COMITÉ EUROPÉEN DES ASSURANCES

SECRETARIAT GENERAL
3bis, rue de la Chaussée d'Antin F 75009 Paris
Tél. : +33 1 44 83 11 73 Fax : +33 1 44 83 11 85
Web : cea.assur.org

DELEGATION A BRUXELLES
Square de Meeûs, 29 B 1000 Bruxelles
Tél. : +32 2 547 58 11 Fax : +32 2 547 58 19
Web : cea.assur.org

PROPERTY INSURANCE COMMITTEE
Prevention Specifications

CEA Specifications for Sprinkler Systems Requirements and test methods for ESFR Sprinklers

CEA 4024: July 1999 (en)

(EFSAC endorsed)

Contents

Tables

Figures

Foreword

It has been assumed in the preparation of this Specification that the execution of its provisions is entrusted to appropriately qualified and experienced organisations.

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

[1)] bar = 10^5 Pa

1 Scope

This Specification specifies requirements for construction and performance of ESFR sprinklers which are operated by a change of state of a fusible element or bursting of a glass bulb under the influence of heat, in automatic sprinkler systems conforming to the Comité Européen des Assurances Rules for Sprinkler Systems - Planning and Installation. Test methods and a recommended test schedule for type approval testing are also given.

2 References

This CEA Specification has dated and undated references to other publications. These references are cited at the appropriate places in the text and the publications are listed below. For dated references, subsequent amendments to or revisions of any of these publications apply to this CEA Specification only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

CEA		-	Rules for Sprinkler Systems - Planning and Installation
ISO 7-1	1982	-	Pipe threads where pressure-tight joints are made on threads - Part 1: Designation dimensions and tolerances.
prEN 12259-1	1997	-	Fixed firefighting systems - Components for sprinkler and water spray systems - Part 1: Sprinklers

3 Definitions

For the purpose of this standard the following definitions apply.

3.1 **conductivity factor [C]**: Measure of the conductance between the sprinkler's heat responsive element and the water filled fitting, expressed in (metres/second)$^{1/2}$.

3.2 **response time index [RTI]**: Measure of the thermal sensitivity of the sprinkler expressed in (metres seconds)$^{1/2}$.

3.4 **ESFR (Early suppression fast response) sprinkler**: Nozzle with a thermally sensitive sealing device which opens to discharge water, distributing it in a specified pattern, with sufficient momentum, over a designated area to achieve suppression of a fire or inhibit growth when connected to the appropriate piping and water supplies.

3.5 **fusible link sprinkler**: Sprinkler which opens when an element provided for that purpose melts.

3.6 **glass bulb sprinkler**: Sprinkler which opens when a liquid-filled glass bulb bursts.

3.8 **pendent sprinkler**: Sprinkler in which the nozzle directs the water downwards.

3.9 **spray pattern sprinkler**: Sprinkler that gives a downward paraboloid pattern of water discharge.

3.10 **supplier**: Company responsible for the design, manufacture and quality assurance of a product

3.11 **upright sprinkler**: Sprinkler in which the nozzle directs the water upwards.

3.12 **sprinkler yoke (arms)**: Part of a sprinkler that maintains the thermally sensitive element in load bearing contact with the sprinkler head valve.

3.13 **assembly load:** The force exerted on the sprinkler body at 0 bar hydraulic pressure at the inlet.

3.14 **service load:** The combined force exerted on the sprinkler body by the assembly load of the sprinkler and the equivalent force of a 12 bar hydraulic pressure at the inlet.

3.15 **design load**: The force exerted on the release element at the service load of the sprinkler.

4 Construction and performance

4.1 Product assembly

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

4.2 Dimensions

Sprinklers shall have a nominal thread size of 3/4 inches

4.2.1 Nominal thread sizes shall be suitable for fittings threaded in accordance with ISO 7 1:1982.

4.2.2 It shall be possible for a sphere of ($8^{+0,01}_{-0}$) mm diameter to pass through each water passage in the sprinkler.

4.3 Nominal operating temperature

4.3.1 The nominal operating temperatures of ESFR glass bulb sprinklers are given in Table 1 column 1.

The nominal operating temperature ranges of ESFR fusible link sprinklers are given in Table 1 column 4.

4.3.2 ESFR sprinklers shall be colour coded according to the nominal operating temperature as given in Table 1, columns 3 or 6 as appropriate.

4.4 Operating temperatures

4.4.1 When tested in accordance with annex B, ESFR fusible link sprinklers, glass bulbs and glass bulb sprinklers shall operate at a temperature within the range given in Table 1, columns 2 or 5 as appropriate.

Table 1: Nominal operating temperatures, operating temperature ranges and colour codes

Glass bulb sprinklers			Fusible link sprinklers		
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Nominal operating temperature [°C]	Operating temperature range [°C]	Liquid colour code	Nominal operating temperature within range [°C]	Operating temperature range [°C]	Yoke arms colour code
68	(68± 3)	red	68 to 74	(*t*± 0,035*t*)	uncoloured
79	(79 ±4)	yellow			
93	(93 ±4)	green	93 to 104	(*t*± 0,035*t*)	white
100	(100 ±5)	green			
NOTE: where *t* is the nominal operating temperature					

4.5 Water flow and distribution

4.5.1 K-factor

The K-factor of the sprinklers shall be within the range (202 ± 8) $l\ min^{-1}\ bar^{-½}$, when determined in accordance with annex C. All values tested shall be in the acceptable range.

4.5.2 Water distribution using a single sprinkler

When a single sprinkler is tested in accordance with D.1, using the parameters given in columns 1 and 2 of table 2, it shall meet the requirements specified for water coverage in columns 3 to 14 of Table 2.

Table 2: Water distribution requirements for single sprinkler tests

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Distance ceiling/ containers [mm]	Flow [l/min]	Minimum density in group [mm/min]									Min. collection on 9 m^2 [%]1)	Max. collection on 9 m^2 [%]1)	Min. Collection on 25 m^2 [%]1)
		1	1	2	2	3	3	4	5	A			
		av.	ind.	av.	ind.	av.	ind.	av.	av.	av.			
2700	373	60	50	20	10	16	10	11	10	10	50	70	80
2700	456	80	75	28	10	22	10	14	12,5	12,5	55	75	85

av. average
ind. Individual
1) % of the total water flow

4.5.3 Water distribution using arrays of four sprinklers

When 4 sprinklers are tested in accordance with D.2, using the parameters given in columns 1 and 2 of table 3, they shall meet the requirements specified for water coverage in columns 3 to 14 of Table 3.

Table 3: Water distribution requirements for four sprinkler array tests

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Distance ceiling/ containers [mm]	Flow [l/min]	Minimum density in group [mm/min]								Maximum density in group [mm/min]		Collection on area A [%]1)	
		1	1	2	2	3	3	4	5	4	5	A	A
		av.	ind.	av.	ind.	av.	ind.	av.	av.	ind.	ind.	min.	max.
1275	1492	100	85	22,5	20	20	17,5	25	20	50	50	1,5	4
1275	1824	135	120	35	22,5	25	20	30	25	60	55	1,5	4
2700	1492	65	40	25	12,5	25	20	22,5	22,5	55	55	2	5
2700	1824	80	60	35	10	30	22,5	27,5	30	75	75	2	5

av. average
ind. Individual
1) % of the total water flow

4.6 Function

4.6.1 When tested in accordance with E.1 the sprinkler shall open and within 10 s of release of the thermally sensitive element shall operate satisfactorily and shall conform to the requirements of 4.5.1.

Any lodgement of released parts shall be cleared within 60 s of the release of the thermally sensitive element and the sprinkler shall conform to the requirements of 4.5.2.

NOTE: In most instances visual examination of the equipment will be sufficient to establish conformity with the requirements of 4.5.1 and 4.5.2.

4.6.2 When tested in accordance with E2 the deflector and its supporting parts shall conform to the requirements of 4.5.2.

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

4.7 Strength of sprinkler body and deflector

4.7.1 The sprinkler body shall not show permanent elongation of more than 0,2 % between the load-bearing parts when subjected to twice the service load when tested in accordance with F.1.

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

4.8 Strength of release element

4.8.1 Glass bulb sprinklers

When tested in accordance with G.1. glass bulbs shall:

a) have an average strength of at least twice the average design load, which is created by the average service load

b) have a lower tolerance limit of at least two times the upper tolerance limit for the release element design load based on calculations with a degree of confidence (y) of 0,99 for 99 percent samples of (P).

NOTE: Calculations should be based on the Normal or Gaussian Distribution except where another distribution is shown to be more applicable.

4.8.2 Fusible link sprinklers

It shall be determined that:

- the temperature sensitive elements withstand a load of 15 times the maximum design load for a period of 100h, without failure; or
- the estimated time to failure of temperature sensitive elements is not less than 876.600 h at the design load, when tested in accordance with G.2.

4.9 Leak resistance

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

4.10 Heat exposure

4.10.1 All sprinklers

When tested in accordance with J.1 the sprinklers shall not operate during the exposure period. After the exposure period four sprinklers shall be tested in accordance with E.3; the sprinklers shall operate such that the waterway is cleared. Any lodgements shall be disregarded. Four sprinklers shall be tested in accordance with annex H.1 and shall comply with 4.9. Four sprinklers shall be tested in accordance with annex B and shall comply with 4.4.

4.10.2 Glass bulb sprinklers

There shall be no damage to the glass bulb when sprinklers are tested in accordance with J.2.

4.11 Thermal shock

When glass bulb sprinklers are tested in accordance with annex K, the glass bulbs shall remain intact. After immersion when subjected to a function test in accordance with E.3, they shall operate such that the waterway is cleared; any lodgements shall be disregarded.

4.12 Corrosion

4.12.1 Stress corrosion using aqueous ammonia solution

Sprinklers shall be subjected to a stress corrosion test as described in L.1. Those sprinklers in which cracks, delamination or failure of an operating part is observed shall show no evidence of leakage in the leak resistance test described in L.1. After exposure, when subjected to a function test in accordance with E.3 the sprinkler shall operate such that the waterway is cleared; any lodgements shall be disregarded.

Those sprinklers which show evidence of cracking, delamination or failure of a non-operating part shall show no visible evidence of separation of permanently attached parts when subjected to the flow test described in L.1.

4.12.2 Sulphur dioxide corrosion

Sprinklers shall be subjected to a sulphur dioxide corrosion test in accordance with L.2. After exposure, when subjected to a function test in accordance with E.3 the sprinkler shall operate such that the waterway is cleared: any lodgement shall be disregarded.

4.12.3 Salt mist corrosion

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

4.13 Water hammer

Sprinklers shall not leak when subjected to pressure surges in accordance with annex M. After the test, when subjected to a leakage test in accordance with H.1, the sprinkler shall not leak. After the leakage test, when subjected to a function test in accordance with E.3, the sprinkler shall operate such that the waterway is cleared; any lodgements shall be disregarded.

4.14 Thermal response

4.14.1 When tested in accordance with N.2, sprinklers shall operate within the response time index (RTI) ranges and limit given in Table 4:

Table 4: Thermal response ranges and limit

Sprinkler orientation	Allowable RTI range or limit [$m^{½}s^{½}$]
A	(28±8)
B	(28±8)
C	138 maximum

4.14.2 When tested in accordance with N.3 the conductivity factor shall not exceed 1,0 $(m/s)^{0.5}$.

4.15 Resistance to heat

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

4.16 Resistance to vibration

After being subjected to a vibration test in accordance with annex Q, the sprinkler shall show no visible evidence of damage. After the test, when subjected to a leakage test in accordance with H.1, the sprinkler shall not leak. After the leakage test the sprinkler shall conform to 4.14.1.

4.17 Resistance to impact

4.17.1 After being subjected to the impact test in accordance with annex R, the sprinkler shall conform to 4.9 and 4.14.1.

Any sprinkler showing deformation shall satisfy the requirements of 4.5.2.

4.17.2 After being subjected to the tumble test in accordance with annex S, the sprinkler shall conform to 4.9 and 4.14.1

Any sprinkler showing deformation shall satisfy the requirements of 4.5.2.

4.18 Resistance to low temperature

After exposure to low temperature in accordance with annex T, the sprinkler shall either be visibly damaged, leak subsequent to thawing, or not be damaged. Sprinklers not visibly damaged shall not leak, when subjected to a leakage test in accordance with H.1. After the leakage test, when subjected to a function test in accordance with E.3, the sprinkler shall operate such that the waterway is cleared; any lodgements shall be disregarded.

4.19 Lateral discharge

When tested in accordance with annex U there shall be no direct impingement of water on any part of the target sprinkler.

4.20 30 day leakage resistance

When tested in accordance with annex V sprinklers shall not leak, following which the sprinklers shall operate when tested in accordance with E.3.

4.21 Actual delivered density

When sprinklers are tested in accordance with annex W, using the parameters given in columns 1, 2, 3, 4, 5, 6 and 7 of table 5, they shall satisfy the discharge density requirements of columns 8 and 9 of table 5.

Table 5: Actual delivered density parameters

1	2	3	4	5	6	7	8	9
Number of sprinklers in test array	Sprinkler spacing [m]1)	Pipe spacing [m]1)	Ceiling clearance to water collection cans [m]	Freeburn convective heat release [kw]	Pressure [bar]	Direction of feed flow	Minimum average ADD for 16 pans [mm/min]	Minimum average density for 4 flue space pans [mm/min]2)
1	N.A	N.A	4,57	1318	3,4	Double	19,18	60,38
1	N.A	N.A	4,57	2636	3,4	Double	9,79	20,40
2	3,66	N.A	1,22	2636	3,4	Single	11,83	N.R
2	N.A	3,66	1,22	2636	3,4	Double	14,28	N.R
4	2,44	3,66	1,22	2636	3,4	Double	26,11	N.R

NOTES: 1) N.A denotes no applicable parameter.
2) N.R denotes no requirement.

4.22 Thrust force

When sprinklers are tested in accordance with X.1, using the parameters given in columns 1, 2, and 3 of table 6, they shall satisfy the minimum thrust requirements of column 4 of table 6.

Table 6: Thrust requirements and test parameters

1	2	3	4
Pressure [bar]	Water feed pipe arrangement	Ceiling clearance to thrust measurement location [m]	Minimum thrust [millibar]
3,4	Double	1,2	0,71
3,4	Double	2,1	0,44
5,1	Single	2,1	0,99

4.23 Reaction force test

Pendent sprinklers shall meet the minimum reaction force requirements given in Table 7 when tested in accordance with X.2.

Table 7: Reaction force

Pressure [bar]	Minimum reaction force[1)] [N]
3,4	56,8
5,1	85,2
NOTE [1)] Minimum reaction forces are 35% of maximum reaction force achievable with a K 202 nozzle (47,6 x 0,35 = 16,7 N/bar)	

4.24 Vacuum resistance

Sprinklers shall meet the requirements of 4.9 after testing in accordance with Annex Y. The sprinklers shall operate as intended when tested in accordance with E.3.

5 Marking

5.1 General

Sprinklers shall be marked with the following:

a) name or trade mark of supplier; and

b) model number, catalogue designation or equivalent marking; and

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

d) letters indicating the type of sprinkler and mounting position in accordance with Table 8.

e) nominal operating temperature; and

NOTE: In addition to any colour coding indicating the nominal operating temperature (see 4.3.1 and table 2) the nominal operating temperature should be stamped or cast on the fusible element of the fusible link sprinklers. All sprinklers should be stamped, cast, engraved or colour-coded in such a way that the nominal operating temperature is recognizable even if the sprinkler has operated.

In countries where colour-coding of yoke arms of glass bulb sprinklers is required, the colour code given in table 2 for fusible link sprinklers should be used.

f) year of manufacture.

NOTE: This should be given in a full form, "1994" or a short form "94" and may include the last 3 months of the preceding year and the first 6 months of the following year.

Table 8: Marking letters for types of sprinklers and mounting positions

Type of sprinkler and mounting position	Type Marking	Mounting position marking
Early suppression fast response sprinkler	ESFR	
Pendent sprinkler		P
Upright sprinkler		U
NOTE: Type marking shall precede the mounting position marking.		

6 Instruction charts

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

Annex A (normative)

A.1 General conditions for testing

Except where specified otherwise, carry out tests at room temperature.
Examine sprinklers for visually obvious defects before testing.

A.2 Type approval testing (test schedule)

The schedule of table A.1 shall be used for type approval testing of one type with one or several temperature ratings and, in the case of glass bulb sprinklers, only one type of glass bulb.

Table A.1 Summary test schedule for type approval testing

Test	Annex	No. of samples for 1 temperature rating		No. of samples for several temperature ratings (only additional requirements)		verification tests (see also table A.2)
		Glass bulb sprinklers	Fusible el. sprinklers	Glass bulb sprinklers	Fusible el. Sprinklers	
Operating Temperature	B	12 + 40 bulbs	12	per t.r. 12 + 40 bulbs	per t.r. 12	
Water flow	C	4	4			
Water distribution	D	12	12			
Function	E.1	80	80	per t.r. ≥ 40	per t.r. ≥ 40	
Function (deflector)	E.2	3	3			
Strength of sprinkler body	F.1	15	15	per t.r. ≥ 5	per t.r. ≥ 5	
Strength of deflector	F.2	3	3			
Strength of glass bulbs	G.1	15	------			
Strength of fusible elements	G.2	------	≥ 10			
Leakage	H.1/2	10	10			
Heat exposure (all sprinklers)	J.1	12	12	per t.r. 12	per t.r. 12	E.3, H.1, B, J.1
Heat exposure (glass bulb spr.)	J.2	4	------	per t.r. 4	per t.r. 4	
Thermal shock (glass bulb spr.)	K	24	------	per t.r. 24	per t.r. 24	E.3
Corrosion (stress)	L.1	6	6			H.3, E.3, L.1
Corrosion (sulphur dioxide)	L.2	6	6			E.3
Corrosion (salt mist)	L.3	5	5			E.3
Water hammer	M	5	5			H.1, E.3
Thermal response (RTI)	N.2	12	12	per t.r. 12	per t.r. 12	
Thermal response (C)	N.3	10	10	per t.r. 10	per t.r. 10	
Heat resistance	P	1	1			
Vibration	Q	4	4			H.1, N.2
Impact	R	5	5			H.1, N.2, D.1
Tumble	S	5	5			H.1, N.2, D.1
Freezing	T	6	6			H.1, E.3
Lateral discharge	U	1	1			
30 day leakage	V	5	5			E.3
Actual delivered density	W	12	12			
Thrust	X.1	3	3			
Reaction force	X.2	3	3			
Vacuum	Y	3	3			H.1, E.3

The schedule of table A.2 shall be used for the verification tests.

Table A.2 Test schedule for verification tests

Test	Annex	Samples tested	Following verification tests
Heat exposure (all sprinklers)	J.1	12	4 samples E.3 4 samples H.1 4 samples B In the case of failures in these tests: for each verification test where failures appeared, at least 8 additional samples J.1 and the specific verification test
Thermal shock (glass bulb spr.)	K	24	All samples E.3
Corrosion (stress)	L.1	6	Samples with cracks, delamination or failure of any operating part: H.3, E.3. Samples with cracks, delamination or failure of any non-operating part: flow test in accordance to L.1.
Corrosion (sulphur dioxide)	L.2	6	All samples E.3
Corrosion (salt mist)	L.3	5	All samples E.3
Water hammer	M	5	All samples H.1, E.3
Vibration	Q	4	All samples H.1, N.2
Impact	R	5	All samples H.1, N.2. In addition, samples showing deformation D.1
Tumble	S	5	All samples H.1, N.2. In addition, samples showing deformation D.1
Freezing	T	6	No verification test for samples visibly damaged and samples leaking subsequent to thawing. Other samples H.1, E.3.
30 day leakage	V	5	All samples E.3
Vacuum	Y	3	All samples H.1, E.3

Annex AA (informative)

Information on thermal response - Bibliography

NOTE. See 4.14 and P.

The plunge test and the prolonged exposure ramp test are described in the following publications:

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

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

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

d) ISO TC21 SC5 WG 1 document N 157, VdS Cologne 1988.

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

Annex B (normative)

B Test to determine operating temperatures of fusible link sprinklers and glass bulb sprinklers

NOTE. See 4.4.

For each temperature rating, twelve glass bulb sprinklers plus forty additional separate bulbs shall be tested.

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

Ensure that the temperature deviation within the test zone in the liquid bath does not exceed +0,5% of the nominal operating temperature of the sprinklers or +0,5 °C, whichever is the greater.

Place the sprinklers or separate glass bulbs in the liquid bath and heat them from room temperature to (20^{+2}_{0})°C below their nominal operating temperature, at a rate of increase of temperature not more than 20 °C/min. Maintain this temperature for at least 10 min. Then increase the temperature at a rate between 0,4 °C/min to 0,7 °C/min until the fusible link fuses or the glass bulb bursts. Measure the temperature of the operation of each to within ± 0,5% of the nominal operating temperature.

Annex C (normative)

C Water flow test

NOTE. See 4.5.1.

4 sprinklers shall be tested.

Mount the sprinkler on a supply pipe together with a pressure gauge (see figure C.1). Measure the flow rate, by direct measurement of flow rate or by collecting and measuring the weight or volume of water discharged, for water pressures of 1,0 to 10,0 bar at the sprinkler head at intervals of (1 ± 2%) bar.

The accuracy of the flow measuring device shall be ± 2% of the value measured.

Calculate the K-Factor for each test pressure from the equation (1):

$$K\text{-}Factor = Q/\sqrt{P}$$

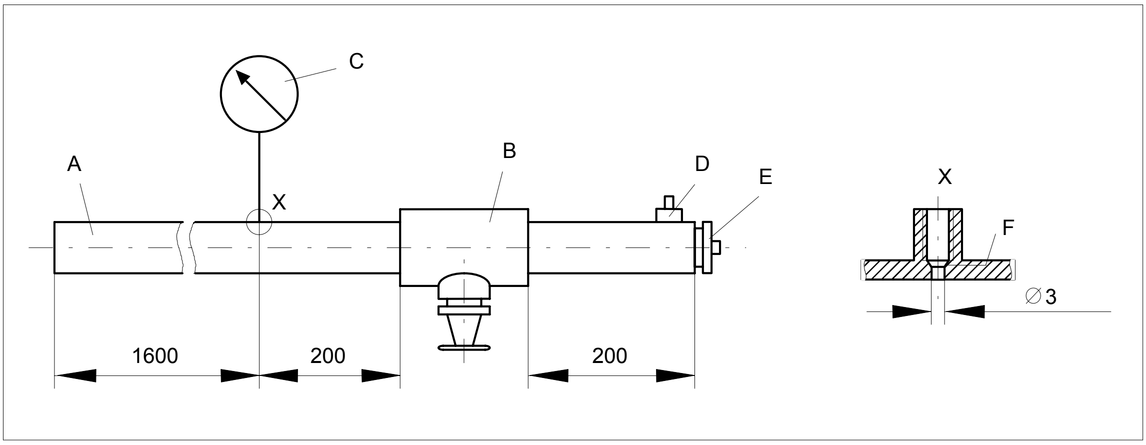
where

P is the pressure in bar

Q is the flow rate in litres per minute

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

Figure C.1: Water flow test apparatus



A: Steel tube nominal internal diameter 50 mm, medium weight (in accordance with ISO 65)
B: Fitting 20 mm (in accordance with ISO 49)
C: Pressure gauge
D: Air bleed valve
E: Plug or cap
F: Deburred orifice

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

Annex D (normative)

D Water distribution test

NOTE. See 4.5.2.

The tolerance for distance ceiling/containers and distance ceiling/deflector is 0,05 m (50 mm).

D.1 Water distribution test for single sprinklers

3 single sprinklers shall be tested. With each sprinkler, two tests with the distance ceiling/containers given in column 1 of table 2 and the water flow given in column 2 of table 2 shall be conducted.

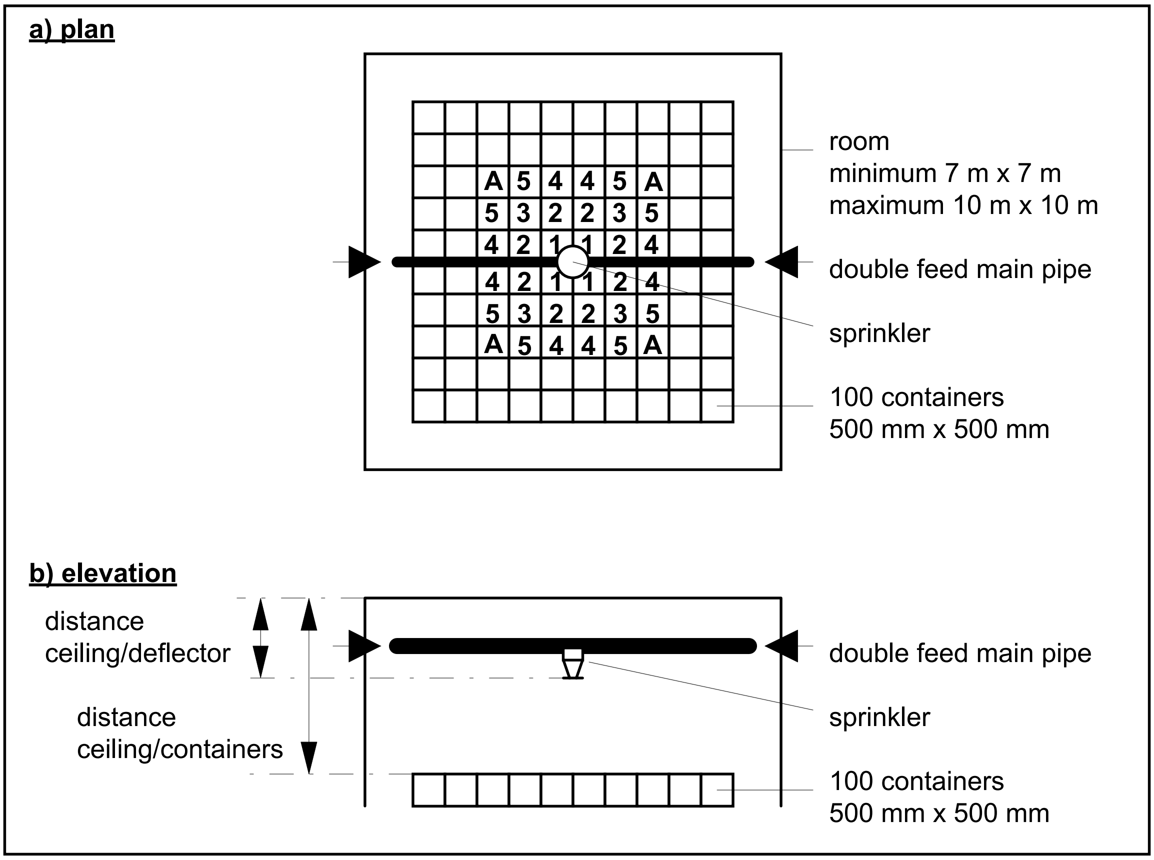
Install, in a test chamber of minimum dimensions 7 m x 7 m and maximum dimensions 10 m x 10 m, one sprinkler on piping prepared for this purpose. Use the arrangement of the piping, sprinkler and containers shown in figure D.1. Ensure the yoke arms of the sprinkler are parallel to the main pipe.

Position upright sprinklers with a distance of 50 mm and pendent sprinklers with a distance of 275 mm between the ceiling and the deflector.

Position the upper edge of the measuring containers in relation to the ceiling in accordance with the measurements given in column 1 of table 2. Collect the water for at least 120 s or until at least one measuring container has been filled. Measure the volume of water distributed over the measurement area indicated in figure D.1.

Determine the flow rate of water into each of the designated containers and analyse the results to determine compliance with table 2.

Figure D.1: Layout of water distribution collection room for single sprinklers



D.2 Water distribution test for arrays of four sprinklers

3 sets of sprinklers shall be tested. With each set of sprinklers, four tests with the distance ceiling/containers given in column 1 of table 3 and the water flow given in column 2 of table 3 shall be conducted.

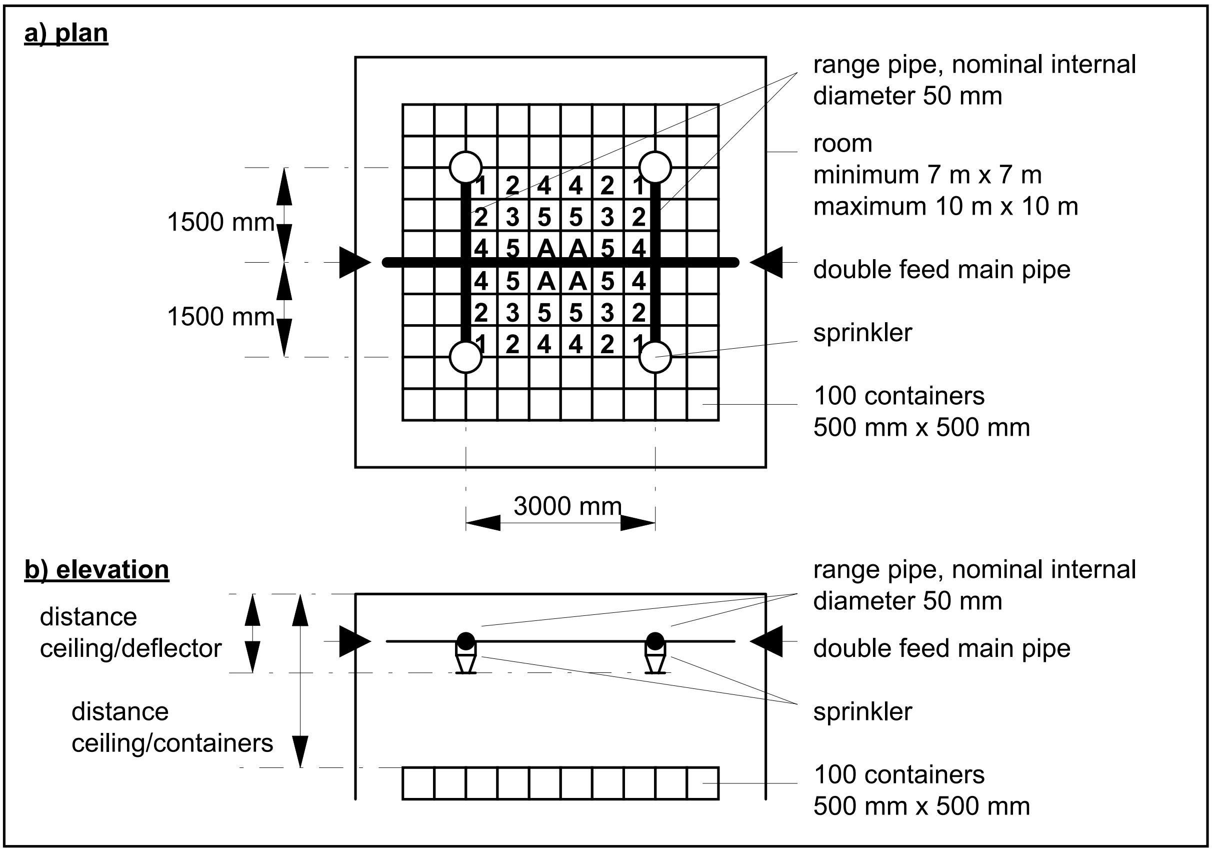
Install, in a test chamber of minimum dimensions 7 m x 7 m and maximum dimensions 10 m x 10 m, four sprinklers of the same type, arranged in a square, on piping prepared for this purpose. Use the arrangement of the piping, sprinklers and containers shown in figure D.2. Ensure the yoke arms of the sprinklers are parallel to the range pipes.

Position upright sprinklers with a distance of 50 mm and pendent sprinklers with a distance of 275 mm between the ceiling and the deflector.

Collect the water for a period of at least 120s or until at least one measuring container has been filled. Measure the flow rate of water distributed over the measurement area between the four sprinklers indicated in figure D.2.

Determine the flow rate of water into each of the designated containers and analyse the results to determine compliance with table 3.

Figure D.2: Layout of water distribution collection room for four sprinkler arrays



Annex E (normative)

E Functional test

NOTE. See 4.6

E.1 Heat the sprinklers in the functional test oven. Whilst being heated, subject the inlet to water pressure as given in table E.1. Increase the temperature at the sprinkler at a rate equivalent to (400 ± 20)°C in not more than 3 min. Continue heating until the sprinkler has operated.

Test ten sprinklers at initial closed valve pressures of (0,35±0,05), (1,70±0,1), (3,40±0,2), (5,10±0,3), (6,80±0,3), (8,50±0,4), (10,2±0,5), (12,0±0,5) bar. Ensure that the flowing pressure, measured within 0,5 m from the sprinkler, is at least 75% of the initial closed valve pressure.

Not less than 5 sprinklers of each temperature rating shall be tested at each pressure.

In the case of sprinklers with only one temperature rating, not less than 10 sprinklers shall be tested at each pressure.

Lodgement is considered to have occurred when one or more of the released parts lodge in the deflector frame assembly in such a way as to cause the water distribution to be significantly impeded for a period of more than 1 min.

E.2 To check the strength of the deflector, submit three sprinklers to a flow test at a pressure of (14 ± 0,5) bar. Allow the water to flow at a running pressure of (14 ± 0,5) bar for a period of (30^{+1}_{0}) min.

E.3 Verification functional test

Heat sprinklers in the functional test apparatus. Increase the temperature at the sprinkler at a rate equivalent to (400 ± 20)°C in not more than 3 minutes. Continue heating until the sprinkler has operated.

Whilst the sprinkler is being heated, subject the sprinkler inlet to a water pressure of (0,35 ± 0,05) bar unless stipulated otherwise in the appropriate test procedure.

Test the type, size and number of sprinklers specified in the appropriate test procedure and establish that the pass criteria is achieved.

Annex F (normative)

F Strength of sprinkler body and deflector tests

NOTE. See 4.7

F.1 Conduct this test on five sprinklers for each temperature rating, but not less than 15 sprinklers.

Measure the service load by securely installing the sprinkler in a tensile/compression test machine and apply an equivalent of a hydraulic pressure of (12 ± 0,1) bar at the inlet.

Alternately, the service load may be determined by measurement of the assembly load and adding a calculated or measured value of the force equivalent to a hydrostatic pressure of (12 ± 0,1) bar at the inlet.

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

Zero the deflection measuring indicator.

Release the 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.

Then 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. Record the mechanical load necessary to achieve this as the service load respectively the assembly load.

If the assembly load is measured, determine the service load by adding a value of the force equivalent to a hydrostatic pressure of (12 ± 0,1) bar at the inlet.

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

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

F.2 3 sprinklers shall be tested. Apply a force of ($70\ ^{+10}_{0}$) N to the deflector by means of a flat metal plate, having a contact edge of at least ($15\ ^{+5}_{0}$) mm, and examine the deflector for permanent deformation.

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

Annex G (normative)

G Strength of release elements test

NOTE. See 4.8.

G.1 Glass bulbs

Conduct this test on fifteen glass bulbs for each temperature rating and bulb type.

Position the bulb in a compression test machine using the sprinkler seating parts and subject it to a uniformly increasing force at a rate not greater than 250 N/s. Record the load at which the bulb breaks. Each test shall be conducted with the bulb mounted in new seating parts.

NOTE. The mounting device may be reinforced externally to prevent its collapse, but in a manner which does not interfere with the bulb breaking.

For each temperature rating, calculate the average bulb strength as the mean value of the measured values for bulb strength .

Calculate the average service load as the mean of the values for service load as measured respectivly as calculated in Annex F.1.

For each value for service load, as measured respectivly as calculated in Annex F.1, determine the design load by a suitable method depending on the design of the sprinkler. Determine the average design load.

Verify compliance with 4.8.1 a).

For each temperature rating calculate the lower tolerance limit (TL1) for bulb strength (see G.3).

From the determined values for design load calculate the upper tolerance limit (TL2) for sprinkler release element design load (see G.3).

Verify compliance with 4.8.1 b).

G.2 Fusible links

Subject fusible links to a constant load in excess of the design load (L_d), producing failure at approximately 1.000 h. Undertake the test with at least ten links at different constant loads for loads not exceeding 15 times the maximum design load, rejecting abnormal failures. Using the times to failure/load values produced by the tests, plot a full logarithmic regression curve using the method of least squares, and from this calculate the loads to failure at 1 h (L_o) and 1.000 H (L_m), where:

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

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

G.3 Tolerance limit calculations

TL1 = lower tolerance limit for bulb strength $= \bar{x}_B - (\gamma_B * \sigma_{(n-1)B})$

TL2 = upper tolerance limit for sprinkler release element design load $= \bar{x}_S + (\gamma_S * \sigma_{(n-1)S})$

where

$\bar{x}_B$ = mean bulb strength

γ_B = bulb strength factor γ from table G.1

$\sigma_{(n-1)B}$ = sample standard deviation for the bulb

$\bar{x}_S$ = mean design load

γ_S = design load factor γ from table G.1

$$\sigma_{(n-1)} = \left(\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1} \right)^{\frac{1}{2}}$$

$\sigma_{(n-1)}$ = standard deviation

$\bar{x}$ = sample mean

x_i = individual values of each sample

n = number of samples tested

Table G.1: Factors for one-sided tolerance limits for normal distributions (99 percent of samples)

n	γ
10	5,075
11	4,828
12	4,633
13	4,472
14	4,336
15	4,224
16	4,124

n	γ
17	4,038
18	3,961
19	3,893
20	3,832
21	3,776
22	3,727
23	3,680

n	γ
24	3,638
25	3,601
30	3,446
35	3,334
40	3,250
45	3,181
50	3,124

Annex H (normative)

H Leak resistance test

NOTE. See 4.9

H.1 Subject ten sprinklers to water pressure of (34 ± 1) bar at the inlet. Increase the pressure from zero to (34 ± 1) bar at a rate not exceeding 1 bar/s, maintain the pressure at (34 ± 1) bar for a period of ($3\ ^{+0,1}_{-0}$) min and then allow it to fall to 0 bar. After the pressure has dropped to 0 bar, increase it to (0,5 ± 0,1) bar in not more than 5 s. Maintain this pressure for ($15\ ^{+5}_{0}$) s, and then increase it to (10 ± 0,5) bar at a rate not exceeding 1 bar/s and maintain it for ($15\ ^{+5}_{0}$) s. Examine the sprinkler for evidence of leakage during the test.

H.2 After testing in accordance with H.1 the ten sprinklers shall be subjected to a water pressure of (48 ± 1) bar. Ensure that the sprinkler inlet is filled with water at (20 ± 5) °C and free of air, increase the pressure from zero to (48 ± 1) bar at a rate not exceeding 1 bar/s. Maintain the pressure at (48 ± 1) bar for a period of ($60\ ^{+5}_{0}$) s. Examine the sprinkler for evidence of leakage during the test.

H.3 Verification leakage test

Sprinklers shall be subjected to a water pressure of (12 ± 0,25) bar unless stipulated otherwise in the test procedure. Ensure that the sprinkler inlet is filled with water and free of air, increase the pressure from zero to (12 ± 0,25) bar at a rate not exceeding 1 bar/s. Maintain the pressure at (12 ± 0,25) bar for a period of ($60\ ^{+5}_{0}$) s. Examine the sprinkler for evidence of leakage during the test.

Annex J (normative)

J Heat exposure

NOTE. See 4.10.

J.1 All sprinklers

Expose twelve sprinklers for each temperature rating for a period of $(90\ ^{+1}_{0})$ days in an oven at the temperature shown in table J.1.

If the service load is dependent on the service pressure, apply an inlet pressure of (12 ± 0,1) bar during the test. After exposure, cool the sprinklers to ambient temperature; then test 4 sprinklers in accordance with each of the test procedures in E.3, annexes B and H.1. If one or more sprinklers fail a test, expose at least eight additional sprinklers as described above and subject to the test in which the failure occurred. All of the additional sprinklers shall pass the test.

Table J.1: Heat exposure test

Nominal operating temperature [°C]	Test temperature [°C]
68-74	(52 ± 2)
93-104	(79 ± 2)

J.2 Glass bulb sprinklers

Place 4 sprinklers for each temperature rating in a liquid bath. Use water (preferably distilled) for sprinklers with a nominal operating temperature of 80°C or less: use refined oil for sprinklers with a nominal operating temperature above 80°C. Raise the temperature of the liquid bath from (20 ± 5)°C to (20 ± 5)°C below the nominal operating temperature of the sprinklers at a rate not exceeding 20°C/min.

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

Annex K (normative)

K Glass bulb sprinkler thermal shock test

NOTE. See 4.11.

Before starting the test ensure the sprinklers attain equilibrium at a temperature of (20 ± 5)°C.

Immerse 24 sprinklers for each temperature rating in a bath of liquid, at a temperature of $(7\ ^{+3}_{0})$ °C below the nominal operating temperature of the sprinklers. After $(5\ ^{+1}_{-0})$ min, remove the sprinklers from the bath and immerse them immediately in another bath of liquid at a temperature of (10 ± 1)°C with the bulb seal pointing downwards. Subject the sprinklers to a function test in accordance with E.3.

Annex L (normative)

L Corrosion tests

NOTE. See 4.12

L.1 Stress corrosion test

L.1.1 Reagents

L.1.1.1 Aqueous ammonia solution, density 0,94 g/cm^3.

L.1.2 Apparatus

L.1.2.1 Glass container, of volume 0,01 m^3 to 0,03 m^3 with a sealable lid, containing a means of supporting the sprinklers under test and a means of preventing condensate dripping onto them, and fitted with a capillary tube, venting to atmosphere, to prevent the build-up of pressure.

L.1.3 Procedure

Put aqueous ammonia solution, having a density of 0,94 g/cm^3 into the container, using 0,01 ml/cm^3 of container volume to give an atmosphere in the container consisting of approximately 35% ammonia, 5% water vapour and 60% air.

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

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

After exposure, rinse and dry the sprinklers, and carry out a detailed visual examination. If cracking, delamination or failure of any operating part is observed, subject the sprinkler(s) to a leak resistance test in accordance with H.3 at (12 ± 0,1) bar for ($1\ ^{+0,25}{}_{0}$) min. After the leak resistance test, subject the sprinklers to a function test in accordance with E.3 at an inlet water pressure of (0,35 ± 0,05) bar.

Subject sprinklers showing cracking, delamination or failure of any non-operating part, after removal of the operating parts, to a flowing pressure of (12 ± 0,5) bar for ($1\ ^{+0,25}{}_{0}$) min, and examine for visible evidence of separation of permanently attached parts.

L.2 Sulphur dioxide corrosion test

This test shall be conducted in accordance with prEN12259-1: 1997, Annex L.2.

Six sprinklers shall be tested.

L.3 Salt mist corrosion test

L.3.1 Reagents

Sodium chloride solution, consisting of (20 ± 1)% (m/m) sodium chloride in distilled water, pH between 6,5 and 7,2 and having a density between 1,126 g/ml and 1,157 g/ml at (35 ± 2)°C.

L.3.2 Apparatus

Fog chamber, of minimum volume 0,43 m^3, fitted with a recirculating reservoir and aspirating nozzles to deliver a salt spray, and means for sampling and controlling the atmosphere in the chamber.

L.3.3 Procedure

Test five sprinklers. Fill each sprinkler with deionized water and seal the inlet by means of a plastic cap. Support the sprinklers in the fog chamber in their normal operating position, and expose them to a salt spray by supplying the sodium chloride solution through the nozzles at a pressure of between 0,7 bar and 1,7 bar, while maintaining the temperature in the exposure zone at (35 ± 2)°C. Ensure that solution running off the sprinklers is collected and not returned to the reservoir for recirculation.

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

Expose sprinklers intended for installation in normal atmospheres for a period of ($10^{+0,25}_{0}$) days.

Expose sprinklers intended for installation in corrosive atmospheres for a period of ($30^{+0,5}_{0}$) days.

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

Annex M (normative)

M Water hammer test

NOTE. See 4.13.

Test five sprinklers, installing each sprinkler on the test apparatus in its 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 ($34\ ^{+3}_{0}$) bar at a rate not exceeding 100 bar/s; after which the pressure shall be returned to (4 ± 2) bar. The pressure cycles shall be repeated ($100.000\ ^{+100}_{0}$) times, at a rate of ($6\ ^{+3}_{0}$) cycles per minute. Measure and record the pressure changes against time. Then test the five sprinklers in accordance with H.1 and E.3.

Annex N (normative)

N Thermal response tests

NOTE. See 4.14.

N.1 General

Test twelve sprinklers of each temperature rating in accordance with N.2 and ten sprinklers of each temperature rating in accordance with N.3 in a wind tunnel with test section dimensions of (270 ± 40) mm width x (150 ± 10) mm depth.

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

Wrap PTFE sealant tape ($1^{+0,5}_{0}$) turns around the threads of each sprinkler and screw into a mounting jig with a torque of (15 ± 3) N m.

N.2 Determination of RTI using the plunge test

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

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

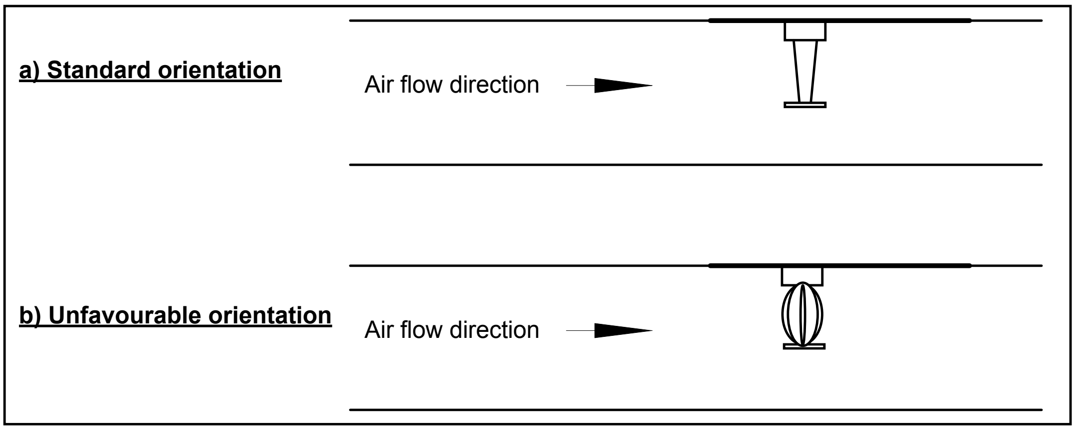
a) standard orientation, yoke arms normal ± 5° to the airflow such that the heat responsive element is fully exposed to the airflow (see figure N.1.a);

b) unfavourable orientation, yoke arms rotated (25 ± 1)° out of alignment with the airflow (see figure N.1.b).

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

c) yoke arms rotated 180° about the axis of the waterway from a).

Figure N.1: Example of sprinkler orientation in the wind tunnel



Test all other sprinklers where the influence other than yoke arm shadows can be encountered in different orientations to establish that the total angle of acceptable operation is ≥ 256°.

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

Maintain the selected air velocity throughout the test and use a timer accurate to ± 0,1s with suitable measuring devices to determine the time between plunging of the sprinkler into the wind tunnel and operation of the sprinkler, in order to establish the response time.

Table N.1: Wind tunnel conditions for plunge test

Nominal operating temperature °C	Air temp. (1) °C	Velocity (2) m/s
57-77	129-141	1,65-1,85
79-107	191-203	1,65-1,85
(1) - The selected air temperature shall be known and maintained constant within the test section throughout the test to an accuracy of ± 1°C for the air temperature range 129°C to 141°C and to an accuracy of ± 2°C for all other temperatures. (2) - The selected air velocity shall be known and maintained constant within the test section throughout the test to an accuracy of ±0,15 m/s.		

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

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

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

where:

t_r is the response time of the sprinkler in seconds

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

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

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

ln is the natural logarithm

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

N.3 Determination of conduction factor C using the prolonged exposure ramp test

Determination of C-factor shall be performed with sprinklers of each temperature rating in either the "a" or "b"-orientation, whichever produced the larger RTI in 4.14.1. Maintain the mount temperature at (30 ± 2) °C for the duration of each test. Insert the sprinkler in the standard orientation (see figure N.1) into the wind tunnel test section, which has been preset to a stabilized air stream velocity of (1 ± 0,15) m/s and an initial air temperature corresponding to the nominal operating temperature of the sprinkler.

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

Calculate the C factor of the sprinkler by equation 3:

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

where:

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

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

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

Annex P (normative)

P Heat-resistance test

NOTE: See 4.15.

Heat a sprinkler test sample in an oven at (800 ± 10)°C for a period of (15^{+1}_{0}) min, with the sprinkler test sample held in its normal installation position. Remove the sprinkler test sample from the oven, holding it by the threaded inlet, and promptly immerse it in a water bath at a temperature of (20 ± 10)°C. Examine the sprinkler test sample for deformation and breakage.

Annex Q (normative)

Q Vibration test

NOTE: See 4.16

Fix four sprinklers vertically to a vibration table. Subject the sprinklers to sinusoidal vibrations. Vibrate in the direction of the axis of the connecting thread.

The sprinklers shall be vibrated continuously at a 0,38 mm amplitude at a varying frequency from 30 to 60 Hz for 25 h and at a 1,27 mm amplitude at a varying frequency from 10 to 30 Hz for 25 h. Amplitude shall be defined as the maximum displacement of sinusoidal motion from the point of rest to one-half the total table displacement. Each half cycle period (e.g. 10 to 30 Hz or 30 to 10 Hz) shall be (25 ± 5) s. If one or more resonant points are detected, the sprinklers shall be vibrated at each of these resonant frequencies for 50 h divided by the number of resonances.

Then test the four sprinklers in accordance with H.1 and N.2.

Annex R (normative)

R Impact test

NOTE: See 4.17.1

Test five samples by dropping a weight onto the deflector of the sprinkler along the axial centre line of the waterway. The kinetic energy of the dropped weight at the point of impact shall be equivalent to that of a weight of the same mass as the test sprinkler dropped from the height of 1 m. Prevent the weight from impacting more than once upon each sample. Examine the sprinklers for signs of deformation. Then test the five sprinklers in accordance with H.1 and N.2. If deformation is evident on any of the five sprinklers tested, test the damaged sprinkler for distribution in accordance with D.1 and examined for compliance with the requirements of 4.5.2.

Annex S (normative)

S Tumble test.

NOTE: See 4.17.2

Impact test five sprinklers by placing single sprinklers (complete with the suppliers normal protective shipping caps) in a hexagonal-section vinyl-lined barrel with five wood blocks. The internal dimensions of the barrel shall be (305 ±5) mm across the hexagonal sides and the length along the axis of rotation shall be (255 ± 5) mm. The wood blocks shall be cubes of hardwood with sides of ($38\ ^{+1}_{0}$) mm. Rotate the barrel with the sprinklers and wood blocks ($60\ ^{+2}_{0}$) times per minute for ($180\ ^{+5}_{0}$) s. Remove the sprinkler and examine for signs of deformation. Then test the five sprinklers in accordance with H.1 and N.2. If deformation is evident on any of the five sprinklers tested, test the damaged sprinkler for distribution in accordance with D.1 and examine for compliance with the requirements of 4.5.2.

Annex T (normative)

T Freezing test

NOTE: See 4.18.

Test a total of six sprinklers.

Two 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 (-5 ± 3)°C for a period of $(24\ ^{+1}_{0})$ h.

Repeat the test two more times with two more pairs of sprinklers at (-18 ± 3)°C and (-30 ± 3)°C.

Annex U (normative)

U Lateral discharge test

NOTE: See 4.19

Test 3 sprinklers.

Install an open sprinkler in the distribution test array for single sprinklers, with the yoke arms in line with the pipe, as shown in Figure D.1(b).

A target sprinkler of the same type as the one under test shall be positioned at a point 2,1 m from the sprinkler being tested, at the same distance below the ceiling. Discharge water from the sprinkler for (185 ±5) s at each pressures of (3,50±0,2) bar, (7,0±0,3) bar, (10,0±0,5) bar and (12,0±0,5) bar. Observations shall be made for water impingement on the target sprinkler. Repeat the test with the yoke arms of the open sprinkler normal to the supply pipe (i.e rotate the sprinkler 90°).

Annex V (Normative)

V Thirty day leakage test

NOTE: See 4.20

Install five sprinklers on a pressure testing manifold and fill with water, removing all air. Pressurize the test manifold to (20,0±0,2) bar for ($30^{+0,5}_{0}$) days. Inspect the sprinklers every (7 ± 1) days for leakage. Examine the sprinklers for leakage and distortion. Release the pressure, remove the sprinklers and re-examine. Subject the sprinklers to a function test in accordance with E.3.

Annex W (Normative)

W Actual delivered density

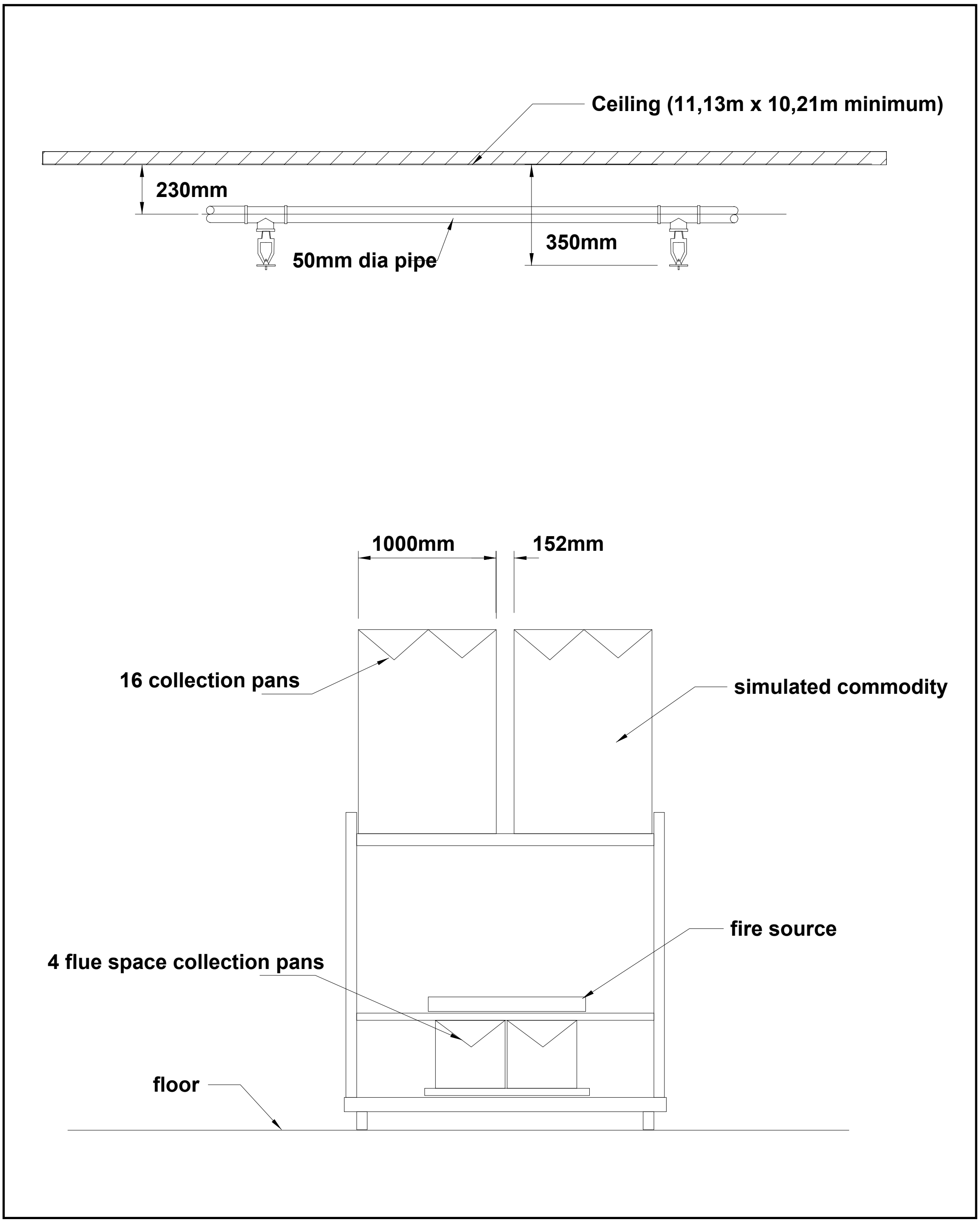
NOTE: See 4.21

Actual Delivered Density (ADD) measurements shall be taken on three samples or sets of samples, using a test apparatus as shown in figure W.1. The apparatus must be calibrated prior to use using a fire products collector. The ADD apparatus shall consist of two major components: a fire source and a simulated commodity. The fire source shall contain a number of spray nozzles equally spaced on the circumference of a circle. Heptane shall be used as the fuel for the fire. Above the fire source shall be 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. Sixteen water collection pans shall be installed on the top surface of the simulated commodity to collect water that reaches the top surface. Four additional pans shall be installed under the fire source to collect water delivered to the flue space. Water collected by the pans is to be channeled to the collectors of the ADD apparatus. A flat horizontal ceiling with a minimum dimension of 11,13 m x 10,21 m shall be suspended above the ADD apparatus. The test apparatus shall be located in a room of sufficient volume to minimize the entrainment of additional water spray. No draughts or other air movement shall be allowed into, or out of, the test area.

The sprinkler(s) shall be installed 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. The sprinkler piping centerline shall be located 23 cm below the ceiling. The sprinkler piping shall have a minimum nominal diameter of 50 mm.

Prior to each measurement, the heptane sprays shall be ignited. The heptane spray shall determine the convective heat release. The heptane flow shall be stabilized at the selected flow rate corresponding to the required heat release. Once the fuel flow rate has been stabilized, the water can be discharged. The test shall be run for a minimum of 10 minutes in accordance with the test program in table 5.

Figure W.1: Actual delivered density test apparatus



Annex X

X Thrust and reaction force tests

NOTE: See 4.22

X.1 Thrust measurement test

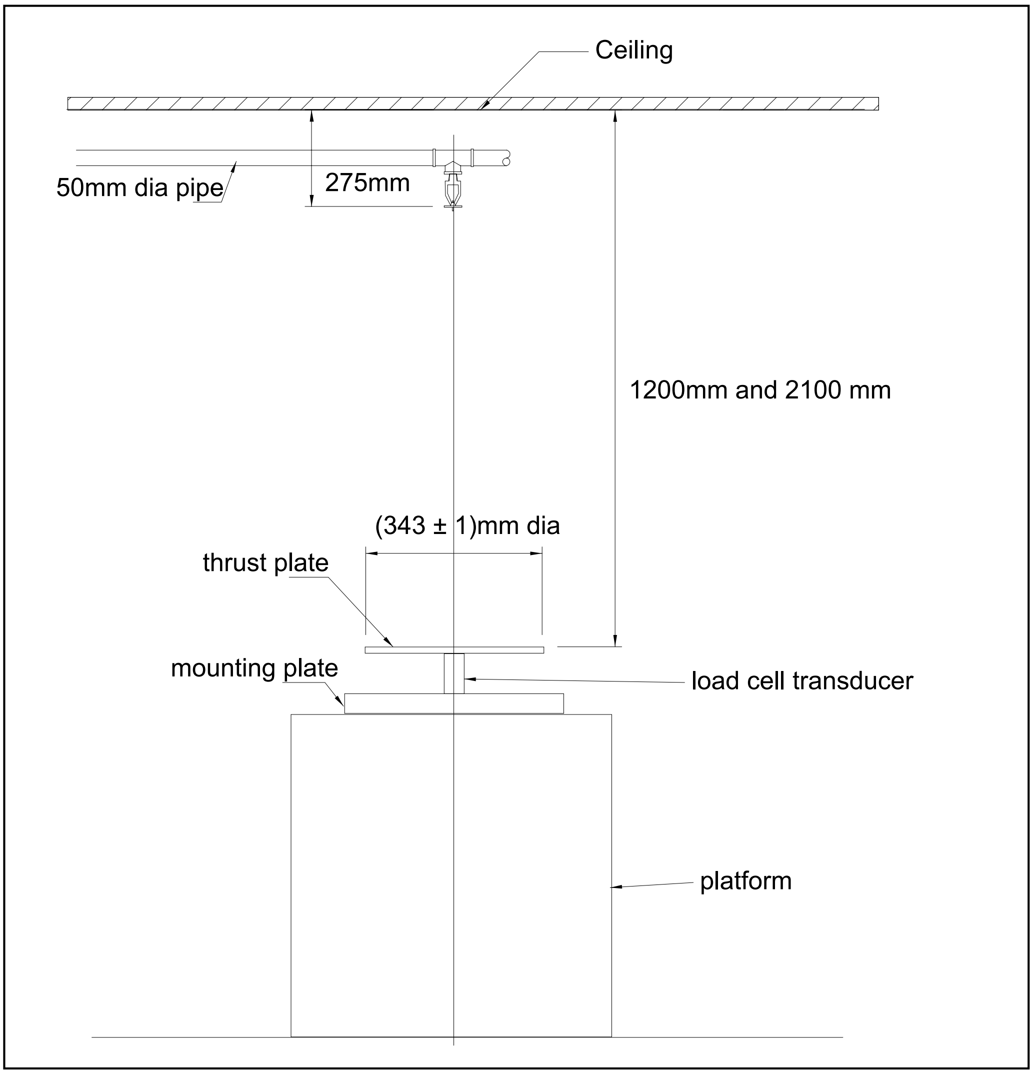
3 sprinklers shall be tested.

Install a sprinkler in the test apparatus prepared for this purpose. Use the arrangement of piping, sprinkler and measuring equipment shown in figure X.1.

Position upright sprinklers with a distance of (50 ± 5)mm and pendent sprinklers with a distance of (275 ± 5)mm between the ceiling and the deflector.

Stabilize the running pressure at the sprinkler in accordance with Table 6. Flow the water at the designated pressure for at least 60 s, recording thrust values. Calculate the mean thrust value for the period of measurement. Repeat the tests two more times with different sprinklers

Figure X.1: Thrust measurement apparatus

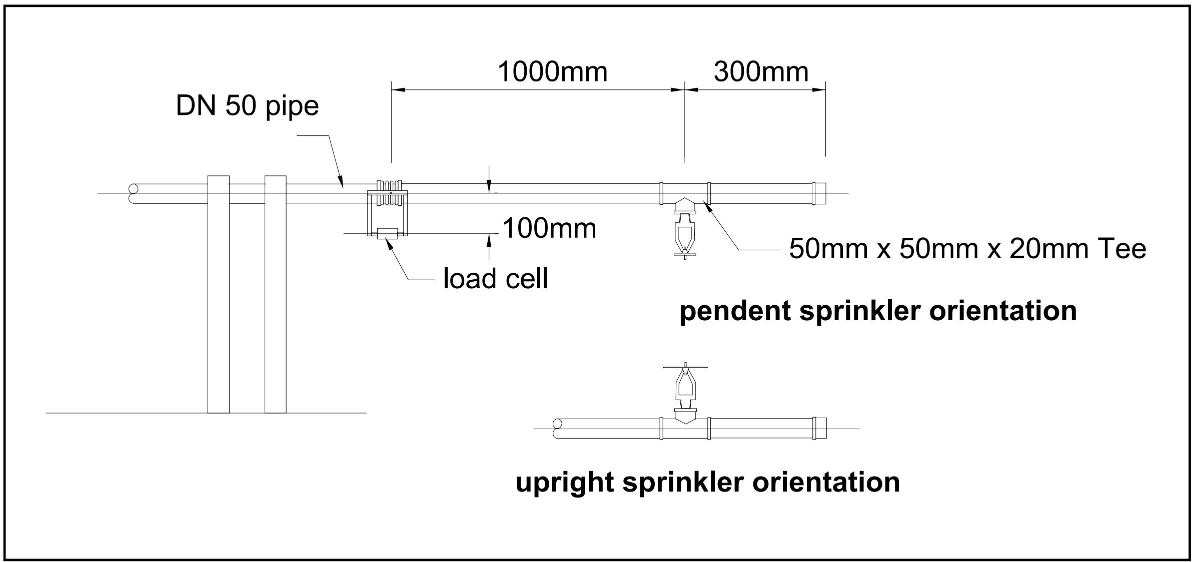


X.2 Reaction force test

3 sprinklers shall be tested.

Install a single sprinkler in the test apparatus shown in Figure X.2. Maintain the pressures given in Table 7 for at least 60 s and measure the reaction force. Calculate the mean reaction force for the duration of measurement. Repeat the tests two more times with different sprinklers

Figure X.2: Reaction force measurement apparatus



Annex Y (normative)

Y Vacuum resistance test

NOTE See 4.24

Install a sprinkler in the test apparatus and gradually apply a vacuum at the sprinkler inlet of (0,88 ± 0,01) bar within (120 ± 60) s and maintain the vacuum for (65 ± 5) s. Release the vacuum and examine the sprinkler to verify that no distortion or mechanical damage has occurred. Then test the sprinkler in accordance with H.1 and E.3. Repeat the test with two more sprinklers

Annex Z (informative)

Z Notes on strength test for fusible link release elements

NOTE. See 4.8.2 and G.2.

The formula given in G.2 is based on the intention of providing fusible elements that are not susceptible to creep stress failure during a reasonable period of service. The duration of 876.600 h (100 years) was selected only as a statistical value with an ample safety factor. No other significance is intended, as many other factors govern the useful life of a sprinkler.

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

The observed data is used to determine, by means of the method of least squares, the load causing failure at 1 h, L_o, and the load causing failure at 1.000 h, L_m. One way of stating this is that, when plotted on log log paper, the slope of the line determined by L_m and L_o shall be greater then or equal to the slope determined by the design load at 100 years, L_d, and L_o; or

$$\ln L_m \geq \left(\ln L_d - \ln L_o\right)\frac{\ln 1000}{\ln 876000} + \ln L_o$$

This is reduced as follows:

$$\frac{\ln L_m - \ln L_o}{\ln 1000} \geq \frac{\ln L_d - \ln L_o}{\ln 876000}$$

$$\geq 0{,}5048 \ (\ln L_d - \ln L_o) + \ln L_o$$

$$\geq 0{,}5048 \ (\ln L_d + \ln L_o(1 - 0{,}5048))$$

$$\geq 0{,}5048 \ \ln L_d + 0{,}4952 \ \ln L_o$$

With an error of approximately 1%, the formula may be approximated by

$$\ln L_M \geq 0{,}5 \ (\ln L_d + \ln L_o)$$

or, compensating for errors

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