m/s)^{0,5}$, a *C* value of 0,25 $(m/s)^{0,5}$ shall be assumed for calculating RTI values.

Test velocity selection shall ensure that:

$$(u_H/u_L)^{0.5} \leq 1,1$$

The test *C* value is the average of the values calculated at the two velocities using the following equation:

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

where

ΔT_g is the actual gas (air) temperature minus the mount temperature (T_m), expressed in degrees Celsius (see 7.7.1 and 7.7.2.1);

ΔT_{ea} is the mean liquid bath operating temperature minus the mount temperature (T_m), expressed in degrees Celsius (see 7.7.1 and 7.7.2.1);

u is the actual air velocity in the test section, expressed in metres per second.

The sprinkler C value is determined by repeating the bracketing procedure three times and calculating the numerical average of the three C values. This sprinkler C value is used to calculate all standard orientation RTI values for determining compliance with 6.14.

For sample calculation see C.1.

7.7.2.2.3 Prolonged exposure ramp test

The prolonged exposure ramp test for the determination of the parameter C shall be carried out in the test section of a wind tunnel and with the requirements for the temperature in the sprinkler mount as described for the dynamic heating test. A preconditioning of the sprinklers is not necessary.

Ten samples of each sprinkler type shall be tested, all sprinklers positioned in standard orientation. The sprinklers shall be plunged into an air stream of a constant velocity of 1 m/s ± 10 % and an air temperature at the nominal operating temperature of the sprinkler at the beginning of the test.

The air temperature shall then be increased at a rate of (1 ± 0.25) °C/min until the sprinkler operates. The air temperature, velocity and mount temperature shall be controlled from the initiation of the rate of rise and shall be measured and recorded at sprinkler operation.

The C value is determined using the same equation as in 7.7.2.2.2 as the average of the ten test values:

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

This method is suitable for sprinklers of all nominal operating temperatures.

7.7.2.3 RTI value calculation

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

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

where

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

u is the actual air velocity in the test section of the tunnel from Table 6, expressed in metres per second;

ΔT_{ea} is the mean liquid bath operating temperature of the sprinkler minus the ambient temperature, expressed in degrees Celsius (see 7.7.2.1);

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

C is the conductivity factor as determined in 7.7.2.2.

For a sample calculation, see C.2.1.

7.7.2.4 Determination of worst-case orientation RTI

The calculation of RTI for the worst-case orientation requires the *C* for the worst-case orientation which is larger than the *C* for the standard orientation by a multiplier. This multiplier is equal to the ratio of the average RTI for the worst-case orientation to the average RTI for the standard orientation. The plunge test expression, therefore, becomes implicit for the RTI in the worst-case orientation, which can be solved iteratively.

For a sample calculation, see C.2.2.

In the case of fast-response sprinklers, if a solution for the worst-case orientation RTI is unattainable, plunge testing in the worst-case orientation shall be repeated using the plunge test conditions under the columns entitled “Special response sprinklers” given in Table 6.

7.8 Heat exposure test (see 6.9)

7.8.1 Glass bulb sprinklers (see 6.9.1)

Four glass bulb sprinklers having nominal release temperatures of ≤ 80 °C shall be heated in a demineralized water bath 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. Glycerine, vegetable oil or synthetic oil shall be used for higher-rated release elements.

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

7.8.2 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 7, whichever is lower, but not less than 49 °C. If the service load is dependent on the service pressure, sprinklers shall be tested under a pressure of 1.2 MPa (12 bar). After exposure, four of the sprinklers shall be subjected to the requirements of 6.8.1 and 6.14.3, four sprinklers to the requirements of 6.5.1 [two at 0.35 MPa (3.5 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.

7.8.3 Coated sprinklers (see 6.9.3)

In addition to the test exposure of 7.8.2 in an uncoated version, twelve coated sprinklers shall be exposed to the test of 7.8.2 using the temperatures given in Table 8 for coated sprinklers.

The test shall be conducted for 90 days. During this period, the sprinklers shall be removed from the oven at intervals of 7 days and allowed to cool for 2 h to 4 h. Following this cooling period, the samples shall be examined. 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 0.35 MPa (3.5 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 coated and uncoated sprinklers

Temperatures in degrees Celsius

Nominal	Uncoated	Coated
57 to 60	49	49
61 to 77	52	52
78 to 107	79	79
108 to 149	121	121
150 to 191	149	149
192 to 246	191	191
247 to 302	246	246
303 to 343	302	302

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

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

7.9.2 Sprinklers having nominal operating temperatures less than or equal to 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 temperature of the bath shall be (10 ±0,5) °C below the lower limit of the tolerance range of the operating temperature of the sprinklers. After 5 min, remove the sprinklers from the bath and immerse them immediately in another bath of liquid (demineralized water), with the bulb seal downwards, at a temperature of (10 ± 0,5) °C. Then test the sprinklers in accordance with 6.5.1.

7.10 Strength test for release elements (see 6.7)

7.10.1 General

At least 55 glass bulbs of the same design 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.

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.

Using the lowest 50 measured bulb strength results, calculate the average strength and the lower tolerance limit (LTL) for bulb strength (see Annex C). Using the values of service load recorded in 7.4.1, calculate the upper tolerance limit (UTL) for the sprinkler release element service load (see Annex B). Verify compliance with 6.7.1.

7.10.2 Fusible elements

7.10.2.1 Determine compliance with the requirements of 6.7.2 a) by subjecting at least ten samples to 15 times the maximum design load for 100 h. Abnormal failures, i.e. those not related to evaluation of the fusible material, shall not be used.

7.10.2.2 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 C). At least 10 samples shall be subjected to different loads up to 15 times the maximum design load. Abnormal failures shall be rejected. Plot a full logarithmic regression curve using the method of least squares, and from this calculate the load at 1 h, L_o, and the load at 1 000 h, L_M, where

$$L_d \leq 1,02\ L_M^2/L_o$$

where L_o is the load at 1 h.

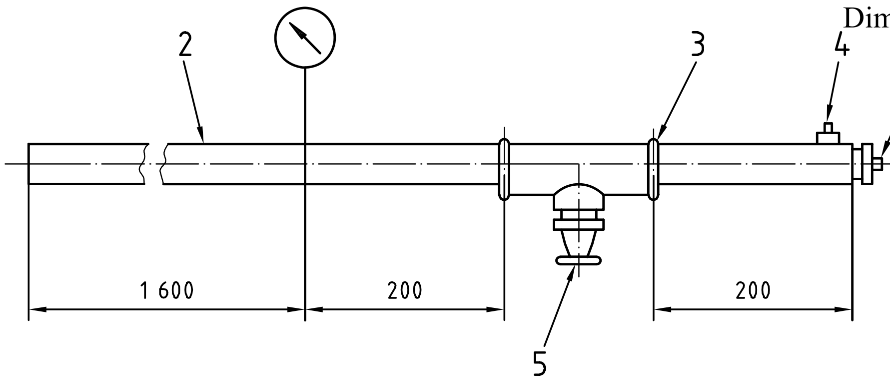
7.10.2.3 The tests of 7.10.2.1 and 7.10.2.2 shall be conducted at an ambient temperature of (20 ± 3) °C.

7.11 Water flow test (see 6.4.1)

The sprinkler shall be mounted with a pressure gauge on a supply pipe as shown in Figure 7. Four sprinklers shall be tested. The frame arms and deflector of sprinklers may be removed to facilitate testing, except in the case of on/off sprinklers. Component parts of on/off sprinklers, such as deflectors, may be removed only providing they do not influence the function of the water-flow control valve. The waterways of on/off sprinklers shall be opened by applying heat to the heat-sensitive element. The water flow shall be measured at pressures of 0.05 MPa to 0.65 MPa (0.5 bar to 6.5 bar) at intervals of 0.1 MPa (1 bar). In one series of tests, the pressure shall be increased to each value, while in the other series, the pressure shall be decreased from 0.65 MPa (6,5 bar) to each value. 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

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

Figure 7 — Water flow test apparatus

7.12 Water distribution tests

7.12.1 Sprinklers other than sidewall types

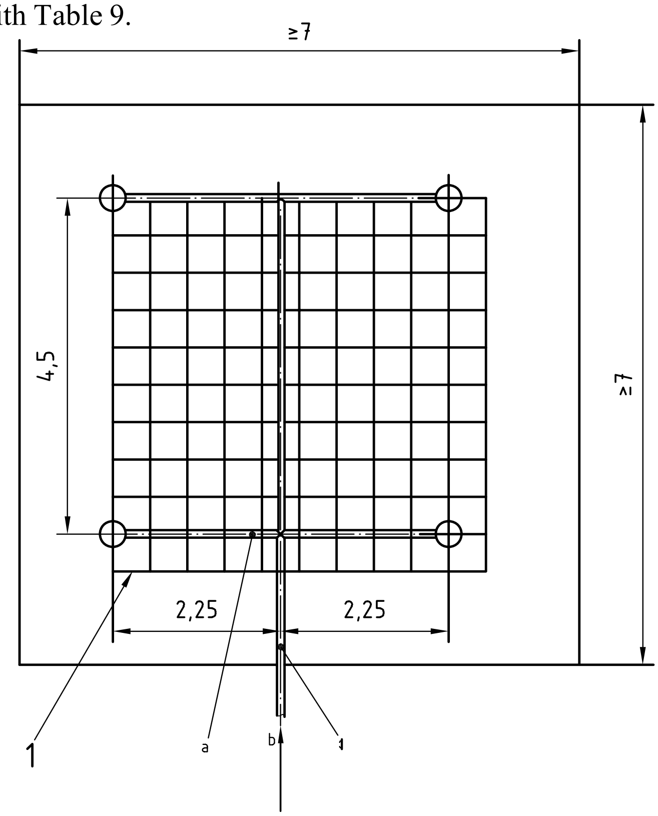
In a test chamber of minimum dimensions 7 m × 7 m, install four sprinklers of the same type and orifice size, arranged in a square, on piping prepared for this purpose. The arrangements of the piping and containers are shown in Figures 8 to 11. The yoke arms of the sprinklers shall be parallel to the supply pipes. Dry type sprinklers of the shortest manufactured length shall be tested.

The distance between the ceiling and the distribution plate 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 “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 9.

Dimensions in metres



Key

1 collecting pans (0,5 m – 0,5 m)

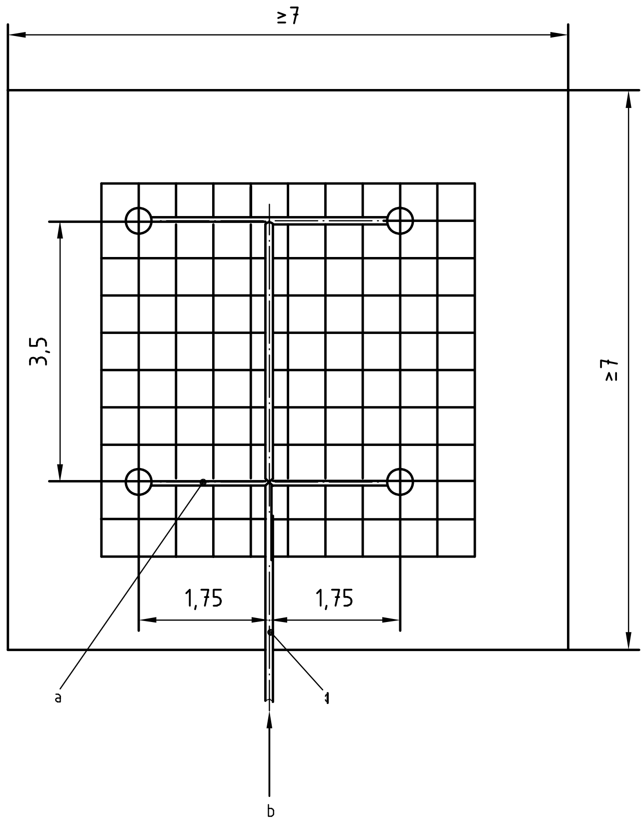
a Nominal bore is 25 mm.

b Water flow.

c Nominal bore is 65 mm.

Figure 8 — Layout of water distribution collection room — Measured area: 20,25 m^2

Dimensions in metres



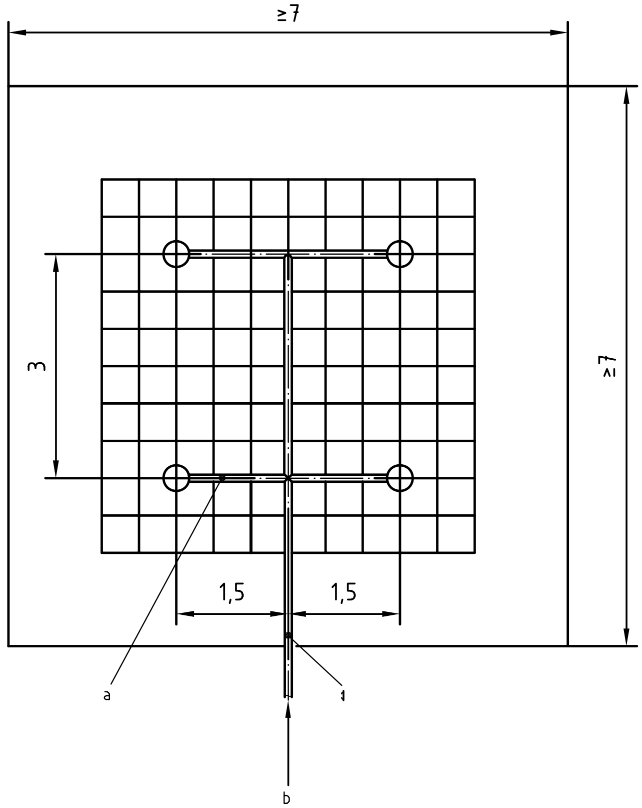
a Nominal bore is 25 mm.

b Water flow.

c BS 1387 medium tube of nominal bore 65 mm.

Figure 9 — Layout of water distribution collection room — Measured area: 12,25 m^2

Dimensions in metres



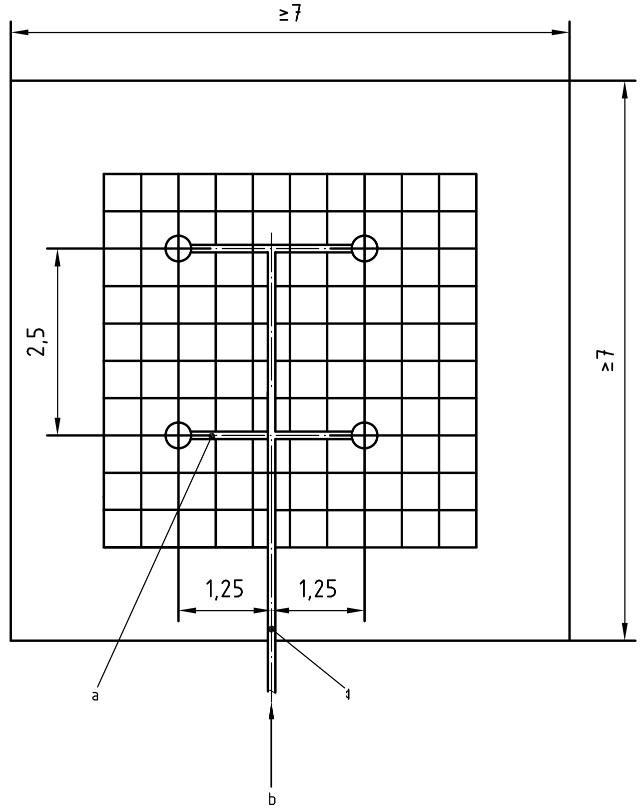
a Nominal bore is 25 mm.

b Water flow.

c BS 1387 medium tube of nominal bore 65 mm.

Figure 10 — Layout of water distribution collection room — Measured area: 9 m²

Dimensions in metres



a Nominal bore is 25 mm.

b Water flow.

c BS 1387 medium tube of nominal bore 65 mm.

Figure 11 — Layout of water distribution collection room — Measured area: 9 m^2

The water distribution in the protected area between the four sprinklers shall be measured by means of square containers measuring 500 mm on a side. The distance between the ceiling and the upper edge of the measuring containers shall be 2,7 m. The measuring containers shall be positioned centrally in the room, beneath the four sprinklers. The number of containers in which the quantity of water is less than 50 % of the water coverage given in Table 9 shall not exceed the value specified in column 6 of Table 9.

Table 9 — Water distribution

Nominal diameter of orifice mm	Water coverage mm/min	Flow rate per sprinkler l/min	Protected area m^2	Sprinkler spacing m	Permitted number of containers with a lower content of water
10	2.5	50.6	20.25	4.5	8
15	5.0	61.3	12.25	3.5	5
20	15.0	135.0	9.00	3.0	4
	10.0	90.0	9.00	3.0	4
	30.0	187.5	6.25	2.5	3

7.12.2 Sidewall sprinklers (see 6.4.2)

In a test chamber of minimum dimensions 7 m x 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 13 and 14.

The distance between the ceiling and the deflector of each sprinkler shall be 100 mm (see Figure 13).

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 12 and 13. 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 nonporous material. The water shall be directed from the nonporous material into the line of containers on the floor adjacent to the wall. (See Figures 12 and 13).

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

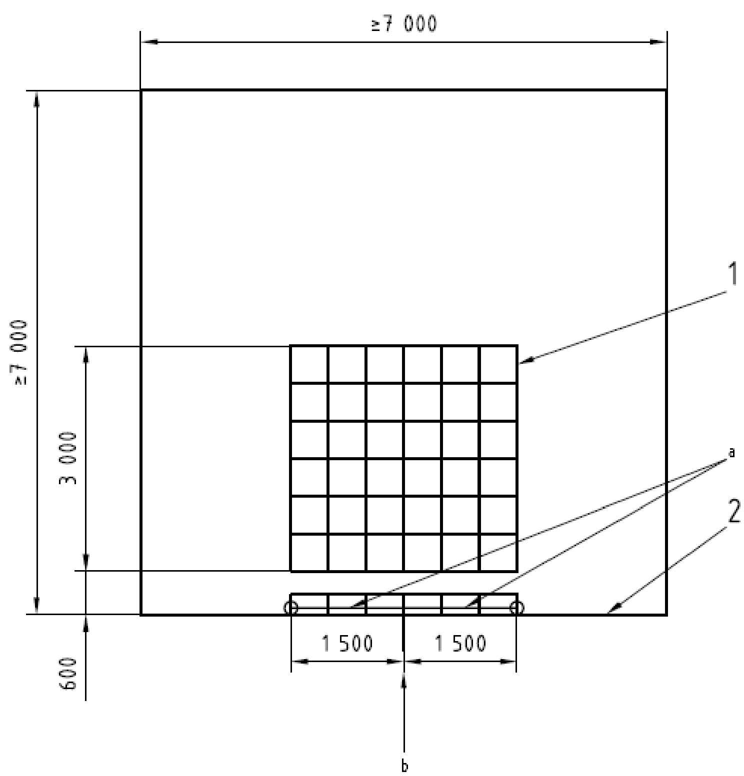
The total quantity of water collected in these containers shall be a minimum of 3.5 % of the total water discharged from the sprinklers during the test.

For sidewall sprinklers having a nominal orifice diameter of 15 mm 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 20 mm nominal orifice diameter sidewall sprinklers, 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.

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 13). 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

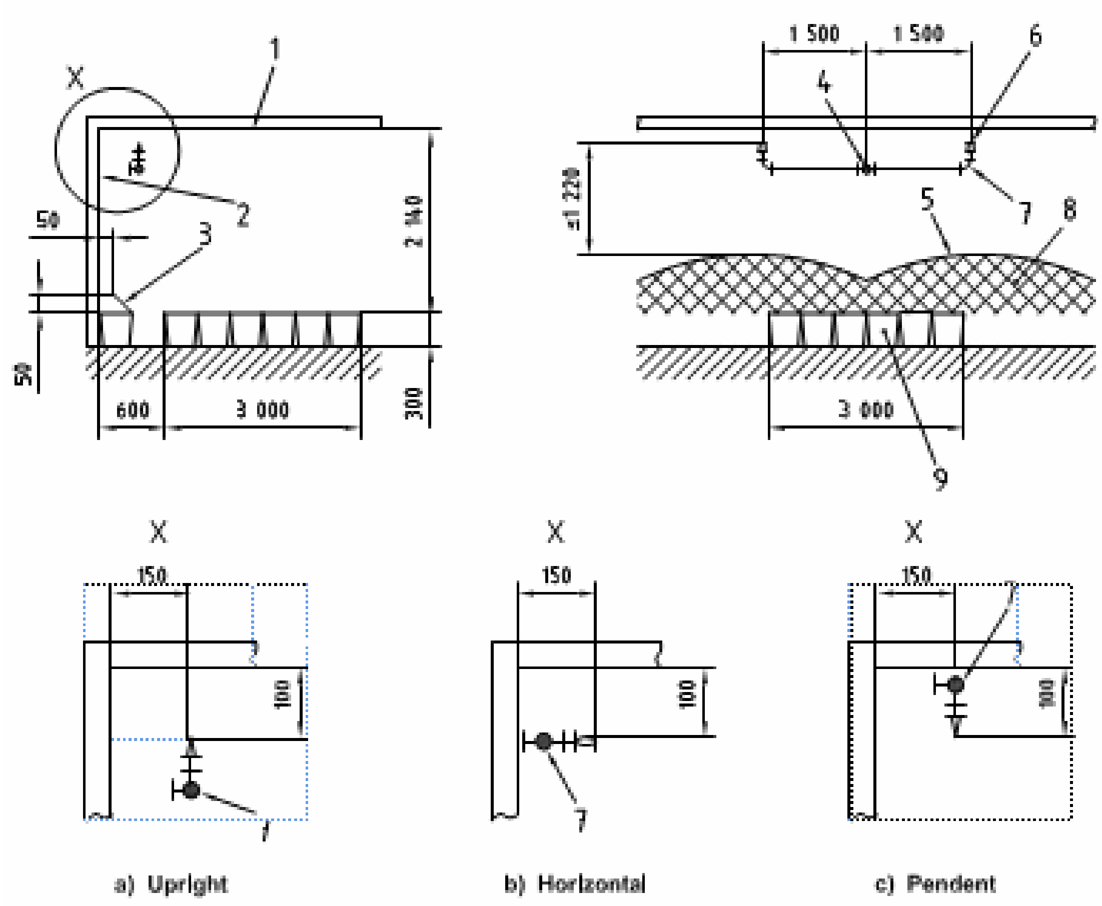
1 500 mm square container — typical

2 back wall

a Nominal pipe diameter is 25 mm.

b Water flow.

Figure 12 — Plan view of sidewall distribution collection room



Key

1 ceiling

2 back wall

3 baffle

4 tee

5 back wall water contact line

6 sprinkler (two required)

7 90⁰ reducer elbow (two required)

8 wetted area

9 500 mm square containers

NOTE Nominal pipe diameter is 25 mm.

Figure 13 — Sidewall sprinkler installation for water distribution test

7.12.3 Water distribution above and below the deflector

The water discharge of sprinklers downward from the deflectors shall be

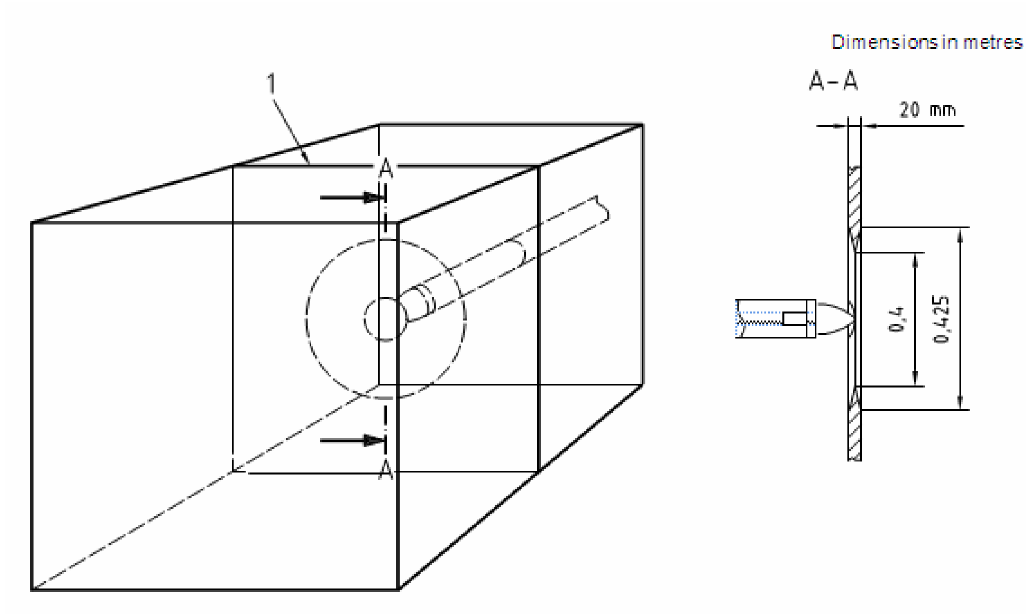
- 40 % to 60 % for conventional sprinklers, and
- 80 % to 100 % for spray sprinklers.

Sprinklers shall be installed horizontally in a test rig, the important features of which are shown in Figure 14. 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 10.

Table 10 — Flow condition

Nominal orifice diameter mm	Water flow rate l/min
10	50.6
15	61.3
20	90.0



Key

1 partition

Figure 14 — Apparatus for determining water distribution above and below the deflectors

7.13 Corrosion tests (see 6.11)

7.13.1 Stress corrosion test with aqueous ammonia solution (see 6.11.1)

Five sprinklers 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 of volume (0.02 ± 0.01) m^3.

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 vapour, 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 condensate drippage. 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 carry out 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 1.2 MPa (12 bar) for 1 min and to the functional 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 1.2 MPa (12 bar) for 30 min.

7.13.2 Sulfur dioxide corrosion test (see 6.11.2)

Ten coated and ten uncoated sprinklers shall be subjected to the following sulfur dioxide corrosion test. For evaluation of dry type sprinklers, the shortest length manufactured shall be used. The inlet of each sample shall be filled with water and sealed with a nonreactive (e.g. plastic) cap.

The test equipment shall consist of a 5 *l* vessel (instead of a 5 *l* vessel, other volumes up to 15 *l* may be used, provided the quantities of chemicals given below are increased in proportion) made of heat-resistant glass, with a corrosion-resistant lid of such a shape as to prevent condensate dripping on the sprinklers. The vessel shall be electrically heated through the base, and provided with a cooling coil around the side walls. A temperature sensor placed centrally 160 mm ± 20 mm above the bottom of the vessel shall regulate the heating so that the temperature inside the glass vessel is 45 °C ± 3 °C. During the test, water shall flow through the cooling coil at a rate sufficient to keep the temperature of the discharge water below 30 °C. This combination of heating and cooling should encourage condensation on the surfaces of the sprinklers. Specimens shall be shielded from condensate drippage.

The sprinklers to be tested shall be suspended in their normal mounting position under the lid inside the vessel. Uncoated sprinklers shall be subjected to a sulfur dioxide atmosphere for 8 d. Coated sprinklers shall be subjected to the sulfur dioxide atmosphere for 16 days. The sulfur dioxide atmosphere shall be obtained by introducing a solution made up by dissolving 20 g of sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$) crystals in 500 ml of water.

The test shall last for one 8-d period for uncoated sprinklers or two 8-d periods for coated sprinklers.

For at least 6 d out of each 8-day period, 20 ml of dilute sulfuric acid consisting of 156 ml of normal H_2SO_4 (0,5 mol/l) diluted with 844 ml of water shall be added at a constant rate. After 8 d, the sprinklers shall be removed from the vessel. This procedure shall be repeated for the second 8-d period for coated sprinklers after the vessel has been emptied and cleaned.

After a total of 8 d for uncoated sprinklers or 16 d for coated sprinklers, the samples shall be removed from the container and allowed to dry for 4 d to 7 d at a temperature not exceeding 35 °C with a relative humidity not greater than 70 %.

After the drying period, five sprinklers shall be functionally tested at 0.035 MPa (0.35 bar) in accordance with 6.5.1, and five sprinklers shall be subjected to the dynamic heating test according to 6.14.2.

7.13.3 Salt spray corrosion test (see 6.11.3)

7.13.3.1 Sprinklers for normal atmospheres

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

During the corrosive exposure, the inlet thread orifice shall be sealed by a nonreactive cap after the sprinklers have been filled with deionized water. The salt solution shall be a 20 %-by-mass sodium chloride solution in 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 (excepting 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 condensate drippage.

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, five sprinklers shall be functionally tested at 0.035 MPa (0.35 bar) only, in accordance with 6.5.1, and five sprinklers shall be subjected to the dynamic heating test according to 6.14.2.

7.13.3.2 Sprinklers for corrosive atmospheres

Sprinklers intended to be used in corrosive atmospheres shall be subjected to the tests specified in 7.13.3.1, except that the duration of the salt spray exposure shall be extended from 10 d to 30 d.

7.13.4 Moist air exposure (see 6.11.4)

Ten sprinklers shall be exposed to a high temperature-humidity atmosphere consisting of a relative humidity of 98 % ± 2 % and a temperature of 95 °C ± 4 °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 0.05 MPa (0.5 bar) only, and five sprinklers shall be subjected to the dynamic heating test (see 6.14.2).

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

7.14 Tests for sprinkler coatings

7.14.1 Evaporation test (see 6.12.2)

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 90-day exposure to determine any loss of volatile matter; the sample shall meet the requirements of 6.12.2.

7.14.2 Low-temperature test (see 6.12.3)

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 6.12.3.

7.15 Heat-resistance test (see 6.15)

One sprinkler body shall be heated in an oven at 800 °C for a period of 15 min, with the sprinkler in its normal installed position. 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. It shall meet the requirements of 6.15.

7.16 Water-hammer test (see 6.13)

7.16.1 Five sprinklers shall be connected, in their normal operating position, to the test equipment. After purging the air from the sprinklers and the test equipment, 3 000 cycles of pressure varying from (0.4 ± 0.05) MPa [(4 ± 0.5) bar] to (3.0 ± 0.1) MPa [(30 ± 1) bar] shall be generated. The pressure shall be raised from 4 bar to 30 bar at a rate of (10 ± 1,0) MPa/s [(100 ± 10) bar/s]. At least 30 cycles of pressure per minute shall be generated. The pressure shall be measured with an electrical pressure transducer.

7.16.2 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.

7.17 Vibration test (see 6.16)

7.17.1 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.

7.17.2 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.

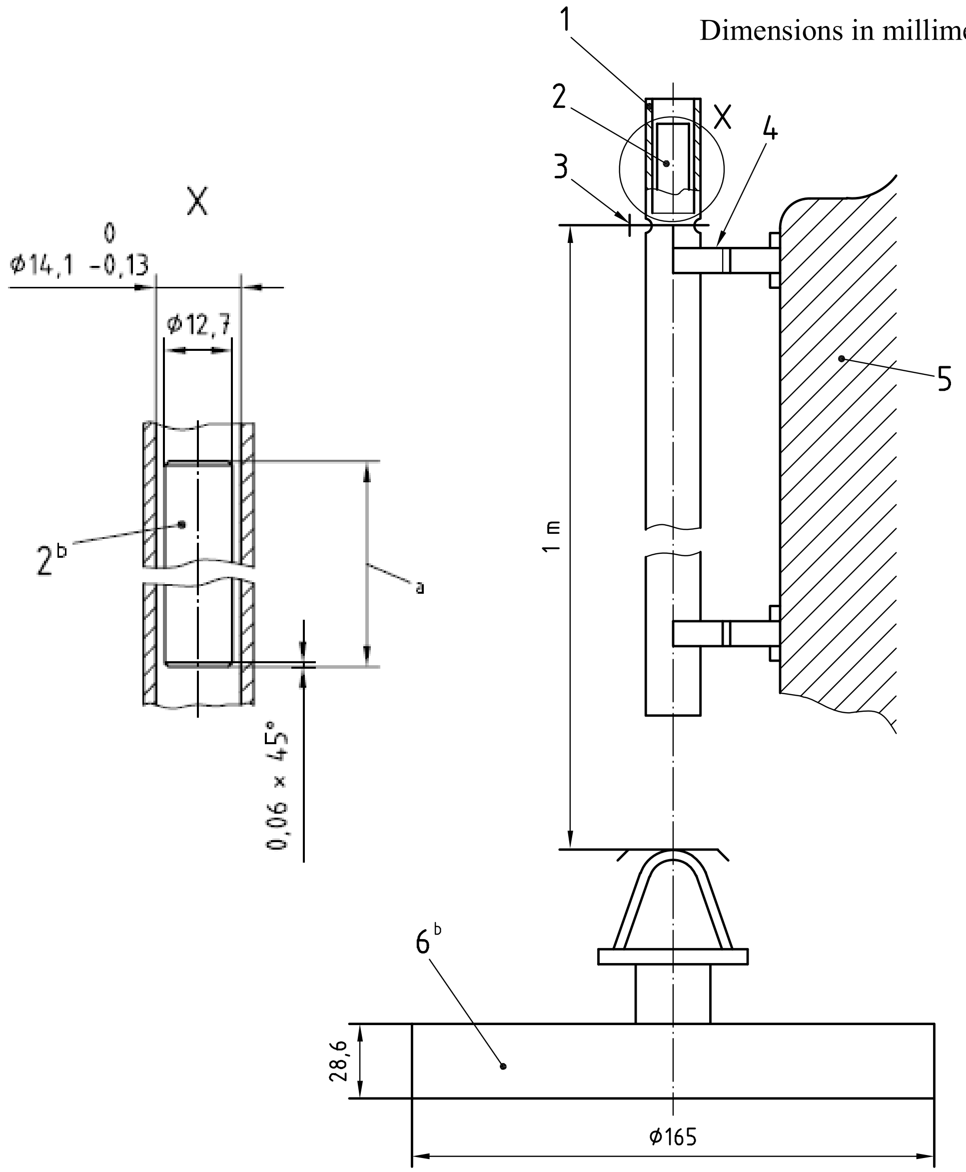
7.17.3 After vibration, each sprinkler shall be subjected to the leak resistance requirement of 6.8.1 and the functional requirement of 6.5.1 at a pressure of 0.035 MPa (0.35 bar) only

7.18 Impact test (see 6.17)

7.18.1 Five sprinklers, other than dry type, shall be impact-tested by dropping a weight onto the deflector end of the sprinkler along the axial centreline of the waterway. Sprinklers provided with shipping caps, which are intended for removal only after completion of the sprinkler installation, shall be impact tested with the caps in place. The kinetic energy of the dropped weight at the point of impact shall be equivalent to a weight equal to that of the test sprinkler dropped from a height of 1 m (see Figure 15). 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.

7.18.2 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	weight
3	latching pin
4	adjustable brackets (2)
5	rigid support
6	sprinkler support
a	Length to be determined (length or required weight).
b	Cold finished steel.

Figure 15 — Impact test apparatus

7.19 Crib fire test (see 6.18)

7.19.1 Fire test assembly

7.19.1.1 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 16).

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 2400 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 frame work shall be sufficiently large to span the steel pan described in 7.19.1.3.

Dimensions in millimetres

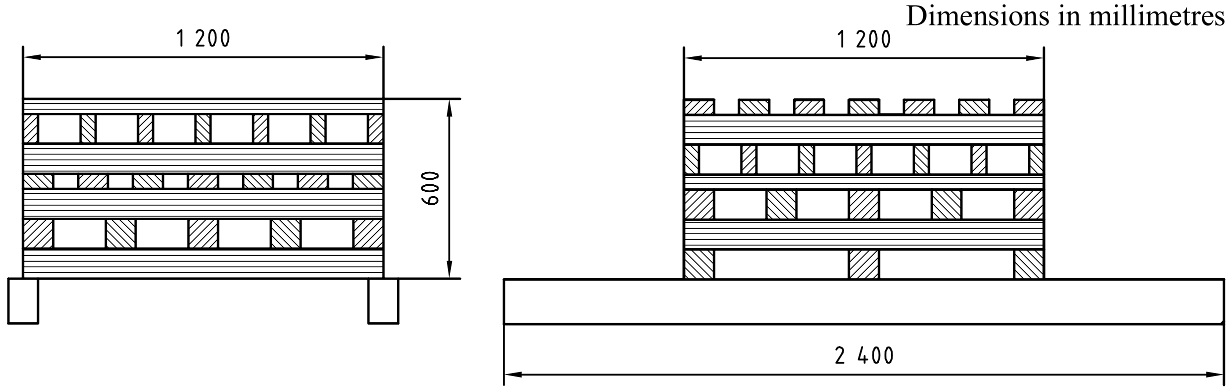


Figure 16 — Test crib

7.19.1.2 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 16. The spray shall form a hollow cone having an angle of approximately 75^0 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.

7.19.1.3 The steel pan shall be 1800 mm x 2 400 mm x 300 mm (depth), constructed of steel plate not less than 5.4 mm thick. The upper corners shall be reinforced by a continuous steel band. The pan shall be liquid-tight and, prior to the test, shall be filled with water to a depth of 100 mm. The pan shall be provided with means of drainage to maintain the water level at 100 mm.

7.19.2 Sprinkler installation

7.19.2.1 Four open sprinklers of the same type and orifice size shall be placed under an unobstructed portion of ceiling having a minimum area of 5000 mm x 5000 mm. The sprinklers shall be mounted in a square configuration, using balanced piping (see Figure 17), with 3000 mm between the sprinklers on each side. The ceiling shall be located (2500 ±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.

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

7.19.2.3 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.

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

7.19.3 Test room

The test room shall be a ventilated, draught-free enclosure and shall have a minimum floor area of 144 m^2, with no floor dimension less than 12 m. Test rooms having a floor area of not less than 100 m^2 with no floor dimension less than 10 m are acceptable provided that the calibration values are comparable. The ceiling height shall be sufficient to accommodate the assembly as shown in Figure 17. 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.

Test rooms shall be cross-calibrated with not less than two other operative test rooms.

7.19.4 Procedure

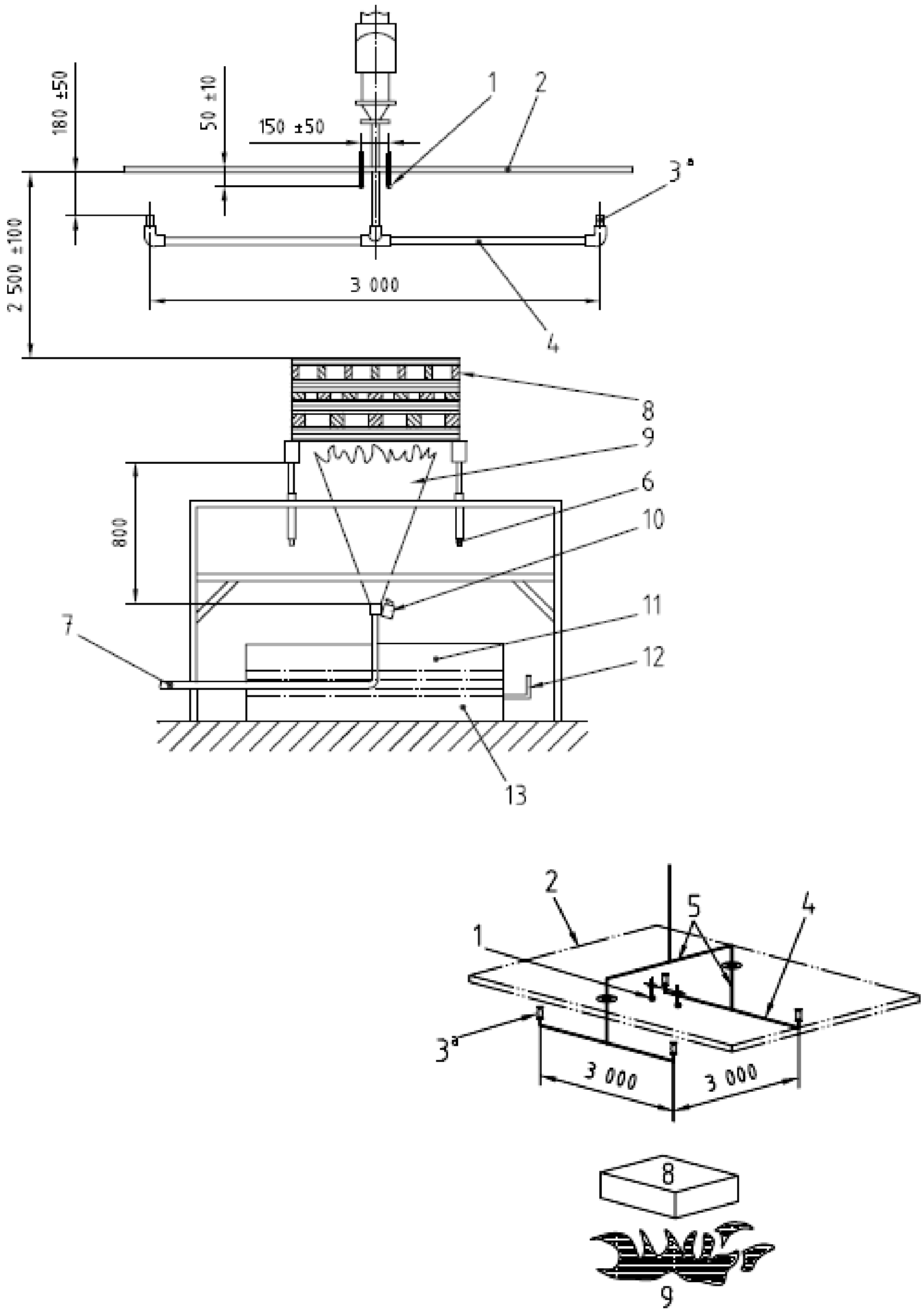
7.19.4.1 Two tests, each of 30 min duration, shall be conducted. For each test, a new wood crib, placed in the centre of the test room, shall be fed for 30 min with *n*-heptane maintained at a temperature between 5 °C and 25 °C. Continuous combustion of the *n*-heptane shall be assured by means of a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

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.

7.19.4.4 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 one week in a sheltered area. The value of the crib mass measured before the test (6 % to 12 % moisture content) and after drying shall be corrected to the value at 0 % moisture before calculations are performed to determine compliance with the mass loss requirement (see 6.18).

Dimensions in millimetres



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

Figure 17 — Crib fire test

7.20 Lateral discharge test (see 6.19)

7.20.1 While discharging water at a service pressure of 0.69 MPa (6.9 bar), 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.

7.20.2 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 0.69 MPa (6.9 bar). 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.

7.20.3 The test shall be repeated with the sprinkler frame arms perpendicular to the pipelines.

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

7.20.5 In all four test conditions, the automatic sprinkler of a given type (upright or pendent) shall operate before the heptane is consumed.

7.21 Thirty-day leakage test (see 6.20)

7.21.1 Five sprinklers shall be installed on a water-filled test line maintained under a constant pressure of 2 MPa (20 bar) for 30 d at an ambient temperature of (20 ± 5) °C.

7.21.2 The sprinklers shall be inspected visually at least weekly for leakage. Following completion of this 30-day test, all samples shall meet the leak resistance requirement specified in 6.8.1. Examine all samples to verify that there is no evidence of distortion or other mechanical damage.

7.22 Vacuum test (see 6.21)

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.

7.23 Water shield angle of protection (see 6.22)

Verify the angle of protection according to 6.22; 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.

7.24 Water shield rotation test (see 6.23)

7.24.1 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

7.24.2 If the water shield rotates at 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 %.

7.25 Thermal response test for concealed, flush and recessed sprinklers (see 6.24)

7.25.1 Three samples shall be tested utilizing the test conditions and orientations determined from the calculations obtained according to 6.24 and Annex E.

a) At least ten each, concealed, flush and recessed sprinklers shall be tested in groups of five and shall operate within the tolerance limits specified in 6.24 when installed in a 2,4 m high ceiling in the centre of a 4,6 m x 4,6 m closed room and subjected to the heat from a sand burner located on the floor in one corner of the room (see Figure 18). Each sprinkler shall be filled with water at 20 ± 5 °C. The sprinklers shall be installed in the maximum recessed position. Concealed, flush and recessed sprinklers shall be installed and tested in a manner that will not inhibit air flow through the escutcheon.

Or

b) Alternatively, each sprinkler under test shall have one to 1.5 wraps of PTFE sealant tape applied to the sprinkler threads. It shall be screwed into the mount to a torque of (15 ± 3) N.m. Each sprinkler shall be mounted on a tunnel section to cover and maintained in a conditioning chamber to allow the sprinkler and cover 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 (see Figure 19) laminar gas stream. The orientations according to Table 4 shall be based on the sprinkler as if it were not concealed, flush or recessed.

7.25.2 The sand burner shall be a 30 cm x 30 cm x 30 cm-high device (see Figure 20) with a flow of natural gas or methane of 9,6 m^3/h for sprinklers having a temperature rating of 77 °C or less. For sprinklers having a temperature rating of 79 °C to 107 °C, the flow of natural gas or methane shall be 26 m^3/h. The natural gas or methane shall have a heat value of (37 600 ± 1 000) kJ/m^3. Gases having a higher heat content may be used provided the heat output obtained is made equivalent by adjusting the flow rate.

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

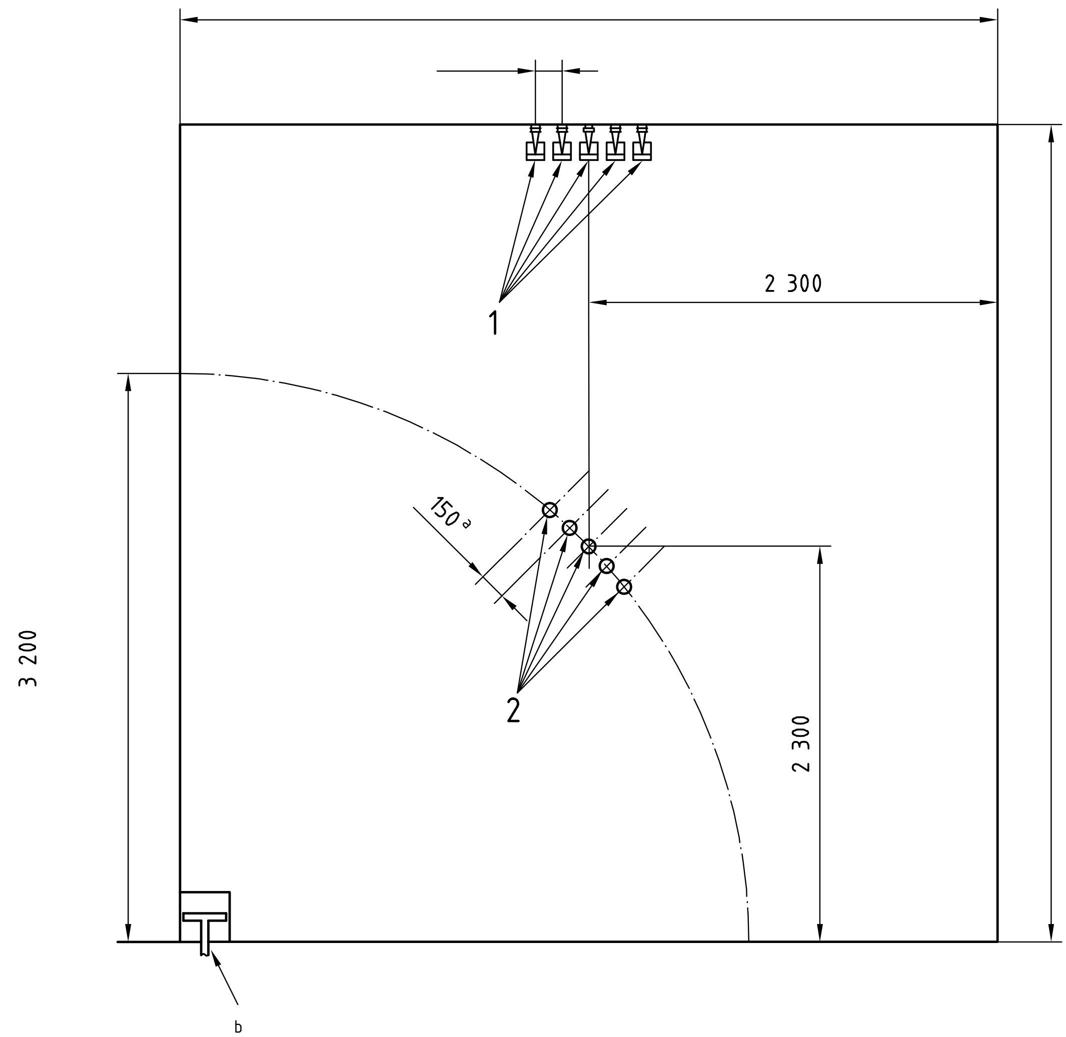
a) (31 ± 1) °C for sprinklers having a temperature rating not exceeding 77 °C, or

b) (49 ± 1.7) °C for sprinklers having a temperature rating between 79 °C and 107 °C.

Alternatively, all sprinklers shall be tested with the inlet end of each sample connected to a source of pressure at 0.05 MPa (0,5 bar).

Record the operating time of each sprinkler.

Dimensions in millimetres



Key

1 sidewall sprinkler locations

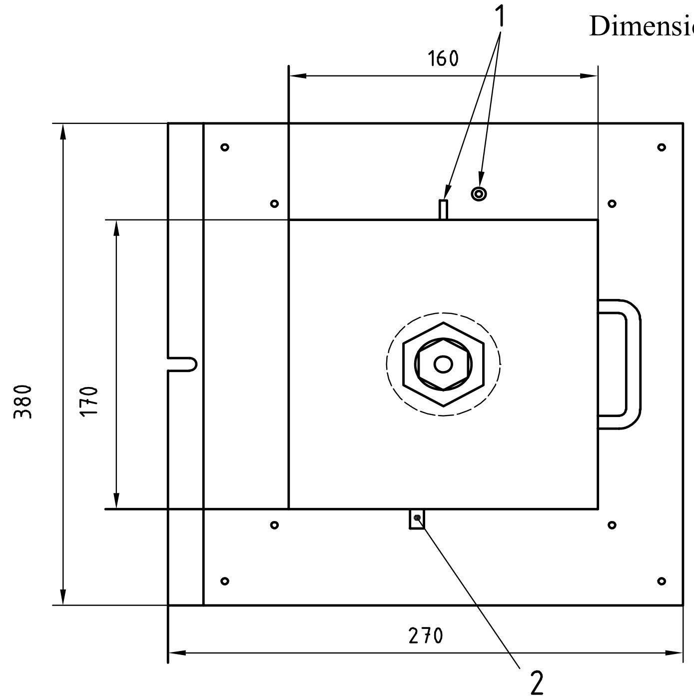
2 pendent sprinkler locations

a Typical dimension.

b For sand burner detail, see Figure 20.

Figure 18 — Plan view of room for concealed, flush and recessed sprinkler thermal response test

Dimensions in millimetres



Key

1 differential pressure ports

2 vacuum port

3 steel frame (3.038 mm ± 0.20 mm)

4 jam nut to lock-in position

5 jam nut welded to inside of enclosure

6 handle

7 0,40 mm thick s/s enclosure

8 Φ 32 mm thread rod x 146 mm long — thread one end for air hose fitting, other end for sprinkler

9 sprinkler installation hole in Marinite® (see Note)

10 2.5 mm thick x 25.4 mm wide gasket (4 sides)

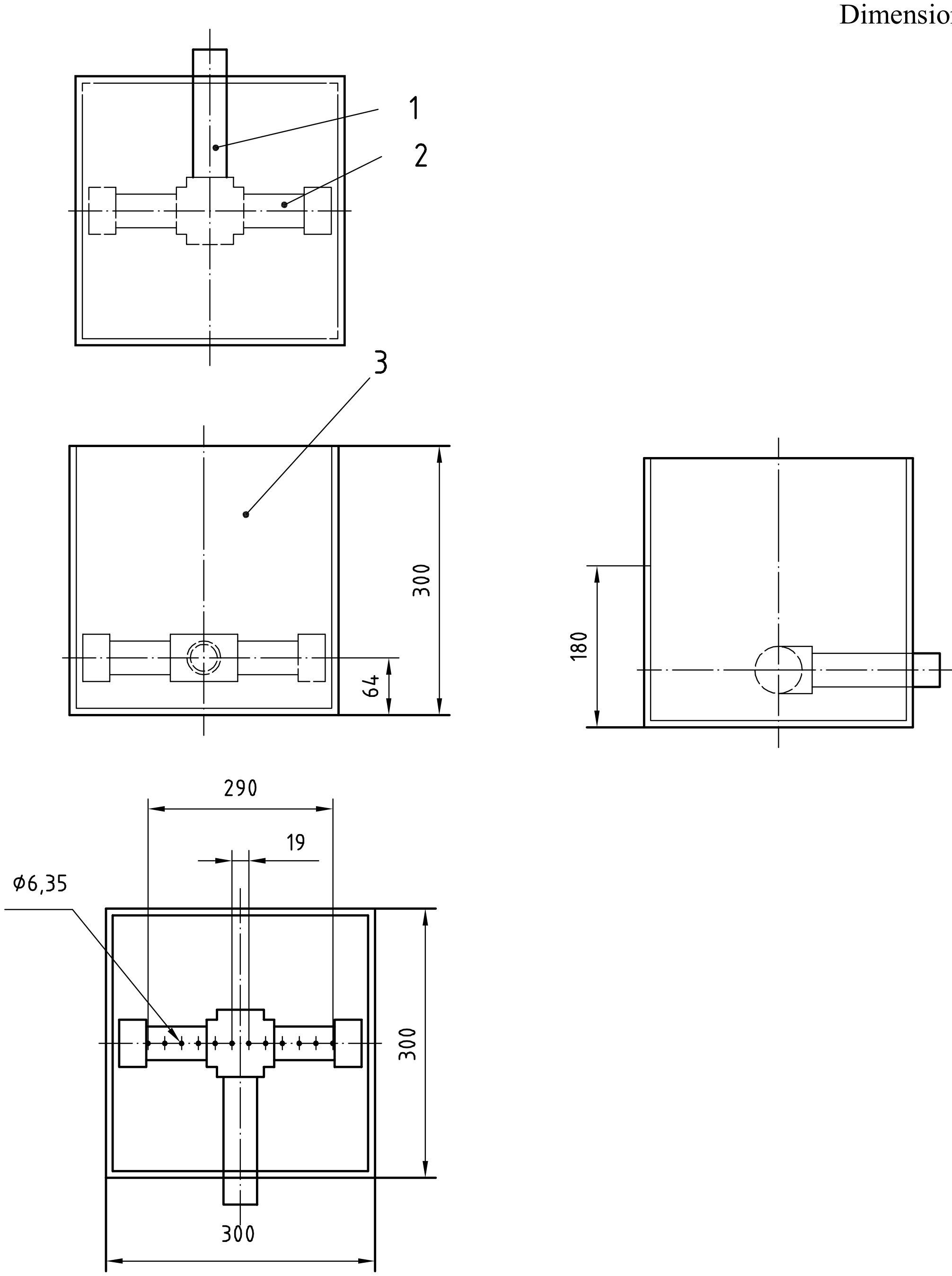
11 pan head screws countersunk in Marinite® used to fasten Marinite® steel frame and flange of enclosure body

NOTE Marinite® is the trade name of a product supplied by ENZ Materials, Inc. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

[a] Marinite® 1.9 cm.

Figure 19 — Dynamic heating test plate for concealed, flush and recessed sprinklers

Dimensions in millimetres



Key

1 nominal pipe Φ 25 mm

2 nominal pipe Φ 40 mm

3 sand

Materials:

— steel plate box, welded,

— steel piping and fittings, with twelve 6,35 holes,

— mason grade sand.

Figure 20 — Details of sand burner

7.25.3 The room shall be constructed of nominal 1,2 cm thick plywood. The ceiling shall be constructed from flat steel decking having a nominal thickness of 1 mm. A non-combustible wall covering may be installed in the corner of the room with the sand burner.

Two tests shall be conducted with five sprinklers for each test. Each sprinkler shall be filled with water at room temperature located 15 cm apart in the centre of the ceiling on a 3,2 m arc from the corner of the room directly above the sand burner. See Figure 18.

For the evaluation of dry sprinklers, the shortest length manufactured shall be used.

7.25.4 Before installing the sprinkler samples, warm the walls and ceiling of the test enclosure by operating these and burner at a flow rate of 26 m^3/h for 10 min.

A timer accurate to ± 0.01 s with suitable measuring devices to sense the time between when the sprinkle is plunged into the tunnel and the time it operates shall be utilized to obtain the response time.

7.25.5 As soon as the sprinkle is plunged into the dynamic heating apparatus, the applied vacuum (as noted in Table 5) shall be applied and maintained throughout the remainder of the testing.

7.26 Operational cycling of an on/off sprinkler (see 6.25)

7.26.1 One sprinkler shall be installed in a test fixture and supplied with water at a pressure of (2.75 ± 0.5) bar. Heat shall be applied to the sprinkler until it operates and attains the fully open position. The heat application then shall be discontinued and the heat sensing element permitted to cool until the sprinkler closes. This procedure shall be repeated until the specified number of test cycles is completed. The interval between each closing of the sample and reapplication of the heat shall not be greater than 60 s.

7.26.2 The water used during the cycling specified in 6.25.2 shall consist of 60 l of tap water into which has been mixed 1.58 kg of contaminants which are sieved as described in Table 11. The solution shall be continuously agitated during the test.

Table 11 — Contaminant for contaminated water cycling test

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

[a] Sieve designations correspond with those specified in the *Standard Specification for Wire-Cloth Sieves for Testing Purposes*, ASTM E11-87. Cenco-Meinzer sieve sizes 25 mesh, 50 mesh, 100 mesh, 200 mesh, and 325 mesh, corresponding with the number designation in the table, have been found to comply with ASTM E11-87.

7.27 Piled-stock fire test for on/off sprinklers (see 6.5.3 and 6.26)[2)]

7.27.1 The test room shall have dimensions not less than 18 m x 18 m and have a ceiling approximately 5 m high. The test room shall be vented and have provision for drainage of sprinkler discharge. See Figure 21.

7.27.2 At least eighteen sprinklers shall be installed on a sprinkler grid consisting of 40 mm minimum size branch lines. The sprinkler grid shall provide a 3 m x 3 m sprinkler spacing. The sprinkler deflectors shall be located 250 mm ± 50 mm below the ceiling for pendent sprinklers and 180 mm ± 50 mm below for upright sprinklers.

7.27.3 Temperatures shall be recorded by means of at least 24 thermocouples located near the ceiling. Six thermocouples, identified as Nos. 1 to 6 in Figure 21, shall be located 50 mm below the ceiling and directly above the sprinklers, and at least one thermocouple shall be located next to the heat-sensitive element of each sprinkler.

7.27.4 The water supply for the sprinkler system shall be adjusted to provide an average water flow of 6,6 l/min/m^2 of floor area for 15-mm orifice sprinklers when all sprinklers are operating.

7.27.5 The water flow during sprinkler discharge shall be continuously monitored so that the water flow can be adjusted as necessary during the test to provide the average sprinkler discharge flow rate specified in 7.27.4.

7.27.6 The piled stock shall consist of at least 30 tri-wall corrugated cartons placed on pallets and arranged in a pile that is at least three pallet-cartons wide by five long by two high. See Figure 22. A 150 mm free space shall be maintained between all carton stacks.

7.27.7 Each carton shall measure 1,1 m x 1,1 m x 1,1 m, and shall comply with the requirements for Class 2, Style E, "AAA" fluting, triple wall corrugated fibre boards in accordance with US Government specification PPP-B-640D. The distance from the inside of the inside wall to the outside of the outside wall shall be 12,7 mm. A carton 1.0 m x 1.0 m x 1.0 m complying with all other requirements above, except overall size, shall be placed inside each larger carton.

7.27.8 To provide structural stability during this test, two pieces of approximately 1.5 mm thick sheet steel measuring 1,3 m x 0,9 m high shall be placed, in crisscross fashion, in each inside carton. Each support member shall have a slit 2 mm wide x 0,5 m long in its middle to facilitate insertion of the other diagonal member.

7.27.9 The ignition source for the fire test shall consist of 0,7 kg of shredded paper placed on the floor in the space between the first and second carton in the middle row and ignited. See Figure 22.

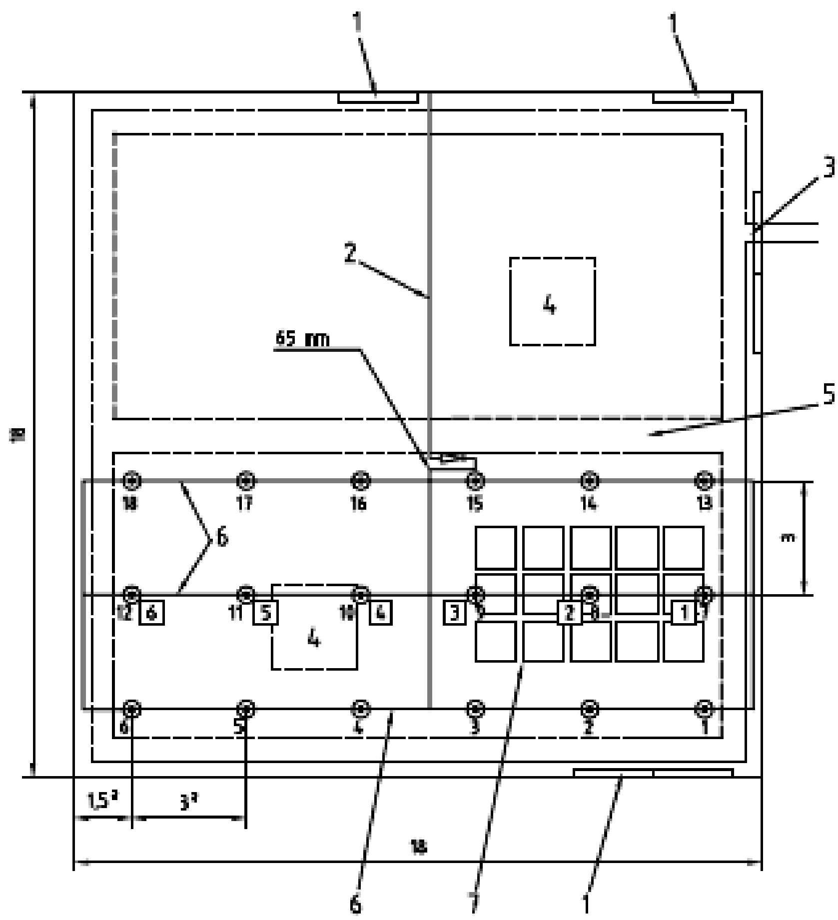
7.27.10 During the fire test, verify that the sprinkler meets the requirements of 6.5.3.

7.27.11 The fire test shall be continued until the fire is extinguished or for a duration of 45 min.

7.27.12 At the completion of water discharge, if the fire in the cartons has not been extinguished, it shall be carefully extinguished to prevent further destruction. The cartons shall be examined visually to determine compliance with the requirement specified in item A of 6.26. If it is not obvious that less than 50 % of the cartons have been destroyed, the cartons shall be:

a) oven-dried and weighed so that the mass of the cartons can be compared with the mass of unaltered cartons, or,

b) weighed 7 d after the fire test, if oven-drying is not possible, so that the mass of the cartons can be compared with the mass of new cartons. During the 7 d, the carton shall be stored in a compartment with a temperature (25 ± 5) °C and a relative humidity not in excess of 70 %.

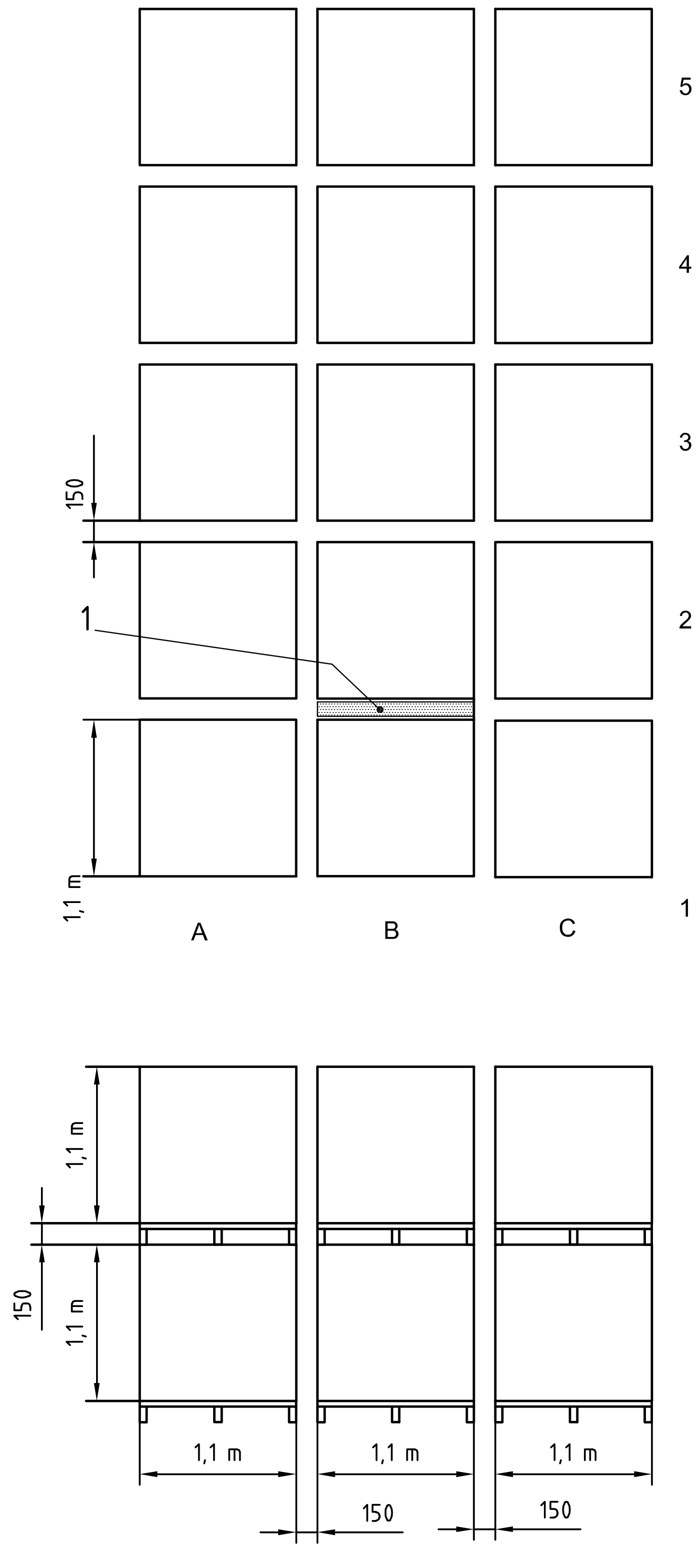


Key

□	thermocouplesb
⊙	sprinkler locations
1	closed door
2	100 mm main
3	sliding doors
4	vent, 2.4 m × 2.4 m
5	floor drain
6	40 mm branch line sprinkler piping
7	piled cartons (see Figure 22)
a	Typical dimension.
b	Located 50 mm below ceiling, above the sprinklers, on the centre branch line.

Figure 21 — Plan view of room for on/off sprinkler fire test

Dimensions in millimetres



Key

1 shredded paper (ignition point)

Figure 22 — Carton arrangement

7.28 High temperature exposure for on/off sprinklers (see 6.27)

7.28.1 Five sprinklers shall be conditioned for 1 h in a preheated circulating air oven maintained at 540 °C. The sprinklers then shall be removed from the oven and allowed to cool for at least 3 h at room temperature. The sprinklers shall be maintained in their intended installation position at all times during the exposure.

7.28.2 After cooling, the sprinklers shall be subjected to the water flow test given in 6.4.1 to determine compliance with the requirements in 6.27.

7.29 Freezer test (see 6.28)

Five samples shall be individually attached to one end of a 100-mm length of 5-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.

8 Marking

8.1 Sprinklers

8.1.1 Each sprinkler complying with the requirements of this standard shall be marked as follows:

a) trademark or manufacturer's name;

b) identification of model;

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

d) identification of release element if more than one type issued;

e) abbreviation of the type of sprinkler and the mounting position (see Clause 3);

f) nominal year of manufacture, which may include the last three months of the preceding year and the first six months of the following year;

g) nominal operating temperature.

8.1.2 Items a) to g) of 8.1.1 shall be permanently marked on non-operating parts except that for fusible element sprinklers, f) or g) may be permanently marked on the fusible element.

8.1.3 Sprinklers having 1/2-in threads with a nominal orifice size other than 15 mm shall have the nominal orifice diameter cast or stamped on a non-operating part of the sprinkler. In addition, a metal rod extension, (10 ± 2) mm long and having a diameter of (5 ± 2) mm, shall be provided beyond the deflector.

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

CUP	Conventional upright or pendent sprinkler
EC	Extended coverage sprinkler
FR	Fast response sprinkler
IR	Special (intermediate) response sprinkler
FSU	Flat spray upright sprinkler
FSP	Flat spray pendent sprinkler
O/O	On/off sprinkler
SU or SSU	Spray upright sprinkler
Sp or SSP	Spray pendent sprinkler
WU	Sidewall pendent sprinkler
WUP	Sidewall upright pendent sprinkler
WH	Sidewall horizontal sprinkler

8.1.5.1 No additional markings are required for the following sprinklers:

a) concealed;

b) flush;

c) recessed;

d) dry upright;

e) dry pendent;

f) water shield.

8.1.6 Except for coated and plated sprinklers, the nominal operating temperature range shall be colour- coded on the sprinkler to identify the nominal rating. For fusible element sprinklers, this code shall be visible on the yoke arms holding the distribution plate and, for glass bulb sprinklers, shall be indicated by the colour of the liquid in the glass bulbs. The colour code shall be in accordance with Table 2. In countries where colour-coding of yoke arms of glass bulb sprinklers is required, the colour code for fusible element sprinklers shall be used.

8.1.7 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 housings (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.

Annex A

(Informative)

Analysis of the strength test for release elements

A.1 The formula given in 7.10.2 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 years) 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 years, 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:

$$\ln L_M \geq (\ln L_d - \ln L_o)\frac{\ln 1000}{\ln 876600} + \ln L_o$$

$$\geq 0.504\,8\,(\ln L_d - \ln L_o) + \ln L_o$$

$$\geq 0.504\,8\,(\ln L_d - \ln L_o) + \ln L_o\,(1 - 0.504\,8)$$

$$\geq 0.504\,8 \ln L_d + 0.495\,2 \ln L_o$$

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

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

Or

$$L_M \leq 1.02 L_M^2/L_o$$

Annex B

(Informative)

Tolerance limit calculations method

B.1 The calculation method for determining compliance with the statistical tolerance limit requirements specified in 6.24 and 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

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

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 6.24 and 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 $(m.s)^{0.5}$.

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 6.24)** 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
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, flush and recessed (see 6.24)]

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

$L_{tol} \leq 3,85$ min for sprinklers having a temperature rating not exceeding 77 °C

$L_{tol} \leq 3,15$ min for sprinklers having a temperature rating between 79 °C and 107 °C

Annex C

(Informative)

Sprinkler response — Sample calculations

C.1 Calculation of *C*-factor

The mean sprinkler operating temperature obtained from tests given in 7.7.1 was 72 °C. Sequential tests were conducted as specified. In the first test, u_L = 0,288 m/s and T_m = 20,3 °C. The actual air temperature was 125 °C. Actuation did not occur in 15 min. In the second test, u_H = 0,342 m/s and T_m = 20 °C and the actual air temperature was 127 °C. Actuation occurred at 350 s.

$$(u_H/u_L)^{0,5} = (0{,}342/0{,}288)^{0,5} \leq 1{,}1$$

Therefore:

$$C_L = [(125 - 20{,}3)/(72 - 20{,}3) - 1](0{,}288)^{0,5}$$

$$C_L = 0{,}55\ (\text{m/s})^{0,5}$$

$$C_H = [(127 - 20)/(72 - 20) - 1](0{,}342)^{0,5}$$

$$C_H = 0{,}62\ (\text{m/s})^{0,5}$$

$$C = 0{,}5\ (0{,}55 + 0{,}62) = 0{,}59\ (\text{m/s})^{0,5}$$

C.2 Calculations of RTI

C.2.1 Example 1

Assume a response time in the plunge test (t_r) equal to 30,1 s for a standard response sprinkler. Also assume

a) the mean liquid bath operating temperature of the sprinkler is 72 °C,

b) the ambient temperature is 20 °C,

c) the actual air temperature in the test section is 197 °C,

d) the actual air velocity in the test section is 2,56 m/s, and

e) the conductivity factor for this sprinkler was determined to be 0,59 (m/s)^{0,5} according to 7.7.2.3

$$RTI = \frac{-30,1(2,56)^{0,5}\,[1 + 0,59 / (2,56)^{0,5}]}{\ln\,[1 - (72 - 20)\,(1 + 0,59 / (2,56)^{0,5} / (197 - 20)]}$$

$$RTI = 128\,(m.s)^{0,5}$$

C.2.2 Example 2

In connection with 7.7.2.4, assume a response time in the worst-case orientation of 45,2 s. Let this RTI be denoted RTI_{WC}:

$$RTI_{WC} = \frac{-45,2\,(2,56)^{0,5}\,[1 + 0,59\,(RTI_{WC} / 128) / (2,56)^{0,5}]}{\ln\left\{1 - (720 - 20)\left[1 + 0,59\,(RTI_{WC} / 128) / (2,56)^{0,5}\right] / (197 - 20)\right\}}$$

The iterative solution is:

$RTI_{WC} = 185(m.s)^{0,5}$

Annex D

(Normative)

Tolerances

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

Table D.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	$\frac{+5}{0}$	seconds
	$\frac{+0,1}{0}$	minutes
	$\frac{+0,1}{0}$	hours
	$\frac{+0,1}{0}$	days

Annex E

(Informative)

Thermal response — Sample calculations

Example sprinkler characteristics:

- Response:	standard
- Nominal temperature rating:	57 °C
- Operating element:	glass bulb
- Example ambient room temperature:	20 °C

From Table 4, the maximum RTI and *C* combinations are:

RTI = $350(m.s)^{0.5}$	C = $1,0(m/s)^{0.5}$	Orientation: standard
RTI = $250(m.s)^{0.5}$	C = $2,0(m/s)^{0.5}$	Orientation: standard
RTI = $600(m.s)^{0.5}$	C = $5,0(m/s)^{0.5}$	Orientation: offset (15^o)

From 6.3, the maximum upper temperature limit for the example sprinkler is 60 °C.

Calculating the theoretical response time utilizing the equation given in 7.7.2.3, solved for t_r (theoretical response time) yields Table E.1.

From Table E.1, Test condition 9 produces the following results for the example sprinkler:

Test condition 9	RTI = 350 $(m.s)^{0.5}$	C = $1,0(m/s)^{0.5}$	t_r = 34,3 s
Test condition 9	RTI = 250 $(m.s)^{0.5}$	C = $2,0(m/s)^{0.5}$	t_r = 26,0 s
Test condition 9	RTI = 600 $(m.s)^{0.5}$	C = $5,0(m/s)^{0.5}$	t_r = 77,4 s

Since only the maximum theoretical response times are utilized, Test condition 9 should be conducted for the example sprinklers in the standard orientation (with a maximum response time of 34,3 s permitted) and for example sprinklers in the offset orientation (with a maximum response time of 77,4 s permitted).

To summarize for the example sprinkler, see Table E.2.

Table E.1 — Theoretical response time

Test condition (from Table 5)	**RTI** (from Table 4) $(m.s)^{0,5}$	*C* (from Table 4) $(m/s)^{0,5}$	**Theoretical response time** t_r s
1	350	1,0	236,2
1	250	2,0	No operation
1	600	5,0	No operation
2	350	1,0	122,8
2	250	2,0	122,5
2	600	5,0	No operation
3	350	1,0	102,4
3	250	2,0	93,3
3	600	5,0	No operation
4	350	1,0	105,2
4	250	2,0	94,4
4	600	5,0	No operation
5	350	1,0	61,1
5	250	2,0	48,8
5	600	5,0	237,2
6	350	1,0	51,9
6	250	2,0	40,7
6	600	5,0	154,7
7	350	1,0	67,5
7	250	2,0	54,5
7	600	5,0	321,9
8	350	1,0	40,2
8	250	2,0	30,7
8	600	5,0	96,9
9	350	1,0	34,3
9	250	2,0	26,0
9	600	5,0	77,4

Table E.2 — Summary of maximum response times for the example sprinkler

Test condition (from Table 5)	Orientation (from Table 4)	Maximum theoretical response time s
1[a]	Standard	No operation
1[a]	Offset	No operation
2	Standard	122,7
2[a]	Offset	No operation
3	Standard	102,4
3[a]	Offset	No operation
4	Standard	105,2
4[a]	Offset	No operation
5	Standard	61,1
5	Offset	237,2
6	Standard	51,9
6	Offset	154,7
7	Standard	67,5
7	Offset	321,9
8	Standard	40,2
8	Offset	96,9
9	Standard	34,3
9	Offset	77,4

[a] Indicates that the test condition and orientation need not be conducted for the example sprinkler.