Draft for Development **DD 252:2001**
March 2001

Components for residential sprinkler systems — Specification and test methods for residential sprinklers

Contents

Foreword

This Draft for Development has been prepared by a Task Group from Technical Committee FSH/18/2. It specifies requirements for the construction and performance, and testing of fire sprinklers for use specifically in residential and domestic occupancies. It is intended for the use of designers, engineers, architects, surveyors, contractors, installers and authorities having jurisdiction. Sprinkler protection for other buildings and industrial plant is specified in BS 5306-2.

Domestic and residential sprinklers are for use in fire sprinkler systems and are designed to provide an additional degree of protection of life and property, above that already achieved by the building design and the installation of smoke and/or fire detectors and systems. This Draft for Development presumes that the sprinkler protection will form part of an integrated fire safety system.

Product certification/inspection/testing. Users of this Draft for Development are advised to consider the desirability of third-party certification/inspection/testing of product conformity with this Draft for Development. Appropriate conformity attestation arrangements are described in BS EN ISO 9001. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

The requirements contained in this Draft for Development result from the best technical information available to the committee at the time of writing. Firefighting and life protection encompasses a wide field of endeavour and as such it is impracticable to cover every possible factor or circumstance that might affect implementation of this Draft for Development. Therefore the design and installation of any system should be entrusted to a suitably qualified and experienced sprinkler contractor.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because UK experience needs to be gained. It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

A review of this Draft for Development will be carried out not later than 2 years after its publication. Notification of the start of the review period, with a request for the submission of comments from users of this Draft for Development, will be made in an announcement in the appropriate issue of *Update Standards*.

According to the replies received, the responsible BSI Committee will judge whether the Draft for Development can be converted into a British Standard or what other action should be taken.

Observations which it is felt should receive attention before the official call for comments will be welcomed.

These should be sent to the Secretary of BSI Technical Committee FSH/18/2 at British Standards House, 389 Chiswick High Road, London W4 4AL.

Summary of pages

This document comprises a front cover, an inside front cover, pages x and xx, pages X to XX, an inside back cover and a back cover.

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1 Scope

This Draft for Development specifies requirements for construction and performance of sprinklers which are operated by a change of state of an element or bursting of a glass bulb under the influence of heat, for use in residential and domestic automatic sprinkler systems conforming to DD 251. Test methods and a recommended test schedule for type approval testing are also given.

NOTE All pressure data in this standard are given as gauge pressures in bar[1)].

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Draft for Development. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS EN 12259-1, *Fixed firefighting systems — Components for sprinkler and water spray systems — Part 1: Sprinklers*.

DD 251, *Spinkler systems for residential and domestic occupancies — Code of practice*.

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

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

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

3 Terms, definitions and abbreviations

For the purposes of this Draft for Development, the terms, definitions and abbreviations in BS EN 12259-1 and the following apply.

3.1
design lower tolerance limit (DLTL)
lowest lower tolerance limit (LTL) for glass bulbs specified and assured by the glass bulb supplier

3.2
design upper tolerance limit (DUTL)
highest upper tolerance limit (UTL) for sprinklers specified and assured by the sprinkler supplier

[1)] 1 bar = 10^5 Pa.

3.3
flush pattern sprinkler
pendent sprinkler for fitting partly above, but with the temperature sensitive element below, the lower plane of the ceiling

3.4
lower tolerance limit (LTL)
lowest strength of a glass bulb determined by testing and statistical analysis of a batch of 55 or more bulbs

3.5
mean design bulb strength
lowest mean bulb strength, specified and assured by the glass bulb supplier, for any batch of 55 or more bulbs

3.6
mean design service load
highest mean service load, specified and assured by the sprinkler supplier, for any batch of 10 or more sprinklers

3.7
residential sprinkler
sprinkler for use in domestic and residential occupancies with an appropriate water distribution

3.8
response time index (RTI)
measure of the thermal sensitivity of the sprinkler

NOTE The response time index is expressed in $(\text{metres}\cdot\text{second})^{1/2}$.

3.9
upper tolerance limit (UTL)
highest service load of a sprinkler determined by testing and statistical analysis of a batch of 20 or more sprinklers

4 Construction and performance

4.1 Product assembly

Sprinklers shall only be assembled in the original equipment supplier's factory, in such a way that any subsequent adjustment or dismantling will result in destruction of an element of construction.

4.2 Dimensions

4.2.1 Nominal thread sizes shall be $^3/_8$ inch or ½ inch and suitable for fittings threaded in accordance with ISO 7-1.

NOTE Flush sprinklers may have larger thread sizes.

4.2.2
It shall be possible for:

a) a sphere of $8^{+0,01}_{0}$ mm diameter to pass through each water passage in the sprinkler.

or

b) a sphere of $6^{+0,01}_{0}$ mm diameter to pass through each water passage in the sprinkler, where the water supply gives a pressure of not less than 3 bar at the sprinkler.

4.3 Nominal operating temperature

4.3.1 The nominal operating temperatures of glass bulb sprinklers shall be in accordance with Table 1.

4.3.2 The nominal operating temperature ranges of fusible link sprinklers shall be in accordance with Table 1.

4.3.3 Glass bulb sprinklers and non-plated and non-coated fusible link sprinklers shall be colour coded according to the nominal operating temperature as given in Table 1.

Table 1 — Nominal operating temperatures and colour codes

Glass bulb sprinklers		Fusible link sprinklers	
Nominal operating temperature ^{o}C	**Liquid colour code**	**Nominal operating temperature within range** ^{o}C	**Yoke arms colour code**
57	Orange	57 to 77	Uncoloured
68	Red	80 to 107	White
79	Yellow	—	—
93	Green	—	—
100	Green	—	—

4.4 Operating temperatures

4.4.1 When tested in accordance with annex A, fusible link sprinklers shall operate at a temperature within the range:

$$[t \pm (0.035\ t + 0,62)]\ ^{o}C$$

where

t is the nominal operating temperature.

When tested in accordance with annex A, glass bulbs and glass bulb sprinklers shall operate within the temperature range specified in Table 2.

Table 2 — Operating temperatures for glass bulbs and glass bulb sprinklers

Nominal operating temperature °C	**Lowest operating temperature** °C	**Temperature at or below which at least 25 of the 50 specimens operate** °C	**Temperature at or below which at least 40 of the 50 specimens operate** °C	**Highest operating temperature** °C
57	54	63	68	74
68	65	74	79	86
79	76	87	92	99
93	90	101	106	113
100	97	108	113	120

4.5 Water flow and distribution

4.5.1 *K-factor*

The K-factor, the orifice coefficent of the sprinkler, calculated as:

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

where

Q = flow;
P = pressure;

shall be within the range given in Table 3, when determined in accordance with annex B.

Table 3 — K-factors

Nominal K-factor	**K-factor tolerance** $l \cdot min^{-1} \cdot bar^{-1/2}$	
< 80	±3	±5
>80	±4	±6

4.5.2 *Water distribution*

When sprinklers are tested in accordance with annex C (see **C.1**) using the parameters given in Table 4, the minimum conditions specified in Table 4 shall be achieved.

Table 4 — Water distribution parameters

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column
Test condition	**Nominal water coverage** mm/min	**Flow rate per sprinkler**[a] l/min	**No of sprinklers under test**	**Minimum test duration** s	**Pan height from floor** m	**Minimum collection value** mm/min	**Not more than 4 pans per plane below** mm/min	**Figure Reference**
Floor (horizontal) collection	4.0	$4 \times S^2$	1[b]	360	—	1.22	—	C.1, C.2
	2.8	$2.8 \times S^2$	1[b]	360	—	1.22	—	C.1, C.2
Wall (vertical) collection	2.8	$2.8 \times S^2$	1[b,c]	900	0.08 to 0.75	Unspecified	Unspecified	C.3, C.4
					0.23 to 1.75	0.244	0.408	
					1.75 to 1.90	0.82	Unspecified	
					1.90 to 2.44	Unspecified	Unspecified	

[a] *S* is the maximum allowable spacing specified by the supplier.
[b] Repeat each test using a second sprinkler sample.
[c] Repeat tests after elevating the collection container arrays by 150 mm.

4.6 Function

When tested in accordance with annex D (see D.1) the sprinkler shall open and within 5 s of release of the thermally sensitive element shall operate satisfactorily and shall conform to the requirements of 4.5.1. Any lodgement of released parts shall be cleared within 60 s of the release of the thermally sensitive element and the sprinkler shall conform to the requirements of 4.5.2.

4.7 Strength of sprinkler body and deflector

4.7.1 The sprinkler body shall not show permanent elongation of more than 0.2 % between the load-bearing parts when subjected to twice the average service load when tested in accordance with annex E (see **E.1**).

4.7.2 The sprinkler deflector and its supporting parts shall withstand an applied force of 70 N without permanent deformation when tested in accordance with **E.2**.

4.7.3 When tested in accordance with **E.3** the deflector and its supporting parts shall conform to the requirements of **4.5.2**.

NOTE In most instances visual examination of the equipment will be sufficient to establish conformity to the requirements of **4.5.2**.

4.8 Strength of release element

4.8.1 *Glass bulb sprinklers*

When evaluated and tested in accordance with annex F (see **F.1**), glass bulb sprinklers shall have:

a) a mean design bulb strength of at least six times the mean design service load;

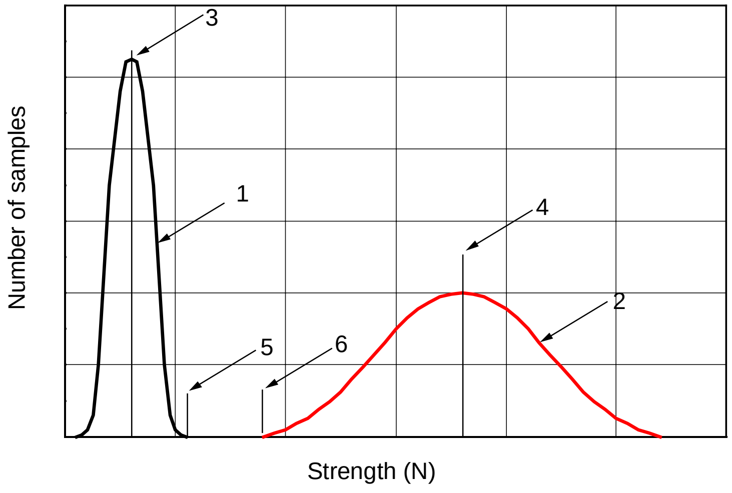
b) a mean bulb strength not less than the mean design bulb strength;

c) a mean service load not more than the mean design service load;

d) a design lower tolerance limit (DLTL) on the distribution curve of at least two times the design upper tolerance limit (DUTL) of the service load distribution curve;

e) an upper tolerance limit (UTL) less than or equal to the design upper tolerance limit (DUTL);

f) a lower tolerance limit (LTL) greater than or equal to the design lower tolerance limit (DLTL) (see Figure 1).



1 Service load distribution curve
2 Bulb strength distribution curve
3 Mean service load
4 Mean bulb strength
5 Upper tolerance limit (UTL)
6 Lower tolerance limit (LTL)

Figure 1 — Graph of service load and bulb strength distribution curves

4.8.2 *Fusible link sprinklers*

For fusible link sprinklers it shall be determined that:

a) the temperature sensitive elements withstand a load of 15 times the maximum design load for a period of 100 h, without failure; or

b) the estimated time to failure of temperature sensitive elements is not less than 876 600 h at the design load, when tested in accordance with **F.2**.

NOTE For further information on the strength test for fusible link elements see annex G.

4.9 Leak resistance

The sprinklers shall not show any sign of leakage when hydraulically pressure-tested in accordance with annex H.

4.10 Heat exposure

4.10.1 *Sprinklers*

When tested in accordance with annex I (see **I.1**) the sprinklers shall not operate during the exposure period. After the exposure period four sprinklers shall be tested in accordance with **D.3**; the sprinklers shall operate such that the waterway is cleared. Any lodgements shall be disregarded. Four sprinklers shall be tested in accordance with annex H and shall conform to **4.9**. Four sprinklers shall be tested in accordance with annex **A** and shall conform to **4.4**.

4.10.2 ***Glass bulb sprinklers***

There shall be no damage to the glass bulb when sprinklers are tested in accordance with **I.3**.

4.11 Thermal shock

When glass bulb sprinklers are tested in accordance with annex J, the glass bulbs shall either:

a) break correctly on cooling such that the waterway is cleared; or

b) remain intact, i.e. after immersion when subjected to a function test in accordance with **D.3**, operate in such a way that the waterway is cleared; any lodgements shall be disregarded.

4.12 Corrosion

4.12.1 ***Stress corrosion***

Sprinklers shall be subjected to a stress corrosion test in accordance with annex K. Those sprinklers in which cracks, delamination or failure of an operating part is observed shall show no evidence of leakage in the leak resistance test described in annex H. After exposure, when subjected to a function test in accordance with **D.3** the sprinkler shall operate in such a way that the waterway is cleared; any lodgements shall be disregarded.

Those sprinklers which show evidence of cracking, delamination or failure of a non-operating part shall show no visible evidence of separation of permanently attached parts when subjected to the flowing test described in **K.1.3**.

4.12.2 Sulphur dioxide corrosion

Sprinklers shall be subjected to a sulphur dioxide corrosion test in accordance with **K.2**. After exposure, when subjected to a function test in accordance with **D.3** the sprinkler shall operate in such a way that the waterway is cleared; any lodgements shall be disregarded.

4.12.3 ***Salt mist corrosion***

Sprinklers shall be subjected to a salt mist corrosion test in accordance with **K.3**. After exposure, when subjected to a function test in accordance with **D.3**, the sprinkler shall operate in such a way that the waterway is cleared; any lodgements shall be disregarded.

4.12.4 ***Moist air exposure***

Sprinklers shall be subjected to moist air exposure in accordance with **K.4**. After exposure, when subjected to a function test in accordance with **D.3**, the sprinkler shall operate in such a way that the waterway is cleared; any lodgements shall be disregarded.

4.13 Integrity of sprinkler coatings (coating resistance to low temperature)

Any coating (paint or metallic) on the sprinkler shall not crack or flake when the coated sprinkler is tested in accordance with annex L.

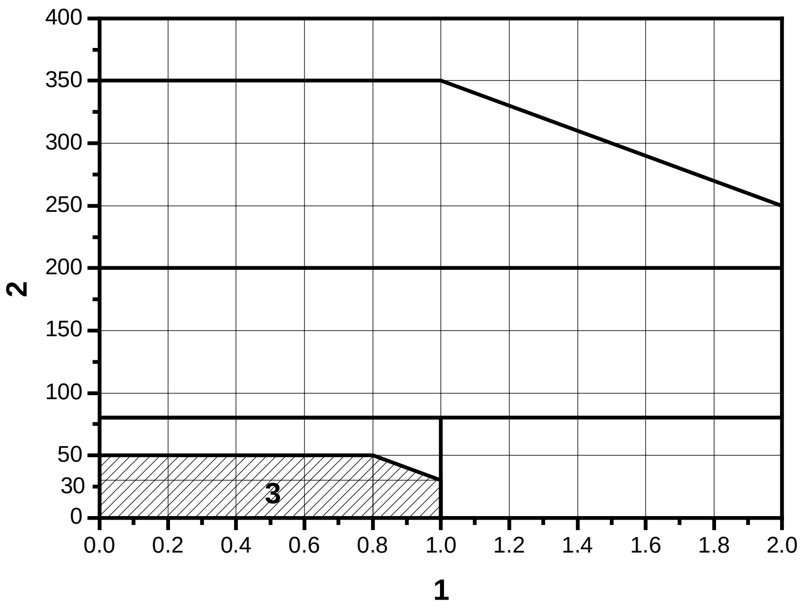
4.14 Water hammer

Sprinklers shall not leak when subjected to pressure surges in accordance with annex M. After the test, when subjected to a function test in accordance with **D.3**, the sprinkler shall operate in such a way that the waterway is cleared; any lodgements shall be disregarded.

4.15 Thermal response

4.15.1 *Response in the standard orientation*

When tested in accordance with annex N, in the standard orientation, [see Figure N.1.a)] residential and domestic sprinklers shall fall within the "quick response" categories with regard to their response time index (RTI) and conductivity factor (C) as shown in Figure 2.



1 C $(m/s)^2$
2 RTI $(m{\cdot}s)^{½}$
3 Quick response

Figure 2 — Standard orientation RTI and C factor limits

4.15.2 ***Response in the unfavourable orientation***

In the unfavourable orientation the influence of any yoke arm shadow effect shall be limited to a nominal angle of 25^{o} each side of the yoke arm (e.g. maximum 104^{o} of the 360^{o}) as shown in Figure N.1.b). When tested in accordance with annex N in the unfavourable orientation the average RTI values shall not exceed 110 % of the relevant limits given in Figure 2. When calculating the RTI in the unfavourable orientation the C factor from the standard orientation test shall be used.

4.16 Resistance to heat

When tested in accordance with annex O, the sprinkler body, deflector and its supporting parts shall show no significant deformation or breakage.

4.17 Resistance to vibration

After being subjected to a vibration test in accordance with annex P, the sprinkler shall show no visible evidence of damage, and shall conform to **4.8** and **4.9**, and when tested in accordance with **D.3** shall operate in such a way that the waterway is cleared; any lodgements shall be disregarded..

4.18 Resistance to impact

After being subjected to the impact test in accordance with annex Q, the sprinkler shall conform to **4.9** and shall function satisfactorily when tested in accordance with **D.3**.

4.19 Resistance to low temperature

The sprinkler shall not operate before the function test, when tested in accordance with annex R. After the test the sprinkler shall show no visible evidence of damage. Following examination, when subjected to a function test in accordance with **D.3** the sprinkler shall operate in such a way that the waterway is cleared; any lodgements shall be disregarded.

4.20 Fire test for residential and domestic sprinklers

Residential and domestic sprinklers shall be capable of controlling the test fires for a period of 10 min, measured from sprinkler operation, when tested in accordance with annex S. Temperatures shall be limited to the values indicated in Table 5. The third sprinkler, external to the room, shall not operate.

Table 5 — Fire test maximum temperatures

Thermocouple location	Maximum allowable temperature °C
75 mm below the underside of the ceiling	320
1.6 m above the floor	95
1.6 m above the floor	55 (for not more than any 120 s interval)
Ceiling temperature - 6.5 mm above the underside of the ceiling	260

5 Marking

5.1 General

Sprinklers shall be marked with the following:

a) name or trade mark of supplier;

b) model number, catalogue designation or equivalent marking;

c) factory of origin, if manufacture is at two or more factories;

d) letters "RES" and letters indicating the type of sprinkler and the mounting position in accordance with Table 6;

e) nominal operating temperature;

NOTE 1 In addition to any colour coding indicating the nominal operating temperature (see **4.3** and Table 2) the nominal operating temperature should be stamped or cast on the fusible element of the fusible link sprinklers. All sprinklers should be stamped, cast, engraved or colour-coded in such a way that the nominal operating temperature is recognizable even if the sprinkler has operated.

Where colour-coding of yoke arms of glass bulb sprinklers is used, the colour code given in Table 2 for fusible link sprinklers should be used.

f) year of manufacture.

NOTE 2 The year of manufacture should be given in a full form, "2000", or a short form, "00", and may include the last 3 months of the preceding year and the first 6 months of the following year.

Table 6 — Marking letters for types of sprinklers and mounting positions

Type of sprinkler and mounting position	**Type marking**	**Mounting position marking**
Concealed sprinkler	CC	
Dry pattern sprinkler	D	
Flush pattern sprinkler	L	
Recessed sprinkler	R	
Sidewall pattern sprinkler	W	
Pendent sprinkler		P
Upright sprinkler		U
Type marking shall precede the mounting position marking.		

5.2 Sidewall sprinklers

5.2.1 *General*

The deflectors of sidewall sprinklers shall be marked with 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”.

5.2.2 *Horizontal sidewall sprinklers*

Horizontal sidewall sprinklers shall have the word “top” marked on the deflector to indicate their orientation.

5.3 Concealed sprinklers

The cover plate of a concealed sprinkler shall be impressed with the words “Do not paint”.

5.4 Removable recessed housing

Recessed housings shall be marked to indicate the sprinkler with which they are to be used unless the housing is a non-removable part of the sprinkler.

6 Instruction charts

An instruction chart, giving the recommended method of installation and instructions on care and replacement, shall be available with each type of sprinkler.

7 Conditions for testing

.Conditions for testing shall be in accordance with annex T.

8 Evaluation of conformity

The compliance of a sprinkler with the requirements of this standard shall be demonstrated by:

initial type testing;

factory production control by the manufacturer;

audit testing.

Annex A (normative)
Test to determine operating temperatures of fusible link sprinklers and glass bulb sprinklers

NOTE See **4.4**.

10 glass bulb sprinklers plus 40 additional separate bulbs or 10 fusible link sprinklers shall be used to determine the operating temperatures of fusible link sprinklers and glass bulb sprinklers.

Carry out the test in a liquid bath. Use water (preferably distilled water) for sprinklers and separate glass bulbs having nominal operating temperatures less than or equal to 80 ^{o}C. Use a suitable oil for higher rated release elements.

Ensure that the temperature deviation within the test zone in the liquid bath does not exceed $\pm$0.5% of the nominal operating temperature (in ^{o}C) of the sprinklers or $\pm$0.5 ^{o}C, whichever is the greater.

Place the sprinklers or separate glass bulbs in the liquid bath and heat them from room temperature to $(20\ ^{+2}_{0})$ ^{o}C below their nominal operating temperature, at a rate of increase of temperature not more than 20 ^{o}C/min. Maintain this temperature for at least 10 min. Then increase the temperature at a rate between 0.4 ^{o}C/min to 0.7 ^{o}C/min until the fusible link fuses or the glass bulb bursts. Measure the temperature of the operation of each to within ±1.5 % of the nominal operating temperature.

Annex B (normative)
Water flow test

NOTE See **4.5.1**.

Mount the sprinkler on a supply pipe together with a means of pressure measurement (see Figure B.1). Bleed the air from the pipe assembly using the bleed valve. Measure the flow rate, by direct measurement of flow rate or by collecting and measuring the weight or volume of water discharged, for water pressures of 0.5 to 6,5 bar at the sprinkler head at intervals of (1 ± 2%) bar.

The maximum permissible error of the flow measuring device shall be ±2% of the value measured.

Calculate the K-factor for each pressure interval from equation (B.1):

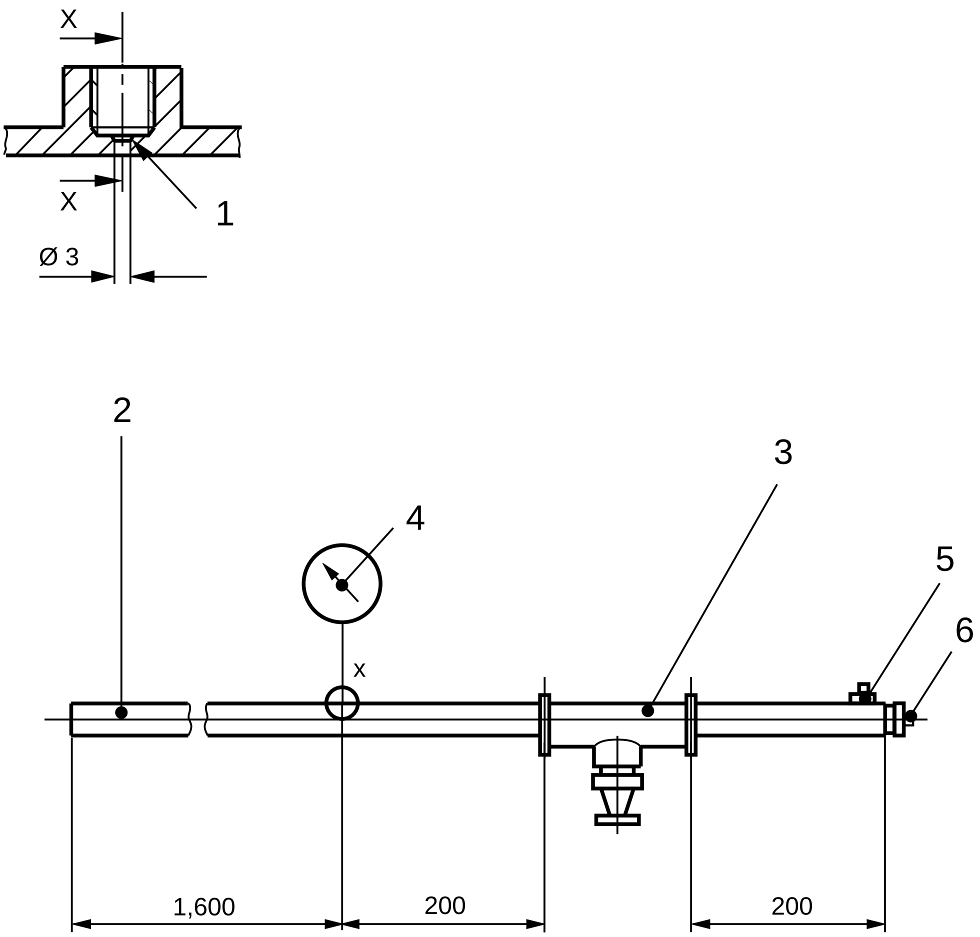
$$K = \frac{Q}{\sqrt{P}} \quad \text{(B.1)}$$

where

P is the pressure in bar

Q is the flow rate in litres per minute (l/min).

NOTE During the test, pressures should be corrected for difference in height between the gauge and the outlet orifice of the sprinkler.



1 Deburred orifice
2 Steel tube nominal internal diameter 40 mm, medium weight (in accordance with ISO 65)
3 Fitting 10 mm, 25, mm, 20 mm or 32 mm (in accordance with ISO 49)
4 Pressure gauge
5 Air bleed valve
6 Plug or cap

Accuracies: Pressure gauge ±2 %, weighing machine ±1 %

Figure B.1 — Water flow test apparatus

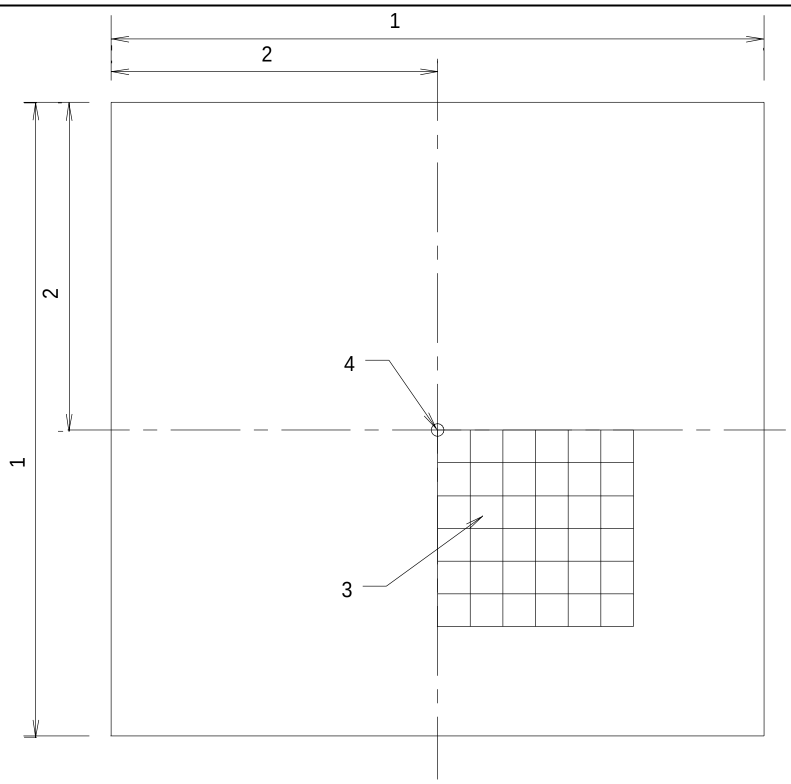
Annex C (normative)
Water distribution tests

C.1 Floor distribution tests

Install a single sprinkler in a test cell of the dimensions shown in Figure C.1, on piping prepared for this purpose. Use the arrangement of piping and containers shown in Figure C.1.

Position sprinklers relative to the ceiling in accordance with the supplier's product data sheet.

Flow water through the sprinkler in accordance with Table 4, for a period which ensures a satisfactory time average measurement has been achieved in each of the measurement areas, but for not less than 360 s. Measure or calculate the volume or mass of water distributed over the measurement area, by means of square measuring containers with sides of (300 ± 10) mm, positioned with a distance of (2.5 ± 0.25) m between the sub ceiling and the upper edge of the measuring containers.



1 (6 000 ± 50) mm
2 (3 000 ± 50) mm
3 36 measuring containers (300 ± 5) mm
4 Sprinkler

Figure C.1 — Layout of water distribution test chamber

C.2 Vertical distribution tests

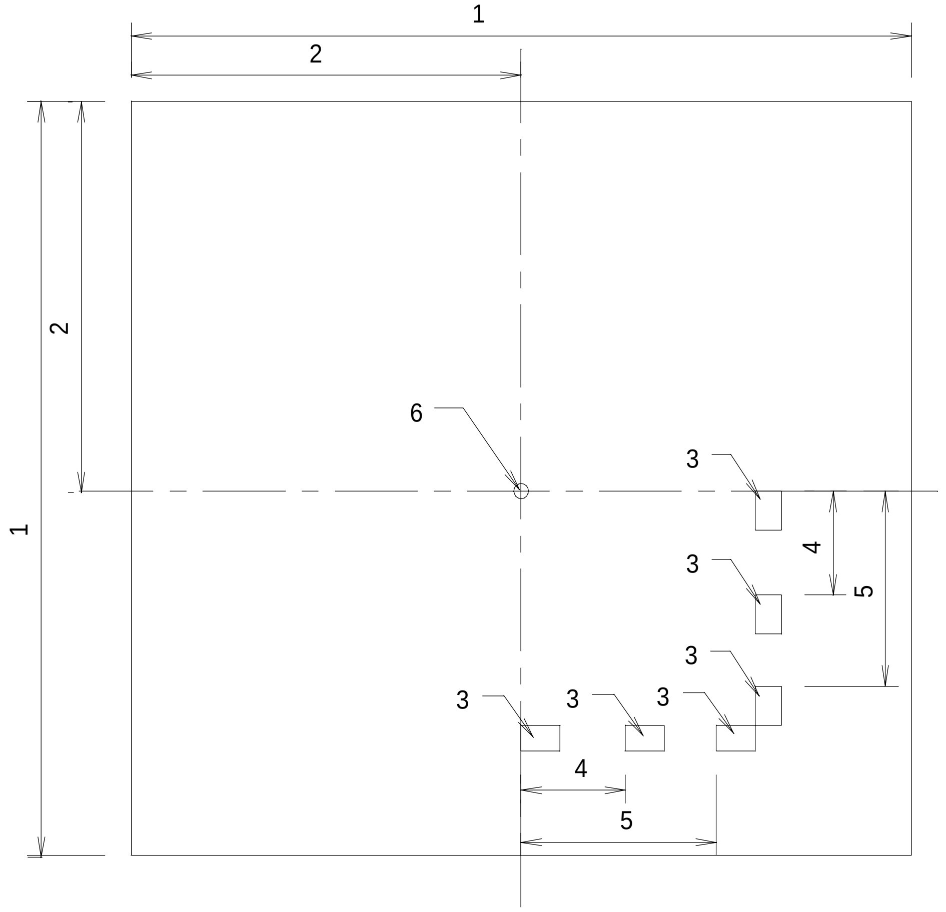
Install a single sprinkler in a test cell of dimensions shown in Figure C.2, on piping prepared for this purpose. Use the arrangement of piping and containers shown in Figure C.2 and C.3.

Position sprinklers relative to the ceiling in accordance with the supplier's product data sheet.

Flow water through the sprinkler in accordance with Table 4, for a period which ensures a satisfactory time average measurement has been achieved in each of the measurement areas, but for not less than 900 s. Measure or calculate the volume or mass of water distributed over the measurement area, by means of the vertical arrays of measuring containers with sides of (300 ± 5) mm × (200 ± 5), positioned as shown in Figures C.2, C.3 and C.4.

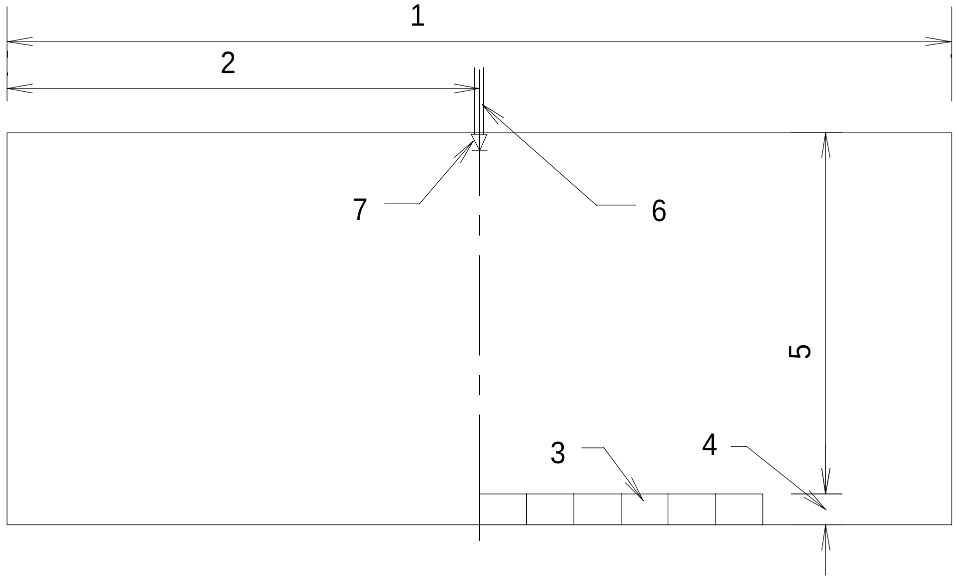
Repeat the water distribution test procedure, after raising the collection arrays (150 ± 2) mm.

Repeat both tests using a second sprinkler sample.



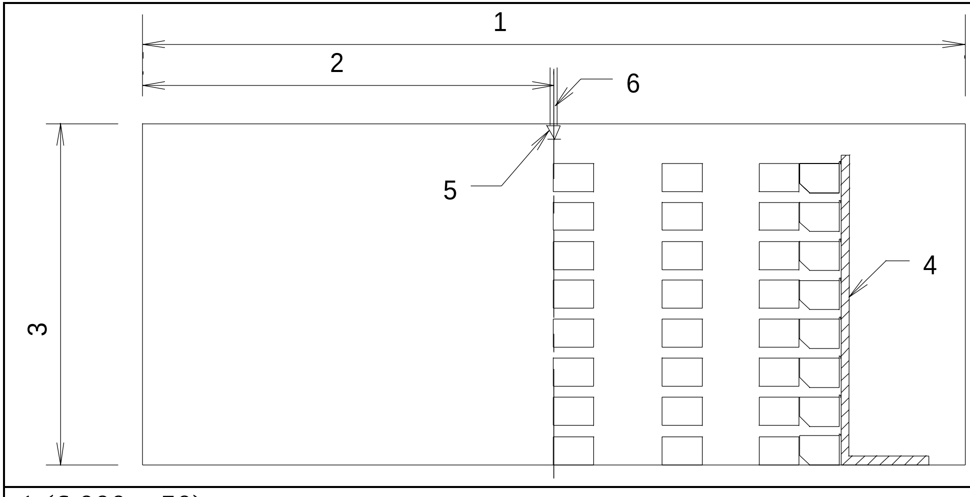
1 (6 000 ± 50) mm
2 (3 000 ± 50) mm
3 Vertical array of 8 measuring containers (300 ± 3) mm × (200 ± 3) mm
4 (750 ± 10) mm
5 (1 500 ± 10) mm
6 Sprinkler

Figure C.2 — Layout of vertical distribution test



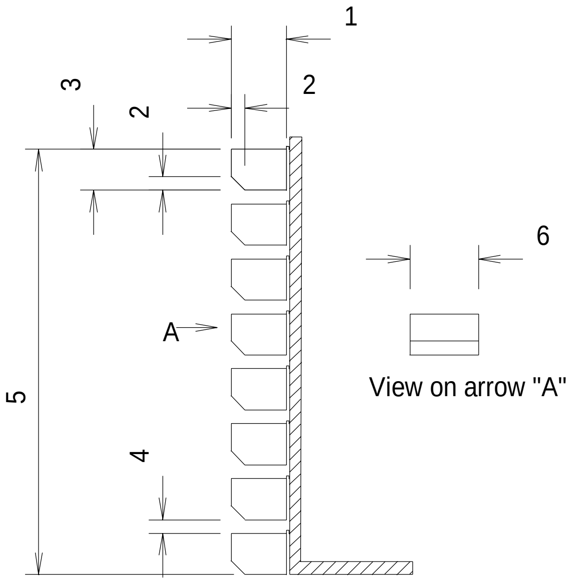
1 (6 000 ± 50) mm
2 (3 000 ± 50) mm
3 36 measuring containers (300 ± 5) mm
4 Measuring container depth (100 ± 10) mm
5 (2 500 ± 25) mm
6 20 mm ND × (300 ± 50) mm drop pipe and fitting
7 Sprinkler

Figure C.3 — Elevation of water distribution chamber



1 (6 000 ± 50) mm
2 (3 000 ± 50) mm
3 (2 450 ± 25) mm
4 Vertical collection container array (for details see Figure C.5)
5 Sprinkler
6 20 mm ND × (300 ±50) mm drop pipe and fitting

Figure C.4 — Elevation of vertical distribution measurement chamber



1 (200 ± 3) mm
2 (75 ± 3) mm
3 (225 ± 3) mm
4 (75 ± 2) mm
5 (2 325 ± 25) mm
6 (300 ± 3) mm

Figure C.5 — Vertical collection container array

Annex D (normative)
Functional test

NOTE See **4.6**.

D.1 Function of thermal sensitive element

Heat the sprinklers, including dry sprinklers that can be accommodated, in the functional test oven shown in Figure D.1. Whilst being heated, subject the inlet to water pressure as given in Table D.1. Increase the temperature at the sprinkler at a rate equivalent to (400 ± 20) ^{o}C in not more than 3 min.

Heat sprinklers having higher nominal operating temperatures than can be accommodated in the functional test oven, and other dry sprinklers, using a suitable heat source. Continue heating until the sprinkler has operated.

Test every sprinkler type and size in each normal mounting position and at the pressure given in Table D.1.

Table D.1 — Functional test parameters

Test pressure bar	**Minimum quantity tested**	**Minimum for each operating temperature**	**Maximum lodgement rate**
0.35 ± 0.05	12	3	1 per 12
3.5 ± 0.1	16	4	1 per 32
12.0 ± 0.1	16	4	

Ensure that the flowing pressure is at least 75 % of initial operating pressure. Measure the oven temperature local to the sprinkler.

Lodgement is considered to have occurred when one or more of the released parts lodge in the deflector frame assembly in such a way as to cause the water distribution to be significantly impeded for a period of more than 60 s.

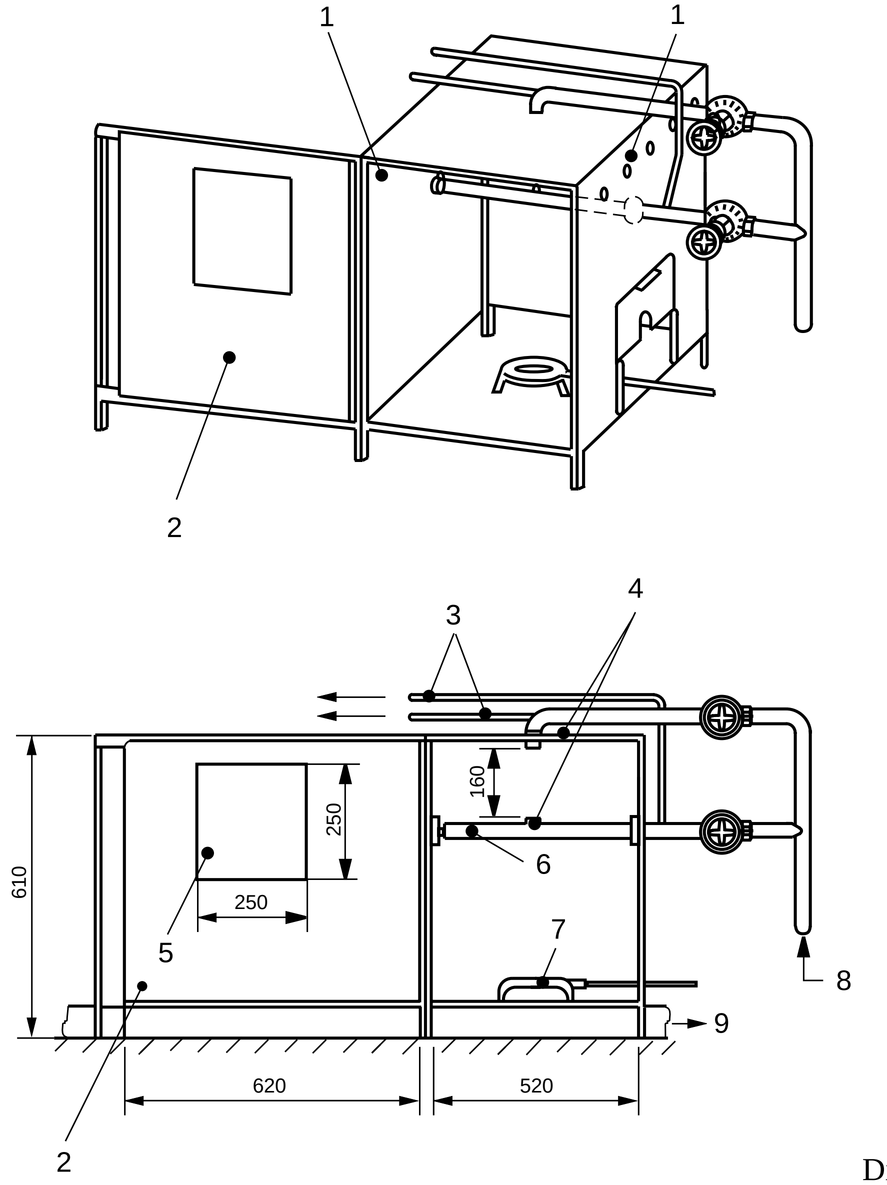
D.3 Verification functional test

Heat sprinklers, including dry sprinklers that can be accommodated in the functional test oven shown in Figure D.1. Increase the temperature at the sprinkler at a rate equivalent to (400 ± 20) ^{o}C in not more than 3 min.

Heat dry sprinklers that cannot be accommodated in the test oven using a suitable heat source. Continue heating until the sprinkler has operated.

Whilst the sprinkler is being heated, subject the sprinkler inlet to a water pressure of (0.35 ± 0.05) bar unless stipulated otherwise by the supplier.

Test the type, size and number of sprinklers specified in Table D.1 and establish that the pass criteria is achieved.



Dimensions in mm

1 Vent	6 Detachable pipe for upright sprinklers
2 Sliding or swinging door	7 Heat source
3 Gauge pipe	8 Water supply
4 Threaded connection for sprinklers	9 Water discharge
5 Window	

Figure D.1 — Example of functional test oven

Annex E (normative)
Strength of sprinkler body and deflector tests

NOTE 1 See **4.7**.

E.1 Measure the service load by securely installing the sprinkler in a tensile/compression test machine and apply an equivalent of a hydraulic pressure of (12 ± 0.1) bar at the inlet.

Use an indicator capable of reading deflection to an accuracy of 0.001 mm to measure any change in length of the sprinkler body between the load bearing points. Preferably avoid or take into account movement of the sprinkler shank thread in the threaded bush of the test machine.

Zero the deflection measuring indicator, (see Figure E.1).

Release the hydraulic pressure and remove the heat responsive element of the sprinkler without damaging the sprinkler. When the sprinkler is at room temperature, make a second measurement using the indicator.

Then apply an increasing mechanical load to the sprinkler, at a rate not exceeding 5 000 N/min, until the indicator reading at the deflector end of the sprinkler returns to the zero value achieved under the hydrostatic load. Record the mechanical load necessary to achieve this as the service load. Conduct this test on five sprinklers and take the arithmetic mean of the results as the average service load.

Increase the applied load progressively at a rate not exceeding 5 000 N/min until twice the average service load has been applied. Maintain this load for (15 ± 5) s.

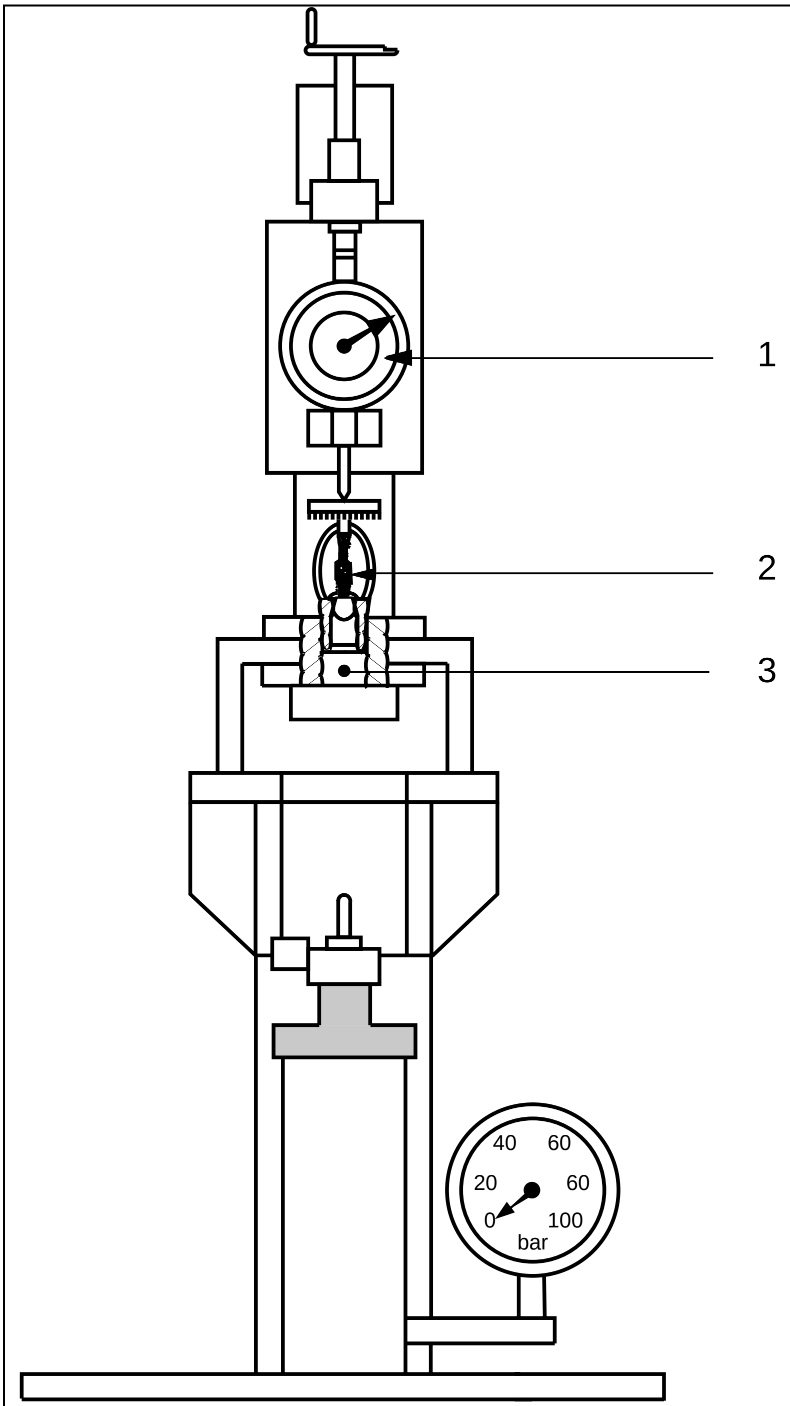
Remove the load and measure any permanent elongation of the sprinkler body.

E.2 Apply a force of $70\,^{+10}_{\ 0}$ N to the deflector by means of a flat metal plate, having a contact edge of at least $15\,^{+5}_{\ 0}$ mm, and examine the deflector for permanent deformation.

NOTE 2 This force should not be applied exclusively to the tines.

E.3 Deflector

To check the strength of the deflector, submit sprinklers to a flow test at a pressure of (12 ± 0.1) bar. Allow the water to flow at a running pressure of (12 ± 0.1) bar for a period of $45\,^{+1}_{\ 0}$ min.



Dimensions in mm

1 Deflector gauge

2 Sprinkler

3 Sprinkler fixture (sprinkler inlet pressure 12 ± 0.1 bar)

Figure E.1 — Example of a tensile/compression test machine

Annex F (normative)
Strength of release elements test

NOTE See **4.8**.

F.1 Glass bulbs

At least 55 glass bulbs of the same batch, design and type shall be positioned individually in a fixture using the sprinkler parts. Subject each bulb to a uniformly increasing force at a rate of (250 ±25) N/s in the test machine until the glass bulb fails.

NOTE The bulb seating parts may be reinforced externally or may be manufactured from hardened steel of Rockwell Hardness (44 ± 6) HRC, in a manner which does not influence bulb failure and in accordance with the sprinkler suppliers' specification.

If the sprinkler suppliers' standard seating parts are used, new seating parts shall be used for each bulb strength test.

Use the lowest 50 values, of the 55 measurements. Calculate the mean bulb strength of the sprinkler bulbs using the following equation:

$$\bar{x}_1 = \frac{\sum_{1}^{n} x_i}{n}$$

where

$\bar{x}_1$ = mean strength;
x_1 = individual glass bulb sample strength test values;
n = number of samples tested.

Calculate the unbiased standard deviation as follows:

$$S_1 = \sqrt{\frac{\sum_{1}^{n} (x_i - \bar{x}_1)^2}{n-1}}$$

where

S_1 = unbiased standard deviation in Newtons (N).

Calculate the bulb strength lower tolerance limit (LTL) using the equation:

$$\text{LTL} = \bar{x}_1 - Y_1 S_1$$

where

Y_1 = Y factor for normal distributions

appropriate to the number of glass bulb samples tested, see Table F.1.

Table F.1 — Y factors for normal distributions to determine one sided tolerance limits

n	Y
10	5.075
15	4.224
20	3.832
25	3.601
30	3.446
35	3.334
40	3.250
45	3.181
50	3.124
NOTE Y factor values for glass bulbs for a confidence level of 0.99 for 99 % of samples.	

Using the values of the service load recorded in E.1, calculate the mean service load using the equation:

$$\bar{x}_2 = \frac{\sum_{1}^{n_2} x_2}{n_2}$$

where

$\bar{x}_2$ = mean service load;
x_2 = individual service load test values;
n_2 = number of service load samples tested.

Calculate the service load standard deviation using the equation:

$$S_2 = \sqrt{\frac{\sum_{1}^{n2} (x_2 - \bar{x}_2)^2}{n_2 - 1}}$$

where

S_2 = service load standard deviation.

Calculate the service load upper tolerance limit (UTL) using the equation:

$$\text{UTL} = \bar{x}_2 + Y_2 S_2$$

where

Y_2 = Y factor for normal distributions appropriate to the number of service load samples tested (see Table F.1).

Verify conformity to **4.8.1**.

F.2 Fusible links

Subject fusible links to a constant load in excess of the design load (L_d), producing failure at approximately 1 000 h. Undertake the test with at least 10 links at different constant loads for loads not exceeding 15 times the maximum design load, rejecting abnormal failures. Using the times to failure/load values produced by the tests, plot a full logarithmic regression curve using the method of least squares, and from this calculate the loads to failure at 1 h (L_o) and 1 000 h (L_m), where:

$$L_d \leq 1{,}02\,\frac{L_m^2}{L_o}$$

Condition the test samples at (20 ± 3) ^{o}C prior to loading and maintain within these temperature limits throughout the test.

Annex G (informative)
Notes on strength test for fusible link release elements

NOTE See **4.8.2** and **F.2**.

The formula given in **F.2** is based on the intention of providing fusible elements that are not susceptible to creep stress failure during a reasonable period of service. 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.

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

The observed data is used to determine, by means of the method of least squares, the load causing failure at 1 h, L_o, and the load causing failure at 1 000 h, L_m i.e. when plotted on log log paper, the slope of the line determined by L_m and L_o is greater than or equal to the slope determined by the design load at 100 years, L_d, and L_o; or

$$\frac{\ln L_m - \ln L_o}{\ln 1000} \geq \frac{\ln L_d - \ln L_o}{\ln 876\,600}$$

This is reduced as follows:

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

$$\geq 0.5048\,(\ln L_d - \ln L_o) + \ln L_o$$

$$\geq 0.5048\,(\ln L_d + \ln L_o(1 - 0.5048))$$

$$\geq 0.5048 \ln L_d + 0.4952 \ln L_o$$

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:

$$L_m \geq 0{,}99\sqrt{L_d \times L_o}$$

$$L_d \geq 1{,}02\frac{L_m^2}{L_o}$$

Annex H (normative)
Leak resistance test

NOTE See **4.9**.

Subject at least four sprinklers to water pressure of (30 ± 1) bar at the inlet.

Increase the pressure from zero to (30 ± 1) bar at a rate not exceeding 1 bar/s, maintain the pressure at (30 ± 1) bar for a period of 3^{+1}_{0} min and then allow it to fall to 0 bar.

After the pressure has dropped to 0 bar, increase it to (0.5 ± 0.1) bar in not more than 5 s.

Maintain this pressure for 15^{+5}_{0} s, and then increase it to (10 ± 0.5) bar at a rate not exceeding 1 bar/s and maintain it for 15^{+5}_{0} s.

Examine the sprinkler for evidence of leakage during the test.

Annex I (normative)
Heat exposure

NOTE See **4.10**.

I.1 Uncoated sprinklers

Expose 12 uncoated sprinklers for a period of 90^{+1}_{0} days in an oven at a temperature that is 11^{+2}_{0} °C below the nominal operating temperature or at the test temperature shown in Table I.1, whichever is lower, but not less than 49 °C. If the service load is dependent on the service pressure apply an inlet pressure of (12 ± 0.1) bar during the test. After exposure, cool the sprinklers to ambient temperature; then test four sprinklers in accordance with each of the test procedures in **D.3**, annex A and annex H. If one or more sprinklers fail a test, expose at least eight additional sprinklers as described above and subject to the test in which the failure occurred. All of the additional sprinklers shall pass the test.

Table I.1 — Heat exposure test

Nominal operating temperature °C	**Test temperature** °C
57-60	49
61-77	52
78-107	79

I.2 Glass bulb sprinklers

Place four sprinklers in a liquid bath. Use water (preferably distilled) for sprinklers with a nominal operating temperature of 80 °C or less; use refined oil for sprinklers with a nominal operating temperature above 80 °C. Raise the temperature of the liquid bath from (20 ± 5) °C to (20 ± 5) °C below the nominal operating temperature of the sprinklers at a rate not exceeding 20 °C/min.

Then increase the temperature at a rate of not more than 1 °C/min to the temperature at which the gas bubble in the glass bulb dissolves, or to 5^{+2}_{0} °C lower than the nominal temperature, whichever occurs first. Remove the sprinkler from the liquid bath and allow it to cool in air until the gas bubble is formed again. During the cooling period, ensure the pointed end of the glass bulb (seal end) is pointing downwards. Execute the test four times on each of four sprinklers.

Annex J (normative)
Glass bulb sprinkler thermal shock test

NOTE See **4.11**.

Before starting the test ensure the sprinklers attain equilibrium at a temperature of $(20 \pm 5)\ ^{o}C$.

Immerse four sprinklers in a bath of liquid, at a temperature of $(10 \pm 2)\ ^{o}C$ below the nominal operating temperature of the sprinklers. After 5^{+1}_{0} min, remove the sprinklers from the bath and immerse them immediately in another bath of liquid at a temperature of $(10 \pm 1)\ ^{o}C$ with the bulb seal downwards. Examine the released sprinklers for proper operation. Examine sprinklers with broken glass bulbs to ensure the valve parts are free to move. Subject any unreleased sprinklers to a functional test in accordance with **D.3**.

Annex K (normative)
Corrosion tests

NOTE See **4.12**.

K.1 Stress corrosion test

K.1.1 ***Reagents***

K.1.1.1 *Aqueous ammonia solution,* density 0.94 g/cm^3.

K.1.2 ***Apparatus***

K.1.2.1 *Glass container,* of volume 0.01 m^3 to 0.03 m^3 with a sealable lid, containing a means of supporting the sprinklers under test and a means of preventing condensate dripping onto them, and fitted with a capillary tube, venting to atmosphere, to prevent the build-up of pressure.

K.1.3 ***Procedure***

Pour aqueous ammonia solution into the container, using 0.01 ml/cm^3 of container volume to give an atmosphere in the container consisting of approximately 35 % ammonia, 5 % water vapour and 60 % air.

Test six sprinklers. Degrease the sprinklers, seal the inlet of each sprinkler with a cap of non-reactive material, e.g. plastics, and place them in the container, supporting them approximately 40 mm above the surface of the ammonia solution.

Seal the container and maintain at a temperature of (34 ± 2)^{o}C for $10\ ^{+0,25}_{0}$ days. Top up the ammonia solution at intervals to maintain the level.

After exposure, rinse in water and dry the sprinklers, and carry out a detailed visual examination. If cracks, delamination or failure of any operating part are observed, subject the sprinkler(s) to a leak resistance test in accordance with annex H at (12 ± 0.1) bar for $1\ ^{+0,25}_{0}$ min. After the leak resistance test, subject the sprinklers to a function test in accordance with **D.3** at an inlet water pressure of (0.35 ± 0.05) bar.

Subject sprinklers showing cracking, delamination or failure of any non-operating part, after removal of the operating parts, to a flowing pressure of (12 ± 0.1) bar for $1\ ^{+0,25}_{0}$ min, and examine for visible evidence of separation of permanently attached parts.

K.2 Sulphur dioxide corrosion test

K.2.1 ***Reagents for apparatus of 5 l volume***

K.2.1.1 *(500 ±5) ml of aqueous solution of sodium thiosulfate*, of (0.161 ± 0.001) M concentration.

NOTE This may be prepared using (20 ± 0.1) g of analytical grade sodium thiosulfate pentahydrate crystals ($Na_2S_2O_3 \cdot 5H_2O$) made up to 500 ml distilled or deionized water in a volumetric flask at 20 °C.

K.2.1.2 *(1 000 ±5) ml of dilute aqueous sulfuric acid of (0.078 ±0.005) M concentration.*

NOTE This may be prepared using (156 ± 1) ml analytical grade 0.5 M sulfuric acid solution made up to 1 000 ml with distilled or deionized water in a volumetric flask at 20 °C.

K.2.2 ***Apparatus***

K.2.2.1 *Glass vessel*, as shown in Figure K.1, of 5 l or 10 l volume, made of heat resistant glass with a corrosion-resistant lid, shaped such that the condensate does not drip onto the sprinklers during the test, fitted with a cooling coil to cool the side walls of the vessel, as shown in Figure K.1 and an electrical heating device regulated by a temperature sensor placed centrally (160 ± 20) mm above the bottom of the vessel.

NOTE If a 10 l vessel is used, the volumes of sodium thiosulfate and sulfuric acid given in **K.2.1** should be doubled.

K.2.3 ***Procedure***

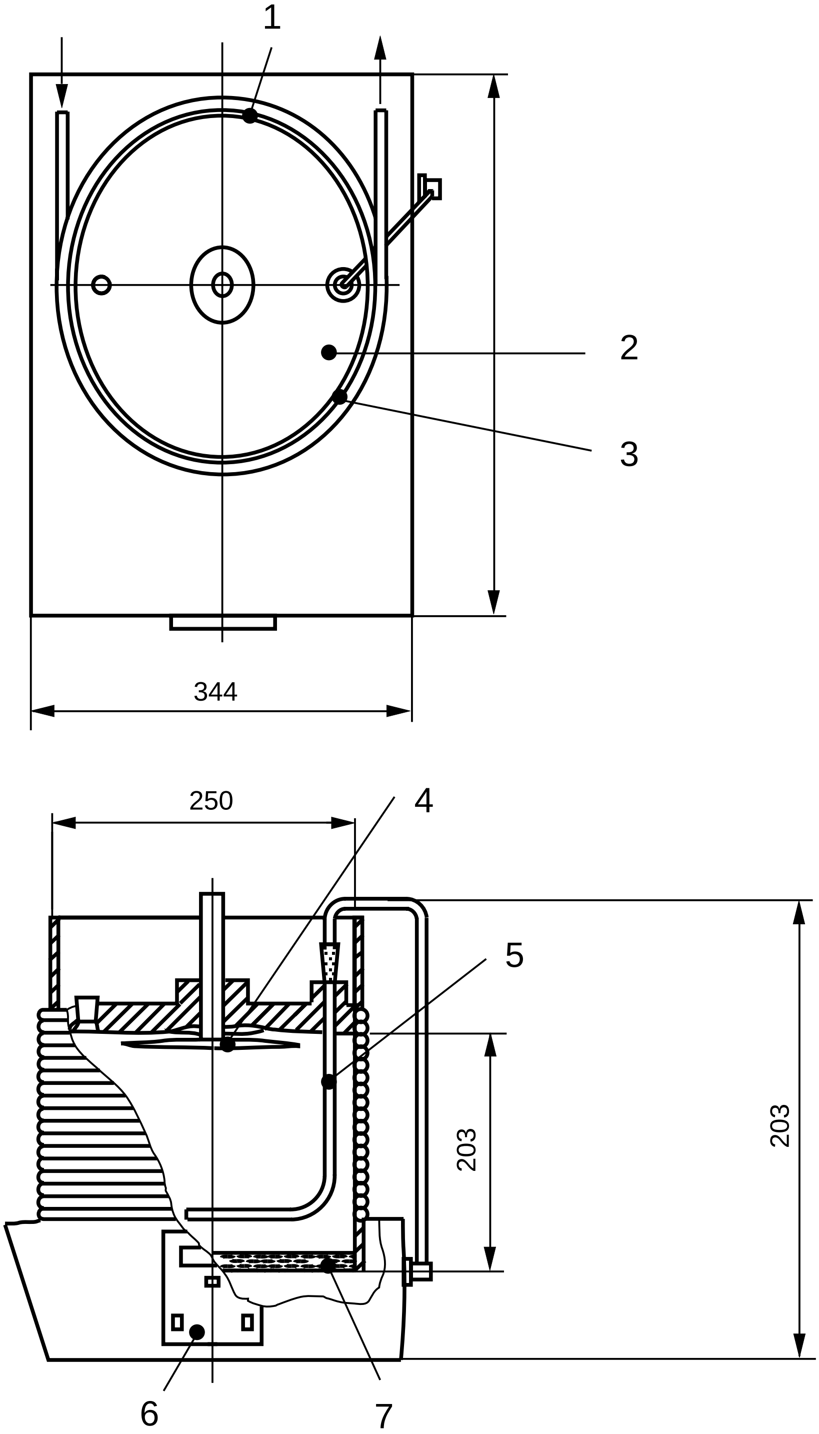
Expose six sprinklers for two periods of eight days each. Place the sodium thiosulfate solution in the vessel. Seal the inlet of each sprinkler with a cap of non-reactive material, e.g. plastics, and suspend the sprinklers freely in the normal mounting position inside the vessel under the lid. Adjust the temperature inside the vessel to (45 ± 3) °C and the flow of water through the cooling coil to give a temperature at the outflow below 30 °C. Maintain these temperatures throughout the test.

NOTE This combination of temperatures is intended to encourage condensation on the surfaces of the sprinklers.

Add (20 ± 0.5) ml of dilute sulfuric acid to the vessel each day. After $8\,^{+0,25}_{\;0}$ days remove the sprinklers from the vessel and empty and clean the vessel. Repeat the above procedure for a second period of $8\,^{+0,25}_{\;0}$ days.

After a total of $16\,^{+0,5}_{\;0}$ days remove the sprinklers from the vessel and allow them to dry for $7\,^{+0,25}_{\;0}$ days at a temperature not exceeding 35 °C and a relative humidity not greater than 70 %.

After the drying period, subject the sprinklers to a functional test in accordance with **D.3**.



Dimensions in mm

1 Glass vessel	5 platinum resistance probe
2 Polymethylmethacrylate(PMMA) lid	6 heating element
3 cooling coils	7 temperature indicator and set point controller
4 adjustable polymethylmethacrylate (PMMA) specimen mounting plate	

Figure K.1 — Typical vessel for sulphur dioxide corrosion test

K.3 Salt mist corrosion test

K.3.1 ***Reagents***

K.3.1.1 *Sodium chloride solution*, consisting of (20 ± 1)% (m/m) sodium chloride in distilled water, pH between 6.5 and 7.2 and having a density between 1.126 g/ml and 1.157 g/ml at (35 ± 2) ^{o}C.

K.3.2 ***Apparatus***

K.3.2.1 *Fog chamber*, of minimum volume 0.43 m^3, fitted with a recirculating reservoir and aspirating nozzles to deliver a salt spray, and means for sampling and controlling the atmosphere in the chamber.

K.3.3 ***Procedure***

Test five sprinklers. Fill each sprinkler with deionized water and seal the inlet by means of a plastic cap. Support the sprinklers in the fog chamber in their normal operating position, and expose them to a salt spray by supplying the sodium chloride solution through the nozzles at a pressure of between 0.7 bar and 1.7 bar, while maintaining the temperature in the exposure zone at (35 ± 2) ^{o}C. Ensure that solution running off the sprinklers is collected and not returned to the reservoir for recirculation.

Collect salt mist from at least two points in the exposure zone and measure the rate of application and the salt concentration. Ensure, for each 80 cm^3 of collection area, a collection rate of 1 ml/h to 2 ml/h over a period of $16\,^{+0,25}_{0}$ h.

Expose sprinklers intended for installation in normal atmospheres for a period of $10\,^{+0,25}_{0}$ days. Expose sprinklers intended for installation in corrosive atmospheres for a period of $30\,^{+0,5}_{0}$ days.

After exposure, remove sprinklers from the fog chamber and allow to dry for $7\,^{+0,25}_{0}$ days at a temperature not exceeding 35 ^{o}C and at a relative humidity not greater than 70 %. After the drying period, subject the sprinklers to a functional test in accordance with **D.3**.

K.4 Moist air atmosphere test

Test five sprinklers. Install the sprinklers on a pipe manifold containing deionized water. Place the entire manifold in an enclosure at a temperature of (95 ± 4) ^{o}C and a relative humidity of (98 ± 2) % for $90\,^{+1}_{0}$ days.

After this period, remove the sprinklers and subject them to a functional test in accordance with **D.3**.

NOTE At the suppliers' option additional samples may be furnished for this test to provide early evidence of failure. Such additional samples may be removed from the test chamber at (30 ± 1) day intervals and tested.

Annex L (normative)
Sprinkler coatings low temperature test

NOTE See **4.13**.

Test five sprinklers, coated by normal production methods. Place the sprinklers in a refrigerated cabinet with an automatic temperature control. Control the temperature to (-10 ± 3) ^{o}C for a period of 24 $^{+1}_{0}$ h. On removal from the cabinet, allow the sprinklers to return to ambient temperature and visually examine the coating.

Annex M (normative)
Water hammer test

NOTE See **4.14**.

Test five sprinklers, installing each sprinkler on the test apparatus in their normal mounting position. Fill the test apparatus with water and purge all the air, making sure that air is not trapped in the sprinkler bores. Subject the sprinklers to a pressure cycle, rising from (4 ± 2) bar to $25\,^{+5}_{0}$ bar at a rate of $45\,^{+10}_{-5}$ bar/s; after which the pressure shall be returned to (4 ± 2) bar. The pressure cycles shall be repeated $3\,000\,^{+100}_{0}$ times, at a rate of $15\,^{+5}_{0}$ cycles per minute. Measure and record the pressure changes against time. Visually examine each sprinkler for leakage. Then test the five sprinklers in accordance with **D.3**.

Annex N (normative)
Thermal response tests

NOTE See **4.15**.

N.1 General

Test five sprinklers in accordance with **N.2** and a second batch of five sprinklers in accordance with **N.3**, in each orientation described, in a wind tunnel with test section dimensions of (270 ± 40) mm width × (150 ± 10) mm depth.

NOTE 1 The design of the wind tunnel should be such that the influence of thermal radiation does not change the measured RTI values by more than 3 % for sprinklers with a nominal operating temperature up to 74 ^{o}C. A suggested method for determining thermal radiation effects is by conducting comparative plunge tests on a blackened (high emissivity) metallic test specimen and a polished (low emissivity) metallic test specimen.

NOTE 2 Background information on thermal response parameters is given in the Bibliography.

Wrap polytetrafluoroethylene (PTFE) sealant tape around the threads of each sprinkler and screw into a mounting jig with a torque of (15 ± 3) N·m. Prime the mounting jig and sprinkler orifice with water.

N.2 Prolonged exposure ramp test

Maintain the mount temperature at (30 ± 2) ^{o}C for the duration of each test. Insert the sprinkler in the standard orientation [see Figure N.1a)] into the wind tunnel test section, which has been preset to a stabilized air stream velocity of (1 ± 0.1) m/s and an initial air temperature corresponding to the nominal operating temperature of the sprinkler.

Increase the air temperature at a nominal rate of rise of 1 ^{o}C/min, with temperature variation from the ideal ramp of not more than ±3 ^{o}C. Monitor and record the air temperature, velocity and mount temperature from the initiation of the test until the sprinkler operates.

Calculate the C factor of the sprinkler using the following equation:

$$C = (\Delta T_g / \Delta T_{ea} - 1)\, u^{1/2}$$

Where:

ΔT_g is the actual gas (or air) temperature in the test section minus the mount temperature (T_m) in degrees Celsius, at the time the sprinkler operates;

ΔT_{ea} is the mean operating temperature of the sprinkler determined in accordance with annex A minus the mount temperature in degrees Celsius at the time the sprinkler operates;

u is the actual gas (or air) velocity in the test section in metres per second (m/s), at the time the sprinkler operates.

Use the mean of the five C factor values for calculation of the standard orientation RTI values in **N.3**.

N.3 Plunge test

Condition the sprinkler, water and mounting jig assembly, prior to the tests to a temperature of (30 ± 2) ^{o}C for a period of at least 30 min. Maintain the temperature of the water within these limits for the duration of the test, measure the temperature by use of a thermocouple located in the water at the centre of the sprinkler orifice.

Test sprinklers with the waterway axis perpendicular to the airflow in the following orientations (see Figure N.1):

a) standard orientation, yoke arms normal ±5 ^{o} to the airflow such that the heat responsive element is fully exposed to the airflow [see Figure N.1.a)];

b) unfavourable orientation, yoke arms rotated (25 ± 1) ^{o} out of alignment with the airflow [see Figure N.1.b)].

Additionally test sprinklers which are asymmetric about the axis of the waterway as follows:

c) yoke arms rotated 180 ^{o} about the axis of the waterway from a).

Test all other sprinklers where the influence other than yoke arm shadows can be encountered, in different orientations to establish that the total angle of acceptable operation is $\geq 256^{o}$.

Plunge the sprinkler into the wind tunnel test section, which has a constant airstream velocity and air temperature corresponding to the values specified in Table N.1.

Maintain the selected air velocity throughout the test and use a timer accurate to ±0.1 s with suitable measuring devices to determine the time between plunging of the sprinkler into the wind tunnel and operation of the sprinkler, in order to establish the response time.

Table N.1 — Wind tunnel conditions for plunge test

Nominal operating temperature °C	**Quick response sprinkler type**	
	Air temperature [a] °C	**Velocity** [b] m/s
57-77	129-141	1.65-1.85
79-107	191-203	1.65-1.85

[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 129 °C to 141 °C and to an accuracy of ±2 °C for all other temperatures.

[b] The selected air velocity shall be known and maintained constant within the test section 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.

Monitor and record the air temperature, velocity and mount temperature from the initiation of the test until the sprinkler operates.

Calculate the RTI of the sprinkler by using the following equation:

$$\mathrm{RTI} = \left[\frac{-t_r \sqrt{u}}{\ln \left\{ 1 - \Delta T_{ea} \left(1 + C / \sqrt{u} \right) / \Delta T_0 \right\}} \right] \left(1 + C / \sqrt{u} \right)$$

where:

t_r is the response time of the sprinkler in seconds (s);

u is the actual gas (or air) velocity in the test section in metres per second (m/s), at the time the sprinkler operates;

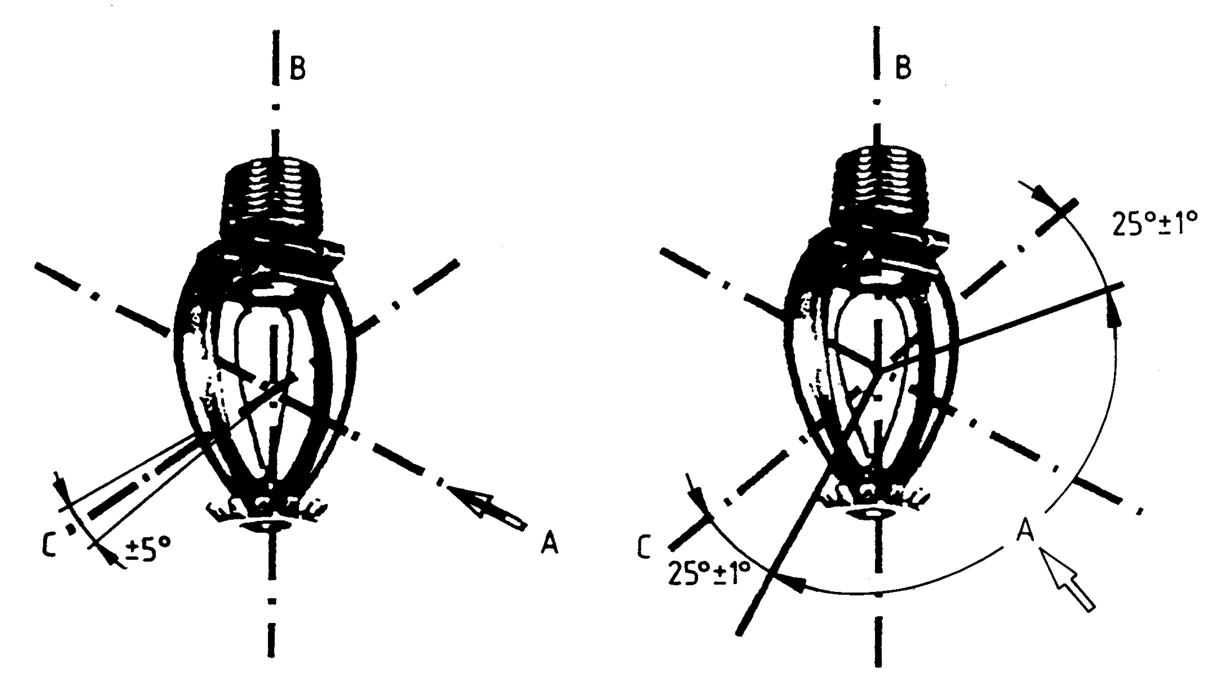
ΔT_{ea} is the mean operating temperature of the sprinkler determined in accordance with annex A minus the mount temperature in degrees Celsius (°C), at the time the sprinkler operates;

ΔT_g is the actual gas (or air) temperature in the test section minus the mount temperature in degrees Celsius (°C) at the time the sprinkler operates;

C is the conductivity factor determined in accordance with **P.2** in (metres/second)$^{1/2}$

ln is the natural logarithm

Calculate the mean of the RTI values from each of the orientation tests.



a) standard orientation	b) unfavourable orientation

A air flow orientation
B waterway axis
C yoke arm orientation

Figure N.1 — Standard orientation and unfavourable orientation

Annex O (normative)
Heat-resistance test

NOTE See **4.16**.

Heat a sprinkler test sample in an oven at (770 ± 10) °C for a period of 15^{+1}_{0} min, with the sprinkler test sample held in its normal installation position. Remove the sprinkler test sample from the oven, holding it by the threaded inlet, and promptly immerse it in a water bath at a temperature of (20 ± 10) °C. Examine the sprinkler test sample for deformation and breakage.

Annex P (normative)
Vibration test

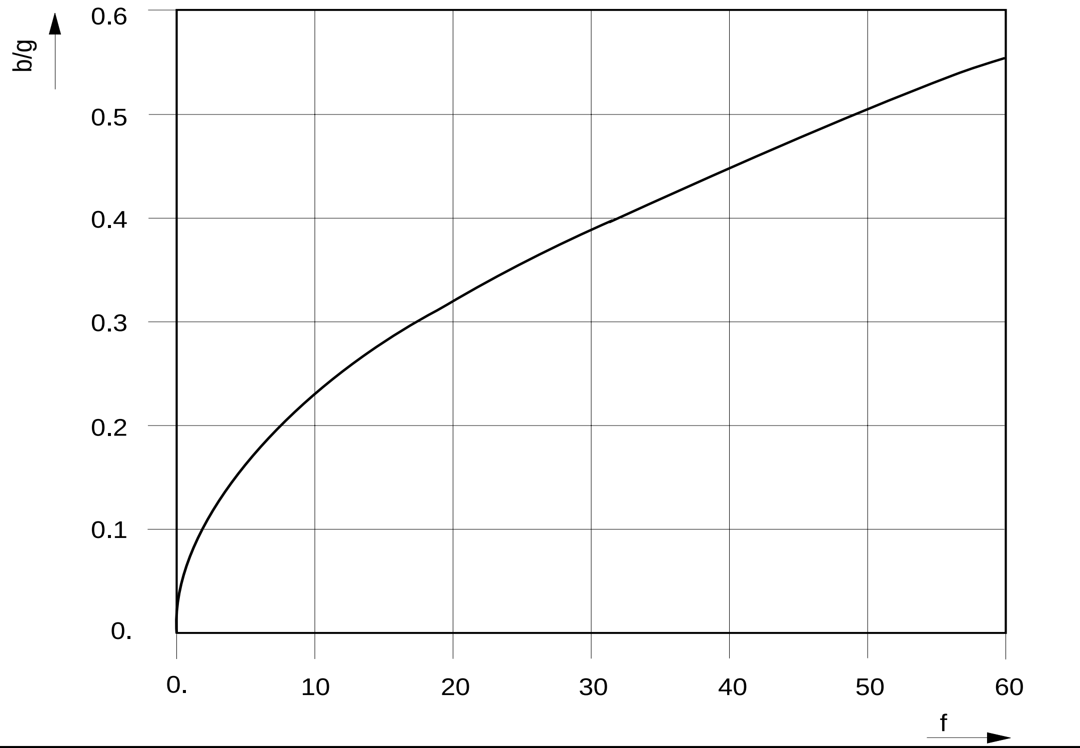
NOTE See **4.17**.

Fix three sprinklers vertically to a vibration table. Subject the sprinklers to sinusoidal vibrations in accordance with the test curve shown in Figure P.1. Vibrate in the direction of the axis of the connecting thread.

Follow the test curve continuously from 5 Hz to 60 Hz at a rate of 1 octave/30 min if one or more resonance points can be clearly detected, after coming to the end of the curve vibrate the sprinkler at each of these resonant frequencies for $1\,^{+0,1}_{\;\;0}$ h at the peak values for vibration acceleration deduced from Figure P.1.

If no resonant frequency is found, subject the sprinkler to vibration at (35 ± 1) Hz for a period of $120\,^{+1}_{\;0}$ h at an amplitude of (1 ± 0.1) mm.

Inspect the sprinklers for damage then subject each sprinkler to one of three tests; a leakage test in accordance with annex H, a strength of release elements test in accordance with **F.1** or **F.2** as appropriate and a functional test in accordance with **D.3**.



$b/g = 0.228\,(f/10)^{1/2}$
where:

f is the frequency in hertz
b is the amplitude of acceleration in m/s^2
g is the acceleration due to gravity (9.81 m/s^2)

Figure P.1 — Vibration test curve

Annex Q (normative)
Impact test

NOTE See **4.18**.

Test five sprinklers by dropping a weight on to the deflector of the sprinkler along the axial centre line of the waterway. The kinetic energy of the dropped weight at the point of impact shall be equivalent to that of a weight of the same mass as the test sprinkler dropped from the height of 1 m. Prevent the weight from impacting more than once upon each sample. Test for leakage in accordance with annex H and functional test in accordance with **D.3**.

Annex R (normative)
Resistance to low temperature test

NOTE See **4.19**.

Subject four sprinklers to a temperature of (-20 ± 2) °C for a period of $24\ ^{+1}_{0}$ h. Then allow the sprinklers to stand for at least 2 h at room temperature. Examine the sprinklers and subject them to a functional test in accordance with **D.3**.

Annex S (normative) Fire tests

S.1 General

Sprinklers of each temperature rating shall be fire tested twice in the two arrangements shown in Figures S.1 and S.2.

Install two sprinklers of the same type, at their maximum sprinkler spacing S, in a test room of the dimensions shown in figure S.1 and S.2. Install a third sprinkler of the same type, outside the test room near the open doorway. The sprinklers shall be installed in accordance with the manufacturer’s instructions, and as shown in Figures S.1 and S.2.

The test room dimensions shall be:

— length: twice the maximum sprinkler spacing (2 × S);

— width: the sprinkler spacing (S)(see table 4);

— ceiling height: (2.5 ± 0.05) m.

— minimum doorway height (2.2 ± 0.05) m

— maximum lintel depth (0.3 ± 0.05) m

— external ceiling height (2.5 ± 0.05) m

Before the start of each test, the room temperature shall be (25 ± 5) °C. The room, wall panels, floor, fuel packages and contents shall be dry and the room relative humidity shall be (60 ± 10) %.

The test room ceiling shall be covered by cellulosic acoustic panels attached by furring strips. The walls shall be covered, floor to ceiling, by two plywood panels 10 mm thick and (2.4 ± 0.1) in length.

> Note: Consistency of the flammability properties of the panels is essential for the repeatability of this test

Fuel packages and ignition packages shall be placed in the test room as shown in Figures S.3 and S.4.

The ignition package shall consist of a 300 mm × 300 mm × 100 mm deep square steel tray made from 12 gauge steel. 200 ml of commercial grade heptane shall be floated on water of 25 mm minimum depth. A wood crib consisting of eight layers of wood sticks of *pinus silvestris*, with four sticks per layer, shall be placed on top of the steel tray. The wood sticks shall be 38 mm × 38 mm cross-section by 305 mm long (actual) and plane finish. The complete wood crib shall have the nominal dimensions of 305 × 305 × 305 mm and shall weigh (5 750 ± 250) g. The crib shall be conditioned before the test, such that the moisture content is (6 ± 1) %, 3 mm below the wood stick surface.

The fuel package shall consist of two sheets of polyether foam 925 × 1 000 × 75 mm having a density of 20 kg/m^3. Each sheet shall be attached to a wooden supporting frame. The foam sheets shall overlap the top of the frame by 150 mm and at the sides of the frame by 125 mm.

S.2 Fire test method

Ignite the heptane in the steel tray and record temperatures and sprinkler operating time(s). Measure the total heat output from ignition to ten minutes after the operation of the first sprinkler. The flow through the first sprinkler to operate shall be sufficient to provide a nominal discharge density of not less than 4.0 mm/min over the single sprinkler area of coverage. The nominal discharge density for two operating sprinklers shall not be less than 2.85 mm/min. Calculate the nominal density using the equation:

$$D = \frac{Q}{a}$$

Where:

D = nominal discharge density (mm/min)
Q = flow into area of coverage (L/min)
a =area of coverage under consideration (m^2)

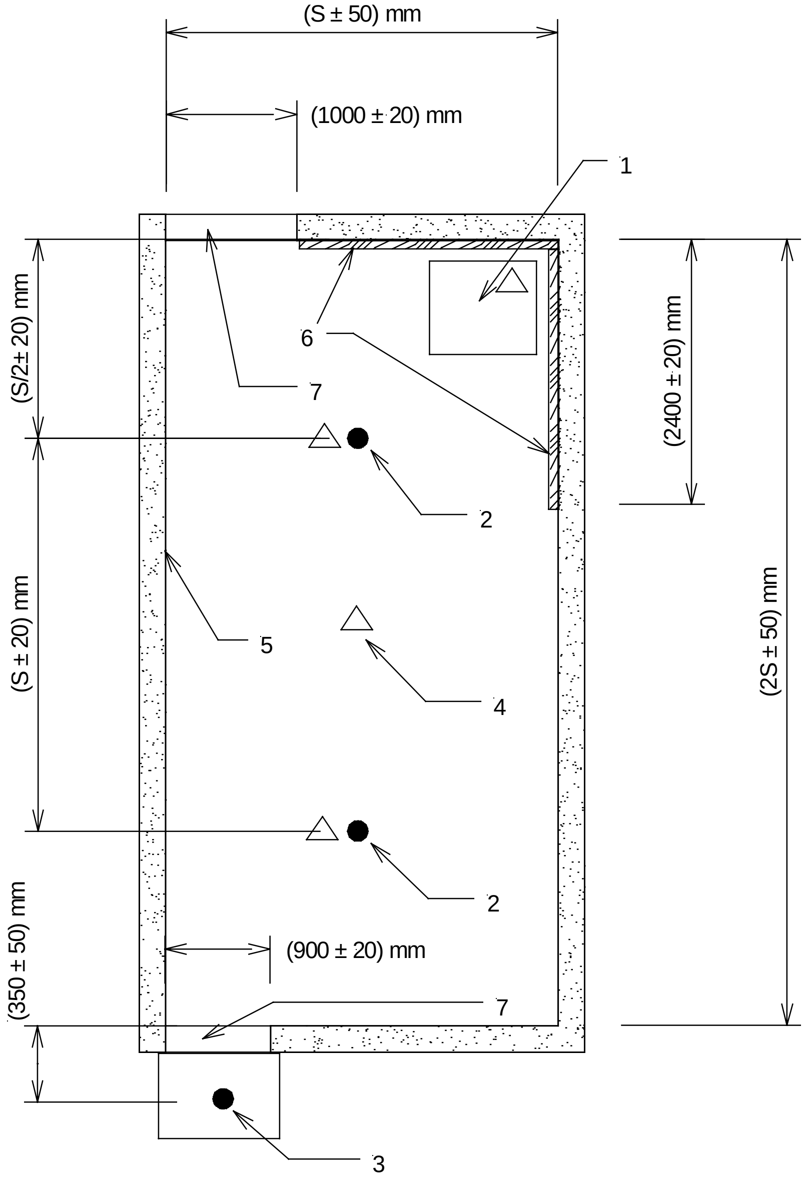
Record the time of sprinkler operations and the thermocouple temperatures.

Repeat the test using the fire test arrangement shown in Figures and.

> NOTE The fuel package may be positioned at any location along the room during this test.

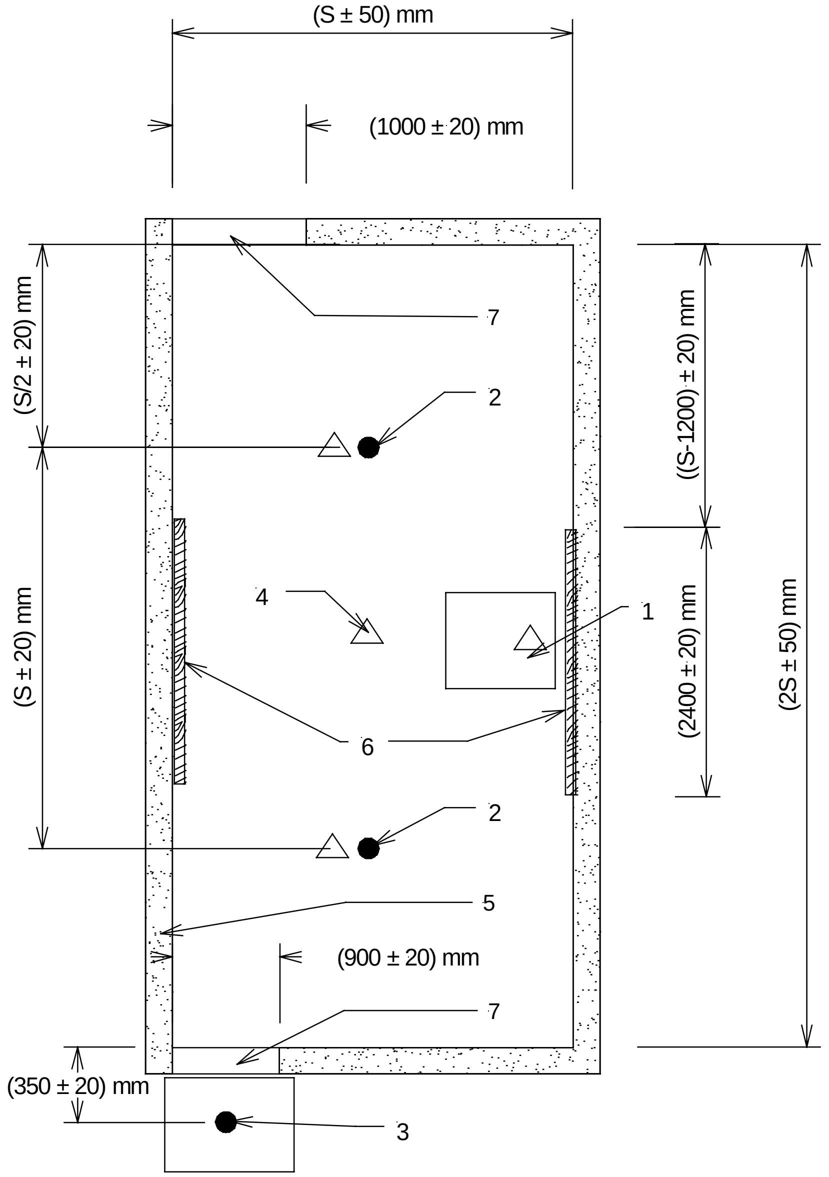
The **[SK1]** fuel package shall be located in the position achieving the lowest water application rates based on the water distribution tests (see annex C)

Measure and record any flow through each of the two room sprinklers at intervals not exceeding 1 Hz.



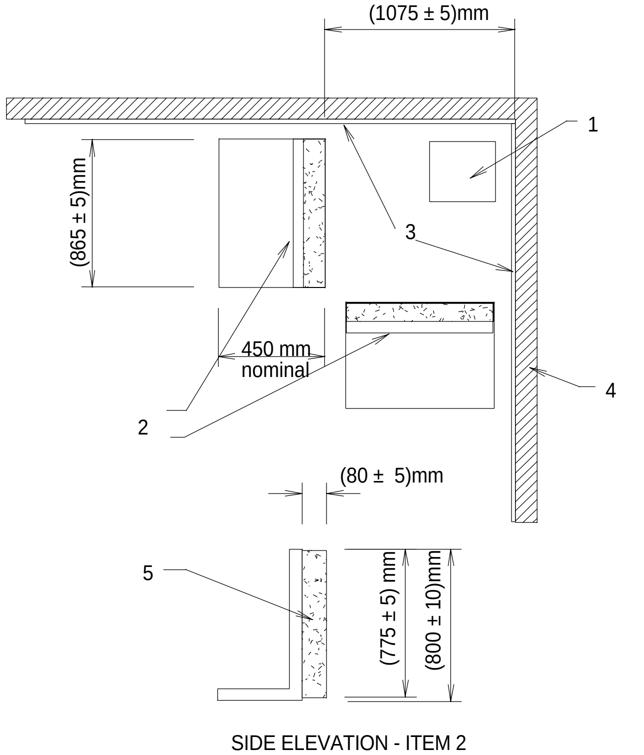
1 Corner fire test ignition and fuel package – see Figure
2 Sprinkler (connected to water supply)
3 Sprinkler (not connected to water supply)
4 Thermocouple
5 Test room
6 Full height plywood panels

Figure S.1 — Fire test 1: room corner layout



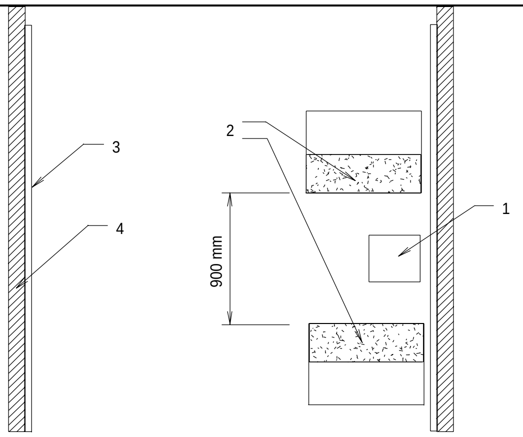
1 Fire test ignition and fuel package – see Figure
2 Sprinkler (connected to water supply)
3 Sprinkler (not connected to water supply)
4 Thermocouple
5 Test room
6 Full height plywood panels

Figure S.2 — Fire test 2: random layout



1 300 mm × 300 mm steel pan with heptane on water and wood crib above
2 fuel package – simulated furniture, foam plastic on a supporting frame
3 Plywood panels
4 Test room walls
5 Foam pad glued to support board

Figure S.3 — Corner fire test ignition and fuel package



1 300 mm × 300 mm steel pan with heptane on water and wood crib above
2 Fuel package – simulated furniture, foam plastic on a supporting frame
3 Plywood panels
4 Test room walls

Figure S.4 — Wall fire test ignition and fuel package

S.3 Sidewall sprinklers

Test method in preparation.

Annex T (normative)
Conditions for tests

Except where specified otherwise carry out tests at (20 $\pm$ 10) ^{o}C.

Visually examine sprinklers for obvious defects before testing.

NOTE The schedule of Figure T.1 should be used for type approval testing.

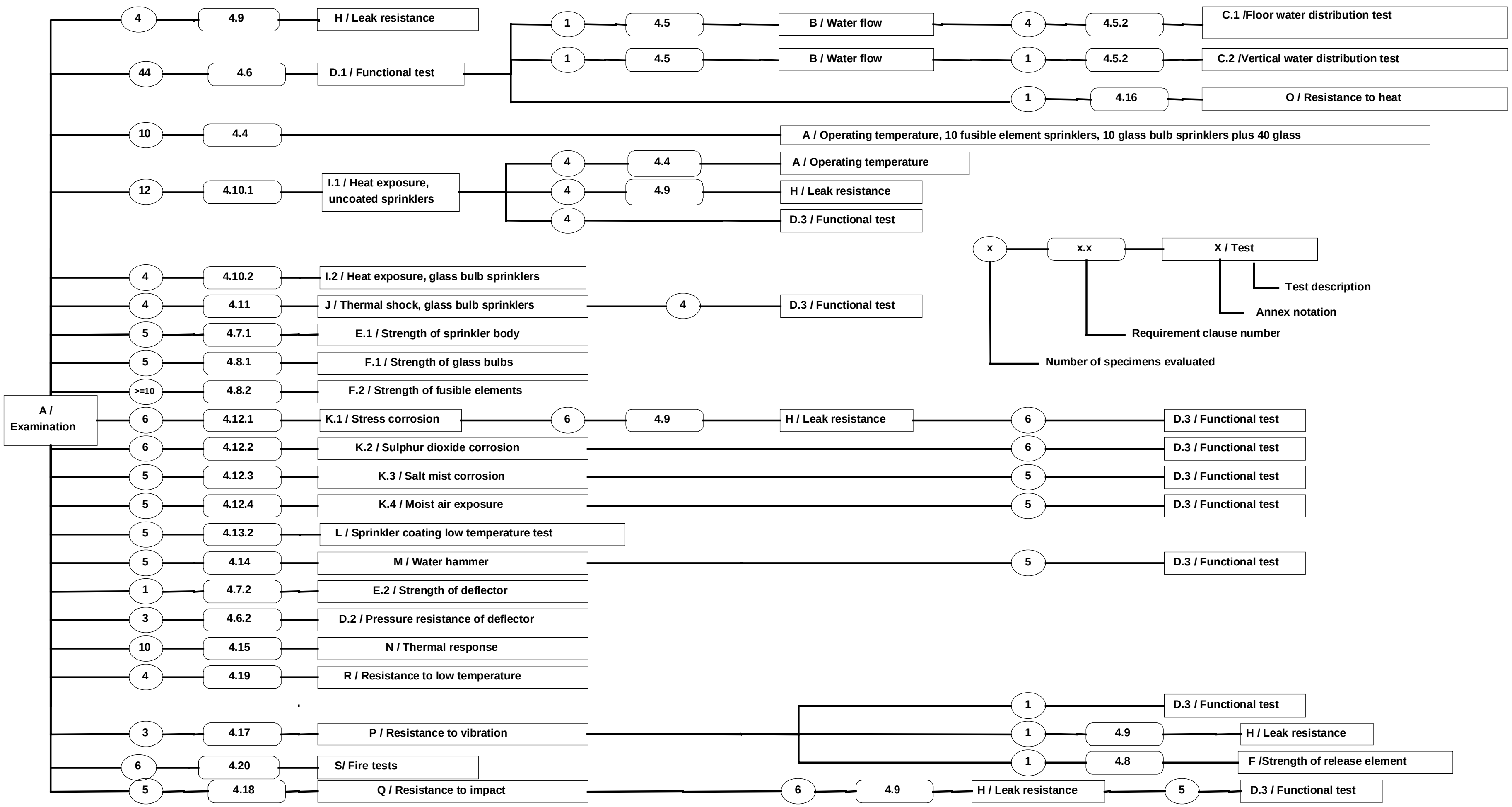


Figure T.1 — Summary test schedule for type approval testing

Bibliography[SK2]

Standards publications

BS 5306-2, *Fire extinguishing installations and equipment on premises — Part 2: Specification for sprinkler systems.*

BS EN ISO 9000-1, *Quality systems — Model for quality assurance in design, development, production, installation and servicing*.

Background reading on thermal response (the plunge test and the prolonged exposure ramp test)

Heskestad, G. and Bill, R.G.,Jr., "Conduction heat loss effects on thermal response of automatic sprinklers" Factory Mutual Research Corporation, September 1987.

Heskestad, G. and Smith, H.F., "Plunge test for determination of sprinkler sensitivity," Factory Mutual Research Corporation, December 1980.

Heskestad, G. and Smith, H.F., "Investigation of a new sprinkler sensitivity approval test:The plunge test," Factory Mutual Research Corporation, December 1973.

ISO TC21 **[SK3]**SC5 WG 1 document N 157, VdS, Cologne, 1988.

ISO TC21 SC5 WG1 document N 186, Job GmbH, September 1990.

Page: 52
[SK1] Verbal forms are not clear. Is this intended to be a recommendation ("should") or is requirement ("shall") intended? Please clarify.

Page: 59
[SK2] A bibliography is needed for all informative references.

Page: 59
[SK3] Which ISO documents are being referred to? Please clarify.