



BSI Standards Publication

Fixed firefighting systems — Components for sprinkler and water spray systems

Part 13: ESFR sprinklers

National foreword

This British Standard is the UK implementation of EN 12259-13:2022.

The UK participation in its preparation was entrusted to Technical Committee FSH/18/2, Sprinkler Systems.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2023
Published by BSI Standards Limited 2023

ISBN 978 0 539 16565 4

ICS 13.220.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2023.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

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 European Standard was approved by CEN on 4 December 2022.

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. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Contents

Page

European foreword	5
Introduction	6
1 Scope.....	7
2 Normative references.....	7
3 Terms and definitions.....	7
4 Assessment methods and criteria.....	10
4.1 Connections.....	10
4.1.1 Assessment method	10
4.1.2 Criteria.....	10
4.2 Leak resistance.....	11
4.2.1 Assessment method	11
4.2.2 Criteria.....	11
4.3 Pneumatic leak resistance.....	11
4.3.1 Assessment method	11
4.3.2 Criteria.....	11
4.4 Leakage resistance	11
4.4.1 Assessment method	11
4.4.2 Criteria.....	11
4.5 Function.....	11
4.5.1 Assessment method	11
4.5.2 Criteria.....	11
4.6 Operating temperatures.....	11
4.6.1 Assessment method	11
4.6.2 Criteria.....	11
4.7 Complete operation	12
4.7.1 Assessment method	12
4.7.2 Criteria.....	12
4.8 Size of water passageways.....	12
4.8.1 Assessment method	12
4.8.2 Criteria.....	12
4.9 Nominal operating temperature	12
4.9.1 Assessment method	12
4.9.2 Criteria.....	13
4.10 Distribution of extinguishing media.....	13
4.10.1 Assessment method	13
4.10.2 Criteria.....	14
4.11 Actual delivered density.....	14
4.11.1 Assessment method	14
4.11.2 Criteria.....	15
4.12 Extinguishing performance.....	15
4.12.1 Assessment method	15
4.12.2 Criteria.....	15
4.13 Discharge coefficient	16
4.13.1 Assessment method	16

4.13.2	Criteria.....	18
4.14	Thrust measurement.....	18
4.14.1	Assessment method.....	18
4.14.2	Criteria.....	18
4.15	Response delay (response time).....	18
4.15.1	Assessment method.....	18
4.15.2	Criteria.....	19
4.16	Strength of sprinkler body and deflector.....	19
4.16.1	Assessment method.....	19
4.16.2	Criteria.....	19
4.17	Strength of release element.....	19
4.17.1	Assessment method.....	19
4.17.2	Criteria.....	19
4.18	Water hammer.....	19
4.18.1	Assessment method.....	19
4.18.2	Criteria.....	19
4.19	Strength of deflector.....	19
4.19.1	Assessment method.....	19
4.19.2	Criteria.....	20
4.20	Resistance to vibration.....	20
4.20.1	Assessment method.....	20
4.20.2	Criteria.....	20
4.21	Resistance to impact.....	21
4.21.1	Assessment method.....	21
4.21.2	Criteria.....	21
4.22	Resistance to low temperature.....	21
4.22.1	Assessment method.....	21
4.22.2	Criteria.....	21
4.23	Vacuum.....	21
4.23.1	Assessment method.....	21
4.23.2	Criteria.....	21
4.24	Heat exposure.....	21
4.24.1	Assessment method.....	21
4.24.2	Criteria.....	21
4.25	Thermal shock of glass bulb sprinklers.....	21
4.25.1	Assessment method.....	21
4.25.2	Criteria.....	22
4.26	Moist air.....	22
4.26.1	Assessment method.....	22
4.26.2	Criteria.....	22
4.27	Corrosion.....	22
4.27.1	Assessment method.....	22
4.27.2	Criteria.....	22
4.28	Product assembly.....	22
4.29	Durability, resistance to thermal shock.....	22
4.29.1	Assessment method.....	22
4.29.2	Criteria.....	22
5	Marking.....	22
6	Manufacturer's installation instructions.....	23
Annex A	(informative) Typical test setup for release under temperature test (liquid bath).....	25
Annex B	(normative) Pipe manifold configuration for lodgement.....	26

Annex C (normative) Pendent sprinkler water distribution	27
C.1 General.....	27
C.2 Values for pendent sprinkler water distribution.....	27
C.3 Test set-up	29
Annex D (normative) Actual delivered density apparatus	34
D.1 General.....	34
D.2 Values for actual delivered density.....	34
D.3 Test set-up	36
D.4 Heptane burner settings	38
Annex E (normative) Extinguishing performance	39
E.1 General.....	39
E.2 Values for performance under fire.....	39
E.3 Fire test scenarios.....	40
E.4 Test set-ups.....	44
Annex F (normative) Thrust measurement	59
F.1 General.....	59
F.2 Values for thrust measurement.....	59
F.3 Test set-up	60
Annex G (normative) Sensitivity (response time index)	61
G.1 General.....	61
G.2 Test conditions	61
G.3 Test set-up	62
Annex H (normative) Tolerances.....	63
Bibliography	64

European foreword

This document (EN 12259-13:2022) has been prepared by Technical Committee CEN/TC 191 “Fixed firefighting systems”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2023, and conflicting national standards shall be withdrawn at the latest by June 2023.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

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.*

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

Introduction

The response characteristics of classic sprinklers (EN 12259-1 and EN 12259-15) is based on the measurement of both sensitivity and conductivity (C-factor). For EN 12259-13 sprinkler type (ESFR) their response characteristics are determined without reference to its conductivity.

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 12259-1:1999+A1:2001¹, *Fixed firefighting systems — Components for sprinkler and water spray systems — Sprinklers*

EN 12845-2, *Fixed firefighting systems — Automatic sprinkler systems — Part 2: Design and installation of ESFR and CMSA sprinkler systems*

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 (all parts) and EN 12259 (all parts) and the following apply.

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

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

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}.

¹ As impacted by EN 12259-1:1999+A1:2001/A2:2004 and EN 12259-1:1999+A1:2001/A3:2006.

3.4

mean design service load

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

3.5

fusible link sprinkler

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

3.6

glass bulb sprinkler

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

3.7

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.

3.8

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

3.9

leak point

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

3.10

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

3.11

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

3.12

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

3.13

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

3.14**orifice**

opening in a sprinkler body through which the water is discharged

3.15**pendent sprinkler**

sprinkler in which the nozzle directs the water downwards

3.16**response time index****RTI**

measure of the thermal sensitivity of the sprinkler

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

3.17**service pressure**

working hydrostatic pressure of a sprinkler system

3.18**strutting**

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

3.19**upright sprinkler**

sprinkler in which the nozzle directs the water upwards

3.20**weep point**

leak point

pressure at which any visible leakage of water is detected

3.21**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

3.22**standard cartoned expanded plastic test 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 with a density of $0,038 \text{ g/cm}^3$. Typical trays weigh approximately 15,25 g each, measure approximately $270 \text{ mm} \times 270 \text{ mm} \times 5 \text{ mm}$ thick and consists of expanded foam plastic. Each carton measures $530 \text{ mm} \times 530 \text{ mm} \times 510 \text{ mm}$, has 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 $2 \times 2 \times 2$ array upon a $1\,070 \text{ mm} \times 1\,070 \text{ mm} \times 130 \text{ mm}$ two-way, slatted deck hardwood pallet. The pallet is minimum 90 % white, red or black oak, with an 8 % to 10 % moisture content.

3.23

standard cartoned unexpanded plastic test 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.

3.24

mean bulb strength

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

3.25

mean design bulb strength

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

3.26

design lower tolerance limit

DLTL

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

3.27

lower tolerance limit

LTL

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

3.28

design upper tolerance limit

DUTL

sprinkler manufacturer's specified and assured highest upper tolerance limit

3.29

upper tolerance limit

UTL

highest service load determined by test and statistical analysis of a batch of 10 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 Leak resistance

4.2.1 Assessment method

The assessment method given in EN 12259-1:1999+A1:2001, Annex H shall be applied.

4.2.2 Criteria

The criteria given in EN 12259-1:1999+A1:2001, 4.9 shall be applied.

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 bar for a period of 30 days and no evidence of distortion or physical damage.

4.5 Function

4.5.1 Assessment method

The assessment method in accordance with EN 12259-1:1999+A1:2001, Annex E shall be performed except for the reference to EN 12259-1:1999+A1:2001, 4.5 (discharge coefficient). Instead, 4.10 in this document shall be applied.

4.5.2 Criteria

The criteria given in EN 12259-1:1999+A1:2001, 4.6 shall be applied.

4.6 Operating temperatures

4.6.1 Assessment method

The assessment method given in EN 12259-1:1999+A1:2001, Annex B shall be applied.

4.6.2 Criteria

The criteria given in EN 12259-1:1999+A1:2001, 4.4 shall be applied.

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 ± 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 or each sprinkler shall be visually examined to ensure all operating parts have been ejected from the sprinkler during 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 Nominal operating temperature

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

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

Samples according to Table C.1 for K200 pendent sprinklers shall be tested. 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. All scenarios in Table C.1 shall be tested.

Samples according to Table C.2 for K240 pendent sprinklers shall be tested. 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. All scenarios in Table C.2 shall be tested.

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 minimize 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 $5_0^{+0,1}$ 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 Figures 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 given in Figures D.1, D.2 and D.3.

A moveable ceiling shall be used of at least $11 \text{ m} \times 10 \text{ m}$ dimensions (in plan view), which is capable of vertical movement such as to provide a variable distance of 5 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 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 3.22), 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 $(11 \text{ m} \times 10 \text{ m}) \pm 2 \%$ shall be suspended above the apparatus. The test apparatus shall be located in a room of sufficient volume to minimize 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 DN 50 sprinkler pipes under the suspended ceiling via DN 50 $\times$ DN 50 $\times$ 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 DN 65 sprinkler pipes under the suspended ceiling via DN 65 × DN 65 × 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 stabilized at a flow rate corresponding to the required heat release. Once the fuel flow rate has been stabilized, 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 Extinguishing performance

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. The nominal temperature rating of the sprinklers shall be 74 °C for solder-link sprinklers and 68 °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 3.22 and 3.23). For fire tests in which aisle jump is specified as a test criterion, 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 l/min/(bar)^{1/2}, 360 l/min/(bar)^{1/2} or 400 l/min/(bar)^{1/2} shall achieve suppression in three 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 l/min/(bar)^{1/2} shall achieve suppression in three 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.

The manufacturer's design and installation criteria for pendent sprinklers with a nominal discharge coefficient of 320, 360 or 400 l/min/(bar)^{1/2} shall state that the number of operating sprinklers in the design area shall not be less than:

- a) 1,5 times the maximum number of sprinklers which operate in any of the 3 tests in Table E.3 (rounded up);
- b) shall not be less than 9 in any case.

4.13 Discharge coefficient

4.13.1 Assessment method

Four samples shall be individually tested using the test apparatus for determining K-factor shown in Figure 1 at increasing and decreasing pressures over the complete operating range, 1,7 to 12,1 bar in (0,7 ± 0,02) bar increments.

With the deflector removed to facilitate testing, each sample shall be inserted into the test fixture and tightened to 180° ± 5° beyond "hand tight" using an appropriate wrench.

The discharge coefficient (K) shall be determined using the expression:

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

Where Q is the flow rate in l/min and P is the pressure in bar.

The accuracy of the pressure measuring equipment shall be within ±3 % of measured value.

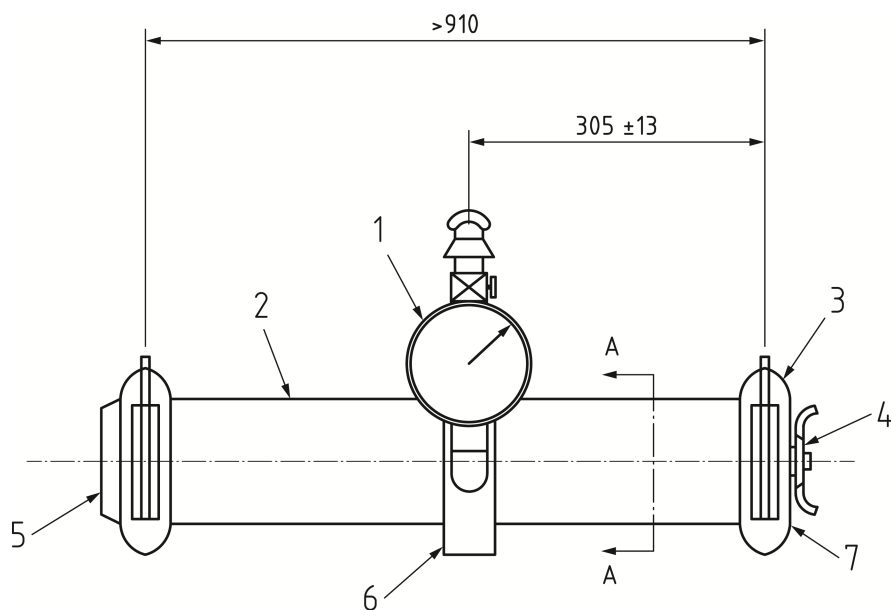
The accuracy of the flow measuring equipment shall be within ±5 % of measured value.

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

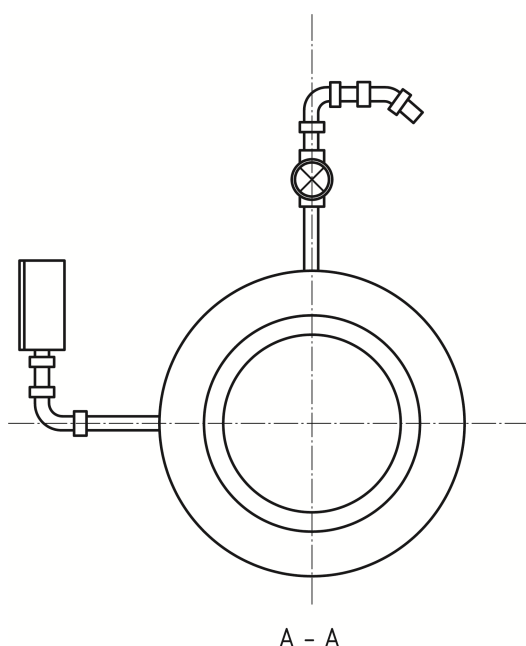
Table 3 — Discharge coefficient ranges

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

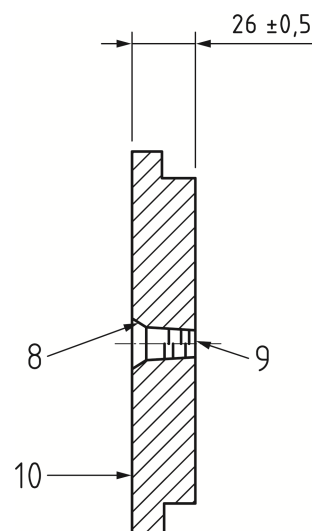
Dimensions in millimetres



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 can be truncated on internal face.

Figure 1 — Test apparatus for measuring nominal discharge coefficient

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 $\pm$ 2 % diameter plate shall be measured while discharging water at the pressures shown in F.2. The accuracy of the thrust measuring equipment shall be within ± 3 % of measured value

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.1.

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

4.15 Response delay (response time)

4.15.1 Assessment method

Testing for RTI shall be determined by operating sprinkler samples in a plunge tunnel. The plunge tunnel setup shall be in accordance with EN 12259-1:1999+A1:2001, N.1.

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.

For a sprinkler nominal temperature rating of 57 °C to 77 °C the temperate in the test section shall be (197 $\pm$ 6) °C. For a sprinkler nominal temperature rating of 79 °C to 107 °C the temperate in the test section shall be (291 $\pm$ 9) °C. The average gas (air) velocity of the test section shall be for both cases (2,56 $\pm$ 0,07) m/s. The response time index (*RTI*) 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 is the response time of sprinkler, in seconds;
- u is the actual air velocity in the test section of the tunnel (2,56 $\pm$ 0,07) m/s;
- ΔT_b is the mean operating temperature of the sprinkler minus the ambient temperature, in °C;
- ΔT_g is the actual gas (air) temperature minus the ambient temperature, in °C.

The above equation is identical to that described in EN 12259-1 with the conductivity factor (*C*) set to zero. Because ESFR sprinklers are designed to operate very rapidly, the contribution of conductivity to overall sensitivity is negligible.

Plunge the sprinkler into the plunge tunnel test section and maintain the selected air velocity throughout the test. Use a timer to determine the time between plunging of the sprinkler into the plunge tunnel and operation of the sprinkler, in order to establish the response time.

4.15.2 Criteria

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

4.16 Strength of sprinkler body and deflector

4.16.1 Assessment method

The assessment method given in EN 12259-1:1999+A1:2001, Annex F shall be applied.

4.16.2 Criteria

The criteria given in EN 12259-1:1999+A1:2001, 4.7 shall be applied.

4.17 Strength of release element

4.17.1 Assessment method

4.17.1.1 Assessment method

The assessment method given in EN 12259-1:1999+A1:2001, Annex G shall be applied.

4.17.2 Criteria

The criteria given in EN 12259-1:1999+A1:2001, 4.8 shall be applied.

4.18 Water hammer

4.18.1 Assessment method

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_0^{+5} bar at a rate of 45_{-5}^{+10} bar/s, after which the pressure shall be returned to (4 ± 2) bar. The pressure cycles shall be repeated 3000_0^{+100} times, at a rate of 15_0^{+5} cycles per minute. Measure and record the pressure changes against time. Visually examine each sprinkler for leakage.

4.18.2 Criteria

Sprinklers shall not leak when subjected to pressure surges. After the test, when subjected to a test in accordance with 4.7.1, at a water pressure of $0,5 \text{ bar} \pm 5 \%$, the sprinkler shall operate in such a way that the waterway is cleared. Any lodgements shall be disregarded.

4.19 Strength of deflector

4.19.1 Assessment method

Three previously untested sprinklers shall be individually installed in the test apparatus detailed in Annex B. Water shall be introduced to the inlet of each sprinkler at a pressure of $(15,5 \pm 0,7)$ bar.

Each sprinkler shall then be operated using a suitable heat source and water flow shall be maintained at $(15,5 \pm 0,7)$ bar for a period of $15_0^{+0,1}$ min.