
**Fire protection — Automatic sprinkler
systems —**

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

*Protection contre l'incendie — Systèmes d'extinction automatiques du
type sprinkler —*

*Partie 7: Prescriptions et méthodes d'essai des sprinklers de type
"extinction précoce/réaction rapide"*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 5, *Fixed firefighting systems using water*.

This second edition cancels and replaces the first edition (ISO 6182-7:2004), which has been technically revised.

The main changes compared to the previous edition are as follows:

- added requirements and test methods for K242 pendent ESFR sprinklers.

A list of all parts in the ISO 6182 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Early Suppression-Fast Response (ESFR) sprinklers are a unique type of sprinkler primarily intended to provide sprinkler protection for storage facilities. Other types of sprinklers are addressed in separate documents in the ISO 6182 series. These sprinklers are specifically designed to discharge water at a location near the ceiling of a structure in a manner that effectively attacks a fast-growing fire that can occur in a storage facility.

These sprinklers characteristically discharge water in a mostly downward trajectory with relatively large water droplets and incorporate a fast-response type heat responsive element intended to allow the discharge of water at an early stage of the fire growth. Due to the relatively quick operation and effective nature of the sprinkler discharge, these sprinklers can be used to provide ceiling-only sprinkler protection for taller storage facilities compared to other types of sprinklers. The performance of ESFR sprinklers is sensitive to obstructions to the sprinkler discharge. ESFR sprinkler installation guidelines need to account for this obstruction sensitivity by limiting the size of obstructions as well as specifying sprinkler installation locations that minimize the impact of these obstructions.

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Fire protection — Automatic sprinkler systems —

Part 7:

Requirements and test methods for early suppression fast response (ESFR) sprinklers

1 Scope

This document specifies performance requirements, test methods and marking requirements for pendent early suppression fast response (ESFR) sprinklers.

NOTE This document currently provides requirements for K202 and K242 ESFR pendent sprinklers.

2 Normative reference

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.

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 following terms and definitions apply.

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

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

3.1 General

3.1.1

actual delivered density

ADD

rate at which water is deposited from an operating sprinkler onto the top horizontal surface of a simulated burning combustible array

3.1.2

assembly load

force exerted on the sprinkler body excluding hydrostatic pressure

3.1.3

average design strength

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

3.1.4

design load

force exerted on the release element at the service load (3.1.10) of the sprinkler

3.1.5

early suppression fast response automatic sprinkler ESFR

sprinkler that is intended to provide early suppression of a fire when installed on the appropriate sprinkler piping

3.1.6

orientation A

orientation with the airflow perpendicular to both the waterway axis and the plane of the frame arms and with the heat responsive element upstream of the frame arms

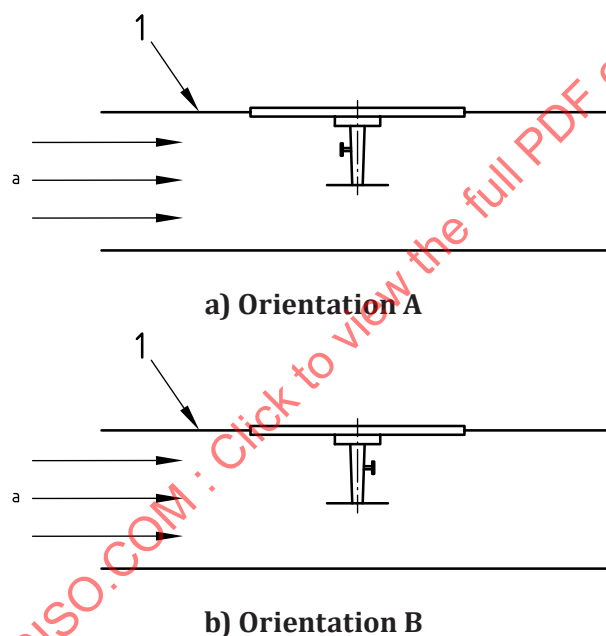
Note 1 to entry: See [Figure 1](#).

3.1.7

orientation B

orientation with the airflow perpendicular to both the waterway axis and the plane of the frame arms and with the heat responsive element downstream of the frame arms

Note 1 to entry: See [Figure 1](#).



Key

1 tunnel test section (elevation view)

a Airflow.

Figure 1 — Orientations A and B

3.1.8

protective covers

protective caps or straps intended to provide temporary protection for sprinklers during shipping, handling and installation

3.1.9

response time index

RTI

measure of sprinkler sensitivity

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

where

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

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

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

3.1.10

service load

combined force exerted on the sprinkler body by the assembly load (3.1.2) of the sprinkler and the equivalent force of the rated pressure on the inlet

3.1.11

sprinkler

thermosensitive device designed to react at a predetermined temperature by automatically releasing a stream of water and distributing it in a specified pattern and quantity over a designated area

Note 1 to entry: For the purposes of this document, "sprinkler" is intended to refer to ESFR (3.1.5) sprinklers.

3.2 Types of sprinklers according to type of heat responsive element

3.2.1

fusible element sprinkler

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

3.2.2

glass bulb sprinkler

sprinkler that opens under the influence of heat by the bursting of the glass bulb through pressure resulting from expansion of the fluid enclosed therein

3.3 Sprinklers classified according to position

3.3.1

pendent sprinkler

sprinkler arranged in such a way that the water stream is directed downwards against the distribution plate

4 Product consistency

4.1 Quality control program

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

4.2 Leak resistance testing

Every manufactured sprinkler shall pass a leak resistance test equivalent to a hydrostatic pressure of at least twice the rated pressure for at least 2 s.

4.3 Glass bulb integrity test

Each glass bulb sprinkler assembly shall be evaluated for glass bulb cracking, breaking, or other damage as indicated by the loss of fluid. The test shall be conducted after the leakage test.

The bubble in each glass bulb shall be examined at room ambient temperature. The sprinkler shall then be heated in a circulating air oven or liquid bath to 5 °C below the minimum operating temperature range of the sprinkler. The bubble shall then be examined to determine the bubble size has been reduced

in accordance with the glass bulb manufacturer's specifications. After cooling, the bubble size shall again be examined to determine the bubble returned to the original size within the tolerance allowed by the glass bulb manufacturer.

5 Product assembly

5.1 General

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

5.2 Dynamic O-ring seals

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

5.3 Rated pressure

Sprinklers shall have a rated pressure of 1,2 MPa (12 bar).

6 Requirements

6.1 Dimensions

6.1.1 Orifice size

All sprinklers shall be constructed so that a sphere of diameter 8 mm can pass through the water passage in the sprinkler.

6.1.2 Nominal thread sizes

6.1.2.1 Sprinklers shall have a nominal thread size of R $\frac{3}{4}$.

6.1.2.2 Nominal thread sizes shall be suitable for fittings threaded in accordance with ISO 7-1. The dimensions of all threaded connections should conform to International Standards where applied. National standards may be used if International Standards are not applicable.

6.2 Temperature ratings and color codings

The marked nominal temperature rating and color coding of sprinkler shall be in accordance with [Table 1](#).

Table 1 — Nominal temperature rating and color coding

Glass bulb sprinklers		Fusible element sprinklers	
Marked nominal temperature rating (°C)	Liquid color code	Marked nominal temperature rating (°C)	Yoke arm color code
68 to 74	red	68 to 74	uncolored
93 to 104	green	93 to 104	white

6.3 Operating temperature (see 7.3)

Sprinklers shall be verified to operate within a temperature range of

$$t = x \pm (0,035x + 0,62) \text{ } ^\circ\text{C}$$

where

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

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

6.4 Water flow constant (see 7.4)

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

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

where

p is the pressure, expressed in MPa;

q is the flow rate, expressed in litres per minute (l/min).

The flow constant for ESFR sprinklers shall have values of 202 ± 10 or 242 ± 12 when determined by the test method of 7.4

6.5 Water distribution (see 7.5)

6.5.1 When tested in accordance with 7.5 the sprinkler shall meet the requirements of Tables 2 or 3, as applicable.

Table 2 — Sprinkler water distribution measurement K202

Number of sprinklers under the water-collection system	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water-collection pans m	Pressure ^{a,b} MPa (bar)	Minimum 16-pan average density ^c mm/min	Minimum flue space (4 pans) average ^c mm/min	Minimum 20-pan average density ^c mm/min	Minimum non-flue 10-pan average density ^{c,d} mm/min	Minimum single non-flue pan density ^c mm/min
1	0	0	3,04	0,34 (3,4)	21,2	40,8	NR	NR	NR
1	0	0	4,42	0,34 (3,4)	19,6	36,3	NR	NR	NR
1	0	0	4,42	0,51 (5,1)	NR	69,4	37,1	20,4	10,6
2	3,04	0	1,27	0,34 (3,4)	24,5	NR	NR	NR	NR
2	3,04	0	3,04	0,34 (3,4)	22,0	NR	NR	NR	NR
2	0	3,04	1,27	0,34 (3,4)	23,7	NR	NR	NR	NR

^a All 0,34 MPa (3,4 bar) tests are performed on a system fed from both directions (double feed).

^b All 0,51 MPa (5,1 bar) tests are performed on a system fed from one direction (single feed), except for the two-sprinklers, single-pipe tests which are performed on a double-feed system.

^c NR = No requirement (see Figures 5 to 9).

^d Average of the ten non-flue pans with the lowest water collection.

Table 2 (continued)

Number of sprinklers under the water-collection system	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water-collection pans m	Pressure ^{a,b} MPa (bar)	Minimum 16-pan average density ^c mm/min	Minimum flue space (4 pans) average ^c mm/min	Minimum 20-pan average density ^c mm/min	Minimum non-flue 10-pan average density ^{c,d} mm/min	Minimum single non-flue pan density ^c mm/min
2	0	3,04	3,04	0,34 (3,4)	23,3	NR	NR	NR	NR
2	3,66	0	1,27	0,34 (3,4)	18,0	NR	NR	NR	NR
2	0	3,66	1,27	0,34 (3,4)	18,4	NR	NR	NR	NR
2	3,04	0	1,27	0,51 (5,1)	NR	NR	31,4	24,5	8,2
2	0	3,04	1,27	0,51 (5,1)	NR	NR	31,4	24,5	8,2
4	3,04	3,04	1,27	0,34 (3,4)	27,7	NR	NR	NR	NR
4	3,04	3,04	3,04	0,34 (3,4)	35,1	NR	NR	NR	NR
4	2,44	3,6	1,27	0,34 (3,4)	26,9	NR	NR	NR	NR
4	3,04	3,04	1,27	0,51 (5,1)	NR	NR	29,0	24,5	15,1
^a All 0,34 MPa (3,4 bar) tests are performed on a system fed from both directions (double feed).									
^b All 0,51 MPa (5,1 bar) tests are performed on a system fed from one direction (single feed), except for the two-sprinklers, single-pipe tests which are performed on a double-feed system.									
^c NR = No requirement (see Figures 5 to 9).									
^d Average of the ten non-flue pans with the lowest water collection.									

Table 3 — Sprinkler water distribution measurement K242

Number of sprinklers under the water-collection system	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water-collection pans m	Pressure ^{a,b} MPa (bar)	Minimum 16-pan average density ^c mm/min	Minimum flue space (4 pans) average ^c mm/min	Minimum 20-pan average density ^c mm/min	Minimum non-flue 10-pan average density ^{c,d} mm/min	Minimum single non-flue pan density ^c mm/min
1	0	0	3,04	0,24 (2,4)	21,2	40,8	NR	NR	NR
1	0	0	4,42	0,24 (2,4)	19,6	36,3	NR	NR	NR
1	0	0	4,42	0,36 (3,6)	NR	69,4	37,1	20,4	10,6
2	3,04	0	1,27	0,24 (2,4)	24,5	NR	NR	NR	NR
2	3,04	0	3,04	0,24 (2,4)	22,0	NR	NR	NR	NR
2	0	3,04	1,27	0,24 (2,4)	23,7	NR	NR	NR	NR
^a All 0,24 MPa (2,4 bar) tests are performed on a system fed from both directions (double feed).									
^b All 0,36 MPa (3,6 bar) tests are performed on a system fed from one direction (single feed), except for the two-sprinklers, single-pipe tests which are performed on a double-feed system.									
^c NR = No requirement (see Figures 5 to 9).									
^d Average of the ten non-flue pans with the lowest water collection.									

Table 3 (continued)

Number of sprinklers under the water-collection system	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water-collection pans m	Pressure ^{a,b} MPa (bar)	Minimum 16-pan average density ^c mm/min	Minimum flue space (4 pans) average ^c mm/min	Minimum 20-pan average density ^c mm/min	Minimum non-flue 10-pan average density ^{c,d} mm/min	Minimum single non-flue pan density ^c mm/min
2	0	3,04	3,04	0,24 (2,4)	23,3	NR	NR	NR	NR
2	3,66	0	1,27	0,24 (2,4)	18,0	NR	NR	NR	NR
2	0	3,66	1,27	0,24 (2,4)	18,4	NR	NR	NR	NR
2	3,04	0	1,27	0,36 (3,6)	NR	NR	31,4	24,5	8,2
2	0	3,04	1,27	0,36 (3,6)	NR	NR	31,4	24,5	8,2
4	3,04	3,04	1,27	0,36 (3,6)	27,7	NR	NR	NR	NR
4	3,04	3,04	3,04	0,24 (2,4)	35,1	NR	NR	NR	NR
4	2,44	3,6	1,27	0,24 (2,4)	26,9	NR	NR	NR	NR
4	3,04	3,04	1,27	0,36 (3,6)	NR	NR	29,0	24,5	15,1

^a All 0,24 MPa (2,4 bar) tests are performed on a system fed from both directions (double feed).

^b All 0,36 MPa (3,6 bar) tests are performed on a system fed from one direction (single feed), except for the two-sprinklers, single-pipe tests which are performed on a double-feed system.

^c NR = No requirement (see Figures 5 to 9).

^d Average of the ten non-flue pans with the lowest water collection.

6.6 Function (see 7.6)

6.6.1 Lodgement (see 7.6.1)

When tested in accordance with 7.6.1, the sprinkler shall open and, any lodgement of released parts shall be cleared within 10 s of release of the heat-responsive element.

6.6.2 Deflector strength (see 7.6.2)

The deflector and its supporting parts shall not sustain significant damage as a result of the deflector strength test specified in 7.6.2.

If minor damage is noted, testing in accordance with 6.5.1 can be done to demonstrate compliance.

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

6.7 Service load and strength of sprinkler body (see 7.7)

6.7.1 The sprinkler body shall comply with the requirements of 6.7.1.1 or 6.7.1.2.

6.7.1.1 The sprinkler body shall not show permanent elongation of more than 0,2 % between the load-bearing points of the sprinkler body after being subjected to twice the service load as measured according to 7.7.1 or 7.7.2.

6.7.1.2 The sprinkler body shall not show permanent elongation of more than 50 % of the sprinkler body with the design load being applied after being subjected to twice the assembly load as measured according to 7.7.3.

6.7.2 The manufacturer shall specify the average and upper limit of the service or assembly load. These values shall not be exceeded when tested in accordance with 7.7.1, 7.7.2, or 7.7.3 as applicable.

6.8 Strength of heat-responsive element (see 7.8)

6.8.1 When tested in accordance with 7.8.1, glass bulb elements shall have a design strength lower tolerance limit (LTL) on the strength distribution curve of at least twice the upper tolerance limit (UTL) of the service load distribution curve, based on calculations with a degree of confidence (γ) of 0,99 for 99 % of samples (P), based on normal or Gaussian distribution except where other distribution can be shown to be more applicable due to manufacturing or design factors (see Figure 2).

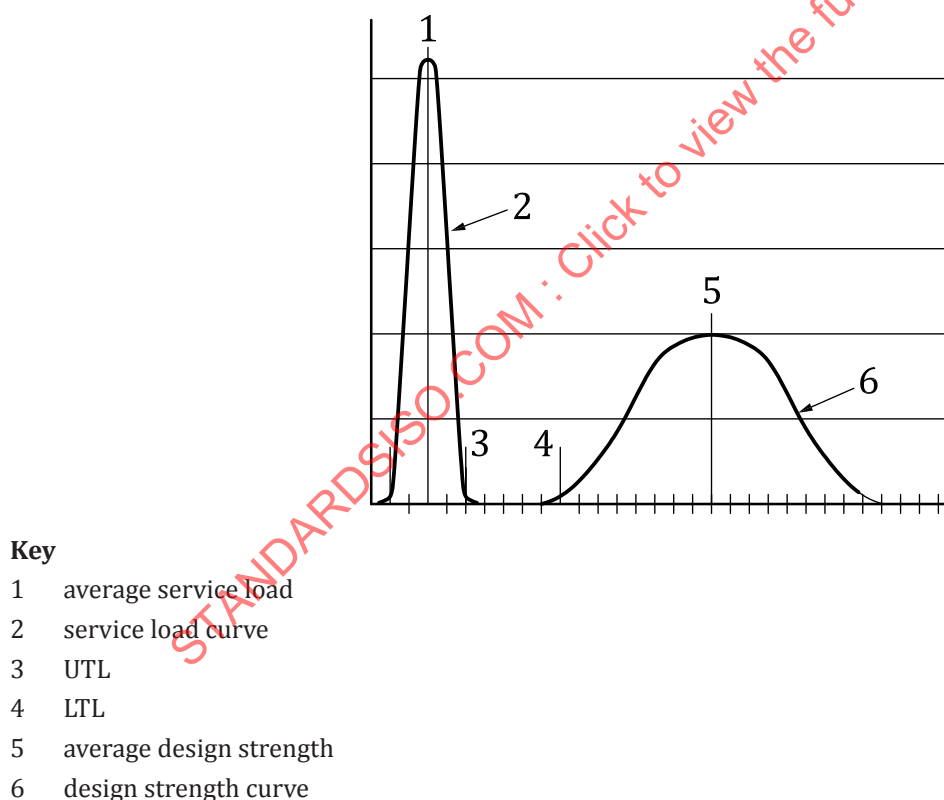


Figure 2 — Strength curve

6.8.2 A fusible heat-responsive element in the ordinary temperature range shall be designed to

- a) sustain a load of 15 times its design load corresponding to the maximum service load measured according to 7.8 for a period of 100 h when tested in accordance with 7.8.2.1, or

- b) demonstrate the ability to sustain the design load when tested in accordance with [7.8.2.2](#) (see [Annex B](#)).

6.9 Leak resistance and hydrostatic strength (see [7.9](#))

6.9.1 A sprinkler shall not show any sign of leakage when tested according to [7.9.1](#).

6.9.2 A sprinkler shall not rupture, operate, or release any parts when tested according to [7.9.2](#).

6.10 Heat exposure (see [7.10](#))

6.10.1 Glass bulb sprinklers (see [7.10.1](#))

There shall be no damage to the glass bulb element when the sprinkler is tested according to [7.10.1](#).

6.10.2 All sprinklers (see [7.10.2](#))

Sprinklers shall withstand exposure to increased ambient temperature without evidence of weakness or failure when tested according to [7.10.2](#).

6.11 Thermal shock for glass bulb sprinklers (see [7.11](#))

Glass bulb sprinklers shall not be damaged when tested according to [7.11](#). Following the thermal shock exposure, the sprinkler shall comply with [6.6.1](#) (Function) when tested with an inlet pressure of 0,035 MPa (0,35 bar).

6.12 Corrosion

6.12.1 Stress corrosion for copper-based alloy components (see [7.12.1](#))

When tested in accordance with [7.12.1](#), each sprinkler shall show no cracks, delamination, or failures which can possibly affect its ability to function as intended.

6.12.2 Sulfur-dioxide/carbon-dioxide corrosion (see [7.12.2](#))

NOTE In some countries this test is not mandatory.

Sprinklers shall be resistant to sulfur dioxide/carbon dioxide saturated with water vapor when conditioned in accordance with [7.12.2](#).

Following exposure, glass bulb sprinkler samples shall either be

- a) tested at 0,035 MPa (0,35 bar) in accordance with [6.6.1](#), or
- b) meet the requirements of [6.14](#) in orientation A.

Following exposure, half of the fusible element sprinkler samples shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with [6.6.1](#) and the remaining samples shall meet the requirements of [6.14](#) when tested in accordance with [7.14.1.2](#).

6.12.3 Hydrogen sulfide corrosion (see [7.12.3](#))

NOTE In some countries this test is not mandatory.

Sprinklers shall be resistant to hydrogen sulfide saturated with water vapor when conditioned in accordance with [7.12.3](#).

Following exposure, glass bulb sprinkler samples shall either be

- a) tested at 0,035 MPa (0,35 bar) in accordance with [6.6.1](#), or
- b) meet the requirements of [6.14](#) in orientation A.

Following exposure, half of the fusible element sprinkler samples shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with [6.6.1](#) and the remaining samples shall meet the requirements of [6.14](#) when tested in accordance with [7.14.1.2](#).

6.12.4 Salt spray loading (see [7.12.4](#))

Sprinklers shall be resistant to salt spray when conditioned in accordance with [7.12.4](#).

Following exposure, glass bulb sprinkler samples shall either be

- a) tested at 0,035 MPa (0,35 bar) in accordance with [6.6.1](#), or
- b) meet the requirements of [6.14](#) in orientation A.

Following exposure, half of the fusible element sprinkler samples shall be functionally tested at 0,035 MPa (0,35 bar) only in accordance with [6.6.1](#) and the remaining samples shall meet the requirements of [6.14](#) when tested in accordance with [7.14.1.2](#).

6.12.5 Moist-air exposure (see [7.12.5](#))

Sprinklers shall be resistant to moist-air exposure when tested in accordance with [7.12.5](#). Following exposure, the sprinklers shall be functionally tested at 0,05 MPa (0,5 bar) in accordance with [6.6.1](#).

6.13 Water hammer (see [7.13](#))

Sprinklers shall not leak during or after the pressure surges described in [7.13](#). After being subjected to the test according to [7.13](#), they shall show no signs of mechanical damage, shall meet the requirement of [6.6.1](#) and shall operate when functionally tested to the requirements of [6.6.1](#) at a pressure of 0,035 MPa (0,35 bar) only.

6.14 Dynamic heating (see [7.14](#))

ESFR sprinklers shall have an RTI of $36 \text{ (m}\cdot\text{s)}^{0,5}$ when tested in orientations A and B as described in [7.14.1.1](#).

6.15 Resistance to heat (see [7.15](#))

Open sprinklers shall be resistant to high temperatures when tested in accordance with [7.15](#). After exposure, the sprinkler shall not fracture or break. If visual deformation is observed on the sprinkler orifice it shall meet the requirements of [6.4](#). If visual deformation is observed on the sprinkler frame or deflector, it shall meet the requirements of [6.5.1](#).

6.16 Vibration (see [7.16](#))

Sprinklers shall be able to withstand the effects of vibration without deterioration when tested in accordance with [7.16](#). After the vibration test of [7.16](#), sprinklers shall show no visible deterioration and shall meet the requirements of [6.9.1](#) and [6.14](#) when tested in accordance with [7.14.1.2](#).

6.17 Impact (see [7.17](#))

Sprinklers shall show no fracture or deformation, and shall meet the requirements of [6.9.1](#) and [6.14](#) in orientation A when tested in accordance with [7.14.1.2](#) after the impact test of [7.17](#).

6.18 Rough usage (see 7.18)

A sprinkler shall withstand the effects of rough usage without deterioration of its performance characteristics. Following 3 min of tumbling as described in 7.18, the sprinkler shall comply with 6.9.1 and 6.14 in orientation A when tested in accordance with 7.14.1.2.

6.19 Lateral discharge (see 7.19)

Sprinklers shall not prevent the operation of adjacent sprinklers when tested in accordance with 7.19.

6.20 Thirty-day leakage resistance (see 7.20)

When tested in accordance with 7.20, sprinklers shall not leak or sustain any mechanical damage. Following exposure, the sprinklers shall meet the requirement of 6.9.1.

6.21 Vacuum resistance (see 7.21)

Sprinklers shall not exhibit distortion or mechanical damage and shall meet the leakage requirements of 6.9.1 after being subjected to the test in 7.21.

6.22 Freezing (see 7.22)

Sprinklers shall be resistant to low temperatures when tested in accordance with 7.22. After exposure, the sprinkler shall either be visibly damaged, leak subsequent to thawing at a pressure not exceeding 0,05 MPa (0,5 bar), or be undamaged. Sprinklers not visibly damaged or leaking at a pressure not exceeding 0,05 MPa (0,5 bar) shall meet the requirements of 6.9.1 and 6.14 in orientation A when tested in accordance with 7.14.1.2.

6.23 Actual delivered density (ADD) (see 7.23)

ESFR sprinklers shall meet the minimum average densities shown in Tables 4 or 5, as applicable when measured in accordance with 7.23.

Table 4 — ADD measurements K202

Number of sprinklers over the ADD apparatus	Sprinkler spacing m	Pipe spacing m	Ceiling clearance to water collection pans m	Freeburn convective heat release kW	Pressure MPa (bar)	Direction of feed flow	Minimum 16-pan average ADD mm/min	Minimum flue space (4 pans) average ^a mm/min
1	0	0	4,57	1 318	0,34 (3,4)	Double	19,1	60,3
1	0	0	4,57	2 636	0,34 (3,4)	Double	9,7	20,4
2	3,66	0	1,22	2 636	0,34 (3,4)	Single	11,8	NR
2	0	3,66	1,22	2 636	0,34 (3,4)	Double	14,2	NR
4	2,44	3,66	1,22	2 636	0,34 (3,4)	Double	26,1	NR

^a NR = No Requirement.

Table 5 — ADD measurements K242

Number of sprinklers over the ADD apparatus	Sprinkler spacing	Pipe spacing	Ceiling clearance to water collection pans	Freeburn convective heat release	Pressure	Direction of feed flow	Minimum 16-pan average ADD	Minimum flue space (4 pans) average ^a
	m	m	m	kW	MPa (bar)		mm/min	mm/min
1	0	0	4,57	1 318	0,24 (2,4)	Double	19,1	60,3
1	0	0	4,57	2 636	0,24 (2,4)	Double	9,7	20,4
2	3,66	0	1,22	2 636	0,24 (2,4)	Single	11,8	NR
2	0	3,66	1,22	2 636	0,24 (2,4)	Double	14,2	NR
4	2,44	3,66	1,22	2 636	0,24 (2,4)	Double	26,1	NR

^a NR = No Requirement.

6.24 Thrust force measurements (see 7.24)

ESFR sprinklers shall meet the minimum thrust force requirements shown in Table 6 when tested in accordance with 7.24.

Table 6 — Thrust

Pressure for sprinklers k202/k242	Direction of feed flow	Ceiling clearance to thrust plate	Minimum required thrust
MPa (bar)		m	kPa (mbar)
0,34/0,24 (3,4/2,4)	Double	1,2	0,071 (0,71)
0,34/0,24 (3,4/2,4)	Double	2,1	0,044 (0,44)
0,51/0,36 (5,1/3,6)	Single	2,1	0,10 (1,00)

6.25 Dezincification of brass components (see 7.25)

NOTE In some countries, this test is not mandatory.

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

- An average dezincification depth exceeding 100 µm; and
- An individual reading of dezincification depth exceeding 200 µm.

6.26 Stainless steel components (see 7.26)

NOTE In some countries, this test is not mandatory.

Sprinklers having components consisting of stainless steel alloys shall be subjected to [7.26](#). The stainless steel components shall not show evidence of fracture, distortion or impending separation from the frame unless tested as described in [7.26.2.4](#).

6.27 Protective covers (see [7.27](#))

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

6.27.1 Sprinklers may be equipped with protective covers that are designed to remain in place during installation and be removed before the sprinkler system is placed in service.

6.27.2 Glass bulb sprinklers equipped with protective covers shall comply with the impact test for protective covers and marking requirements, [7.27](#) and [8.2](#).

6.27.3 A glass bulb sprinkler, with the protective cover installed, shall not be damaged or leak and the cover shall remain in place when tested as described in [7.27](#).

6.27.4 Protective covers shall be designed not to allow damage to the sprinkler and the heat-sensing element during assembly of the sprinkler, installation of the sprinkler and removal of the cover. Removal shall be possible without tools unless specified by the manufacturer.

7 Test methods

7.1 General conditions

The following tests shall be conducted for each type of sprinkler. Before testing, precise drawings of parts and the assembly shall be submitted together with the appropriate specifications (using SI units). Tests shall be conducted at a room temperature of $(20 \pm 5) ^\circ\text{C}$, unless other temperatures are indicated. Sprinklers shall be tested with all the components required by their design and installation.

Unless otherwise stated, the tolerances given in [Annex C](#) shall apply.

7.2 Examination

7.2.1 Preliminary examination

The construction shall be examined to ensure that it complies with the requirements of [Clause 4](#) and [Clause 5](#).

7.2.2 Visual examination

Before testing, examine the sprinklers visually with respect to the following:

- a) marking,
- b) conformity of the sprinklers with the manufacturer's drawings and specifications, and
- c) obvious defects.

7.3 Operating temperature test (see [6.3](#))

7.3.1 Test of static operation

Ten sprinklers shall be heated from a temperature of $(20 \pm 5) ^\circ\text{C}$ to a temperature of $(20_0^{+2}) ^\circ\text{C}$ below their nominal operating temperature. The rate of increase in temperature shall not exceed $20 ^\circ\text{C}/\text{min}$.

and the temperature shall be maintained for 10 min. The temperature shall then be increased at a rate of $(0,5 \pm 0,1) ^\circ\text{C}/\text{min}$ until the sprinkler operates.

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

The test shall be conducted in a liquid bath. Sprinklers having nominal operating temperatures of $\leq 80 ^\circ\text{C}$ shall be tested in a bath of demineralized water. Sprinklers with higher-rated elements shall be tested in a bath of glycerin, vegetable oil or synthetic oil.

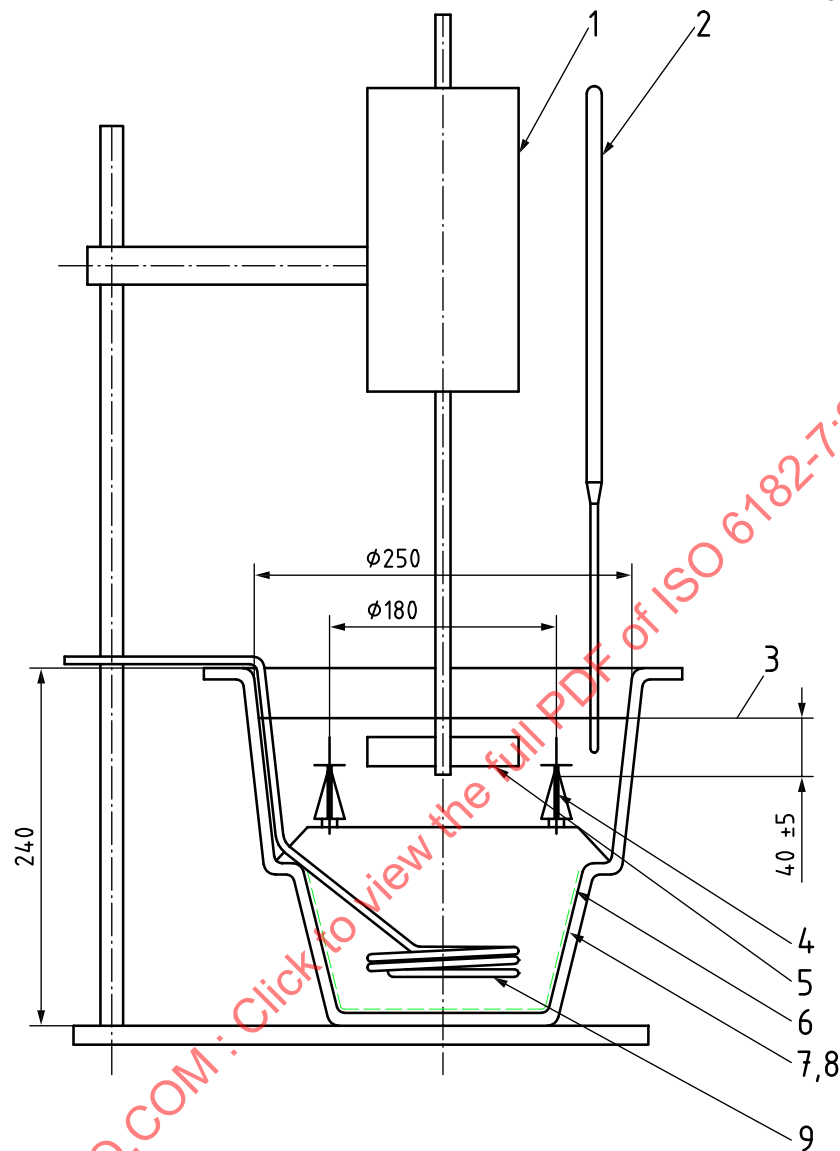
The sprinklers shall be located in the liquid bath in a vertical position and totally immersed under a liquid cover of at least 5 mm. The test zone is located at a distance, below the liquid surface, level with the geometric center of the glass bulb or fusible element. The test zone shall not be less than 35 mm below the liquid surface level. The temperature deviation within the test zone shall be within $\pm 0,25 ^\circ\text{C}$.

NOTE It is preferred to have the test zone at (40 ± 5) mm below the liquid surface level.

Any rupture of a glass bulb within the prescribed temperature range constitutes an operation. Partial or complete operation of any heat responsive element within the prescribed temperature range shall constitute an operation. Partial fracture of any glass bulb or incomplete operation of any heat responsive element shall necessitate verification of function through an additional 50 samples being tested in accordance with [7.3.2](#).

An example of a standardized liquid bath is shown in [Figure 3](#). A laboratory temperature-measuring device, calibrated to a depth of 40 mm immersion, shall be used to determine temperatures of liquids in bath tests and the operating temperature. The bulb of the thermometer shall be held level with the sprinkler operating parts by a support member. To control the temperature in the thermal bath, a PT100 IEC 60751 resistance thermometer or equivalent may be used.

Dimensions in millimetres

**Key**

- 1 agitator motor (150 rpm)
- 2 thermometer calibrated for 40 mm immersion and either PT-100 or thermocouple
- 3 liquid level
- 4 ring to support sprinklers
- 5 double wing agitator (100 mm × 20 mm)
- 6 mesh screen
- 7 standard glass vessel
- 8 desiccators, Ø250, liquid volume, approx. 7 l
- 9 immersion heater

Figure 3 — Example of a liquid bath test apparatus

7.3.2 Fifty previously untested sprinklers shall be placed on their threaded inlets in a programmable oven circulating air at ambient temperature. The temperature in the oven shall be steadily raised to $(11,1 \pm 1,1)$ °C below the nominal temperature rating of the sprinklers over a 20 min period. Once this temperature is reached, the oven shall be maintained at constant temperature for a period of at least

20 min. The temperature shall then be raised at a constant rate of $0,5\text{ °C} \pm 0,3\text{ °C}$ per minute until all sprinklers operate. Partial fracture of a glass bulb or partial operation of a fusible element, i.e. strutting, shall be deemed a failure.

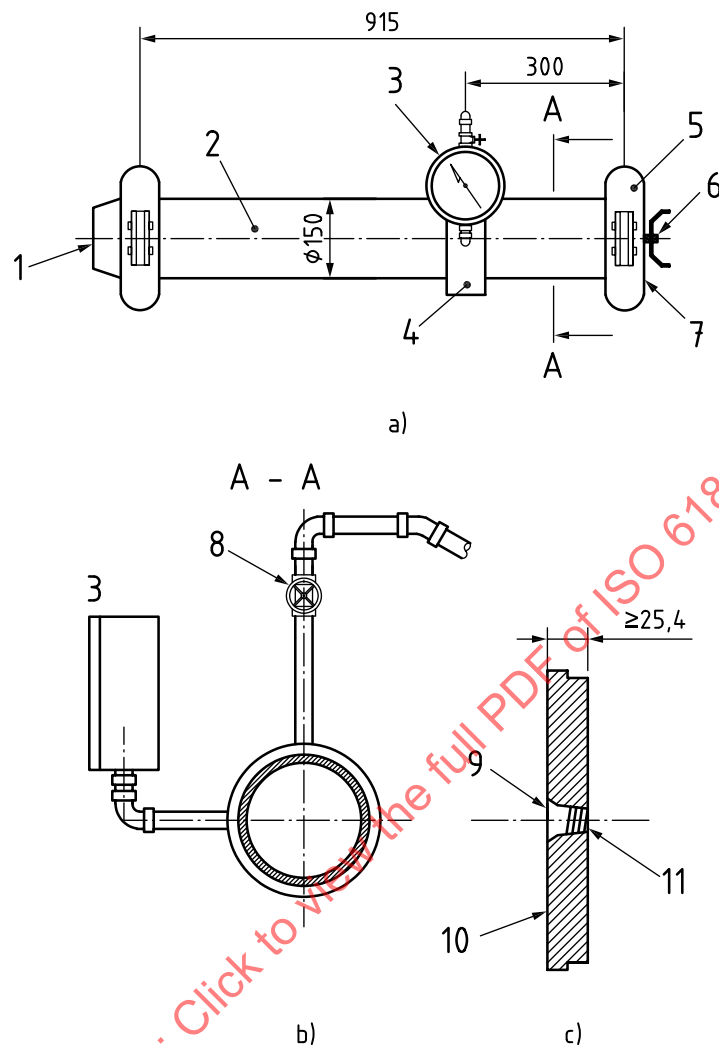
NOTE It is not necessary to meet the operating temperature limits of [6.3](#) in this test.

7.4 Water flow constant test (see [6.4](#))

The sprinkler shall be mounted with a pressure gauge on a supply pipe an example of which is shown in [Figure 4](#). Four sprinklers shall be tested. The frame arms and deflector of sprinklers shall be removed to facilitate testing. The water flow shall be measured at pressures of 0,10 MPa to 1,0 MPa (1,0 bar to 10 bar) at intervals of 0,1 MPa (1 bar). In one series of tests, the pressure shall be increased to each interval, and, in the other series, the pressure shall be decreased from 1,0 MPa (10 bar) to each interval. The K-factor shall be calculated for each flowing pressure and the K-factor shall be averaged for each series of readings. Each calculated K-factor and the average K-factor for each series shall be within the limits specified in [6.4](#). During the test, pressures shall be corrected for differences in height between the gauge and the outlet orifice of the sprinkler.

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Dimensions in metres

**Key**

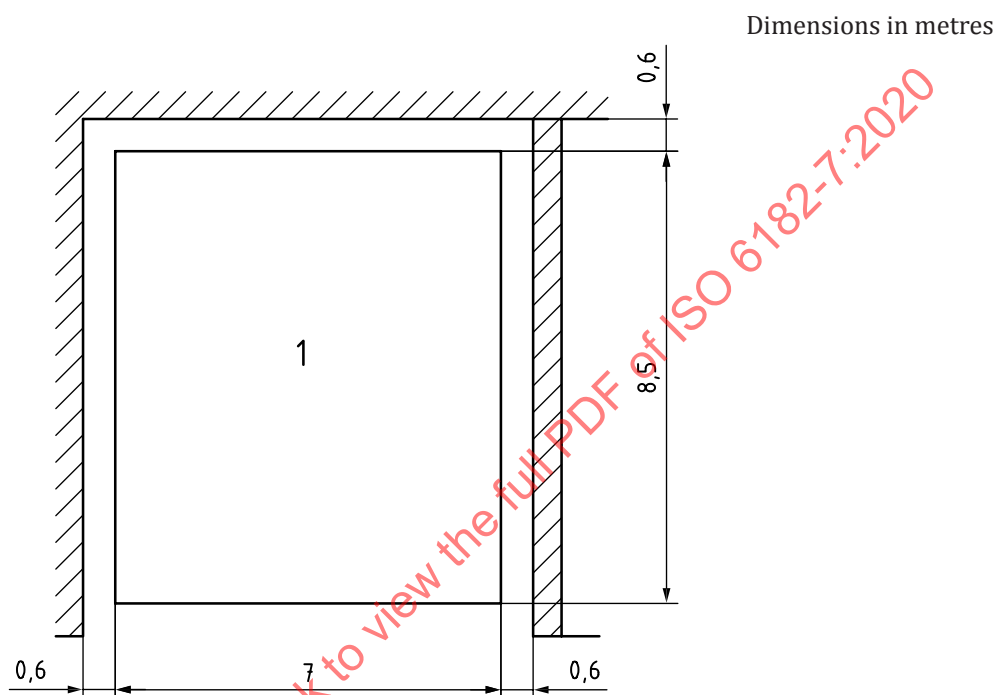
- 1 water source inlet
- 2 pipe
- 3 pressure gauge
- 4 piezometer ring
- 5 coupling (typical)
- 6 sprinkler
- 7 grooved end cap
- 8 valve for air relief
- 9 inlet of tapped hole with nominal 12 mm radius
- 10 flat surface of end cap
- 11 tapped opening to accommodate the size of the inlet thread

Figure 4 — Example of a water flow test apparatus**7.5 Water distribution tests** (see 6.5)

Test three samples, or sets of samples, to the requirements given in Table 2 or Table 3 as applicable. Operate all samples by applying a heat source to remove the heat-sensitive element. The sprinkler test area shall be designed as shown in Figures 5, 6, 7, 8 and 9. Construct the water-collection apparatus in

accordance with the specifications given in [Figure 9](#). Locate the test apparatus in a room of sufficient volume so as to minimize the entrainment of additional water spray. Prevent any drafts or other air movement from entering, or leaving, the test area.

Cover the water-collection system, [Figure 9](#), until the required pressure has been obtained. At that time, quickly remove the cover in such a manner as to not cause water collected on top of the cover to be deposited into the collection pans. Conduct this test for a period of 5 min. At the conclusion of the test, immediately place the cover over the collection pans to prevent any further water from being collected in the pans.

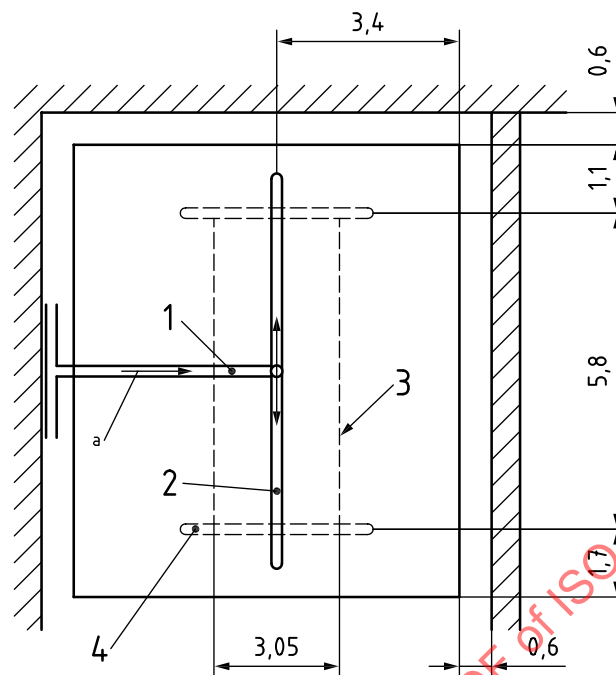


Key

- 1 suspended ceiling

Figure 5 — Minimum dimensions of the water distribution collection apparatus

Dimensions in metres

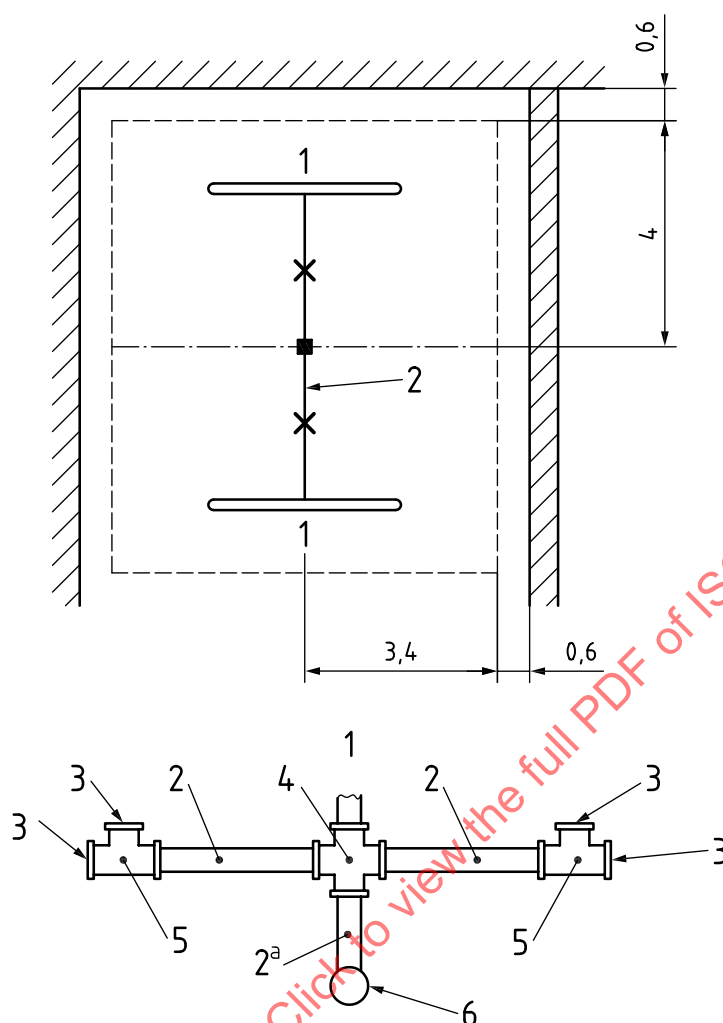
**Key**

----- Indicates piping located below the ceiling (see [Figures 8](#) and [9](#)).

- 1 pipe [Ø100 nom. (mm)]
- 2 pipe [Ø75 nom. (mm)]
- 3 sprinkler pipe (Ø50 mm)
- 4 manifold under ceiling (50 mm)
- a Water flow.

Figure 6 — Overhead piping configuration for water-distribution-collection apparatus

Dimensions in metres



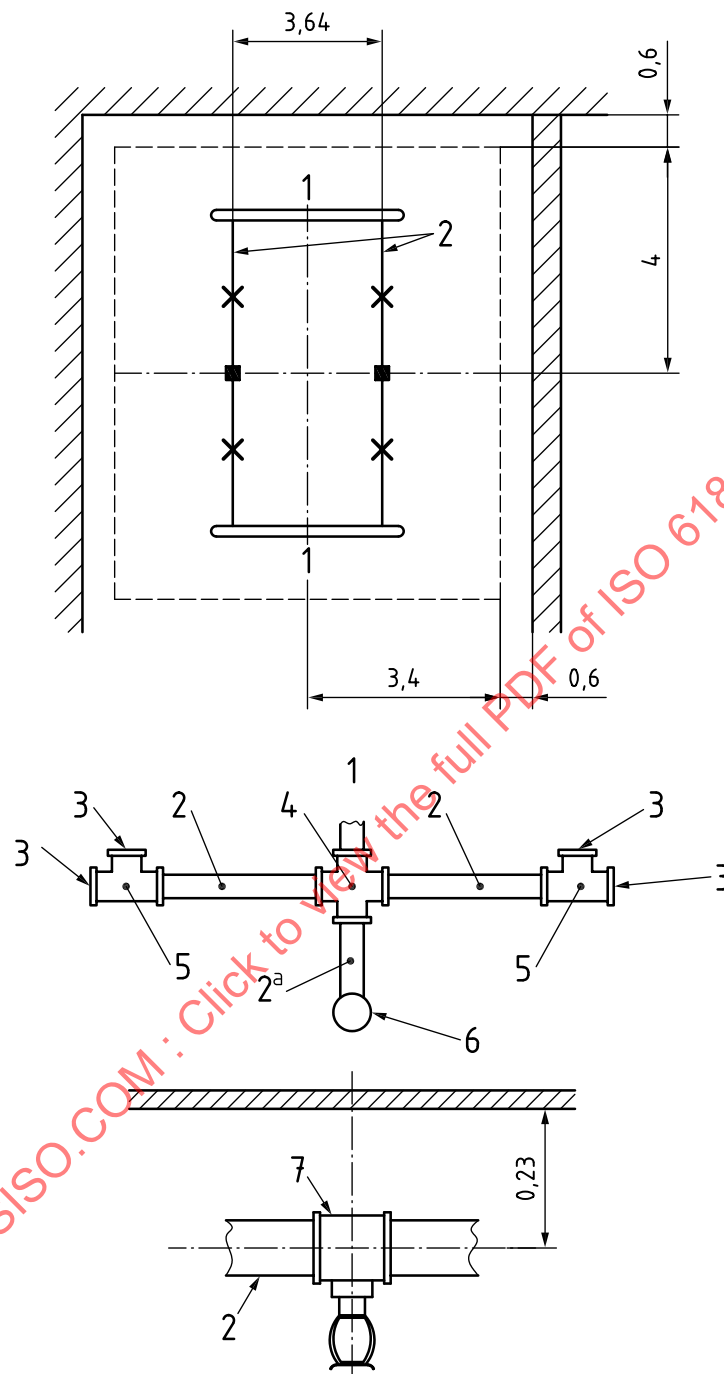
Key

- | | | | |
|---|--|---|--|
| 1 | pipe manifold | ■ | sprinkler location — single sprinkler test |
| 2 | pipe [Ø50 nom. (mm)] | × | sprinkler location — two-sprinkler test |
| 3 | pipe plug | a | 300 mm minimum length. |
| 4 | threaded cross (50 mm × 50 mm × 50 mm) | | |
| 5 | threaded tee (50 mm × 50 mm × 50 mm) | | |
| 6 | nominal feed line from above the ceiling with reducer (Ø75 mm) | | |

NOTE See [Tables 2](#) or [3](#), as applicable for pipe spacing.

Figure 7 — Single sprinkler piping configuration for the water-distribution-collection apparatus

Dimensions in millimetres



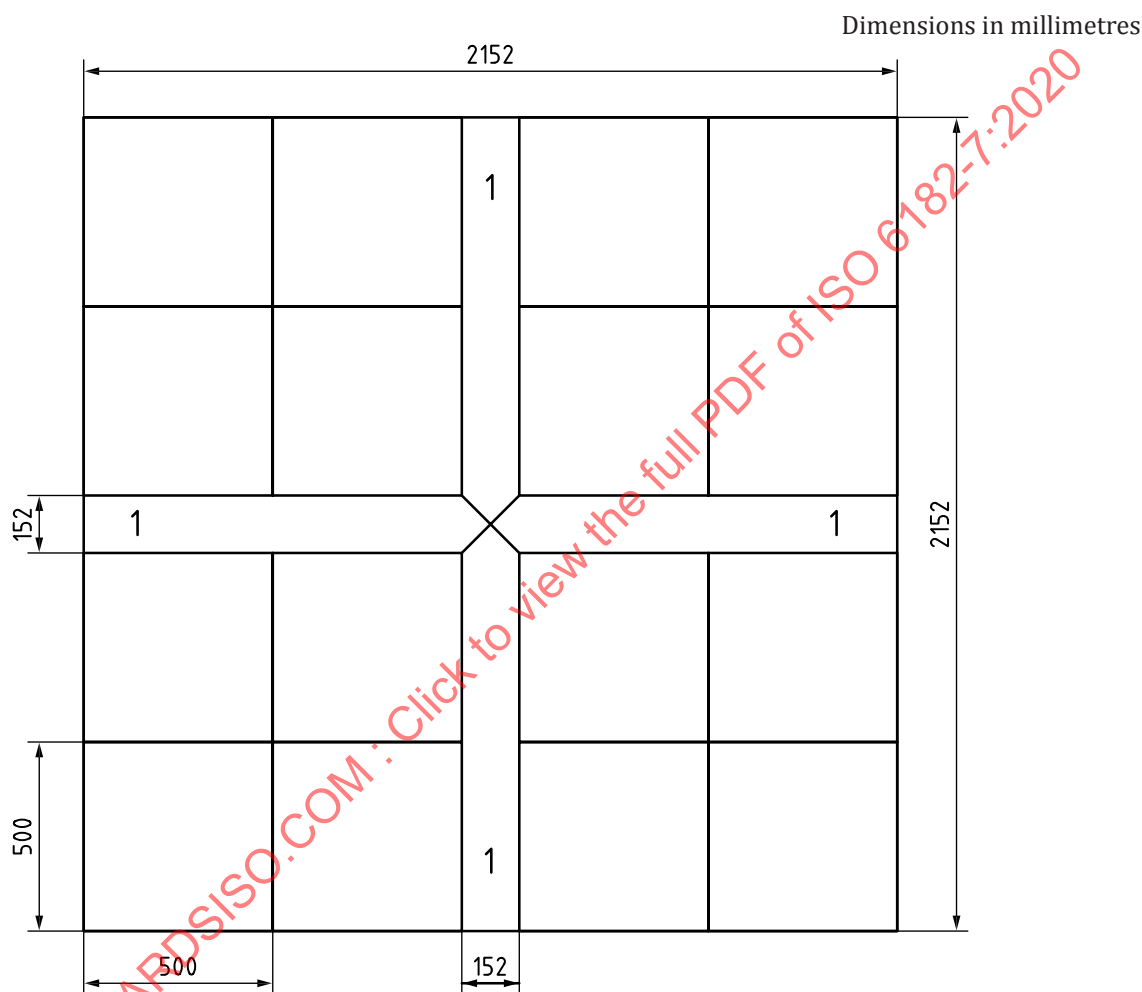
Key

- | | | | |
|---|--|---|--|
| 1 | pipe manifold | ■ | sprinkler location — single sprinkler test |
| 2 | pipe [Ø50 nom. (mm)] | × | sprinkler location — two-sprinkler test |
| 3 | pipe plug | a | 300 mm minimum length. |
| 4 | threaded cross (50 mm × 50 mm × 50 mm) | | |

- 5 threaded tee (50 mm × 50 mm × 50 mm)
- 6 nominal feed line from above the ceiling with reducer (Ø75 mm)
- 7 threaded pipe

NOTE See [Tables 2](#) or [3](#), as applicable for pipe spacing.

Figure 8 — Multiple-sprinkler piping configuration for the water-distribution-collection apparatus



Key

- 1 flue space Top surface of collection pans to be ≥1 000 mm above solid floor surface.

Figure 9 — Collection pan assembly for water distribution collection apparatus

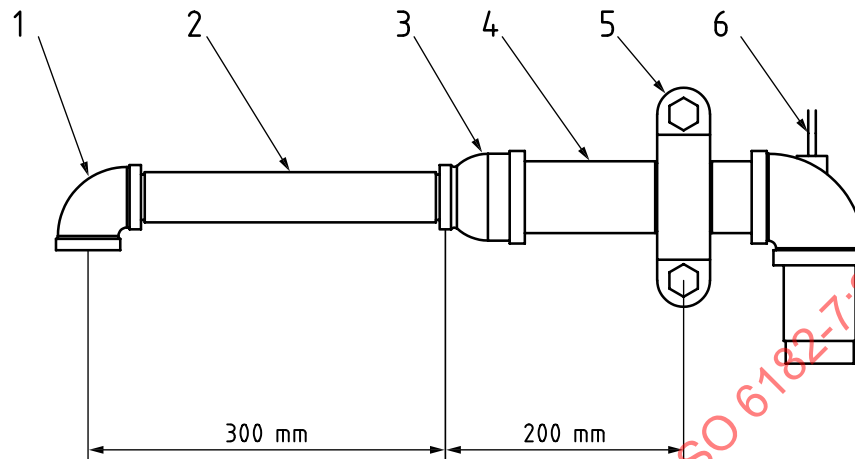
7.6 Function test (see [6.6](#))

7.6.1 Lodgement test (see [6.6.1](#))

7.6.1.1 Automatic sprinklers of any temperature rating shall be individually tested. Each sample shall be installed in its intended installation position on a rigid piping arrangement and supplied with flowing water. Tests shall be conducted using a single-feed ([Figure 10](#) or [11](#)) and a double-feed ([Figure 12](#)) water supply arrangement. The test pressures and number of samples tested at each pressure using each water supply configuration are specified in [Table 7](#). Each sample shall be operated by exposing the heat

responsive element to a uniform application of heat. The service pressure and the action of the operating parts, when releasing, shall be observed to determine compliance with these requirements.

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

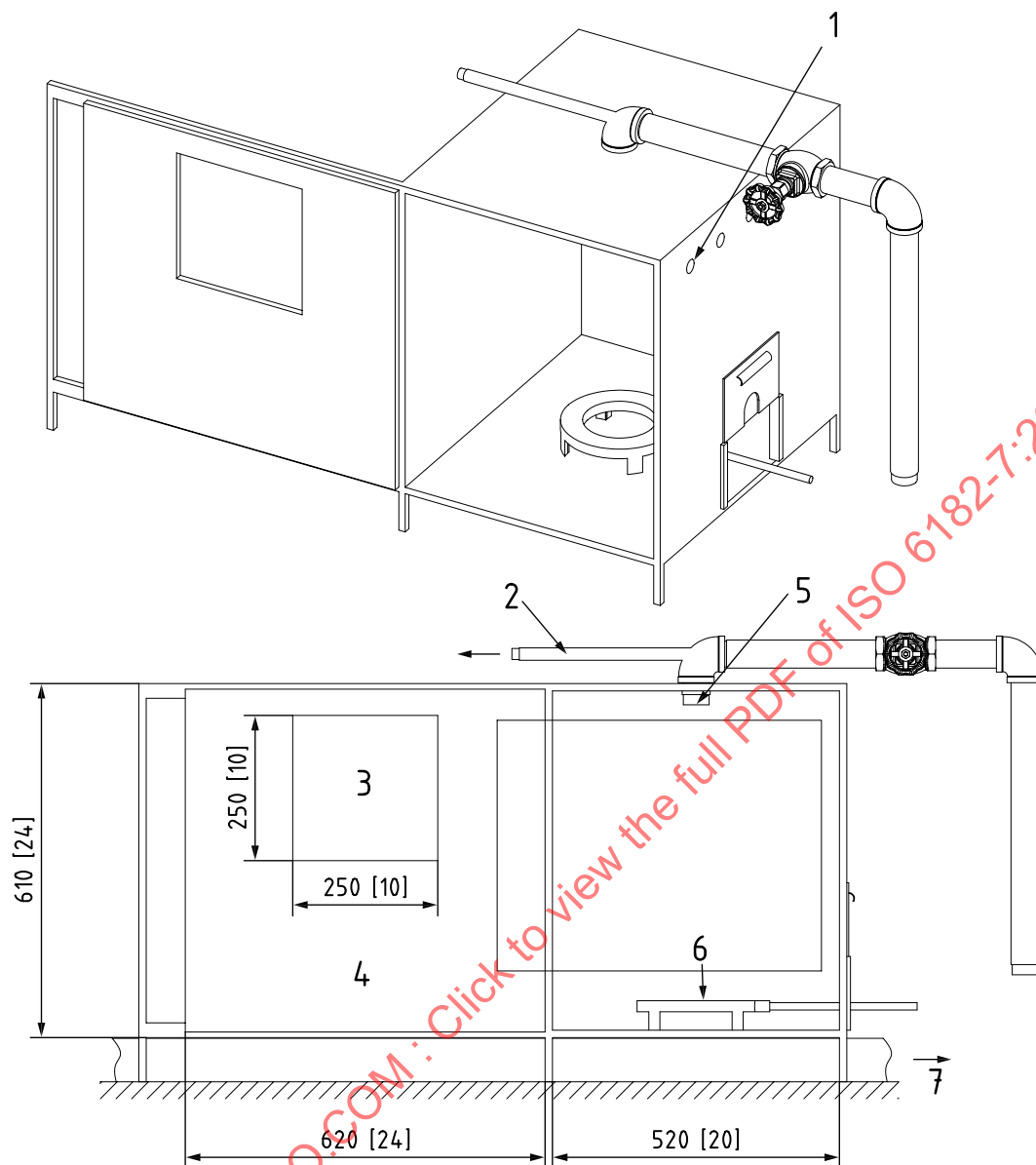


Key

- 1 32 mm nominal elbow (outlet as required)
- 2 32 mm nominal steel pipe
- 3 32 mm × 50 mm nominal reducer
- 4 50 mm nominal steel pipe
- 5 50 mm nominal grooved coupling
- 6 bleed line

NOTE All dimensions are nominal size.

Figure 10 — Typical single feed lodgement test arrangement



Key

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

Figure 11 — Typical function test oven

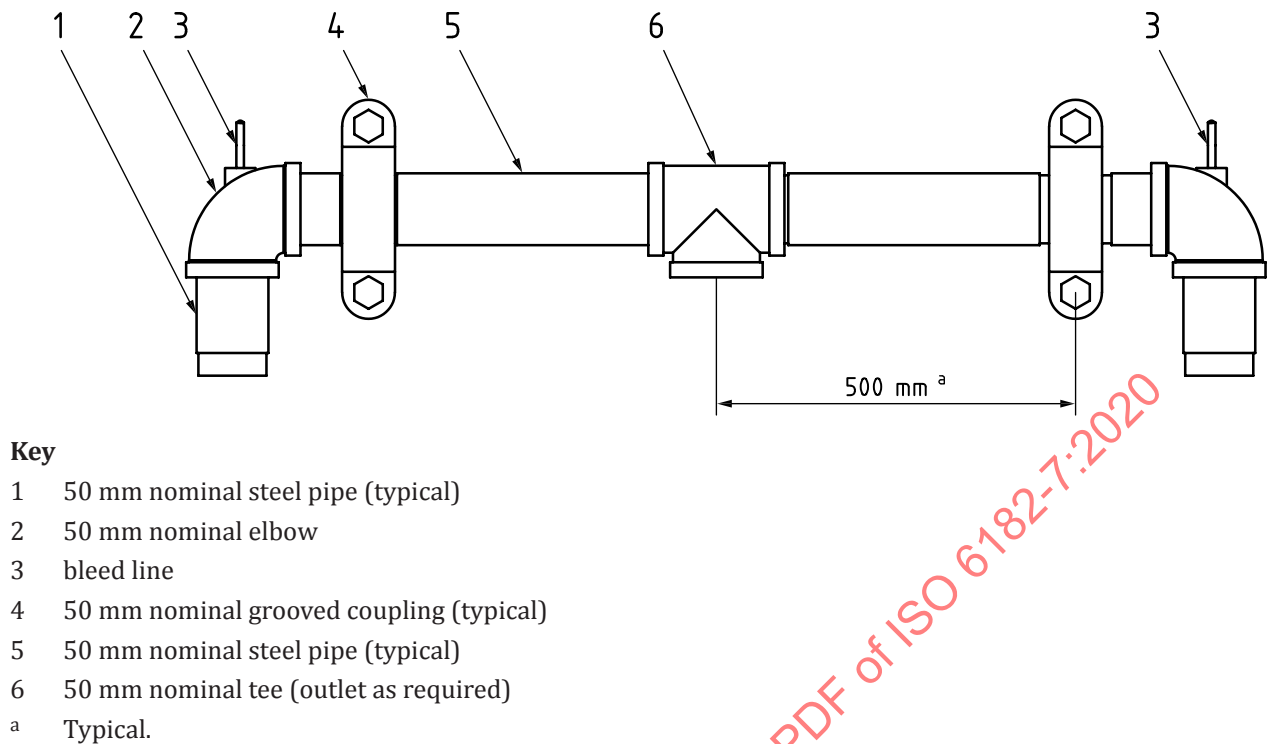


Figure 12 — Typical double feed lodgement test arrangement

Table 7 — Lodgement test pressures and number of test samples

Test pressure ^a		Water supply arrangement	Number of test samples ^b
MPa	bar		
0,035 or 0,05	0,35 or 0,5	Single Feed	5
0,035 or 0,05	0,35 or 0,5	Double Feed	5
0,17	1,7	Single Feed	5
0,17	1,7	Double Feed	5
0,35	3,5	Single Feed	5
0,35	3,5	Double Feed	5
0,52	5,2	Single Feed	5
0,52	5,2	Double Feed	5
0,69	6,9	Single Feed	5
0,69	6,9	Double Feed	5
0,86	8,6	Single Feed	5
0,86	8,6	Double Feed	5
1,0	10	Single Feed	5
1,0	10	Double Feed	5
1,2	12	Single Feed	5
1,2	12	Double Feed	5

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

^a Mandatory test pressures include 0,035 or 0,05 MPa (0,35 or 0,5 bar), 0,35 MPa (3,5 bar), and the rated pressure.

^b Testing using each temperature rating may be required in some countries.

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

7.6.2 Deflector strength test (see 6.6.2)

In order to check the strength of the deflector, three sprinklers shall be submitted to the function test in each normal mounting position at a pressure not less than the rated pressure. The water shall be allowed to flow at a residual pressure not less than the rated pressure for a period of 30 min.

7.7 Service load and strength of sprinkler body (see 6.7)

7.7.1 Test option 1

7.7.1.1 The service load shall be measured on a minimum of 10 sprinklers by securely installing each sprinkler, at room temperature, in a tensile/compression test machine and applying the equivalent of a hydraulic pressure equal to the rated pressure at the inlet.

7.7.1.1.1 Alternatively, the service load may be determined by measuring the assembly load and adding a calculated or measured value of the force equivalent to a hydrostatic pressure equal to the rated pressure at the inlet.

7.7.1.2 An indicator capable of reading deflection to an accuracy of 0,001 mm shall be used to measure any change in length of the sprinkler between the load bearing points of the sprinkler body. Movement of the sprinkler shank thread in the threaded bushing of the test machine shall be avoided or taken into account.

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

7.7.1.3.1 Apply an increasing mechanical load to the sprinkler, at a rate not exceeding 500 N/min, until the indicator reading at the deflector end of the sprinkler returns to the initial value achieved under hydrostatic load. Record the mechanical load necessary to achieve this as the service load.

7.7.1.3.2 Increase the applied load progressively at a rate not exceeding 500 N/min until twice the average service load has been applied. Maintain this load for (15 ± 5) s.

7.7.1.3.3 Remove the load and compare the permanent elongation with the requirement of 6.7.1.1.

7.7.2 Test option 2

A minimum of 10 samples shall be individually mounted into a solid fixture and the pipcap/seat, spring, and frame for orientation purposes shall be marked to record the original assembled position. A dial indicator shall be located on the bottom of the sprinkler, through the waterway and in contact with the bottom of the pipcap/seat. The indicator gauge shall be indexed to zero reading.

The glass bulb element shall be fractured and removed using pliers or another mechanical device. The compression screw shall then be removed from the sprinkler. The components (spring and pipcap/seat) shall be reassembled in the waterway. A hydraulic ram (or other device) shall be set with a load cell on the top of the sprinkler with an extended ram through the setscrew hole and in contact with the pipcap/seat. A load shall then be applied to the pipcap/seat so as to compress the spring to its original position and held for 10 min, after which the load that the cell is reporting shall be recorded and is considered the assembly load. After the reading is taken, apply additional load to the pipcap/seat to verify that the spring is not in the flat position.

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

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

7.7.3 Test option 3

7.7.3.1 The assembly load shall be measured on a minimum of 10 sprinklers by securely installing each sprinkler at room temperature in a tensile/compression test machine.

7.7.3.2 An indicator capable of reading deflection to an accuracy of 0,001 mm shall be used to make the first measurement of any change in length of the sprinkler between the load bearing points of the sprinkler body. Movement of the sprinkler shank thread in the threaded bushing of the test machine shall be avoided or taken into account.

7.7.3.3 Remove the heat-responsive element of the sprinkler by a suitable method. When the sprinkler is at room temperature, make a second measurement using the indicator.

7.7.3.4 Mechanical load shall be applied progressively to the sprinkler at a rate not exceeding 500 N/min until the indicator reading at the first measurement point of the sprinkler returns to the initial value achieved. Record the mechanical load necessary to achieve this as the assembly load.

7.7.3.5 Increase the load progressively at a rate not exceeding 500 N/min until twice the average of assembly load has been applied. Maintain this load for (15 ± 5) s.

7.7.3.6 Remove the load and take a third measurement. Compare the permanent elongation with the requirement of [6.7.1.2](#).

NOTE An amount of change in the length of sprinkler body while applying its assembly load will be the difference between the first and second measurements. The amount of permanent elongation will be the difference between the second and third measurements.

7.8 Strength of heat-responsive element test (see [6.8](#))

7.8.1 Glass bulbs

7.8.1.1 At least 55 glass bulbs of each bulb type shall be positioned individually in a test fixture using the sprinkler seating parts. Each bulb shall then be subjected to a uniformly increasing force at a rate of (250 ± 25) N/s in the test machine until the glass bulb fails.

7.8.1.2 Each test shall be conducted with the bulb mounted in new seating parts. The seating parts may be reinforced externally or manufactured from hardened steel (Rockwell Hardness C44 $\pm$ 6) in accordance with the specifications of the sprinkler manufacturer to prevent collapse, but in a manner which does not interfere with bulb failure. Record the crush force for each bulb.

7.8.1.3 Using the lowest 50 measured bulb strength results, calculate the average strength and the LTL for bulb strength (see [Annex A](#)). Using the values of service load recorded in [7.7.1](#), calculate the UTL for the sprinkler release element service load (see [Annex A](#)). Verify compliance with [6.8.1](#).

7.8.2 Fusible elements

7.8.2.1 Determine compliance with the requirements of [6.8.2\(a\)](#) by subjecting at least 10 samples to 15 times the maximum design load for 100 h. Abnormal failures, those not related to evaluation of the fusible material, shall not be used; however, valid results from at least 10 samples shall be obtained.

7.8.2.2 Determine compliance with the requirements of [6.8.2\(b\)](#) by subjecting fusible heat-responsive elements to loads in excess of the maximum design load, L_d , which will produce failure within and after 1 000 h (see [Annex B](#)). At least 10 samples shall be subjected to different loads up to 15 times the maximum design load. Abnormal failures shall be rejected; however, valid results from at least

10 samples shall be obtained. Plot a full logarithmic regression curve using the method of least squares, and from this, calculate the load at 1 h, L_0 , and the load at 1 000 h, L_M , where

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

where

L_d is the maximum design load;

L_M is the load at 1 000 h;

L_0 is the load at 1 h.

7.8.2.3 The tests of [7.8.2.1](#) and [7.8.2.2](#) shall be conducted at an ambient temperature of $(20 \pm 3) ^\circ\text{C}$.

7.9 Leak resistance and hydrostatic strength tests (see [6.9](#))

7.9.1 Twenty sprinklers shall be tested. They shall be subjected to a water pressure equal to two times the rated pressure.

Increase the pressure from 0 MPa (0 bar) to the value noted above at a rate of $(0,1 \pm 0,03)$ MPa/s $[(1 \pm 0,3)$ bar/s], maintain the pressure for a period of 3 min and then allow it to fall to 0 MPa (0 bar). After the pressure has dropped to 0 MPa (0 bar), increase it to 0,05 MPa (0,5 bar) within not more than 5 s. Maintain this pressure for 15 s and then increase it to 1 MPa (10 bar) at a rate of increase of $(0,1 \pm 0,03)$ MPa/s $[(1 \pm 0,25)$ bar/s], and maintain it for 15 s. Each sprinkler shall meet the requirement of [6.9.1](#).

7.9.2 Following the test of [7.9.1](#), the 20 sprinklers shall be subject to a water pressure equal to 4 times the rated pressure. Fill the sprinkler inlet with water at $(20 \pm 5) ^\circ\text{C}$ and vent it of air. Increase the pressure to four times the rated pressure at a rate not exceeding 0,1 MPa/s (1 bar/s). Maintain at four times the rated pressure for 1 min. The sprinkler shall meet the requirements of [6.9.2](#).

7.10 Heat exposure test (see [6.10](#))

7.10.1 Glass bulb sprinklers (see [6.10.1](#))

Four glass bulb sprinklers having nominal release temperatures of $\leq 80 ^\circ\text{C}$ shall be heated in a water bath (preferably distilled water) from $(20 \pm 5) ^\circ\text{C}$ to $(20 \pm 2) ^\circ\text{C}$ below their nominal operating temperature. The rate of increase in temperature shall not exceed $20 ^\circ\text{C}/\text{min}$. A suitable fluid shall be used for higher-rated release elements.

This temperature shall then be increased at a rate of $1 ^\circ\text{C}/\text{min}$ to the temperature at which the gas bubble dissolves, or to a temperature $5 ^\circ\text{C}$ lower than the lower limit of the tolerance range of the operating temperature, whichever is lower. Remove the sprinkler from the liquid bath and allow it to cool in air until the gas bubble has formed again. During the cooling period, the pointed end of the glass bulb (seal end) shall be pointing downwards. This test shall be performed four times on each of 4 sprinklers.

7.10.2 All sprinklers (see [6.10.2](#))

Twelve sprinklers shall be exposed for a period of 90 days to a high ambient temperature that is given in [Table 8](#). After exposure, 4 of the sprinklers shall be subjected to the requirements of [6.9.1](#) and [6.14](#) in orientation A, 4 sprinklers to the requirements of [6.6.1](#) [two at 0,035 MPa (0,35 bar) and two at 1 MPa (10 bar)] and 4 sprinklers to the requirements of [6.3](#). If a sprinkler fails a test, 8 additional sprinklers shall be tested as described above and subjected to the test in which the failure was recorded. All 8 sprinklers shall pass the test.

Table 8 — Test temperatures for sprinklers

Marked nominal temperature rating	Sprinkler test temperature
68 °C to 74 °C	52 °C
93 °C to 104 °C	79 °C

7.11 Thermal shock test for glass bulb sprinklers (see 6.11)

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

7.11.2 Sprinklers having nominal operating temperatures less than or equal to 80 °C shall be tested in a bath of de-mineralized water. Sprinklers with higher-rated elements shall be tested in a bath of suitable fluid. The temperature of the bath shall be $(10 \pm 0,5)$ °C below the lower limit of the tolerance range of the operating temperature of the sprinklers. After 5 min, remove the sprinklers from the bath and immerse them immediately in another bath of liquid (de-mineralized water), with the bulb seal downwards, at a temperature of $(10 \pm 0,5)$ °C. Then test the sprinklers in accordance with 6.6.1 at 0,035 MPa (0,35 bar).

7.12 Corrosion tests

7.12.1 Stress corrosion for copper-based alloy components test (see 6.12.1)

Five sprinklers without any plating or coating shall be subjected to the following aqueous ammonia test. The inlet of each sample shall be sealed with a nonreactive (e.g. plastic) cap.

Degrease the samples to be tested and then expose them for 10 d to a moist ammonia-air mixture in a glass container.

An aqueous ammonia solution, having a density of 0,94 g/cm³, shall be maintained in the bottom of the container, approximately 40 mm below the bottom of the samples. A volume of aqueous ammonia solution corresponding to 0,01 ml/cm³ of the volume of the container will give approximately the following atmospheric concentrations: 35 % ammonia, 5 % water vapor, and 60 % air.

The moist ammonia-air mixture shall be maintained as closely as possible at atmospheric pressure, with the temperature maintained at (34 ± 2) °C. Provision shall be made for venting the chamber via a capillary tube to avoid the build-up of pressure. Specimens shall be shielded from dripping condensate. The glass container shall be placed in an enclosure which shall be heated uniformly to prevent condensate on the test sample.

After exposure, rinse and dry the sprinklers, and conduct a detailed examination. If a crack, delamination or failure of any operating part is observed, the sprinkler(s) shall be subjected to a leak resistance test at 1,2 MPa (12 bar) for 1 min and to the function test at 0,035 MPa (0,35 bar) only. See 6.9 and 6.6.1.

Sprinklers showing cracking, delamination or failure of any non-operating part shall not show evidence of separation of permanently attached parts when subjected to a flowing pressure of 1,2 MPa (12 bar) for 30 min.

7.12.2 Sulfur dioxide/carbon dioxide corrosion test (see 6.12.2)

Subject 8 sprinklers to the following moist sulfur-dioxide/carbon-dioxide corrosion test. Fill the inlet of each sample with deionized water and seal it with a non-reactive cap, e.g. plastic.

Use test equipment consisting of a vessel made of non-reactive material, with a lid of such a shape as to prevent condensate dripping on the sprinklers. Regulate the heating of the vessel so as to maintain the temperature inside the vessel at (25 ± 3) °C. Shield specimens from dripping condensate.

Suspend the sprinklers to be tested in their normal mounting position under the lid inside the vessel. Sulfur dioxide and carbon dioxide shall be supplied to the test chamber from commercial cylinders.

Introduce an amount of sulfur dioxide equivalent to 1 % of the volume of the test chamber, and an equal volume of carbon dioxide, into the chamber each working day. Maintain a small amount of potable or de-mineralized water at the bottom of the chamber.

Conduct the test for a period of 10 d. After a total of 10 d, remove the samples from the container and allow them to dry for 1 d to 5 d at a temperature not exceeding 35 °C with a relative humidity no greater than 70 %.

After the drying period, the samples shall be tested as described in [6.12.2](#).

7.12.3 Hydrogen sulfide corrosion test (see [6.12.3](#))

Subject 8 sprinklers to the following moist hydrogen-sulfide corrosion test. Fill the inlet of each sample with deionized water and seal it with a non-reactive cap, e.g. plastic.

Use test equipment consisting of a vessel made of non-reactive material, with a lid of such a shape as to prevent condensate dripping on the sprinklers. Regulate the heating of the vessel so as to maintain the temperature inside the vessel at (25 ± 3) °C. Shield specimens from dripping condensate.

Suspend the sprinklers to be tested in their normal mounting position under the lid inside the vessel. Hydrogen-sulfide shall be supplied to the test chamber from a commercial cylinder. Introduce an amount of hydrogen-sulfide equivalent to 1 % of the volume of the test chamber into the chamber each working day. Maintain a small amount of water at the bottom of the chamber.

Conduct the test for a period of 10 d. After a total of 10 d, remove the samples from the container and allow them to dry for 1 d to 5 d at a temperature not exceeding 35 °C with a relative humidity no greater than 70 %.

After the drying period, the samples shall be tested in accordance with [6.12.3](#).

7.12.4 Salt spray loading test (see [6.12.4](#))

Ten sprinklers shall be exposed to a salt spray within a fog chamber. The inlet of each sample shall be filled with water and sealed with a nonreactive (e.g. plastic) cap.

During the corrosive exposure, the inlet thread orifice shall be sealed by a nonreactive cap after the sprinklers have been filled with deionized water. The salt solution shall be a 20 %-by-mass sodium chloride solution in deionized water. The pH shall be between 6,5 and 7,2 and the density between 1,126 g/ml and 1,157 g/ml when atomized at 35 °C. Suitable means of controlling the atmosphere in the chamber shall be provided. The specimens shall be supported in their normal operating position and exposed to the salt spray (fog) in a chamber having a volume of at least 0,4 m³, in which the exposure zone shall be maintained at a temperature of (35 ± 2) °C. The temperature shall be recorded at least once per day, at least 7 h apart (except weekends and holidays when the chamber normally would not be opened). Salt solution shall be supplied from a recirculating reservoir through air-aspirating nozzles, at a pressure of between 0,07 MPa (0,7 bar) and 0,17 MPa (1,7 bar). Salt solution runoff from exposed samples shall be collected and shall not return to the reservoir for recirculation. Specimens shall be shielded from dripping condensate.

Fog shall be collected from at least 2 points in the exposure zone to determine the rate of application and salt concentration. The fog shall be such that for each 80 cm² of collection area 1 ml to 2 ml of solution shall be collected per hour over a 16 h period and the salt concentration shall be (20 ± 1) % by mass.

The sprinklers shall withstand exposure to the salt spray for a period of 10 d. After this period, the sprinklers shall be removed from the fog chamber and allowed to dry for 4 d to 7 d at a temperature not exceeding (20 ± 5) °C in an atmosphere having a relative humidity not greater than 70 %. After the drying period, the samples shall be tested in accordance with [6.12.4](#).

7.12.5 Moist air exposure test (see 6.12.5)

Five sprinklers shall be exposed to a high temperature-humidity atmosphere consisting of a relative humidity of $98\% \pm 2\%$ and a temperature of $94\text{ °C} \pm 2\text{ °C}$. For evaluation of dry type sprinklers, the shortest length manufactured shall be used.

The sprinklers shall be installed on a pipe manifold containing deionized water. The entire manifold shall be placed in the high temperature humidity enclosure for 90 d. After this period, the sprinklers shall be removed from the high temperature-humidity enclosure and allowed to dry for 4 d to 7 d at a relative humidity not greater than 70 %. Following the drying period, 5 sprinklers shall meet the functional requirements of 6.6.1 at a pressure of 0,035 MPa (0,35 bar) only.

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

7.13 Water-hammer test (see 6.13)

7.13.1 Five sprinklers shall be connected to the test equipment. After purging the air from the sprinklers and the test equipment, 100 000 cycles of pressure varying from $(0,4 \pm 0,05)\text{ MPa}$ [$(4 \pm 0,5)\text{ bar}$] to twice the rated pressure shall be generated. The pressure shall be raised at a minimum rate of 4 MPa/s (40 bar/s) with no more than 60 cycles of pressure per minute. The pressure shall be measured electronically with a pressure transducer.

7.13.2 Visually examine each sprinkler for leakage during the test. After the test, each sprinkler shall meet the leak resistance requirements of 6.9.1 and the functional requirement of 6.6.1 at a pressure of 0,035 MPa (0,35 bar) only.

7.14 Dynamic heating test (see 6.14)

7.14.1 Plunge test

7.14.1.1 Test orientations

Subject 10 sprinklers in each nominal temperature rating to the plunge test in orientations A and B in accordance with 7.14.1.3. For sprinklers with symmetrical heat responsive elements and frames, Orientation A would be the same as Orientation B. Testing in both positions is not required. Calculate the RTI as described in 7.14.2 for each orientation.

7.14.1.2 Exposure verification for plunge test

Subject the sprinklers to the plunge test in orientation A when tested in accordance with 7.14.1.3.

7.14.1.3 Test conditions

Conduct the plunge tests using a brass sprinkler mount. Apply 1 wrap to 1,5 wraps of PTFE sealant tape to the sprinkler threads of the sprinkler under test. Screw the sprinkler into a mount to a torque of $(15 \pm 3)\text{ N}\cdot\text{m}$. Mount each sprinkler on a tunnel test section cover and maintain the sprinkler and its cover in a conditioning chamber for a period of no less than 30 min.

At least 25 ml of water, conditioned to ambient temperature, shall be introduced into the sprinkler inlet prior to testing. Test all sprinklers with the inlet end of each sample connected to a source of pressure at $(0,035 \pm 0,005)\text{ MPa}$ [$(0,35 \pm 0,05)\text{ bar}$].

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

A timer accurate to $\pm 0,01\text{ s}$ with suitable measuring devices to sense the time between when the sprinkler is plunged into the tunnel and the time it operates shall be utilized to obtain the response time.

A tunnel shall be used with air flow and temperature conditions at the test section (sprinkler location) selected from the appropriate range of the conditions given in [Table 9](#) to minimize radiation exchange between the sensing element and the boundaries confining the flow, the test section of the apparatus shall be designed to limit radiation effects to within ± 3 % of calculated RTI values.

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

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

NOTE A suggested method for determining radiation effects is by conducting comparative plunge tests on a blackened (high emissivity) metallic test specimen and polished (low emissivity) metallic test specimen.

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

Nominal operating temperatures °C	Air temperature °C	Velocity range m/s
57 to 77	129 to 141	2,4 to 2,6
79 to 107	191 to 203	2,4 to 2,6

Where results are shown to be equivalent, testing laboratories may use other conditions.

7.14.2 RTI value calculation

Determine the RTI value using formula:

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

where

- t_r is the response time, expressed in seconds, of the sprinkler;
- u is the actual air velocity, expressed in metres per second (m/s), in the test section of the tunnel taken from [Table 9](#);
- ΔT_{ea} is the temperature difference, expressed in degrees Celsius (°C), between the mean liquid-bath operating temperature of the sprinkler and the ambient temperature;
- ΔT_g is the temperature difference, expressed in degrees Celsius (°C), between the actual air temperature in the test section, corrected for radiation effects on the temperature sensing device, and the ambient temperature.

7.15 Resistance to heat test (see [6.15](#))

One sprinkler body shall be heated in an oven at $770 \text{ °C} \pm 10 \text{ °C}$ for a period of 15 min, with the sprinkler in on its inlet thread. The sprinkler body shall then be removed, holding it by the threaded inlet, and shall be promptly immersed in a water bath at a temperature of 15 °C .

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

7.16 Vibration test (see [6.16](#))

7.16.1 Five sprinklers shall be fixed vertically to a vibration table and subjected at room temperature to sinusoidal vibrations. The direction of vibration shall be along the axis of the connecting thread.

7.16.2 The sprinklers shall be vibrated continuously from 5 Hz to 40 Hz at a maximum rate of 5 min/octave and an amplitude of 1 mm (1/2 peak-to-peak value). If one or more resonant points are detected, the sprinklers, after coming to 40 Hz, shall be vibrated at each of these resonant frequencies for 120 h per number of resonances. If no resonances are detected, the vibration from 5 Hz to 40 Hz shall be continued for 120 h.

7.16.3 After vibration, each sprinkler shall be subjected to the leak resistance requirement of [6.9.1](#) and the function requirement of [6.6.1](#) at a pressure of 0,035 MPa (0,35 bar) only.

7.17 Impact test (see [6.17](#))

Five sprinklers shall be impact-tested by dropping a mass onto the deflector end of the sprinkler along the axial centerline of the waterway. Sprinklers provided with protective covers, which are intended for removal only after completion of the sprinkler installation, shall be impact tested with the covers in place. The mass equivalent to that of a sprinkler shall be dropped from a height of 1 m (see [Figure 13](#)). The dropped weight shall be prevented from impacting more than once upon each sample. After the impact test, each sprinkler shall meet the requirements of [6.17](#).

7.18 Rough usage test (see [6.18](#))

Five sprinklers shall be tested. The sprinklers shall be permitted to be tested with a protective cover in place if the cover is intended to be removed from the sprinkler after the sprinkler is installed.

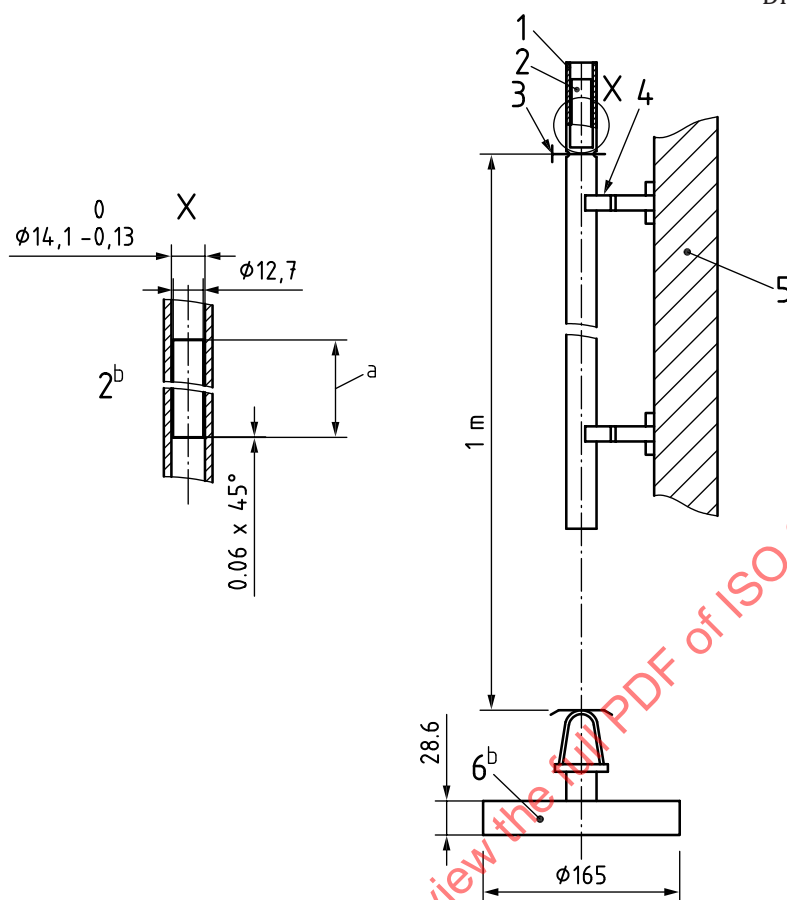
Five samples shall be individually placed in a vinyl-lined right-hexagonal-prism-shaped drum designed to provide a tumbling action. The drum is to have an axis of rotation of 250 mm. The distance between opposite sides shall be 300 mm. For each test, one sample and five 38 mm hardwood cubes shall be placed in the drum. The drum shall be rotated at 1 rev/s for 3 min. The sample shall be removed from the drum, examined for signs of damage, and then subjected to the leakage test in [6.9.1](#) and to the RTI requirements in [6.14](#), in orientation A.

7.19 Lateral discharge test (see [6.19](#))

7.19.1 While discharging water at a service pressure of 0,69 MPa (6,9 bar), an open sprinkler shall not prevent the operation of a 57 °C to 77 °C temperature-rated automatic sprinkler of the same type and response located 1,83 m distant on an adjacent pipeline in the same horizontal plane.

7.19.2 A sprinkler having a nominal release temperature of 57 °C to 77 °C shall be installed on piping 1,83 m distant (center-to-center) from a second open sprinkler of the same type. The sprinklers shall be on separate parallel pipelines with the frame arms parallel to the pipe and the sprinkler deflectors located 355 mm below a flat ceiling. Water shall be discharged from the open sprinkler at a service pressure of 0,69 MPa (6,9 bar). After water flow is established, the automatic sprinkler shall be exposed to the heat and flame from a 305 mm square pan 102 mm deep containing 0,47 l of heptane. The top of the pan shall be located 152 mm below the heat responsive element.

Dimension in millimetres



Key

- 1 cold drawn seamless steel tubing
- 2 mass
- 3 latching pin
- 4 adjustable brackets (2)
- 5 rigid support
- 6 sprinkler support
- a Length to be determined (length of required mass).
- b Cold finished steel.

Figure 13 — Impact test apparatus

7.20 Thirty-day leakage test (see 6.20)

7.20.1 Five sprinklers shall be installed on a water-filled test line maintained under a constant pressure of 2 MPa (20 bar) for 30 d at an ambient temperature of $(20 \pm 5) ^\circ\text{C}$.

7.20.2 The sprinklers shall be inspected visually at least weekly for leakage. Following the 30-day period, all samples shall meet the leak resistance requirement specified in 6.9.1 and show no evidence of distortion or other mechanical damage.

7.21 Vacuum test (see 6.21)

Three sprinklers shall be subjected to a gradually increasing vacuum of up to 460 mm Hg¹⁾ applied to a sprinkler inlet for 1 min at an ambient temperature of $(20 \pm 5) ^\circ\text{C}$. Following this test, each sample shall be examined to verify that no distortion or mechanical damage has occurred and then shall meet the leak resistance requirement specified in 6.9.1.

7.22 Freezing test (see 6.22)

Five samples shall be individually attached to one end of a 100-mm length of 25-mm nominal diameter steel pipe using an appropriate fitting. A pipe coupling shall be attached to the opposite end of each pipe. Each assembly shall then be filled to capacity with water and sealed using a pipe plug. The assemblies shall be exposed to a temperature of $(-30 \pm 5) ^\circ\text{C}$ for a period of 24 h. After exposure, the sprinklers shall be allowed to thaw at room temperature and shall be tested for leakage at 0,05 MPa (0,5 bar) for 15 s. Sprinklers which do not leak shall meet the requirements of 6.9.1 and 6.14 when tested in accordance with 7.14.1.2.

7.23 Actual delivered density (ADD) test (see 6.23)

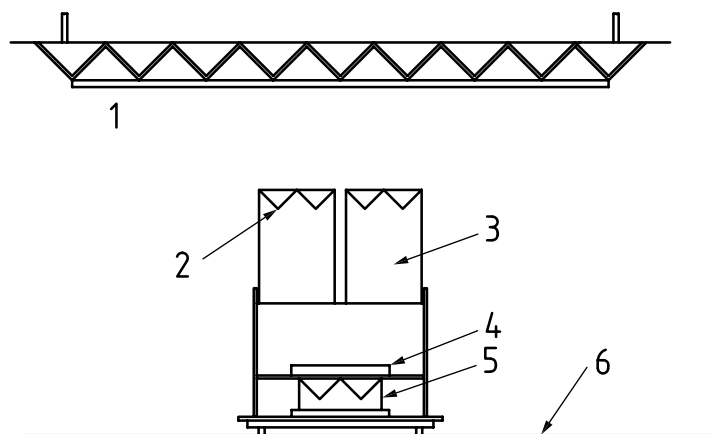
Take measurements of the ADD on three samples or sets of samples, using a test apparatus as shown in Figure 14. Calibrate the apparatus prior to use, using a fire-products collector. The ADD apparatus shall consist of two major components: a fire source and a simulated commodity. Use a fire source containing a number of spray nozzles equally spaced on the circumference of a circle. Use heptane as the fuel for the fire. Above the fire source, place a simulated commodity which approximates the geometry and size of a single tier rack-storage commodity of two pallet loads deep and two pallet loads wide, with a 15,2 cm flue space between the pallets. Install 16 water-collection pans on the top surface of the simulated commodity to collect water that reaches the top surface. Install four additional pans under the fire source to collect water delivered to the flue space. Channel water collected by the pans to the collectors of the ADD apparatus. Suspend a flat horizontal ceiling with minimum dimensions of 11 m $\times$ 10 m above the ADD apparatus. Locate the test apparatus in a room of sufficient volume to minimize the entrainment of additional water spray. Do not allow any drafts or other air movement to enter, or leave, the test area.

Install the sprinkler(s) in the same way as the non-fire measurements, i.e. with the deflector 35 cm below the ceiling with the frame arms parallel to the sprinkler piping. Locate the sprinkler piping centreline 23 cm below the ceiling. Use sprinkler piping having a minimum nominal diameter of 50 mm.

Prior to each measurement, ignite the heptane sprays. Adjust the heptane spray so as to obtain the convective heat release required. Stabilize the heptane flow at the selected flow rate corresponding to the required heat release. Once the fuel flow rate has been stabilized, discharge the water. Run the test for a minimum of 10 min in accordance with the test programme specified in Tables 4 or 5, as applicable.

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

Dimension in millimetres

**Key**

- 1 ceiling level
- 2 collection pans (16)
- 3 simulated commodity
- 4 fire source
- 5 collection pans (4) for flue space
- 6 floor level

Figure 14 — Actual delivered density (ADD) test apparatus

7.24 Thrust force test (see [6.24](#))

Install the sprinkler in the thrust force apparatus as shown in [Figure 15](#). Measure and record the thrust at the pressures specified in [Table 6](#). Repeat the test two more times with different sprinklers.