



DPC: 21/30432191 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

English Version

Fixed firefighting systems - Components for sprinkler and water spray systems - Part 13: ESFR sprinklers

Installations fixes de lutte contre l'incendie -
Composants des systèmes d'extinction du type
sprinkleur et à pulvérisation d'eau - Partie 13 :
Sprinkleurs ESFR

Ortsfeste Brandbekämpfungsanlagen - Bauteile für
Sprinkler- und Sprühwasseranlagen - Teil 13: ESFR-
Sprinkler

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 191.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 12259-13:2021) has been prepared by Technical Committee CEN/TC 191 “Fixed firefighting systems”, the secretariat of which is held by BSI.

This document is currently submitted to the CEN Enquiry.

EN 12259, *Fixed firefighting systems - Components for sprinkler and water spray systems*, consists of the following parts:

- *Part 1: Sprinklers;*
- *Part 2: Wet alarm valve assemblies;*
- *Part 3: Dry alarm valve assemblies;*
- *Part 4: Water motor alarms;*
- *Part 5: Water flow detectors;*
- *Part 9: Deluge alarm valves;*
- *Part 12: Pumps;*
- *Part 13: ESFR sprinklers;*
- *Part 14: Sprinklers for residential applications.*

1 Scope

This document specifies requirements and test methods for early suppression and fast response (ESFR) sprinklers with a nominal discharge coefficient of 200 (pendent and upright), 240 (pendent and upright), 320 (pendent), 360 (pendent), 400 (pendent) and 480 (pendent) l/min/(bar)^{1/2}.

2 Normative references

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

EN 12845, *Fixed firefighting systems - Automatic sprinkler systems - Design, installation and maintenance*

EN 12259, *Fixed firefighting systems - Components for sprinkler and water spray systems*

EN 60751, *Industrial platinum resistance thermometers and platinum temperature sensors*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12845, EN 12259 and the following apply.

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

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

actual delivered density

ADD

measure of the rate at which water is actually deposited from an operating sprinkler type device(s) onto the top horizontal surface of a burning combustible array

Note 1 to entry: ADD is expressed in l/min/m².

3.2

service load

measure of the force applied to the sprinkler frame due to assembly of the operating parts, plus the equivalent force resulting from the maximum rated inlet pressure

3.3

conductivity

C-factor

measure of the conductance between the sprinkler's heat responsive element and the water filled fitting

Note 1 to entry: Conductivity is expressed in (m/s)^{1/2}.

3.5

mean design service load

sprinkler manufacturer's specified and assured highest mean load applied on the operating element at the maximum rated inlet pressure

3.6

cartoned expanded plastic

commodity product consisting of expanded polystyrene plastic food service trays (or meat trays) packaged in single-wall corrugated cartons

Note 1 to entry: Each carton contains 200 plastic trays arranged in four stacks of 50 trays each with a density of 0,038 g/cm³. Typical trays weigh approximately 15,25 g each, measure approximately 270 mm × 270 mm × 5 mm thick and consists of expanded foam plastic. Each carton measures 530 mm × 530 mm × 510 mm, shall have a moisture content of between 3,8 % and 7,4 % and weigh 4 kg when filled with the plastic trays. Each pallet load consists of eight cartons placed in a 2 × 2 × 2 array upon a 1 070 mm × 1 070 mm × 130 mm two-way, slatted deck hardwood pallet. The pallet shall be minimum 90 % white, red or black oak, with an 8 % to 10 % moisture content.

3.7

standard plastic test commodity

product of cartoned, unexpanded, rigid crystalline, polystyrene jars

Note 1 to entry: Measuring 89 mm in diameter, 91,44 mm high and 1,42 mm thick (with a volume of 0,47 l), packaged in compartmented, single wall, cardboard cartons measuring 530 mm × 530 mm × 510 mm. Jars are arranged in five layers, 25 per layer giving total of 125. Eight cartons are stacked two wide by two deep by two high; on a two-way, slatted deck hardwood pallet measuring 1070 mm × 1 070 mm × 1 300 mm.

3.8

fusible link sprinkler

sprinkler which opens when an element provided for that purpose melts at a prescribed temperature

3.9

glass bulb sprinkler

sprinkler which opens when a liquid-filled glass bulb bursts at a prescribed temperature

3.10

lodgement

malfunction in the operation of a sprinkler which, when operated under a typical system water pressure, experiences the hang-up of an operating part on, or between, the frame, deflector and/or compression screw, adversely affecting the water distribution for a period in excess of ten seconds

Note 1 to entry: A momentary hesitation of an operating part to clear itself from temporary contact with the frame, deflector and/or compression screw does not constitute a lodgement.

3.11

heat responsive element

component of a sprinkler assembly that, when subjected to the influence of heat, ruptures, bursts or otherwise functions, causing water to be discharged through the sprinkler orifice

3.12

leak point

pressure at which there is leakage of water from the sprinkler in excess of one drop per minute

3.14

operating temperature

temperature in degrees at which the heat responsive element of a sprinkler operates when subjected to a controlled rate-of-temperature-rise liquid bath

3.15

orientation 'A'

plunge tunnel condition in which the sprinkler is situated such that the air flow is perpendicular to both the waterway axis and the plane of the frame arms and the heat responsive element is upstream of the frame arms

3.16

orientation 'B'

plunge tunnel condition in which the sprinkler is situated such that the air flow is perpendicular to both the waterway axis and the plane of the frame arms and the heat responsive element is downstream of the frame arms

3.17

orientation 'C'

plunge tunnel condition in which the sprinkler is situated such that the axis of the sprinkler inlet is parallel to the air flow and the deflector faces and is perpendicular to the air flow

3.18

orifice

opening in a sprinkler body through which the water is discharged

3.19

pendent sprinkler

sprinkler in which the nozzle directs the water downwards

3.20

response time index

RTI

measure of the thermal sensitivity of the sprinkler

Note 1 to entry: RTI is expressed in $(\text{ms})^{1/2}$.

3.21

service pressure

working hydrostatic pressure of a sprinkler system

3.22

strutting

partial fracture of a glass bulb or partial rupture of a fusible link heat responsive element which does not result in sprinkler operation

3.23

upright sprinkler

sprinkler in which the nozzle directs the water upwards

3.24

weep point

leak point

pressure at which any visible leakage of water is detected

3.25

aisle jump

propagation of fire through radiant heat from the commodity immediately surrounding the ignition location to the remote commodity which is separated from the main array by a 1,2 m aisle

3.26

cartoned expanded plastic commodity

commodity product consisting of expanded polystyrene plastic food service trays packaged in single-wall corrugated cartons

Note 1 to entry: Each carton contains 200 plastic trays arranged in four stacks of 50 trays each. Typical trays weigh approximately 15 g each, measure approximately 27 cm × 27 cm × 0,5 cm thick and consist of expanded foam plastic. Each carton measures 53 cm × 53 cm × 51 cm and weighs 4,0 kg when filled with the plastic trays. Each pallet load consists of eight cartons placed in a 2 × 2 × 2 array upon a 107 cm × 107 cm × 13 cm two-way, slatted deck hardwood pallet.

3.27

cartoned unexpanded plastic commodity

commodity product of cartoned unexpanded plastic, consisting of rigid crystalline polystyrene jars (empty, approximately 473 ml) packaged in compartmented, single wall, corrugated cartons measuring 53 cm × 53 cm × 51 cm

Note 1 to entry: Jars are arranged in five layers, 25 per layer for a total of 125. Each pallet load consists of eight cartons, arranged in a 2 × 2 × 2 array upon a 107 cm × 107 cm × 13 cm two-way, slatted deck hardwood pallet.

3.28

mean bulb strength

glass bulb mean bulb strength for any batch of 55 or more bulbs

3.29

mean design bulb strength

glass bulb manufacturer's specified and assured lowest mean bulb strength for any batch of 55 or more bulbs

3.30

design lower tolerance limit

DLTL

glass bulb manufacturer's specified and assured lowest lower tolerance limit

3.31

lower tolerance limit

LTL

glass bulb lowest strength determined by test and statistical analysis of a batch of 55 or more bulbs

3.32

design upper tolerance limit

DUTL

sprinkler manufacturer's specified and assured highest upper tolerance limit

3.33**upper tolerance limit****UTL**

highest service load determined by test and statistical analysis of a batch of 5 or more sprinklers

4 Assessment methods and criteria**4.1 Connections****4.1.1 Assessment method**

The sprinkler connection, e.g. the thread size shall be assessed by measurements.

4.1.2 Criteria

The thread connections of the sprinkler shall be in accordance with ISO 7-1 or shall be grooved connections. Alternative connection methods that have been tested and validated for use in fire sprinkler systems also fulfil 4.1.2.

4.2 Hydrostatic strength and hydraulic leak resistance**4.2.1 Assessment method**

Subject the sprinklers to water pressure of (30 ± 1) bar at the inlet. Increase the pressure from 0 to (30 ± 1) bar at a rate not exceeding 1 bar/s, maintain the pressure at (30 ± 1) bar for a period of 3_0^{+1} min and then allow it to fall to 0 bar. After the pressure has dropped to 0 bar, increase it to $(0,5 \pm 0,1)$ bar in not more than 5 s. Maintain this pressure for 15_0^{+5} s, and then increase it to $(10 \pm 0,5)$ bar at a rate not exceeding 1 bar/s and maintain it for 15_0^{+5} s. Examine the sprinkler for evidence of leakage during the test.

After testing, each sample shall be further subjected to a gradually increasing hydrostatic pressure to $48,3 \text{ bar} \pm 3 \%$ at a rate not to exceed $20,7 \text{ bar} \pm 3 \%$ per second. The test pressure shall be maintained for $1_0^{+0,1}$ min. If leakage at the orifice prevents testing at $48,2 \text{ bar} \pm 3 \%$, the maximum attainable test pressure shall be maintained for $1_0^{+0,1}$ min. Leakage at the orifice above a hydrostatic pressure of $34,5 \text{ bar} \pm 3 \%$ shall be deemed acceptable.

4.2.2 Criteria

No visible hydraulic leakage at 30 bar for a period of 3 min and no rupture with an internal hydrostatic pressure of up to $48,3 \text{ bar}$ for a period of 1 min.

4.3 Pneumatic leak resistance**4.3.1 Assessment method**

Four previously untested sprinklers shall be individually conditioned at $(-29 \pm 6) ^\circ\text{C}$ for $24_0^{+0,1}$ h. Each sample shall then be pneumatically pressurized to $2,1 \pm 0,1$ bar, immersed in glycol liquid conditioned to $(-29 \pm 6) ^\circ\text{C}$ and observed for $5_0^{+0,1}$ min.

4.3.2 Criteria

No visible pneumatic leakage.

4.4 Leakage resistance

4.4.1 Assessment method

Five previously untested samples shall be hydrostatically tested to confirm that there are no weep or leak points at, or below, $34,5 \text{ bar} \pm 3 \%$. The samples shall then be installed on a water-filled test apparatus which is to be maintained at ambient temperature and at a constant pressure of $20,7 \text{ bar} \pm 3 \%$ for $30_0^{+0,25}$ days. The samples shall be visually examined weekly during the test period for evidence of leakage at the seal.

4.4.2 Criteria

No visible leakage at $20,7 \text{ bar}$ for a period of 30 days and no evidence of distortion or physical damage.

4.5 Release of the sprinkler at minimum operating pressure

4.5.1 Assessment method

Ten previously untested sprinklers shall be installed in their intended orientation, subjected to an inlet water pressure of $0,35 \text{ bar} \pm 3 \%$ and operated using a suitable heat source. If a sample does not operate fully as described above, the pressure shall be slowly increased to determine the actual minimum operating pressure.

4.5.2 Criteria

All parts which are intended to prohibit the discharge or leakage of water have cleared the exit of the waterway within 5_0^{+5} s .

4.6 Release under temperature

4.6.1 Assessment method

4.6.1.1 Apparatus

Laboratory temperature measuring device having an accuracy of $\pm 0,25 \%$ of the nominal rating, calibrated to a depth of 40 mm immersion, for determining temperatures of liquids in bath tests and operating temperatures. The thermally sensitive part of the sensor (e.g. bulb of a thermometer) shall be held level with the centre of the sprinkler operating parts (fusible element). To control the temperature in the thermal bath, a PT100 sensor in accordance to EN 60751 shall be used.

For sprinklers with a nominal operating temperature less than or equal to $80 \text{ }^\circ\text{C}$ a liquid bath of demineralized water shall be used. For sprinklers with higher rated elements a liquid bath of glycerine, vegetable oil or synthetic oil shall be used.

NOTE An example of a typical bath is given in Figure A.1.

4.6.1.2 Procedure

A total of 10 sprinklers is to be tested. Heat sprinklers in a liquid bath from a temperature of $(20 \pm 5) \text{ }^\circ\text{C}$ to an intermediate temperature of $11,1 \pm 1,1 \text{ }^\circ\text{C}$ below their nominal operating temperature. The rate of temperature increase shall not exceed $20_0^{+2} \text{ }^\circ\text{C}$ per minute. Maintain the intermediate temperature for 10_0^{+1} min . Then increase the temperature at a rate of $(0,5 \pm 0,1) \text{ }^\circ\text{C}$ per minute until the sprinklers operate or up to $2,0 \text{ }^\circ\text{C}$ above the upper operating limit.

Determine the nominal operating temperature with temperature measuring device having an accuracy of $\pm 0,25 \%$ of the nominal temperature rating.

The sprinklers shall be located in the vertical position and totally covered by the liquid to a depth of at least 5 mm. The geometric centre of the fusible element shall be located not less than 35 mm below the liquid surface and in alignment with the temperature sensing device. The temperature deviation within the test zone should be within 0,25 °C.

The preferred location of the geometric centre of the fusible element and temperature measuring device should be (40 ± 5) mm below the liquid surface.

If strutting occurs during the test the air bath test (see 4.6.1.3) shall be performed.

4.6.1.3 Air bath test

Fifty previously untested sprinklers shall be placed on their threaded inlets in a programmable oven circulating air at ambient temperature. The temperature in the oven shall be steadily raised to $11,1 \pm 1,1^\circ\text{C}$ below the nominal temperature rating of the sprinklers over a $20_0^{+0,1}$ minute period. Once this temperature is reached, the oven shall be maintained at constant temperature for a period of 60 ± 5 min. The temperature shall then be raised at a constant rate of $0,5 \pm 0,3$ °C per minute until the temperature reaches $22 \pm 2,8$ °C above the nominal temperature rating of the sprinklers.

4.6.2 Criteria

Full rupture of heat responsive element in liquid bath (see 4.6.1.2) within a temperature range of $t \pm (0,035 t + 0,62)$ °C, where 't' is the nominal operating temperature, resulting in sprinkler operation.

When subjected to the air bath test no partial fracture of a glass bulb or no partial rupture of a fusible link (i.e. strutting) shall occur.

4.7 Complete operation

4.7.1 Assessment method

Samples shall be selected in accordance with Table 1 and shall be individually installed in their intended installation position, on a pipe manifold as shown in Annex B. Each sample shall be subjected to an inlet water pressure in accordance with 4.7.2, operated using a suitable open flame heat source, and observed for complete and proper functioning. A total of 80 sprinklers shall be tested.

Five samples shall be tested at each pressure with the pipe manifold configured for double-fed flow, and the remaining samples shall be tested with single-fed flow as shown in Annex B.

Table 1 — Lodgement

Pressure ^a	Number of samples
0,5 bar	10
1,7 bar	10
3,4 bar	10
5,2 bar	10
6,9 bar	10
8,6 bar	10
10,3 bar	10
12,1 bar	10
^a A tolerance of $\pm 5\%$ applies to all pressures specified in the table.	

4.7.2 Criteria

Upon activation of each sample, the discharge coefficient shall be measured to verify complete operation.

4.8 Size of water passageways

4.8.1 Assessment method

Pass a sphere of diameter 9,5 mm through each water passage in the sprinkler. If it does not pass check if the sprinkler is fitted with an additional strainer.

4.8.2 Criteria

The sphere passes freely through each water passage or the sprinkler is fitted with an additional strainer.

4.9 Sprinkler temperature identification

4.9.1 Assessment method

4.9.1.1 Glass bulb sprinklers

Perform visual inspection to determine the colour of the liquid inside the bulb.

4.9.1.2 Fusible link sprinklers

Perform visual inspection to determine colour painted on frame arm surface. Perform visual inspection to ensure at least 50 % of frame arm surface is painted the colour, and that paint is visible from all directions. If percentage of painted colour surface is in doubt, optical measurement shall be applied.

4.9.2 Criteria

Sprinklers shall be in accordance with Table 2. In addition, fusible link sprinklers are painted for at least 50 % of each frame arm surface and the paint is visible from all directions.

Table 2 — Nominal operating temperatures and colour codes of EN 12259-1:1999 + A1:2001

Glass bulb sprinklers		Fusible link sprinklers	
Nominal operating temperature °C	Liquid colour code	Nominal operating temperature within range °C	Yoke arms colour code
57	orange	57 to 77	uncoloured
68	red	80 to 107	white
79	yellow	121 to 149	blue
93	green	163 to 191	red
100	green	204 to 246	green
121	blue	260 to 302	orange
141	blue	320 to 343	black
163	mauve	-	-
182	mauve	-	-
204	black	-	-
227	black	-	-
260	black	-	-
286	black	-	-
343	black	-	-

4.10 Distribution of extinguishing media

4.10.1 Assessment method

At least one sample set is tested to the values of Table C.1 for K200 pendent sprinklers. All 3,4 bar tests are performed on a system fed from both directions (double feed). All 5,2 bar tests are performed on a system fed from one direction (single feed), except for the two sprinkler, single pipe tests which are performed on a double feed system.

At least one sample set is tested to the values of Table C.2 for K240 pendent sprinklers. All 2,4 bar tests are performed on a system fed from both directions (double feed). All 3,4 bar tests are performed on a system fed from one direction (single feed), except for the two sprinkler, single pipe tests which are performed on a double feed system.

Prior to the test, all samples shall be operated using a suitable heat source to remove the heat responsive assembly. The sprinkler test area shall be in accordance with Figures C.1 to C.5. The water distribution collection areas shall be in accordance with Figure C.6. The test apparatus shall be in a room of sufficient volume so as to minimise the entrainment of additional water spray. No significant drafts or other air movement shall be allowed into, or out of, the test area.

The water collection system, Figure C.6, shall be covered until the required pressure has been obtained. At that time, the cover shall be quickly removed in such a manner as to not cause water collected on top of the cover to be deposited into the collection pans. The test shall be conducted for $5^{+0,1}_0$ min, or until the water level in the fullest collection bucket reaches its maximum measurable level, whichever occurs first. At the conclusion of the test, the cover shall be immediately placed over the collection pans to prevent further water collection.

4.10.2 Criteria

Pendent sprinklers with a nominal discharge coefficient of $200 \text{ l/min}/(\text{bar})^{1/2}$ shall be in accordance with Table C.1. Pendent sprinklers with a nominal discharge coefficient of $240 \text{ l/min}/(\text{bar})^{1/2}$ shall be in accordance with Table C.2.

4.11 Actual delivered density

4.11.1 Assessment method

ADD measurements shall be taken using the test apparatus shown in Figure D.1 and D.2. The ADD apparatus shall consist of two major components: a fire source and a simulated commodity. The fire source shall consist of a number of spray nozzles equally spaced on the circumference of a circle. Heptane shall be used as the fuel for the fire. Below the fire source shall be an array of collection pans representing a simulated commodity. Collection pans shall be of the dimensions defined in Figure D.1, D.2 and D.3.

A moveable ceiling of at least $11,13 \text{ m} \times 10,21 \text{ m}$ dimensions (in plain view), which is capable of vertical movement such as to provide a variable distance of $4,88 \text{ m}$ maximum above a set of collection pans.

A means of producing a fire plume of varying heat release rates, from 500 kW to 3 MW in accordance with Annex D shall be used. The plume is to be generated using a set of nine spray nozzles, with eight nozzles set in a circular pattern of $1,2 \text{ m}$ diameter, and with a central nozzle. The nozzles are to be supplied with a source of liquid Heptane, under pressure, with a control system capable of adjustment of heptane flow such that the required fire sizes are achieved. In addition, an air blower system is required which will deliver $18,4 \text{ m}^3$ per minute of air into the centre of the fire plume.

The array shall approximate the geometry and size of a single tier rack-storage commodity of two pallet loads deep and two pallet loads wide (see 3.7), with a $15,2 \text{ cm} \pm 2 \%$ flue space between each pallet. Sixteen square water collection pans, representing the top surface of the commodity within the ignition area, shall collect water that would normally reach the commodity's top surface. Four additional pans, representing the flue spaces between pallet loads of commodity, shall collect water that would normally be delivered to the flue spaces.

A flat horizontal ceiling with minimum dimensions of $(11,13 \text{ m} \times 10,21 \text{ m}) \pm 2 \%$ shall be suspended above the apparatus. The test apparatus shall be located in a room of sufficient volume to minimise the entrainment of additional water spray.

For sprinklers having a nominal K-factor of 200 or $240 \text{ l/min}/(\text{bar})^{1/2}$, open sprinklers shall be connected to DN50 sprinkler pipes under the suspended ceiling via DN $50 \times \text{DN } 50 \times \text{DN } 20$ threaded tees, threaded outlet fittings with bushings, or a suitable alternative.

For sprinklers having a nominal K-factor of $320 \text{ l/min}/(\text{bar})^{1/2}$, $360 \text{ l/min}/(\text{bar})^{1/2}$, $400 \text{ l/min}/(\text{bar})^{1/2}$ or $480 \text{ l/min}/(\text{bar})^{1/2}$ open sprinklers shall be connected to DN65 sprinkler pipes under the suspended ceiling via DN $65 \times \text{DN } 65 \times \text{DN } 25$ threaded tees, threaded outlet fittings with bushings, or a suitable alternative.

Pendent sprinklers shall be installed with sprinkler piping centre line located $23 \text{ cm} \pm 2 \%$ below the ceiling. Upright sprinklers shall be installed with sprinkler piping centre line located $30 \text{ cm} \pm 2 \%$ below the ceiling.

The frame arms of each sprinkler shall be aligned with the sprinkler pipe. The pipes shall be fed with water flowing from either a single direction, or both directions, as specified in D.2 as appropriate.

For all tests, prior to each ADD measurement, the heptane spray shall be ignited and the flow stabilised at a flow rate corresponding to the required heat release. Once the fuel flow rate has been stabilised, water shall be discharged from the sprinklers. Water collected by all pans is to be channelled to the collectors of the apparatus, as shown in Figure D.2. Water shall be collected until one or more 170 l

collection buckets are filled, or for a minimum of 10 min, whichever occurs first, for each test detailed in the applicable Table.

For all tests, the average water collected shall be recorded for at least two sets of sprinkler samples.

4.11.2 Criteria

Pendent sprinklers having a nominal K-factor of 200 and 240 shall have a minimum actual delivered density as given in D.2. For other upright sprinklers ADD tests are used only to determine the ignition locations for full scale fire testing – minimum collection requirements are not specified. The least favourable ignition scenario will be identified by the lowest average density collected

4.12 Performance under fire

4.12.1 Assessment method

The tests detailed Annex E shall be conducted in an indoor fire test facility with an adjustable ceiling approximately $12,2 \text{ m} \pm 2 \%$ from the floor, with the fuel array positioned atop a raised platform. Sprinklers shall be installed on $(3,0 \text{ m} \times 3,0 \text{ m}) \pm 2 \%$ spacing, on DN50 diameter pipe with 3,9 mm wall thickness sprinkler pipes.

In order to simulate the effect of large pipe sizes on the sprinkler distribution pattern, the outside diameter of the pipe(s) in the area over ignition shall be equal to that of a nominal DN65 diameter 5,2 mm wall thickness sprinkler pipe.

Ignition for the fire test shall take place at the bottom of the first tier of the test array, located as shown in Annex E. Temperatures shall be monitored by Type k, mineral insulated, metal clad, sheathed thermocouples located at the ceiling. A typical thermocouple layout is shown in Figure E.16. The nominal temperature rating of the sprinklers shall be $74 \text{ }^{\circ}\text{C}$ for solder-link sprinklers and $68 \text{ }^{\circ}\text{C}$ for glass bulb sprinklers. Two-way, $(1\,050 \text{ mm} \times 1\,050 \text{ mm} \times 125 \text{ mm}) \pm 2 \%$, slatted hardwood pallets placed in metal storage racks shall support the commodity (see 3.6 and 3.7). For fire tests in which aisle jump is specified as a test criteria, a target array shall be located adjacent to the test array, separated by an aisle space $1,2 \text{ m} \pm 2 \%$ wide. The commodity type, storage arrangement and height of the target array shall be selected to correspond to the test array.

4.12.2 Criteria

Upright sprinklers with a nominal discharge coefficient of $200 \text{ l/min}/(\text{bar})^{1/2}$ shall achieve suppression in five full-scale fire test scenarios in accordance with Table E.4 within the limits given in Table E.1.

Upright sprinklers with a nominal discharge coefficient of $240 \text{ l/min}/(\text{bar})^{1/2}$ shall achieve suppression in five full-scale fire test scenarios in accordance with Table E.5 within the limits given in Table E.2.

Pendent sprinkler with a nominal discharge coefficient of 320, 360 or $400 \text{ l/min}/(\text{bar})^{1/2}$ shall achieve suppression in the full-scale fire test scenarios in accordance with Table E.6 or E.7 within the limits given in Table E.3.

Pendent sprinkler with a nominal discharge coefficient of $480 \text{ l/min}/(\text{bar})^{1/2}$ shall achieve suppression in the full-scale fire test scenarios in accordance with Table E.8 within the limits given in Table E.3.

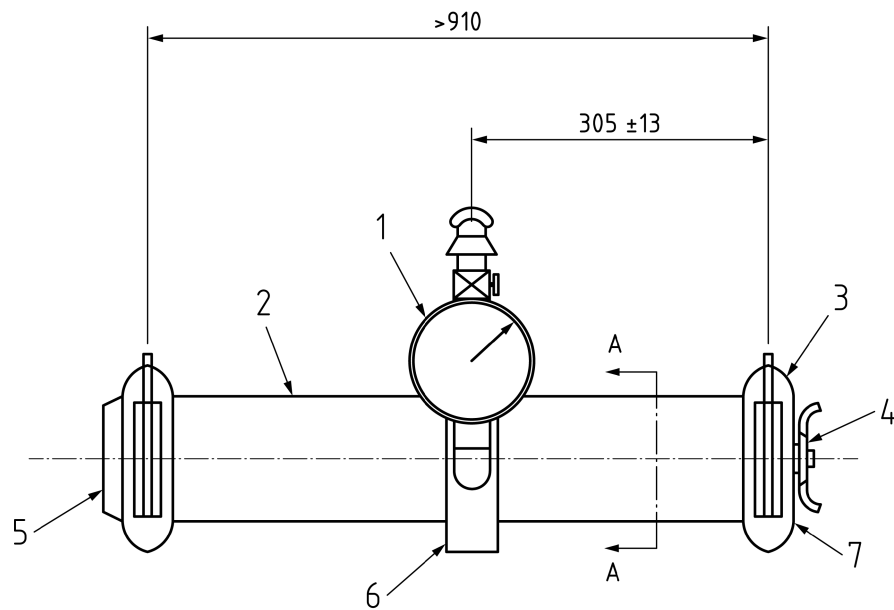
NOTE Pendent sprinklers having a nominal K-factor of 200 and 240 are tested as given in 4.11 and D.2. For other sprinklers than those mentioned above ADD tests are used only to determine the ignition locations for full scale fire testing. Minimum collection requirements are not specified. The least favourable ignition scenario will be identified by the lowest average density collected.

4.13 Discharge coefficient

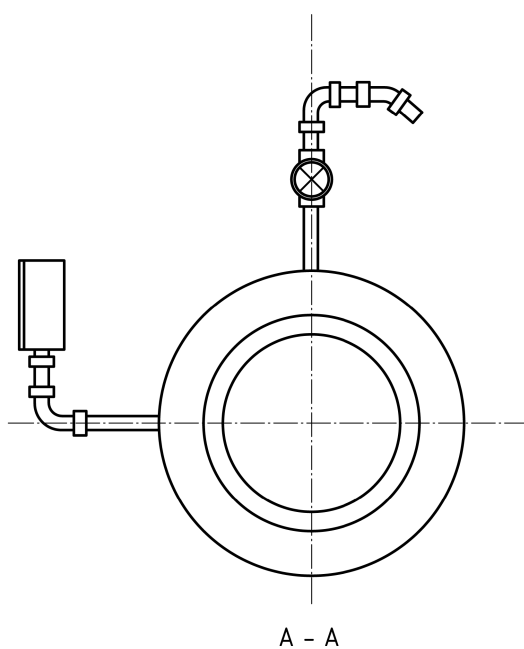
4.13.1 Assessment method

Four samples shall be individually tested using the test apparatus shown in Figure 1 at increasing and decreasing pressures over the complete operating range, 1,7 to 12,1 bar in $0,7 \pm 3 \%$ bar increments.

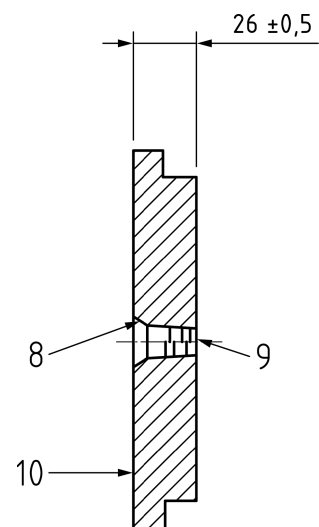
Dimensions in millimetres



a) Test apparatus



b) Section A-A



c) Detail B grooved end cap cross section

Key

1	gauge	6	piezometer ring
2	DN150 pipe	7	grooved end cap
3	grooved coupling	8	radius tangent to orifice
4	sprinkler butt	9	approx. tapped hole in accordance with pipe thread standard
5	water source inlet	10	internal face of end cap

NOTE All dimensions are nominal size unless otherwise indicated. Radius on inlet may be truncated on internal face.

Figure 1 — Test apparatus for measuring nominal discharge coefficient

With the deflector and a portion of the frame removed, if necessary, to facilitate testing, each sample shall be inserted into the test fixture. The discharge coefficient shall be determined using the formula:

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

where

Q is the flow rate in l/min;

P is the pressure in bar.

The results shall be checked against Table 3 and the range determined.

Table 3 — Discharge coefficient ranges

Nominal discharge coefficient l/min/(bar) ^{1/2}	Nominal discharge coefficient range l/min/(bar) ^{1/2}
200	195-209
240	231-254
320	305-336
360	344-382
400	380-420
480	456-504

4.13.2 Criteria

Mean value of the discharge coefficient shall be between the range in Table 3. When sprinklers are tested, for each sample and pressure, not more than one individual value falls outside of the stated range in Table 3.

4.14 Thrust measurement

4.14.1 Assessment method

Three open K200 or K240 pendent sprinklers shall be individually installed in accordance with Annex F. The centre core thrust over a nominal 345 mm ± 2 % diameter plate shall be measured while discharging water at the pressures shown in F.2.

4.14.2 Criteria

Pendent sprinklers with a nominal discharge coefficient of 200 or 240 l/min/(bar)^{1/2} shall be in accordance with Table F.2.

NOTE This clause is not relevant for other sprinklers than those mentioned.

4.15 Sensitivity (Response time index)

4.15.1 Assessment method

Testing for RTI shall be determined by operating sprinkler samples in a plunge tunnel.

Twelve samples of each nominal operating temperature shall be tested. Four tests shall be conducted for each of the three orientations in accordance with Figure G.1.

All tests shall be conducted with the geometric centre of the heat responsive element located at least $38 \text{ mm} \pm 2 \%$ from the interior horizontal surfaces of the test section in the plunge tunnel.

The plunge test is to be conducted using the sprinkler, mounted in accordance with Figure G.2. Each sprinkler shall have one to three wrap(s) of PTFE sealant tape applied to the sprinkler threads and shall be threaded into the mount.

Each sprinkler and sprinkler mount shall be allowed to reach ambient temperature for a period of not less than $30_0^{+0,1}$ min prior to testing. An air supply is then attached at the air hose connection in accordance with Figure G.2 and shall be pressurized to $0,3_0^{+0,04}$ bar.

A timer accurate to $\pm 0,01 \text{ s}$, with suitable controlling devices, e.g. mercury switch for plunge (start) and pressure switch for operation (stop); shall be utilised to accurately measure the time to operate.

A tunnel with gas velocity and temperature conditions at the test section established in accordance with Table G.1 shall be utilised to conduct the sensitivity test. To minimise radiation exchange between the sensing element and the boundaries confining the flow, the test section of the apparatus shall be constructed of appropriate materials with an un-insulated metal test duct. Tunnel conditions shall be stabilised for a minimum of $30_0^{+0,1}$ min prior to testing.

The response time index shall be calculated using the following formula:

$$RTI = \frac{-t_r(u)^{1/2}}{\ln \left[1 - \frac{\Delta T_b}{\Delta T_g} \right]}$$

where

t_r - response time of sprinkler, in seconds;;

u - actual air velocity in the test section of the tunnel 2,56 m/s;

ΔT_b - mean operating temperature of the sprinkler minus the ambient temperature, in °C;

ΔT_g - actual gas (air) temperature minus the ambient temperature, in °C.

4.15.2 Criteria

When tested in orientation A and B, the sprinkler shall have a response time index of 19 to 36 $(\text{m}\times\text{s})^{1/2}$. When tested in orientation C the response time index shall be a maximum of 138 $(\text{m}\times\text{s})^{1/2}$.

4.16 Frame strength

4.16.1 Assessment method

Measure the service load of five previously untested sprinklers by securely installing the sprinkler in a tensile or compression test machine and apply an equivalent of a hydraulic pressure of $(12 \pm 0,1)$ bar at the inlet.

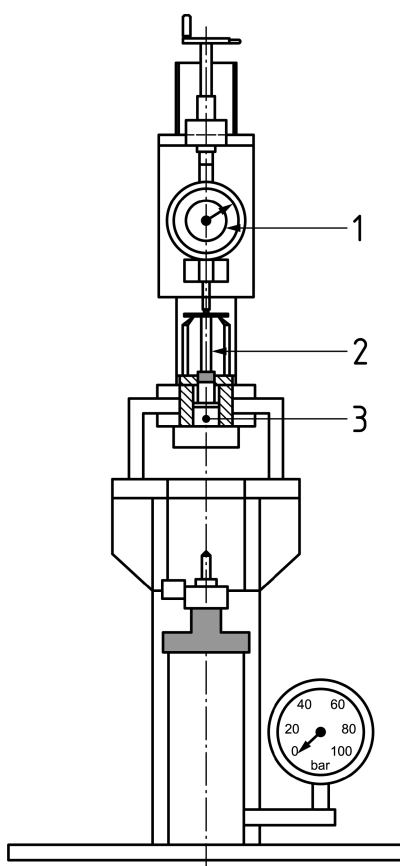
Use an indicator capable of reading deflection to an accuracy of 0,001 mm to measure any change in length of the sprinkler body between the load bearing points. Preferably avoid or take into account movement of the sprinkler thread in the threaded bush of the test machine.

Zero the deflection measuring indicator, see Figure 2.

Release the hydraulic pressure 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.

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.



Key

- 1 deflector gauge
- 2 sprinkler
- 3 sprinkler fixture (sprinkler inlet pressure $12 \pm 0,1$ bar)

Figure 2 —Example of a tensile/compression test machine

4.16.2 Criteria

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.

4.17 Fusible link type

4.17.1 Assessment method

Fifteen samples shall be loaded with a weight representing the equivalent of 15 times the design load. All samples must remain intact after sustaining this load for a period of $100_0^{+0,1}$ h.

In case fusible type heat responsive elements do not withstands 15 times the design load, the following shall be tested.

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, reject 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:

$$L_d \leq 1,02 \left(\frac{L_m^2}{L_o} \right)$$

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

4.17.2 Criteria

The temperature sensitive element shall withstand a load of 15 times its maximum design load for a period of $100_0^{+0,1}$ h without failure. The estimated time to failure of temperature sensitive elements is not less than 876 600 h at the design load.

4.18 Bulb type

4.18.1 Assessment method

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

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 manufacturer specification. If the sprinkler manufacturer 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 sprinklers using the following formula:

$$\overline{\chi_1} = \frac{\sum \chi_1}{n}$$

where

$\overline{\chi_1}$ is the mean bulb strength;

χ_1 is the individual glass bulb sample strength test values;

n is the number of samples tested.