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EARLY SUPPRESSION, FAST RESPONSE (ESFR), K202 TO 480, UPRIGHT AND PENDENT AUTOMATIC FIRE SPRINKLER

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This European Assessment Document (EAD) has been developed considering up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

This EAD covers early suppression, fast response (ESFR) K202 to 480, upright and pendent automatic fire sprinklers (in the following referred to as ESFR sprinklers) with a fusible link or glass bulb heat responsive element and a nominal discharge coefficient of 202, 240, 360, 400 and 480 l/min/ (bar)$^{1/2}$. Extended application is not covered.

The product is not fully covered by the harmonised European Standard (hEN) EN 12259-1[1] as the hEN is defined for a different intended use. ESFR sprinklers are special sprinklers intended to be used in industrial and storage applications with unique hazards. The hEN covers generic applications and limits the sprinkler to a nominal thread size of up to 20 mm (see e.g., Table 3, EN 12259-1) while ESFR sprinklers have a nominal thread size beyond that.

Further deviations regarding the assessment methods as provided for in this EAD from EN 12259-1:

- The assessment methods given in EN 12259-1 for the assessment of the distribution of extinguishing media and response delay are not applicable for ESFR sprinklers as the methods simulate a different intended use. The new assessment methods represent the specific configuration that an ESFR sprinkler is intended to protect, namely rack storage of boxed or palletised commodity. Since the areas of use can differ, several proxy characteristics had to be added for this purpose to measure the performance.
- The discharge coefficient k-factor assessment given in EN 12259-1 cannot be applied to ESFR sprinklers as EN 12259-1 does not address discharge coefficients over 115 l/min/ (bar)$^{1/2}$. In addition, the assessment methods in EN 12259-1 would skew the discharge coefficient results due to significant pressure loss through the piping and inaccurate pressure measurements at the higher flows associated with ESFR sprinklers. The assessment methods in this document are designed to accommodate the larger orifice sizes of ESFR sprinklers and to minimize the influence of the test apparatus on measurements by incorporating a large pipe diameter relative to the sprinkler orifice diameter, the sprinkler orifice oriented such that water is discharged in the principal direction of flow, and pressure measured using a piezometer ring in place of a pressure gauge. The extinguishing performance assessment is intended to directly assess the performance of the sprinkler in realistic application scenarios.
- The added assessment method for water distribution uses collection pans to represent the specific configuration that an ESFR sprinkler is intended to be used for. The square pans represent the footprint of individual boxes in a pallet load of commodity, while the long flue pans represent the spaces between stored pallet loads. The assessment method given in EN 12259-1 is specified only for sprinklers with a nominal thread size of 20 mm and smaller. The test set-up in EN 12259-1 requires that the sprinklers be installed on DN25 branch line pipe. This pipe is too small for K200 and larger sprinklers which can therefore not be tested in accordance with this test set-up.
- The assessment method for the actual delivered density is a distribution test that includes the influence of a large fire source on the sprinkler discharge pattern. It simulates the impact of an actual warehouse fire on the sprinkler's ability to deliver extinguishing media as intended to the commodity being protected (square pans) and to the source of the fire (long flue pans). It can be used in conjunction with distribution and thrust tests to assess a sprinkler for use in certain hazard applications.
- Large warehouse fires are characterized by a strong vertical plume velocity, and typically consist of large quantities of commodity (fuel) that are mostly shielded from the extinguishing media. To help assess the performance of an ESFR sprinkler, the thrust measurement method was added. The method determines the force of the discharge from an ESFR sprinkler, which is necessary to overcome the plume velocity to deliver extinguishing media to the fuel and to the fire source. It can be used in conjunction with distribution and extinguishing performance assessments to evaluate a sprinkler for use in certain hazard applications.
- The assessment method for response delay (response time) in EN 12259-1 is not applicable for ESFR sprinklers as ESFR sprinklers are intended to be used in large warehouse scenarios, which are characterized by a strong vertical plume velocity that transitions into a strong horizontal airflow once it hits the ceiling. Sprinklers protecting such warehouses operate when subjected to hot air flowing principally in the vertical direction, when located directly over the fire source, or principally in the horizontal direction, when located adjacent to the fire source. This test evaluates the sensitivity of the sprinkler in all likely airflow directions whereas the assessment method in EN 12259-1 addresses only horizontal airflow.

1 All undated references to standards or to EADs in this EAD are to be understood as references to the dated versions listed in chapter 4.

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the ESFR sprinkler will be installed in accordance with the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

ESFR sprinklers are intended to be used as part of a fixed firefighting system, permanently installed in the works. They are intended to protect industrial warehouses containing open rack storage.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the ESFR sprinkler for the intended use of 25 years when installed in the works (provided that the ESFR sprinkler is subject to appropriate installation (see 1.1)). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product, the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[2].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD

1.3.1 General

For the purposes of this document, the terms and definitions given in EN 12259-1, and the following apply.

1.3.2 Actual delivered density (ADD)

A measure of the rate at which water is deposited from (an) operating sprinkler type device(s) onto the top horizontal surface of a burning combustible array, expressed in l/min/m^2.

1.3.3 Cartoned expanded plastic

A commodity product consisting of expanded polystyrene plastic food service trays (or meat trays) packaged in single-wall corrugated cartons. Each carton contains 200 plastic trays arranged in four stacks of 50 trays each with a density of 0,035-0,041 g/cm^3. Trays weigh 14-17 g each, measure 250-290 mm × 250-290 mm × 3-7 mm thick and consist of expanded foam plastic. Each carton measures 510-550 mm × 510-550 mm × 490-530 mm, shall have a moisture content of between 3,8 % and 7,4 % and weigh 3.8-4.2 kg when filled with the plastic trays. See Figure 1 for an expanded polystyrene plastic food service tray filled carton. Each pallet load consists of eight cartons placed in a 2 × 2 × 2 array upon a 1100-1300 mm × 750-850 mm × 135-155 mm or 970-1170 mm × 970-1170 mm × 120-140 mm two-way, slatted wood deck pallet with an 8 % – 10 % moisture content.

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2 The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

Figure 1 Expanded polystyrene plastic food service tray filled carton

1.3.4 Standard plastic test commodity

A product of cartoned, unexpanded, rigid crystalline, polystyrene jars. Measuring 85-95 mm in diameter, 85-95 mm high and 1-2 mm thick (with a volume of 0,45-0,50 l), packaged in compartmented, single wall, cardboard cartons measuring 510-550 mm × 510-550 mm × 490-530 mm, with a moisture content of between 3,8 % and 7,4 %. Jars are arranged in five layers, 25 per layer giving total of 125. Eight cartons are stacked, two wide by two deep by two high, on a two-way, slatted wood deck pallet measuring 1100-1300 mm × 750-850 mm × 135-155 mm or 970-1170 mm × 970-1170 mm × 120-140 mm with an 8 % – 10 % moisture content.

1.3.5 Heat responsive element

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

1.3.6 Operating temperature

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

1.3.7 Orientation ‘A’

A plunge tunnel condition in which the sprinkler is situated such that the air flow is perpendicular to both the waterway axis and the plane of the frame arms and the heat responsive element is upstream of the frame arms (see Figure E.1).

1.3.8 Orientation ‘B’

A plunge tunnel condition in which the sprinkler is situated such that the air flow is perpendicular to both the waterway axis and the plane of the frame arms and the heat responsive element is downstream of the frame arms (see Figure E.1).

1.3.9 Orientation ‘C’ (head on)

A plunge tunnel condition in which the sprinkler is situated such that the axis of the sprinkler inlet is parallel to the air flow and the deflector faces and is perpendicular to the air flow (see Figure E.1).

1.3.10 Orifice

The opening in a sprinkler body through which the water is discharged.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1 shows how the performance of ESFR sprinklers is assessed in relation to the essential characteristics.

Table 2.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Nominal activation conditions		
1.1	Nominal operating temperature	EN 12259-1, 4.3	description
1.2	Operating temperatures	EN 12259-1, 4.4	level
2	Distribution of extinguishing media		
2.1	Discharge coefficient (k-factor)	2.2.1.1	level
2.2	Extinguishing performance	2.2.1.2	level
2.3	Water distribution	2.2.1.3	level
2.4	Actual delivered density (ADD)	2.2.1.4	level
2.5	Thrust Measurement	2.2.1.5	level
3	Response delay (response time)	2.2.2	level
4	Operational reliability		
4.1	Product assembly	EN 12259-1, 4.1	description
4.2	Function	2.2.3	description
4.3	Strength of sprinkler body and deflector	EN 12259-1, 4.7	description
4.4	Strength of release element	EN 12259-1, 4.8	level
4.5	Leak resistance	EN 12259-1, 4.9	description
4.6	Heat exposure - uncoated sprinklers	EN 12259-1, 4.10.1	description
4.7	Heat exposure - coated sprinklers	EN 12259-1, 4.10.2	description
4.8	Heat exposure - Glass bulb sprinklers	EN 12259-1, 4.10.3	description
4.9	Water hammer	EN 12259-1, 4.14	description
4.10	Resistance to vibration	EN 12259-1, 4.17	description
4.12	Resistance to impact	EN 12259-1, 4.18	description
4.12	Resistance to low temperature	EN 12259-1, 4.19	description
Aspects of durability			
5	Durability, resistance to heat exposure	EN 12259-1, 4.16	description
6	Durability, resistance to thermal shock	EN 12259-1, 4.11	description
7	Durability, resistance to corrosion	EN 12259-1, 4.12 and 4.13	description

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

2.2.1 Distribution of extinguishing media

2.2.1.1 Discharge coefficient (k-factor)

Purpose of the assessment

To determine the relationship between water flow and discharge pressure over the intended range of application of the sprinkler.

Assessment method

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

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

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

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

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

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

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

Expression of results

The ETA shall state the level of the calculated average discharge coefficient in l/min/(bar)$^{1/2}$.

2.2.1.2 Extinguishing performance

Purpose of the assessment

To evaluate the sprinkler for the ability to control a rack storage fire.

Assessment method

The applicable method detailed in Annex A shall be conducted, depending on the discharge coefficient as assessed according to 2.2.1.1 and the test scenario. The accuracy of the temperature measuring equipment shall be within ±5% of measured value.

Expression of results

The ETA shall state the level of the maximum temperature at the ceiling in °C, the number of sprinklers which operated, the extent of the fire damage to the commodity and the test scenario used, including the size of the pallets and material (wood species) used in each test.

The extended application of results is not possible and the results of tests apply only for test scenarios used.

2.2.1.3 Water distribution

Purpose of the assessment

To evaluate the sprinkler arrangement for the ability to distribute water in a uniform manner.

Assessment method

Sprinklers shall be assessed for a level of performance of water distribution as with reference to Table 2.2.1 for ESFR K202 pendent sprinklers or Table 2.2.2 for ESFR K240 pendent sprinklers. Other ESFR sprinklers may be assessed for water distribution at the conditions specified for actual delivered density (ADD) per 2.2.1.4.

Table 2.2.1 Sprinkler water distribution test conditions for ESFR K202 pendent sprinklers

Number of sprinklers over the water collection system	Sprinkler spacing in m	Pipe spacing in m	Ceiling clearance to water collection pans in m	Pressure in bar
1	0	0	3,04 ± 0,06	3,4 ± 0,1
1	0	0	4,42 ± 0,09	3,4 ± 0,1
1	0	0	4,42 ± 0,09	5,2 ± 0,16
2	3,04 ± 0,06	0	1,27 ± 0,03	3,4 ± 0,1
2	3,04 ± 0,06	0	3,04 ± 0,06	3,4 ± 0,1
2	0	3,04 ± 0,06	1,27 ± 0,03	3,4 ± 0,1
2	0	3,04 ± 0,06	3,04 ± 0,06	3,4 ± 0,1
2	3,66 ± 0,07	0	1,27 ± 0,03	3,4 ± 0,1
2	0	3,66 ± 0,07	1,27 ± 0,03	3,4 ± 0,1
2	3,04 ± 0,06	0	1,27 ± 0,03	5,2 ± 0,16
2	0	3,04 ± 0,06	1,27 ± 0,03	5,2 ± 0,16
4	3,04 ± 0,06	3,04± 0,06	1,27 ± 0,03	3,4 ± 0,1
4	3,04 ± 0,06	3,04 ± 0,06	3,04 ± 0,06	3,4 ± 0,1
4	2,44 ± 0,05	3,66 ± 0,07	1,27 ± 0,03	3,4 ± 0,1
4	3,04 ± 0,06	3,04 ± 0,06	1,27 ± 0,03	5,2 ± 0,16

Table 2.2.2 Sprinkler water distribution test conditions for ESFR K240 pendent sprinklers

Number of sprinklers over the water collection system	Sprinkler spacing in m	Pipe spacing in m	Ceiling clearance to water collection pans in m	Pressure in bar
1	0	0	3,04 ± 0,06	2,4 ± 0,07
1	0	0	4,42 ± 0,09	2,4 ± 0,07
1	0	0	4,42 ± 0,09	3,4 ± 0,1
2	3,04 ± 0,06	0	1,27 ± 0,03	2,4 ± 0,07
2	3,04 ± 0,06	0	3,04 ± 0,06	2,4 ± 0,07
2	0	3,04 ± 0,06	1,27 ± 0,03	2,4 ± 0,07
2	0	3,04 ± 0,06	3,04 ± 0,06	2,4 ± 0,07
2	3,66 ± 0,07	0	1,27 ± 0,03	2,4 ± 0,07
2	0	3,66 ± 0,07	1,27 ± 0,03	2,4 ± 0,07
2	3,04 ± 0,06	0	1,27 ± 0,03	3,4 ± 0,1
2	0	3,04 ± 0,06	1,27 ± 0,03	3,4 ± 0,1
4	3,04 ± 0,06	3,04 ± 0,06	1,27 ± 0,03	2,4 ± 0,07
4	3,04 ± 0,06	3,04 ± 0,06	3,04 ± 0,06	2,4 ± 0,07
4	2,44 ± 0,07	3,66 ± 0,07	1,27 ± 0,03	2,4 ± 0,07
4	3,04 ± 0,06	3,04 ± 0,06	1,27 ± 0,03	3,4 ± 0,1

A set of four samples shall be tested and water distribution performance assessed using the conditions of Tables 2.2.1 or 2.2.2 or clause 2.2.1.4, as applicable. Prior to the test, all samples shall be operated using a suitable heat source to remove the heat responsive assembly. The sprinkler test area shall be in accordance with

Annex B. The water distribution collection areas shall be in accordance with Figure B.5. The test apparatus shall be located in a room with volume of at least 140 m^3 so as to minimise the entrainment of additional water spray. The sprinklers shall be centred over the collection apparatus but need not be centred with respect to the ceiling (see Figure B.4). No significant drafts or other air movement shall be allowed into, or out of, the test area.

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

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

Expression of results

The ETA shall state the level of average collection of the array of pans in mm/min.

2.2.1.4 Actual delivered density (ADD)

Purpose of the assessment

To evaluate the sprinkler arrangement for the ability to distribute water in a uniform manner for the intended application while subjected to the influence of a fire plume.

Assessment method

When upright and pendent sprinklers are tested in accordance with the assessment method given below, a level of performance shall be recorded in relation to Table 2.2.3 to Table 2.2.10, as applicable.

Table 2.2.3 ADD test conditions for K202 upright ESFR sprinklers

Number of sprinklers centred over the ADD apparatus	Sprinkler spacing in m	Pipe spacing in m	Ceiling clearance to water collection pans in m	Free burn convective heat release in MW	Pressure in bar
1	0	0	3,05 ± 0,06	0,5 ± 0,04	3,4 ± 0,1
1	0	0	3,05 ± 0,06	0,5 ± 0,04	5,2 ± 0,16
2	3,05 ± 0,06	0	1,52 ± 0,03	2,0 ± 0,16	3,4 ± 0,1
2	3,05 ± 0,06	0	1,52 ± 0,03	2,0 ± 0,16	5,2 ± 0,16
2	0	3,05 ± 0,06	1,52 ± 0,03	2,0 ± 0,16	3,4 ± 0,1
2	0	3,05 ± 0,06	1,52 ± 0,03	2,0 ± 0,16	5,2 ± 0,16
4	3,05 ± 0,06	3,05 ± 0,06	1,52 ± 0,03	2,5 ± 0,2	3,4 ± 0,1
4	3,05 ± 0,06	3,05 ± 0,06	1,52 ± 0,03	2,5 ± 0,2	5,2 ± 0,16

Table 2.2.4 ADD test conditions for K202 pendent ESFR sprinklers

Number of sprinklers centred over the ADD apparatus	Sprinkler spacing in m	Pipe spacing in m	Ceiling clearance to water collection pans in m	Free burn convective heat release in MW	Pressure in bar	Direction of feed flow
1	0	0	4,57 ± 0,09	1,3 ± 0,1	3,4 ± 0,1	Double
1	0	0	4,57 ± 0,09	2,6 ± 0,21	3,4 ± 0,1	Double
2	3,66 ± 0,07	0	1,22 ± 0,02	2,6 ± 0,21	3,4 ± 0,1	Single
2	0	3,66 ± 0,07	1,22 ± 0,02	2,6 ± 0,21	3,4 ± 0,1	Double
4	2,44 ± 0,05	3,66 ± 0,07	1,22 ± 0,02	2,6 ± 0,21	3,4 ± 0,1	Double

Table 2.2.5 ADD test conditions for K240 upright ESFR sprinklers

Number of sprinklers centred over the ADD apparatus	Sprinkler spacing in m [1]	Pipe spacing in m [1]	Ceiling clearance to water collection Pans in m [1]	Free burn convective heat release in MW [3]	Pressure in bar [2]
1	0	0	3,05 ± 0,06	0,5 ± 0,04	2,4 ± 0,07
1	0	0	3,05 ± 0,06	0,5 ± 0,04	3,4 ± 0,1
2	3,05 ± 0,06	0	1,52 ± 0,03	2,0 ± 0,16	2,4 ± 0,07
2	3,05 ± 0,06	0	1,52 ± 0,03	2,0 ± 0,16	3,4 ± 0,1
2	0	3,05 ± 0,06	1,52 ± 0,03	2,0 ± 0,16	2,4 ± 0,07
2	0	3,05 ± 0,06	1,52 ± 0,03	2,0 ± 0,16	3,4 ± 0,1
4	3,05 ± 0,06	3,05 ± 0,06	1,52 ± 0,03	2,5 ± 0,2	2,4 ± 0,07
4	3,05 ± 0,06	3,05 ± 0,06	1,52 ± 0,03	2,5 ± 0,2	3,4 ± 0,1

Table 2.2.6 ADD test conditions for K240 pendent ESFR sprinklers

Number of sprinklers centred over the ADD apparatus	Sprinkler spacing in m	Pipe spacing in m	Ceiling clearance to water collection Pans in m	Free burn convective heat release in MW	Pressure in bar	Direction of feed flow
1	0	0	4,57 ± 0,09	1,3 ± 0,1	2,4 ± 0,07	Double
1	0	0	4,57 ± 0,09	2,6 ± 0,21	2,4 ± 0,07	Double
2	3,66 ± 0,07	0	1,22 ± 0,02	2,6 ± 0,21	2,4 ± 0,07	Single
2	0	3,66 ± 0,07	1,22 ± 0,02	2,6 ± 0,21	2,4 ± 0,07	Double
4	2,44 ± 0,05	3,66 ± 0,07	1,22 ± 0,02	2,6 ± 0,21	2,4 ± 0,07	Double

Table 2.2.7 ADD test conditions for K325 and K360 pendent ESFR sprinklers

Sprinkler nominal discharge coefficient in l/min/(bar)$^{1/2}$	Number of sprinklers centred over the ADD apparatus	Sprinkler spacing in m	Pipe spacing In m	Ceiling clearance to water collection pans in m	Free burn convective heat release in MW	Pressure in bar	Direction of feed flow
325	2	3,7 ± 0,07	-	1,8 ± 0,04	2,6 ± 0,21	1,4 ± 0,04	Double
325	4	3,7 ± 0,07	2,4 ± 0,05	1,8 ± 0,04	3,0 ± 0,24	1,4 ± 0,04	Double
360	2	3,7 ± 0,07	-	1,8 ± 0,04	2,6 ± 0,21	1,0 ± 0,03	Double
360	4	3,7 ± 0,07	2,4 ± 0,05	1,8 ± 0,04	3,0 ± 0,24	1,0 ± 0,03	Double

Table 2.2.8 ADD test conditions for K400 pendent ESFR sprinklers

Number of sprinklers centred over the ADD apparatus	Sprinkler spacing in m	Pipe spacing in m	Ceiling clearance to water collection Pans in m	Free burn convective heat release in MW	Pressure in bar
1	0	0	4,6 ± 0,09	0	5,5 ± 0,17
2	3,0 ± 0,06	0	1,8 ± 0,04	2,6 ± 0,21	5,5 ± 0,17
4	3,0 ± 0,06	3,0 ± 0,06	1,8 ± 0,04	3,0 ± 0,24	5,5 ± 0,17

Table 2.2.9 ADD test conditions for K480 pendent ESFR sprinklers

Number of sprinklers centred over the ADD apparatus	Sprinkler spacing in m	Pipe spacing in m	Ceiling clearance to water collection Pans in m	Free burn convective heat release in MW	Pressure in bar
1	0	0	4,6 ± 0,09	0	3,8 ± 0,11
2	3,0 ± 0,06	0	1,8 ± 0,04	2,6 ± 0,21	3,8 ± 0,11
4	3,0 ± 0,06	3,0 ± 0,06	1,8 ± 0,04	3,0 ± 0,24	3,8 ± 0,11

Table 2.2.10 ADD test conditions for K202 and 240 dry pendent ESFR sprinklers

Sprinkler nominal discharge coefficient in l/min/(bar)$^{1/2}$	Number of sprinklers centred over the ADD apparatus	Sprinkler spacing in m	Pipe spacing in m	Ceiling clearance to water collection Pans in m	Free burn convective heat release in MW	Pressure in bar
202	2	3,7 ± 0,07	0	1,8 ± 0,04	2,6 ± 0,21	3,4 ± 0,1
	4	3,7 ± 0,07	2,4 ± 0,05	1,8 ± 0,04	2,6 ± 0,21	3,4 ± 0,1
240	2	3,7 ± 0,07	0	1,8 ± 0,04	2,6 ± 0,21	2,4 ± 0,07
	4	3,7 ± 0,07	2,4 ± 0,05	1,8 ± 0,04	2,6 ± 0,21	2,4 ± 0,07

ADD measurements shall be taken using the test apparatus shown in Annex C. The ADD apparatus shall consist of two major components: a fire source and a simulated commodity.

A fire plume of varying heat release rates, from 500 KW to 3 MW, is to be generated using a set of nine spray nozzles, with eight nozzles set in a circular pattern of 1,2 m diameter, and with a central nozzle. The nozzles are to be supplied with a source of liquid heptane, under pressure, with a control system capable of adjustment of heptane flow such that the required fire sizes are achieved. In addition, an air blower system is required which will deliver 18,4 m^3 per minute of air into the centre of the fire plume. Below the fire source shall be an array of collection pans representing a simulated commodity. Collection pans shall be of the dimensions defined in Annex C.

The array shall approximate the geometry and size of a single tier rack-storage commodity of two pallet loads deep and two pallet loads wide, with a 15,2 cm ± 0,3 cm flue space between each pallet. Sixteen square water collection pans, representing the top surface of the commodity within the ignition area, shall collect water that would normally reach the commodity's top surface. Four additional pans, representing the flue spaces between pallet loads of commodity, shall collect water that would normally be delivered to the flue spaces.

A flat horizontal ceiling with minimum dimensions of (11,13 m ± 0,22 m) × (10,21 m ± 0,2 m) shall be suspended above the apparatus. The test apparatus shall be located in a room with volume of at least 140 m^3 to minimise the entrainment of additional water spray.

In the case of ESFR sprinklers having a nominal k-factor of 202 l/min/(bar)$^{1/2}$, open sprinklers shall be connected to DN50 sprinkler pipes under the suspended ceiling via DN50 × DN 50 × DN20 threaded tees fittings with bushings.

In the case of ESFR sprinklers having a nominal k-factor of 240 l/min/(bar)$^{1/2}$, open sprinklers shall be connected to DN50 sprinkler pipes under the suspended ceiling via DN50 × DN 50 × DN20 threaded tees fittings with bushings.

In the case of ESFR sprinklers having a nominal k-factor greater than 240 l/min/(bar)$^{1/2}$, open sprinklers shall be connected to DN65 sprinkler pipes under the suspended ceiling via DN65 × DN65 × DN25 threaded tees fittings with bushings.

Pendent sprinklers shall be installed with sprinkler piping centre line located 23 cm ± 0,46 cm below the ceiling. Upright sprinklers shall be installed with sprinkler piping centre line located 30 cm ± 0,6 cm below the ceiling.

The frame arms of each sprinkler shall be aligned with the sprinkler pipe. The pipes shall be fed with water flowing from both directions unless "single" is specified in the applicable table.

For all tests, prior to each measurement of actual delivered density, the heptane spray shall be ignited, and the flow stabilised at a flow rate corresponding to the required heat release. Once the fuel flow rate has been stabilised, water shall be discharged from the sprinklers. Water collected by all pans is to be channelled to the collectors of the apparatus, as shown in Figure C.2. Water shall be collected until one or more collection buckets are filled, or for a minimum of 10 minutes, whichever occurs first, for each test detailed in Table 2.2.3 through Table 2.2.10, as applicable.

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

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

Expression of results

The ETA shall state the level average collection of the array of pans in mm/min.

2.2.1.5 Thrust measurement

Purpose of the assessment

To determine thrust force generated by the water discharging from the sprinkler at its intended discharge pressure.

Assessment method

The performance of ESFR K202 and K240 pendent ESFR sprinklers shall be assessed and reported using the conditions shown in Table 2.2.11. For other sprinkler K-factors, use the test pressures identified in the appropriate table provided in 2.2.1.4.

Table 2.2.11 Thrust measurements

Sprinkler nominal k-factor	Pressure in bar	Direction of feed flow	Ceiling clearance to thrust plate in m
202	3,4	Double	1,2
	3,4	Double	2,1
	5,1	Single[1]	2,1
240	2,4	Double	1,2
	2,4	Double	2,1
	3,4	Single[1]	2,1
[1] For the single direction flow condition, the maximum thrust may not occur at a point centred directly beneath the sprinkler.			

Three open sprinklers shall be individually installed in accordance with Annex F. The centre core thrust over a nominal 345 mm ± 5 mm diameter plate shall be measured while discharging water at the pressures shown in Table 2.2.11.

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

Expression of results

The ETA shall state the level of the resulting minimum recorded thrust in bar for each of the ceiling conditions given in Table 2.2.11.

2.2.2 Response delay (response time)

Purpose of the assessment

To determine the speed of operation of the sprinkler.

Assessment method

Except as noted below, operate sprinkler samples in a plunge tunnel. The plunge tunnel setup shall be in accordance with EN 12259-1, Annex N.1. Twelve samples of each nominal temperature rating shall be tested. Four tests shall be conducted for each of the orientations in accordance with Figure E.1.

Gas velocity and temperature conditions at the test section shall be established in accordance with Table 2.2.12.

Table 2.2.12 Plunge test conditions

Sprinkler nominal temperature rating in °C	Temperature in test section in °C	Average gas (air) velocity of test section
57 - 77	197 ± 6	2,56 ± 0,07
79 - 107	291 ± 9	

The response time index (RTI) shall be calculated as follows:

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

Where:

t_r - response time of sprinkler in seconds, measured to an accuracy of ± 2% of measured value;

u - actual air velocity in the test section of the tunnel in m/s, measured to an accuracy of ±2% of measured value;

ΔT_b - mean operating temperature of the sprinkler; minus the ambient temperature, in °C, measured to an accuracy of ±5% of measured value;

ΔT_g - actual gas (air) temperature minus the ambient temperature, in °C, measured to an accuracy of ±5% of measured value,

NOTE: The above equation is identical to that described in EN12259-1 Annex N.1, with the conductivity factor (C) set to zero. Because ESFR sprinklers are designed to operate very rapidly, the contribution of conductivity to overall sensitivity is negligible.

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

Expression of results

The ETA shall state the level of the response time index in $(ms)^{1/2}$ calculated after testing.

2.2.3 Operational reliability – Function

Purpose of the assessment

To evaluate the sprinkler function.

Assessment method

The assessment method in accordance with EN 12259-1, 4.6 shall be performed except for the referenced Clause 4.5 (discharge coefficient). Instead, 2.2.1.1 in this document shall be applied.

Expression of results

The results shall be expressed in accordance with EN 12259-1, 4.6.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is Commission Decision 96/577/EC, as amended by Commission Decision 2002/592/EC.

The system is 1.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

Table 3.2.1 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
1	Nominal activation conditions				
1.1	Nominal operating temperature	EN 12259-1, 4.3	As defined in control plan	As defined in control plan	As defined in control plan
1.2	Operating temperatures	EN 12259-1, 4.4	As defined in control plan	As defined in control plan	As defined in control plan
2	Distribution of extinguishing media				
2.1	Discharge coefficient	2.2.1.1	As defined in control plan	As defined in control plan	As defined in control plan
2.2	Extinguishing performance	2.2.1.2	As defined in control plan	As defined in control plan	As defined in control plan
2.3	Water distribution	2.2.1.3	As defined in control plan	As defined in control plan	As defined in control plan
2.4	Actual delivered density	2.2.1.4	As defined in control plan	As defined in control plan	As defined in control plan
2.5	Thrust Measurement	2.2.1.5	As defined in control plan	As defined in control plan	As defined in control plan
3	Response delay (response time)	2.2.2	As defined in control plan	As defined in control plan	As defined in control plan
4	Operational reliability				
4.1	Product assembly	EN 12259-1, 4.1	As defined in control plan	As defined in control plan	As defined in control plan
4.2	Function	2.2.3	As defined in control plan	As defined in control plan	As defined in control plan
4.3	Strength of sprinkler body and deflector	EN 12259-1, 4.7	As defined in control plan	As defined in control plan	As defined in control plan
4.4	Strength of release element	EN 12259-1, 4.8	As defined in control plan	As defined in control plan	As defined in control plan

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
4.5	Leak resistance	EN 12259-1, 4.9	As defined in control plan	As defined in control plan	As defined in control plan
4.6	Uncoated sprinklers	EN 12259-1, 4.10.1	As defined in control plan	As defined in control plan	As defined in control plan
4.7	Coated sprinklers	EN 12259-1, 4.10.2	As defined in control plan	As defined in control plan	As defined in control plan
4.8	Glass bulb sprinklers	EN 12259-1, 4.10.3	As defined in control plan	As defined in control plan	As defined in control plan
4.9	Water hammer	EN 12259-1, 4.14	As defined in control plan	As defined in control plan	As defined in control plan
4.10	Vibration	EN 12259-1, 4.17	As defined in control plan	As defined in control plan	As defined in control plan
4.11	Resistance to impact	EN 12259-1, 4.18	As defined in control plan	As defined in control plan	As defined in control plan
4.12	Resistance to low temperature	EN 12259-1, 4.19	As defined in control plan	As defined in control plan	As defined in control plan
5	Durability, resistance to heat exposure	EN 12259-1, 4.10.1, 4.10.3 and 4.17	As defined in control plan	As defined in control plan	As defined in control plan
6	Durability, resistance to thermal shock	EN 12259-1, 4.11	As defined in control plan	As defined in control plan	As defined in control plan
7	Durability, resistance to corrosion	EN 12259-1, 4.12 and 4.13	As defined in control plan	As defined in control plan	As defined in control plan

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.3.1.

Table 3.3.1 Control plan for the notified body; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	The notified product certification body shall verify the ability of the manufacturer to maintain continuous and orderly manufacturing of the product according to the manufacturer's control plan.	Verification of the complete FPC, to be implemented by the manufacturer	As defined in control plan	As defined in control plan	When starting the production line or a new production line.
Continuous surveillance, assessment, and evaluation of factory production control					
2	The notified product certification body shall verify that the manufacturing process and the system of factory production control is maintained.	Verification of the controls carried out by the manufacturer on the process and on the product as indicated in table 3.2.1	As defined in control plan	As defined in control plan	As defined in control plan but at minimum once a year.

4 REFERENCE DOCUMENTS

EN 12259-1:1999 +A1:2001 +A2:2004 +A3:2006	Fixed firefighting systems – Components for sprinkler and water spray systems – Part 1: Sprinklers

ANNEX A: EXTINGUISHING PERFORMANCE ASSESSMENT METHOD

A.1 Extinguishing performance assessment for K202 upright

The assessment detailed in Table A.1 shall be conducted in an indoor fire test facility with an adjustable ceiling suspended above the floor. Sprinklers shall be installed on (3,0 m ± 0,06 m) × (3,0 m ± 0,06 m) spacing, on DN50 diameter pipe with 3,9 mm wall thickness sprinkler pipes.

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

Ignition for the fire test shall take place at the bottom of the first tier of the test array, located as shown in Figure A.1.1 to A.1.5 as referenced in Table A.1. Temperatures shall be monitored by Type 'k' (or equivalent), mineral insulated, metal clad, sheathed thermocouples located at the ceiling. A thermocouple layout is shown in Figure A.1.6. The nominal temperature rating of the sprinklers shall be 74 °C. Metal storage racks shall support the commodity (in accordance with 1.3.3 and 1.3.4). For fire tests in which aisle jump is specified as a test criterion, a target array shall be located adjacent to the test array, separated by an aisle space 1,2 m ± 0,02 m wide. The commodity type, storage arrangement and height of the target array shall be selected to correspond to the test array.

Table A.1 K202 upright extinguishing performance scenarios

	Test				
	A[1]	B	C[2]	D	E
Storage type	Double-row rack (Figure A.1.1)	Double-row rack (Figure A.1.2)	Double-row rack (Figure A.1.3)	Double-row rack (Figure A.1.4)	Double-row rack (Figure A.1.5)
Fuel (commodity)	Cartoned expanded plastic (see 1.3.3)	Cartoned expanded plastic (see 1.3.3)	Standard plastic (see 1.3.4)	Standard plastic (see 1.3.4)	Standard plastic (see 1.3.4)
Nominal array height in m	5,8	7,3	7,3	7,3	8,8
Nominal clearance-to-ceiling in m	3,3	1,8	1,8	3,3	1,8
Deflector to ceiling in mm	180	180	180	180	180
Ignition[3]	Centred below one sprinkler	Centred between two sprinklers	Centred between two sprinklers	Centred below one sprinkler	Centred between two sprinklers
System water pressure, based on K202 l/min/(bar)$^{1/2}$ in bar	3,4	3,4	3,4	5,2	5,2
Test duration in min	30	30	30	30	30

[1] This test shall include a bar joist obstruction consisting of 100 mm web, centred directly above the ignition location, oriented along the longitudinal flue of the main array

[2] One of the two sprinklers shall be rendered inoperative to simulate a plugged sprinkler condition.

[3] Sprinklers shall be arrayed around the ignition point as per the applicable figure.

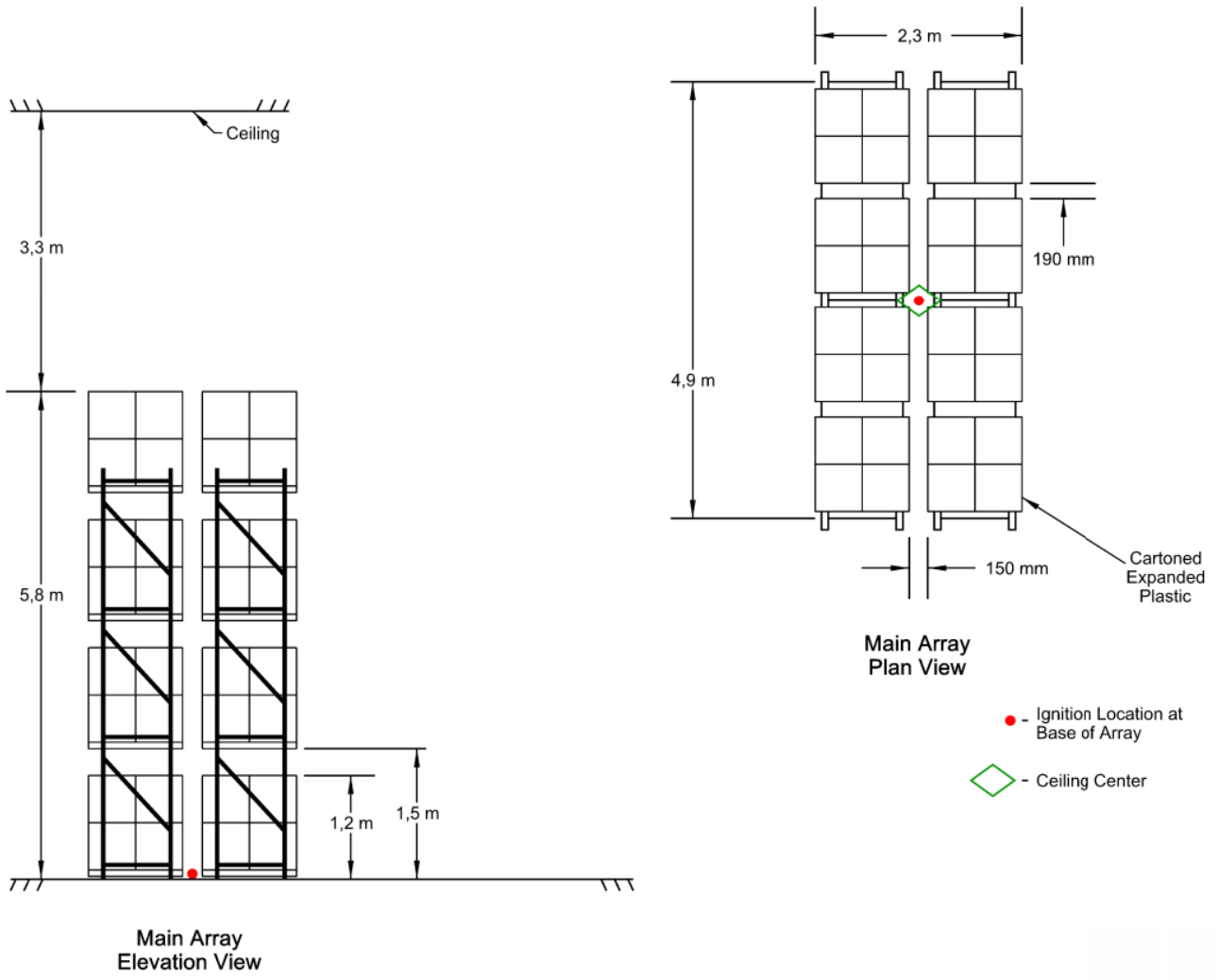


Figure A.1.1 Full scale fire test array for ESFR K202 upright, Test A

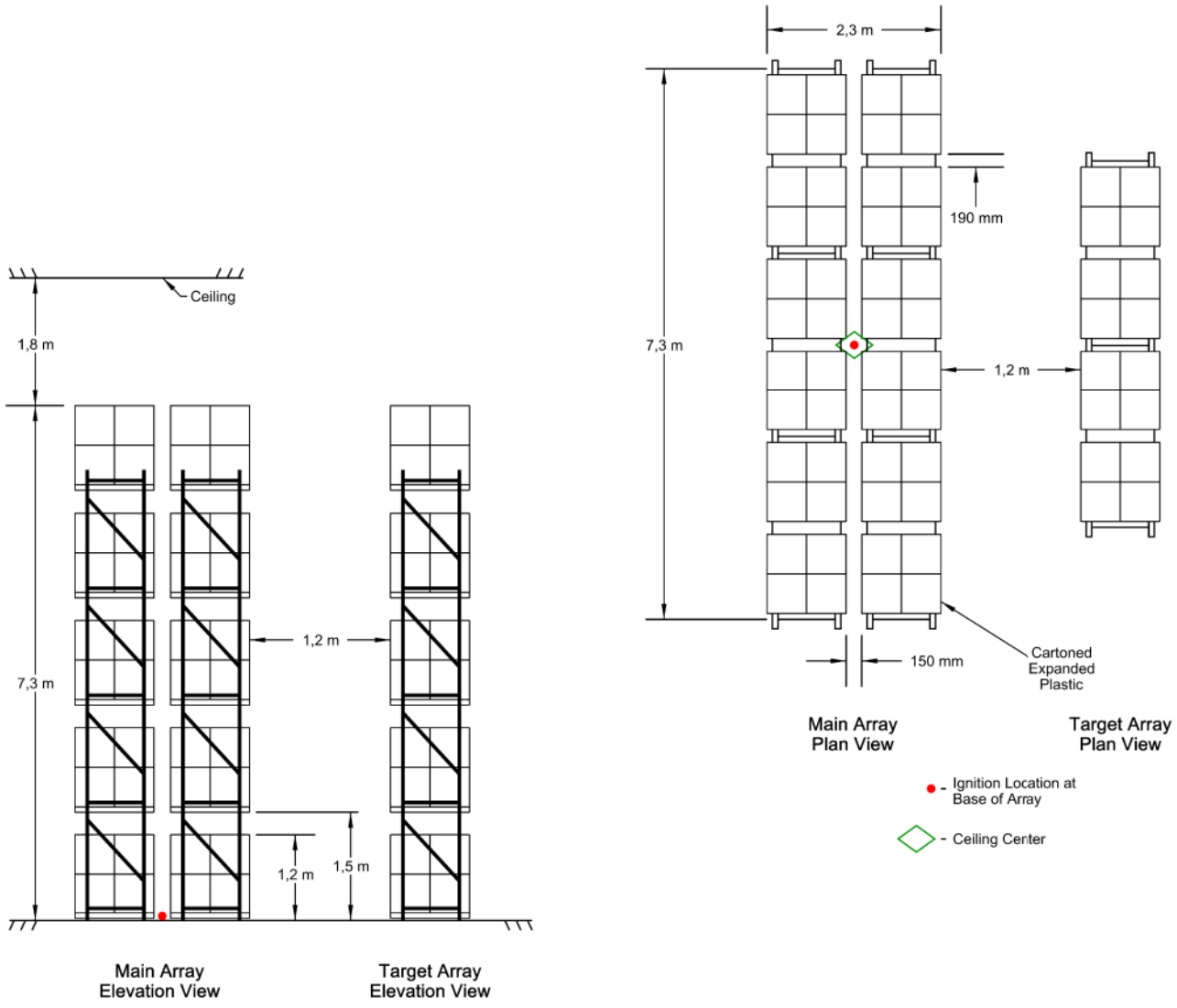


Figure A.1.2 Full scale fire test array for ESFR K202 upright, Test B

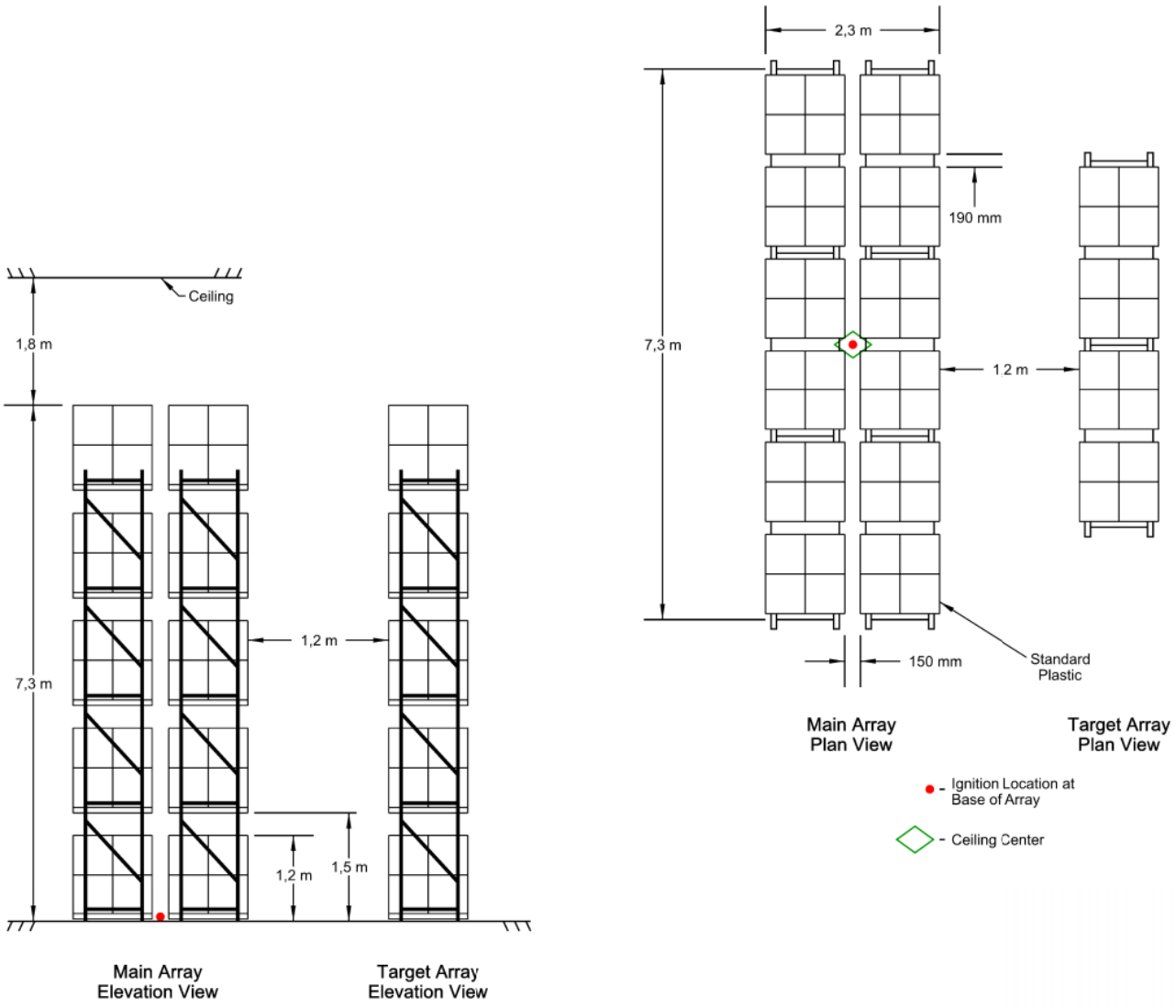


Figure A.1.3 Full scale fire test array for ESFR K202 upright, Test C

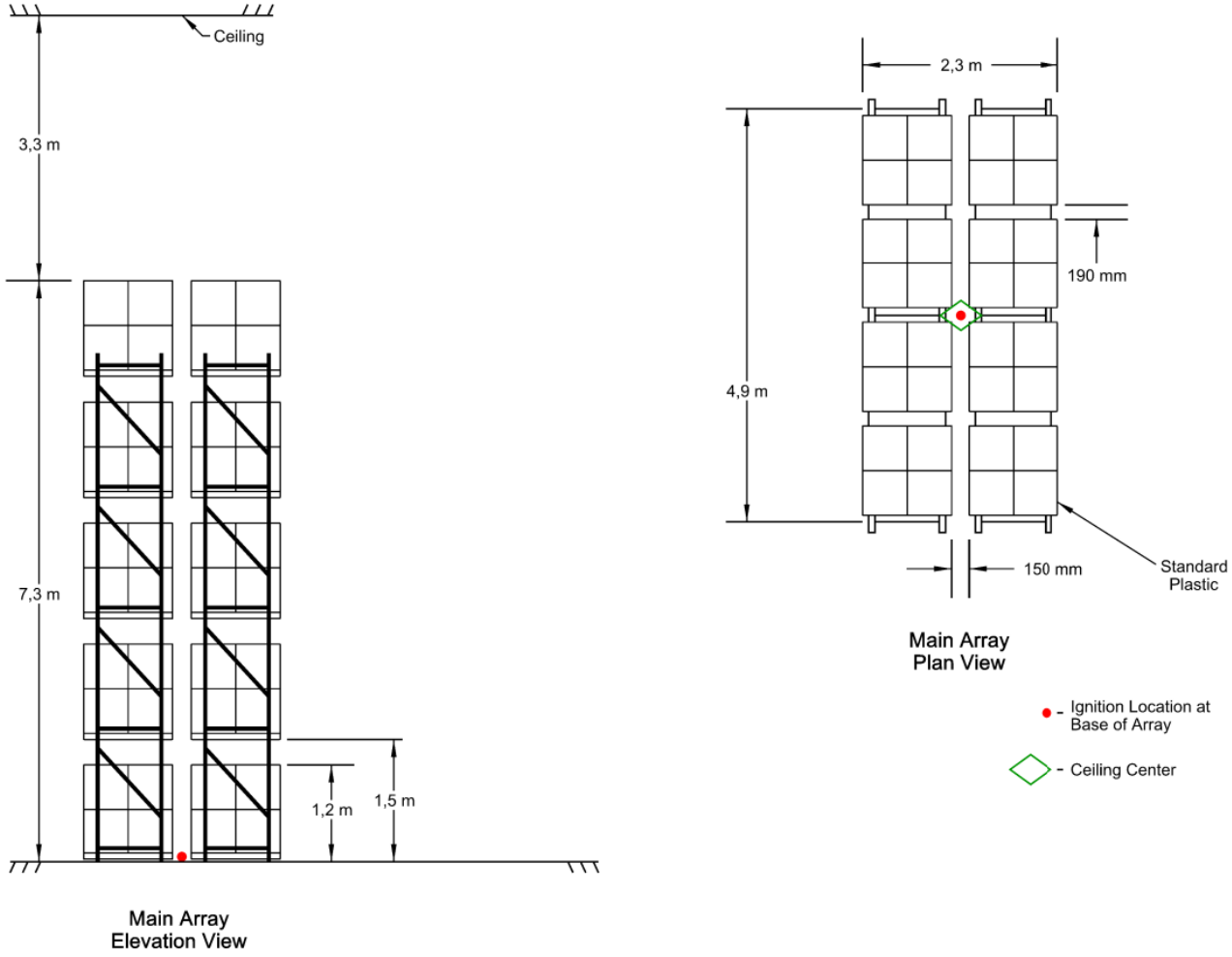


Figure A.1.4 Full scale fire test array for ESFR K202 upright, Test D

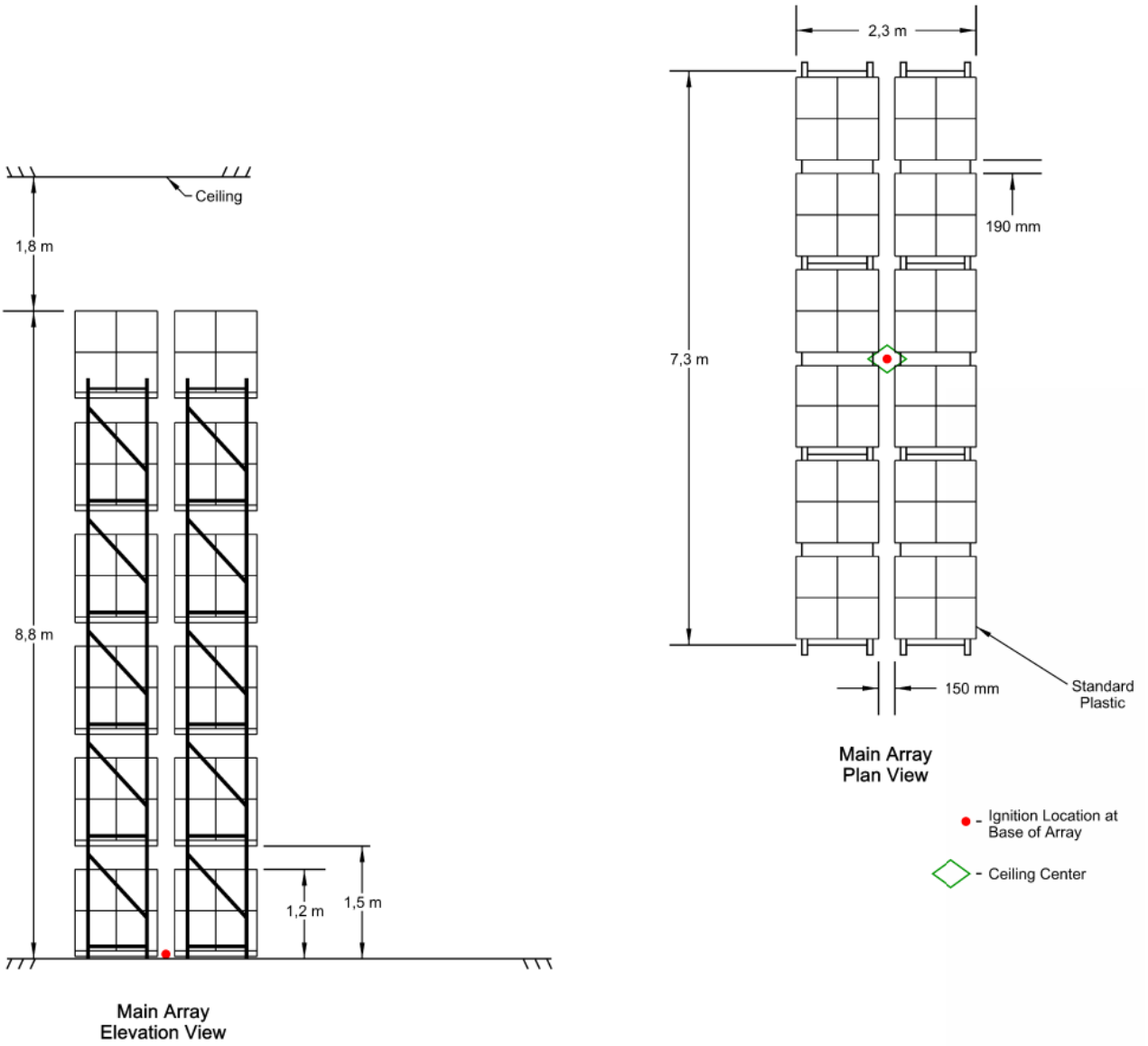


Figure A.1.5 Full scale fire test array for ESFR K202 upright, Test E

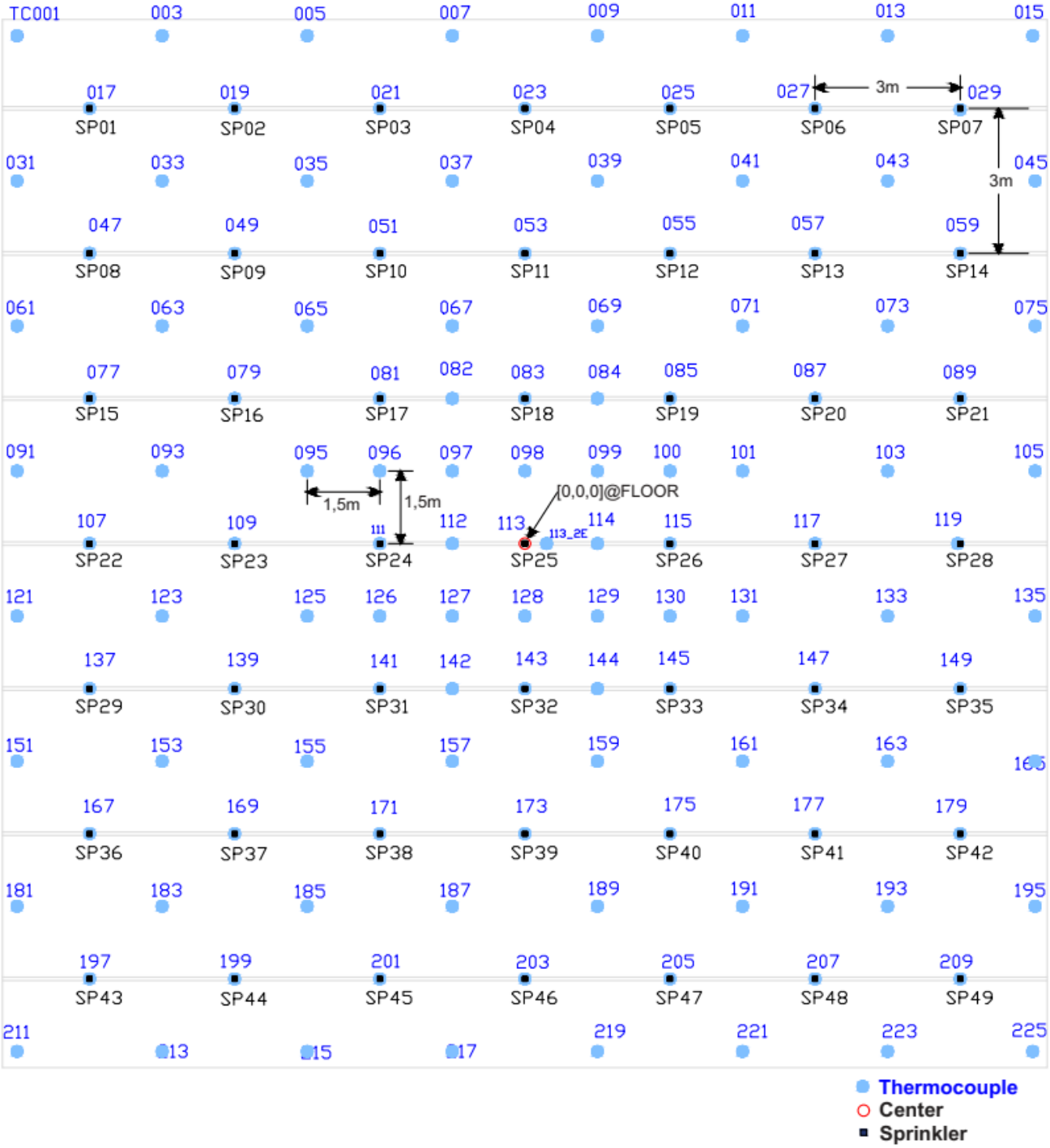


Figure A.1.6 Typical thermocouple layout

A.2 Extinguishing performance assessment for K240 upright

The tests detailed in Table A.2 shall be conducted in an indoor fire test facility with an adjustable ceiling suspended above the floor. Sprinklers shall be installed on (3,0 m ± 0,06 m) × (3,0 m ± 0,06 m) spacing, on DN50 diameter pipe with 3,9 mm wall thickness sprinkler pipes.

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

Ignition for the fire test shall take place at the bottom of the first tier of the test array, located as shown in the applicable Figure as referenced in Table A.2. Temperatures shall be monitored by Type 'k', mineral insulated, metal clad, sheathed thermocouples located at the ceiling. A typical thermocouple layout is shown in Figure A.1.6. The nominal temperature rating of the sprinklers shall be 74 °C. Metal storage racks shall support the commodity (in accordance with 1.3.3 and 1.3.4). For fire tests in which aisle jump is specified as a test criterion, a target array shall be located adjacent to the test array, separated by an aisle space 1,2 m ± 0,02 m wide. The commodity type, storage arrangement and height of the target array shall be selected to correspond to the test array.

Table A.2 - K240 upright test scenarios

	Test				
	A[1]	B	C[2]	D	E
Storage type	Double-row rack (Figure A.2.1)	Double-row rack (Figure A.2.2)	Double-row rack (Figure A.2.3)	Double-row rack (Figure A.2.4)	Double-row rack (Figure A.2.5)
Fuel (commodity)	Cartoned expanded plastic (see 1.3.3)	Cartoned expanded plastic (see 1.3.3)	Standard plastic (see1.3.4)	Standard plastic (see 1.3.4)	Standard plastic (see 1.3.4)
Nominal array height in m	5,8	7,3	7,3	7,3	8,8
Nominal clearance-to-ceiling in m	3,3	1,8	1,8	3,3	1,8
Deflector to ceiling in mm	180	180	180	180	180
Ignition[3]	Centred below one sprinkler	Centred between two sprinklers	Centred between two sprinklers	Centred below one sprinkler	Centred between two sprinklers
System water pressure, based on K240 l/min/(bar)$^{1/2}$ in bar	2,4	2,4	2,4	3,4	3,4
Test duration in min	30	30	30	30	30

[1] This test shall include a bar joist obstruction consisting of 100 mm web, centred directly above the ignition location, oriented along the longitudinal flue of the main array.

[2] One of the two sprinklers shall be rendered inoperative to simulate a plugged sprinkler condition.

[3] Sprinklers shall be arrayed around the ignition point as per the applicable figure.

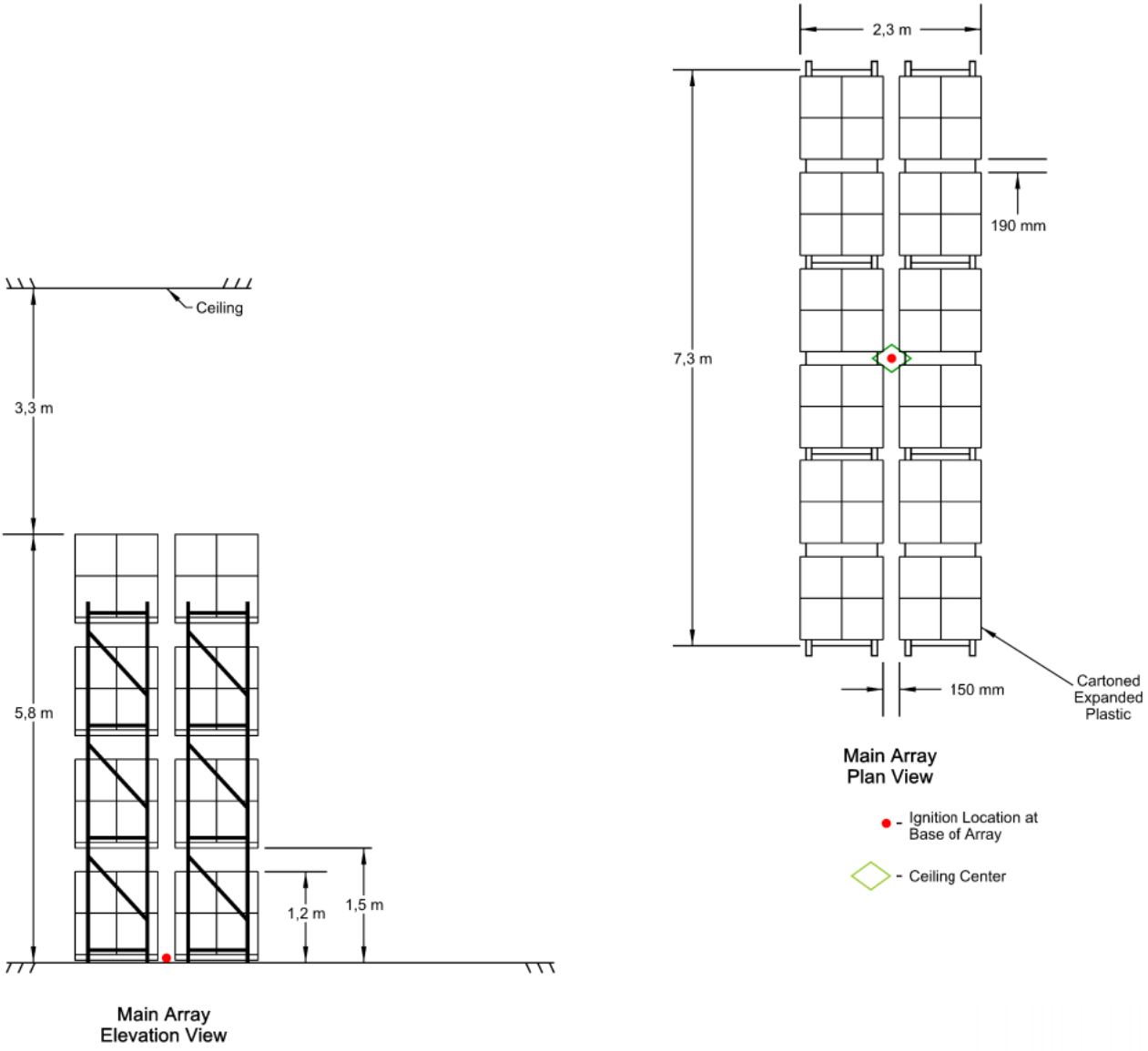


Figure A.2.1 Full scale fire test array for ESFR K240 upright, Test A

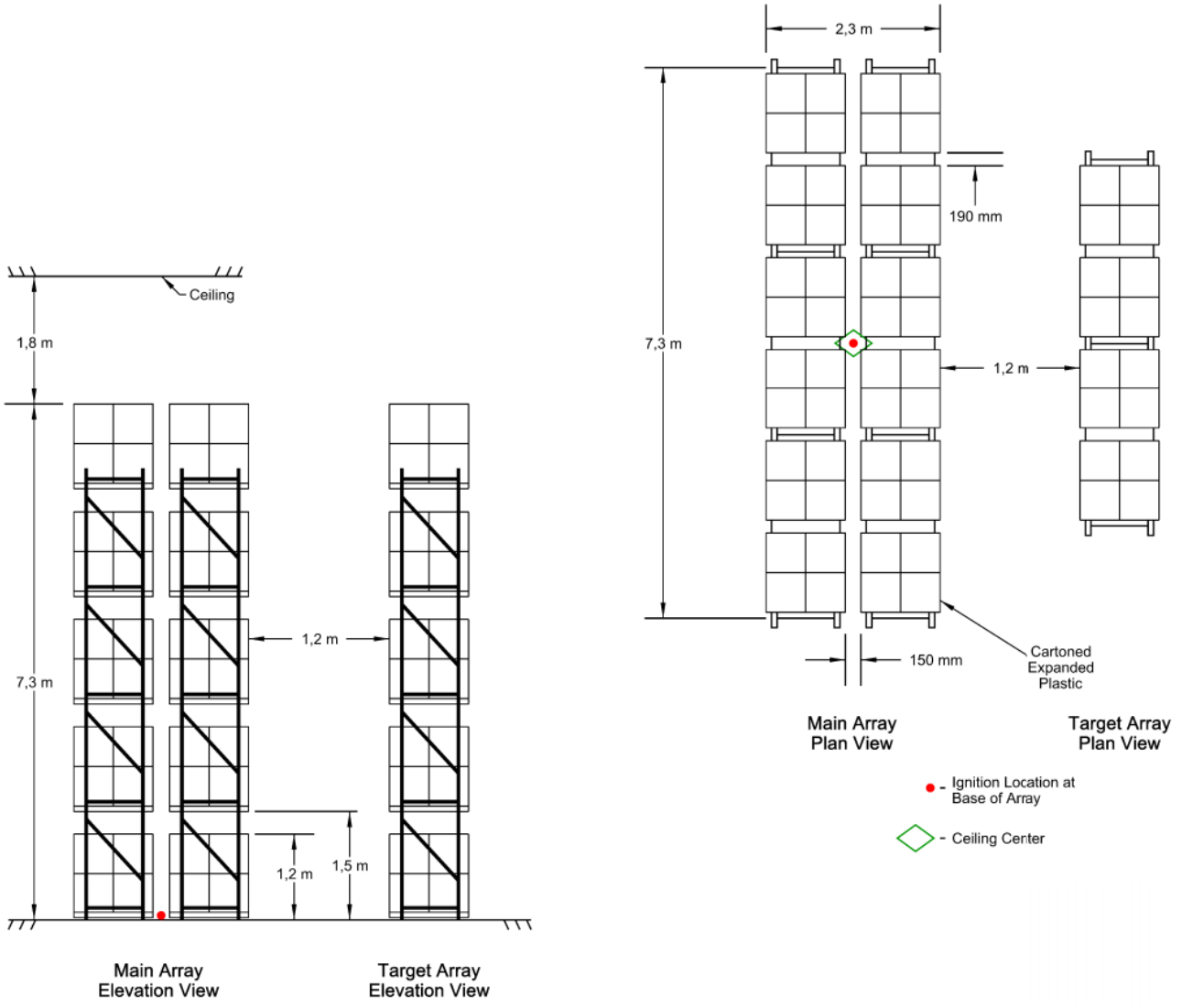


Figure A.2.2 Full scale fire test array for ESFR K240 upright, Test B

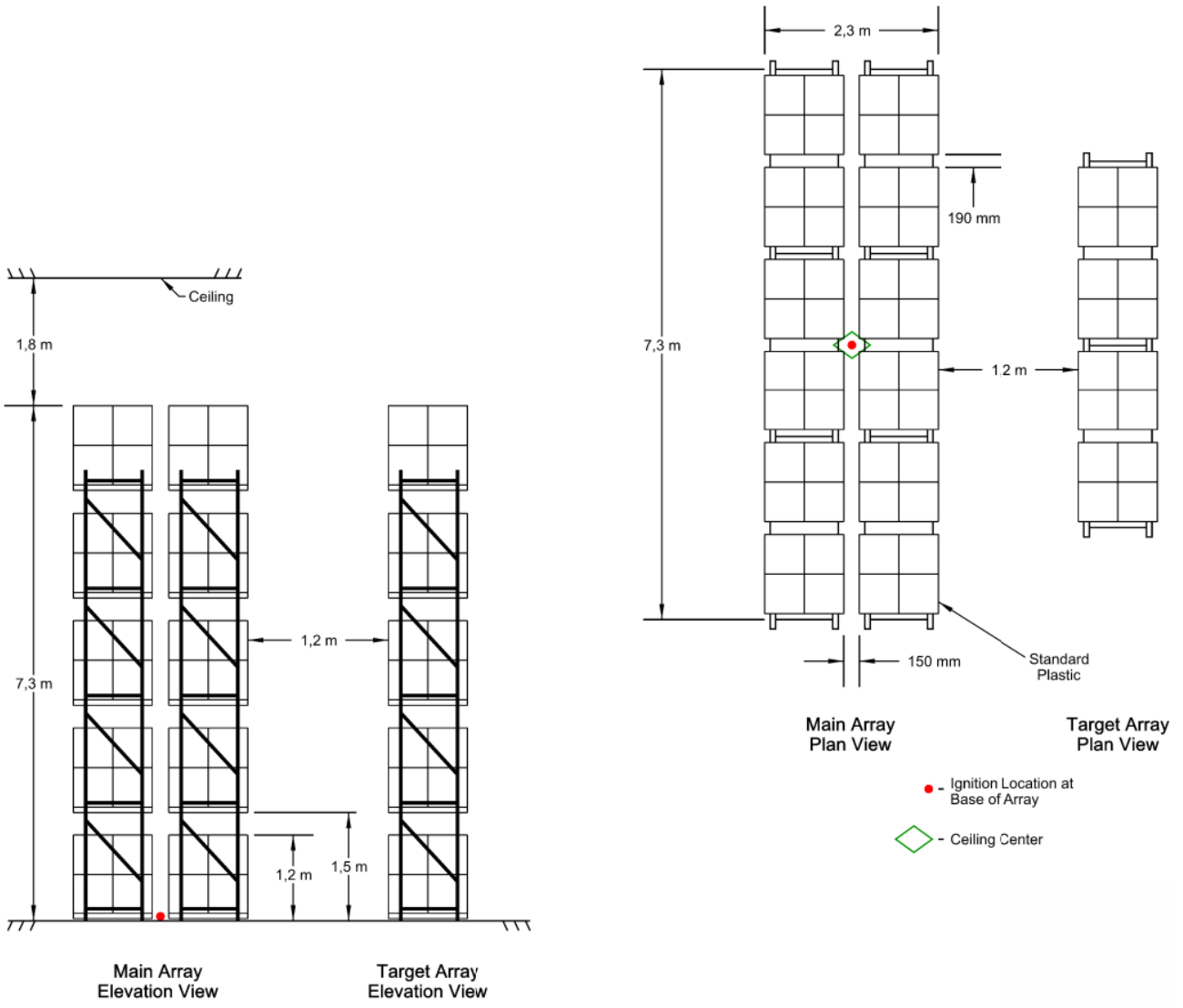


Figure A.2.3 Full scale fire test array for ESFR K240 upright, Test C

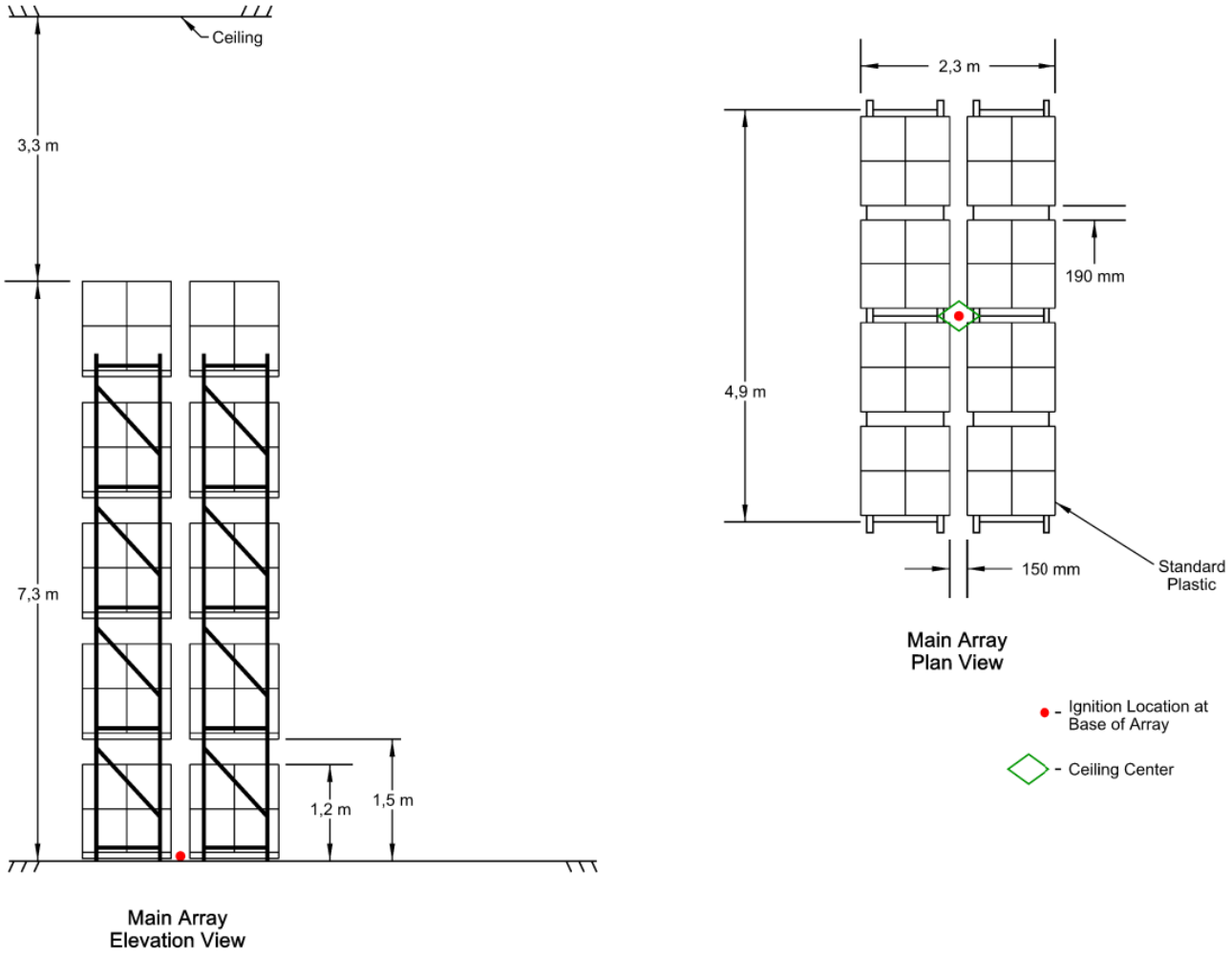


Figure A.2.4 Full scale fire test array for ESFR K240 upright, Test D

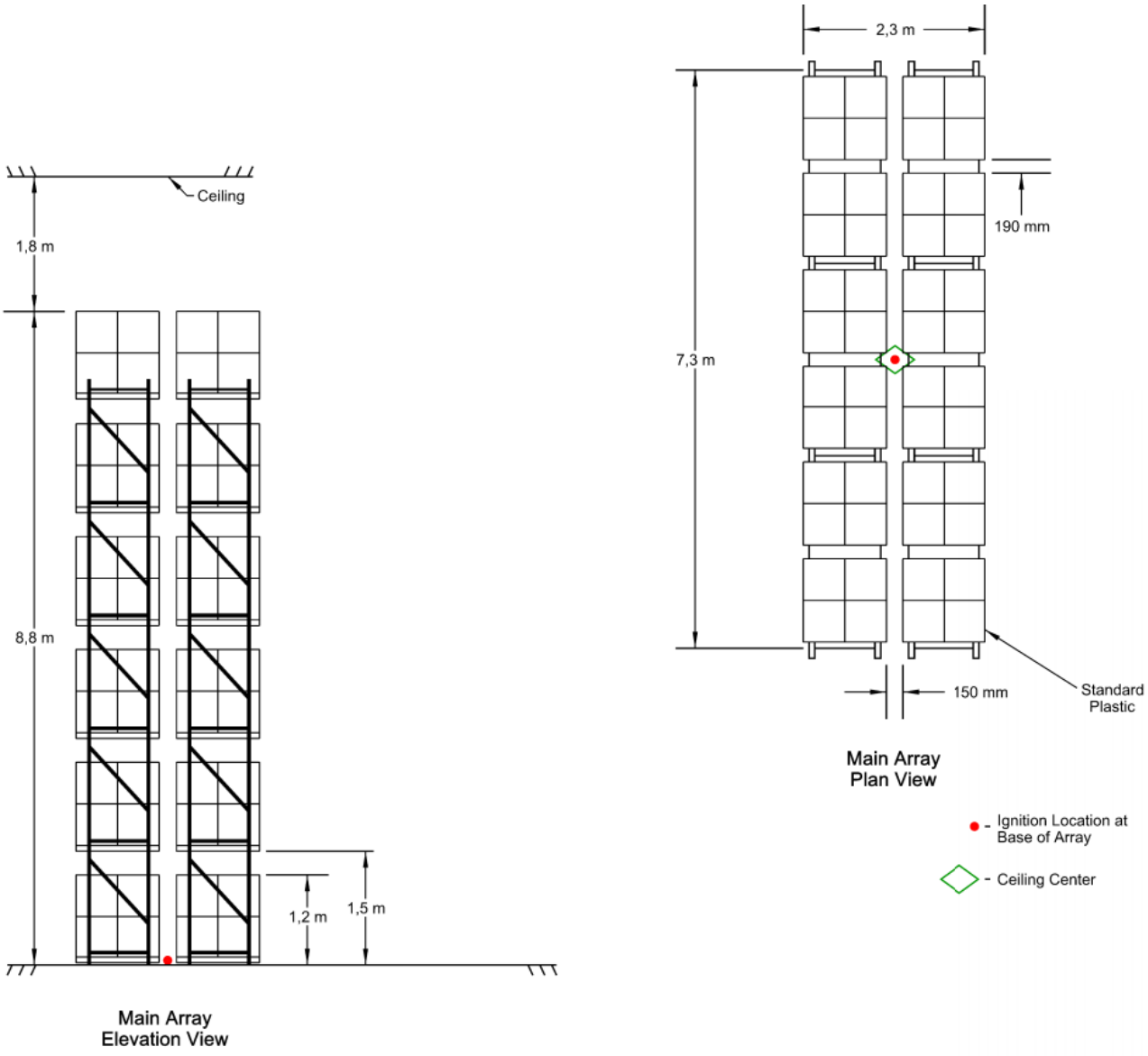


Figure A.2.5 Full scale fire test array for ESFR K240 upright, Test E

A.3 Extinguishing performance assessment for K325 and K360 pendent

The tests detailed in Table A.3 shall be conducted in an indoor fire test facility with an adjustable ceiling suspended above the floor. Sprinklers shall be installed on DN65 diameter pipe with 5,2 mm wall thickness sprinkler pipes.

Ignition for the fire test shall take place at the bottom of the first tier of the test array, located as shown in the applicable figure as referenced in Table A.3. Temperatures shall be monitored by Type 'k', mineral insulated, metal clad, sheathed thermocouples located at the ceiling. A typical thermocouple layout is shown in Figure A.1.6. The nominal temperature rating of the sprinklers shall be 74 °C. Metal storage racks shall support the commodity (in accordance with 1.3.4). For fire tests in which aisle jump is specified as a test criterion, a target array shall be located adjacent to the test array, separated by an aisle space 1,2 m ± 0,02 m wide. The commodity type, storage arrangement and height of the target array shall be selected to correspond to the test array.

Table A.3 - K325 and K360 pendent test scenarios

	Test		
	A	B	C[3]
Storage type	Double-row rack (Figure A.3.1)	Double-row rack (Figure A.3.1)	Double-row rack (Figure A.3.2)
Fuel (commodity)	Standard plastic (see 1.3.4)	Standard plastic (see 1.3.4)	Standard plastic (see 1.3.4)
Nominal array height in m	7,3	5,8	5,8
Nominal clearance-to-ceiling in m	1,8	3,3	3,3
Heat responsive element to ceiling in mm	430	430	430
Main array size, number of pallet loads (l × w × h)	8 × 2 × 5	8 × 2 × 4	8 × 2 × 4
Target array size, number of pallet loads (l × w × h)	4 ×1 × 5	4 × 1 × 4	4 × 1 × 4
Ignition[1]	Centred between two or four sprinklers [2]	Centred below one sprinkler	Centred below one sprinkler
Sprinkler spacing in m × m	2,4 x 3,7	2,4 x 2,4	3,0 x 3,0
System water pressure, based on K325 l/min/(bar)$^{1/2}$ in bar	1,4	1,4	1,4
System water pressure, based on K360 l/min/(bar)$^{1/2}$ in bar	1,0	1,0	1,0
Test duration in min	30	30	30

[1]Sprinklers shall be arrayed around the ignition point as per the applicable figure.

[2]The ignition location for Test A is based on worst-case scenario determined by ADD testing. If ADD testing is not conducted select between two ignition scenarios.

[3] If Test B results in only one sprinkler operating, Test C may be skipped.

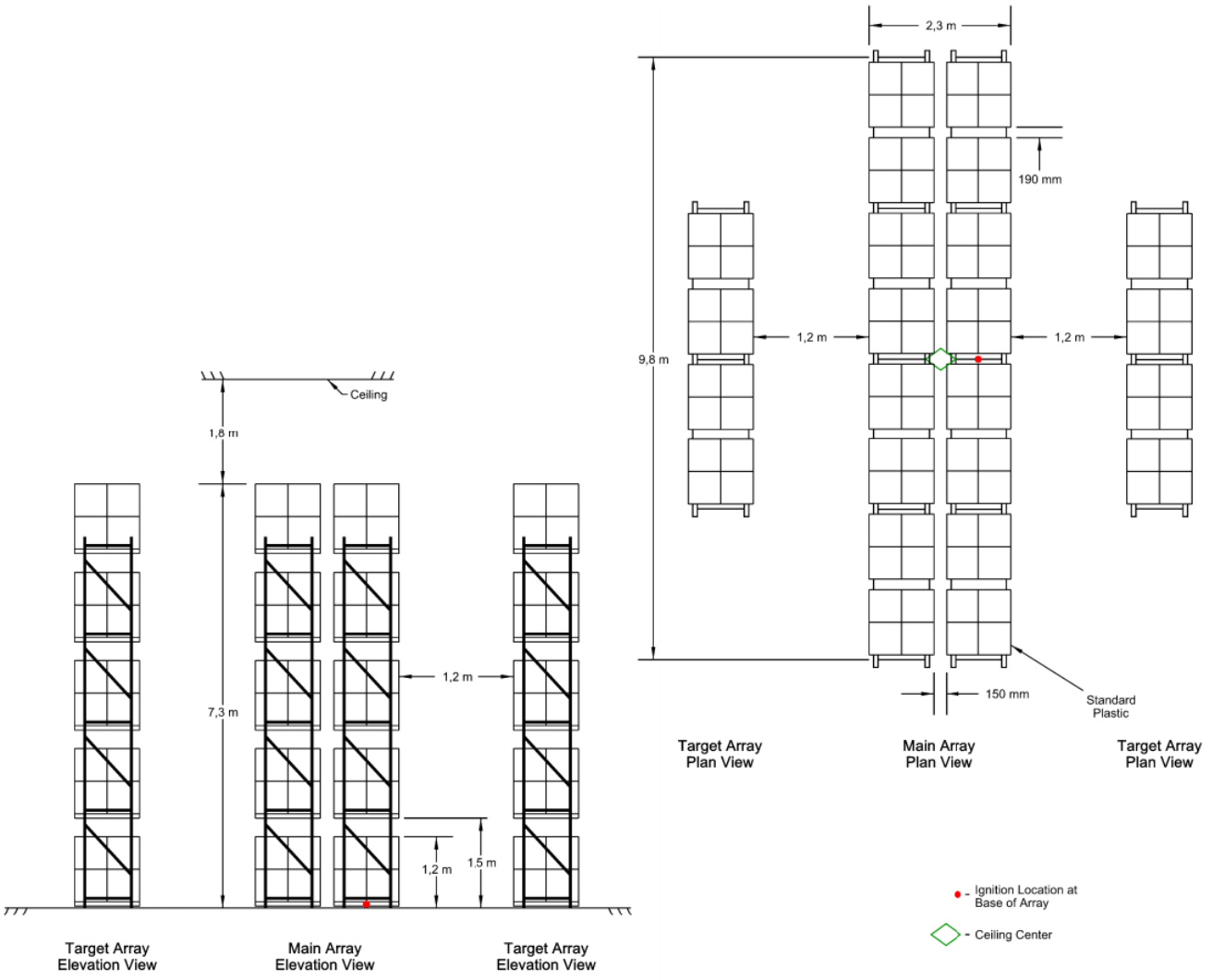


Figure A.3.1 Full scale fire test array for ESFR K325 and K360 pendent, Test A

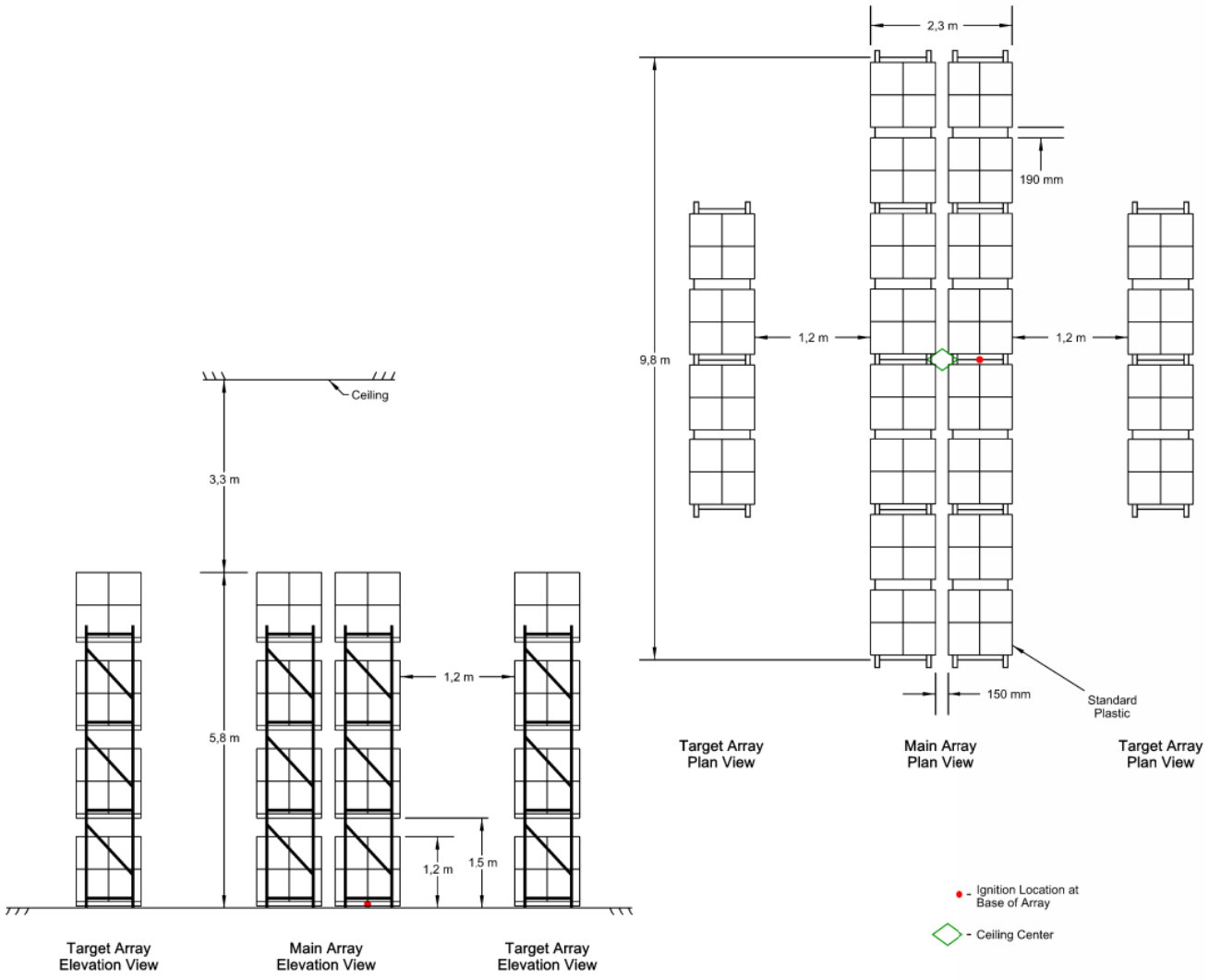


Figure A.3.2 Full scale fire test array for ESFR K325 and K360 pendent, Test B and C

A.4 Extinguishing performance assessment for K400 pendent

The tests detailed in Table A.4 shall be conducted in an indoor fire test facility with an adjustable ceiling suspended above the floor. Sprinklers shall be installed on DN65 diameter pipe with 5,2 mm wall thickness sprinkler pipes.

Ignition for the fire test shall take place at the bottom of the first tier of the test array, located as shown in the applicable figure as referenced in Table A.4. Temperatures shall be monitored by Type ‘k’, mineral insulated, metal clad, sheathed thermocouples located at the ceiling. A typical thermocouple layout is shown in Figure A.1.6. The nominal temperature rating of the sprinklers shall be 74 °C. Metal storage racks shall support the commodity (in accordance with 1.3.4). For fire tests in which aisle jump is specified as a test criterion, a target array shall be located adjacent to the test array, separated by an aisle space 2,4 m ± 0,05 m. The commodity type, storage arrangement and height of the target array shall be selected to correspond to the test array.

Table A.4 – K400 Pendent Test Scenarios

	Test		
	A	B	C[3]
Storage type	Double-row rack (Figure A.4.1)	Double-row rack (Figure A.4.2)	Double-row rack (Figure A.4.2)
Fuel (commodity)	Standard plastic (see 1.3.4)	Standard plastic (see 1.3.4)	Standard plastic (see 1.3.4)
Nominal array height in m	14,9	13,4	13,4
Nominal clearance-to-ceiling in m	1,8	3,3	3,3
Heat responsive element to ceiling in mm	330	330	330
Main array size, number of pallet loads (l × w × h)	12 × 2 × 10	12 × 2 × 9	12 × 2 × 9
Target array size, number of pallet loads (l × w × h)	8 ×1 × 10	8 × 1 × 9	8 × 1 × 9
Ignition[1]	Centred between two or four sprinklers[2]	Centred below one sprinkler	Centred below one sprinkler
Sprinkler spacing in m × m	3,0 × 3,0	2,4 × 2,4	3,0 × 3,0
System water pressure, based on K400 i/min/(bar)$^{1/2}$ in bar	5,5	5,5	5,5
Test duration in min	30	30	30

[1]Sprinklers shall be arrayed around the ignition point as per the applicable figure.

[2]The ignition location for Test A is based on worst-case scenario determined by ADD testing. If ADD testing is not conducted select between two ignition scenarios.

[3] If Test B results in only one sprinkler operating, Test C may be skipped.

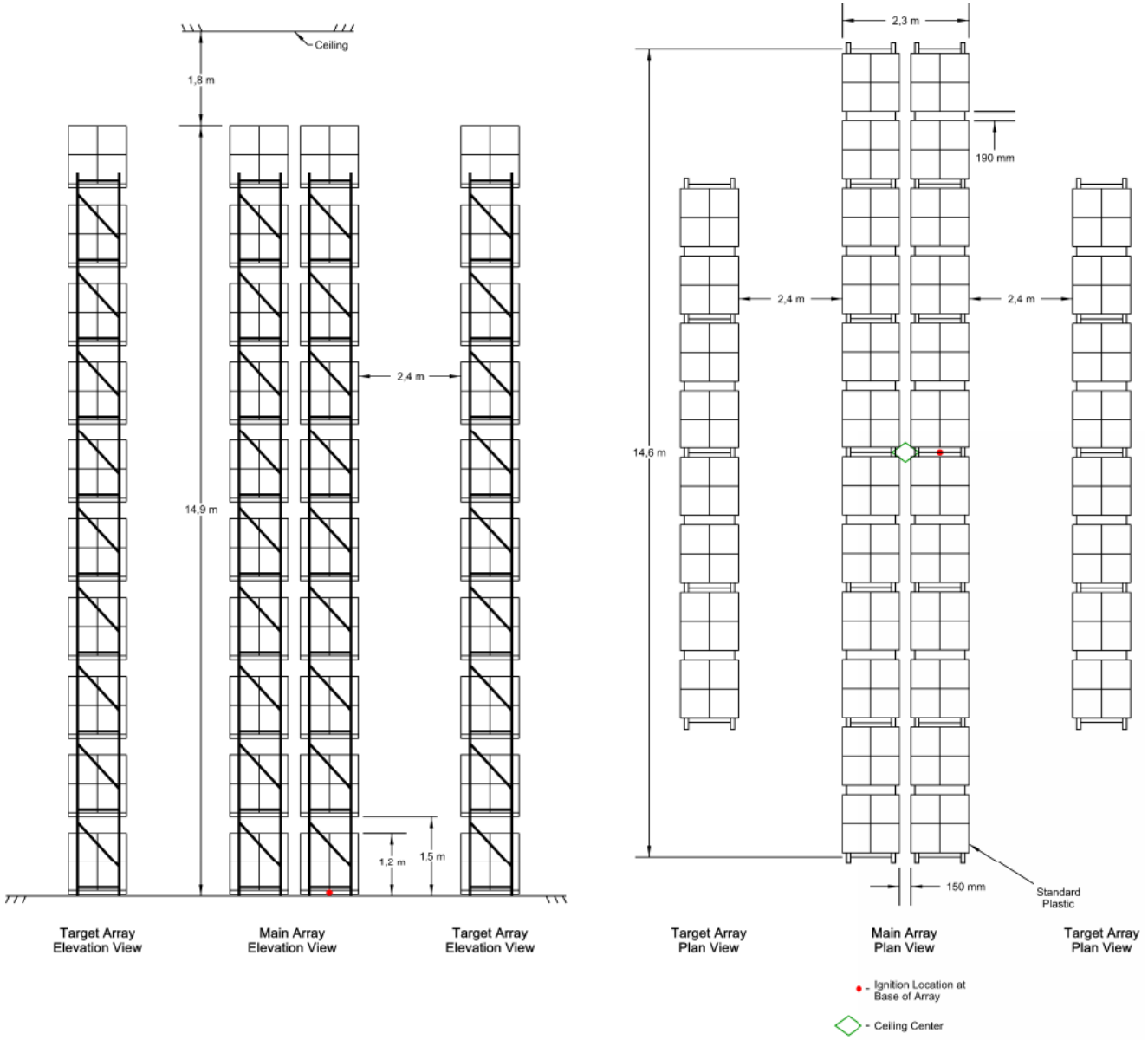


Figure A.4.1 Full scale fire test array for ESFR K400 pendent, Test A

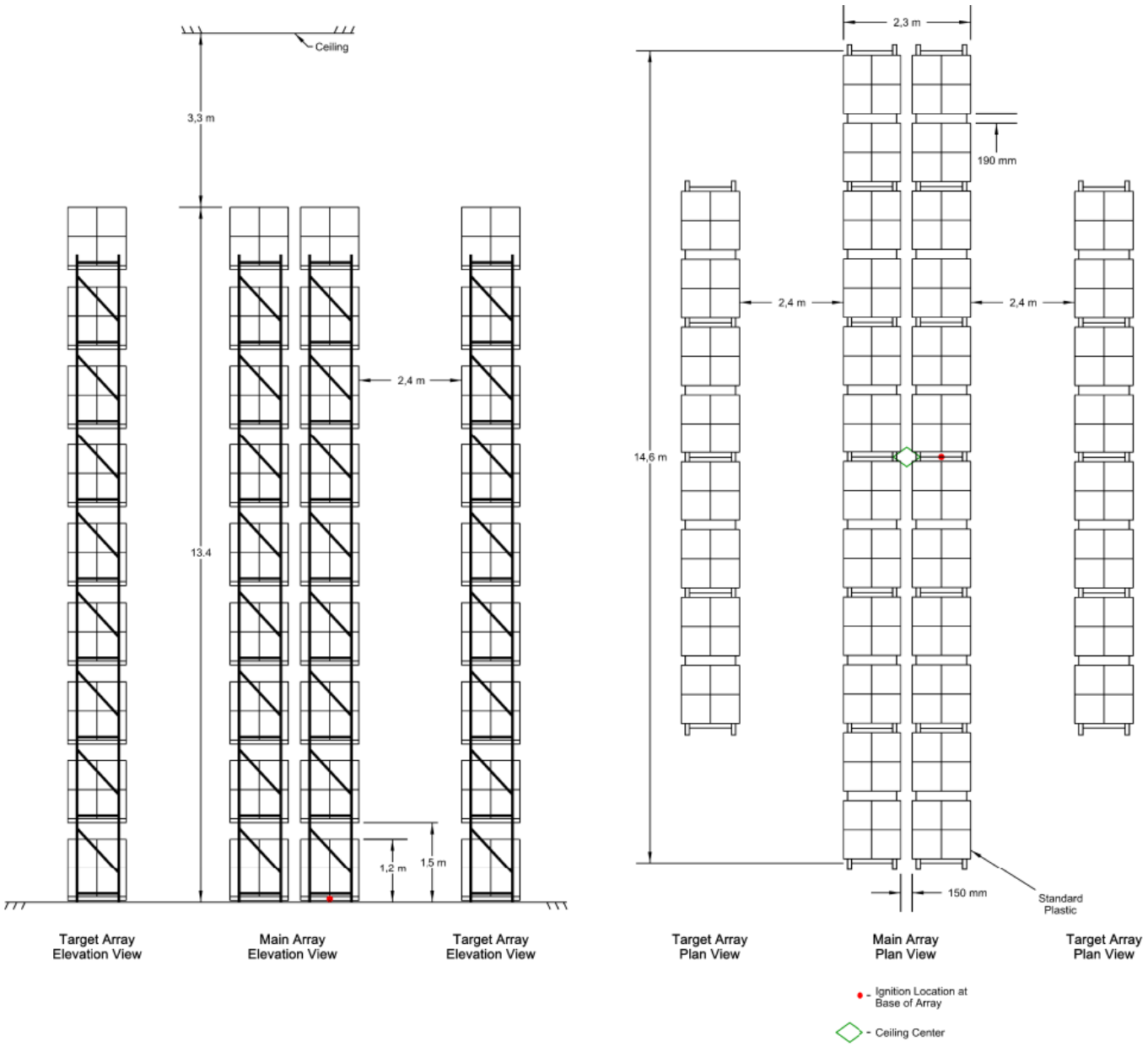


Figure A.4.2 Full scale fire test array for ESFR K400 pendent, Test B and C

A.5 Extinguishing performance assessment for K480 pendent

The tests detailed in Table A.5 shall be conducted in an indoor fire test facility with an adjustable ceiling suspended above the floor. Sprinklers shall be installed on DN65 diameter pipe with 5,2 mm wall thickness sprinkler pipes.

Ignition for the fire test shall take place at the bottom of the first tier of the test array, located as shown in the applicable figure as referenced in Table A.5. Temperatures shall be monitored by Type 'k', mineral insulated, metal clad, sheathed thermocouples located at the ceiling. A typical thermocouple layout is shown in Figure A.1.6. The nominal temperature rating of the sprinklers shall be 74 °C. Metal storage racks shall support the commodity (in accordance with 1.3.4). For fire tests in which aisle jump is specified as a test criterion, a target array shall be located adjacent to the test array, separated by an aisle space 1,8 m ± 0,04 m wide. The commodity type, storage arrangement and height of the target array shall be selected to correspond to the test array.

Table A.5 – K480 Pendent Test Scenarios

	Test		
	A	B	C[3]
Storage type	Double-row rack (Figure A.5.1)	Double-row rack (Figure A.5.2)	Double-row rack (Figure A.5.2)
Fuel (commodity)	Standard plastic (see 1.3.4)	Standard plastic (see 1.3.4)	Standard plastic (see 1.3.4)
Nominal array height in m	14,9	13,4	13,4
Nominal clearance-to-ceiling in m	1,8	3,3	3,3
Heat responsive element to ceiling in mm	430	430	430
Main array size, number of pallet loads (l × w × h)	12 × 2 × 10	8 × 2 × 9	8 × 2 × 9
Target array size, number of pallet loads (l × w × h)	8 × 1 × 10	8 × 1 × 9	8 × 1 × 9
Ignition[1]	Centred between two or four sprinklers[2]	Centred below one sprinkler	Centred below one sprinkler
Sprinkler spacing in m × m	3,0 x 3,0	2,4 x 2,4	3,0 x 3,0
System water pressure, based on K480 l/min/(bar)$^{1/2}$ in bar	3,8	3,8	3,8
Test duration in min	30	30	30

[1]Sprinklers shall be arrayed around the ignition point as per the applicable figure.

[2]The ignition location for Test A is based on worst-case scenario determined by ADD testing. If ADD testing is not conducted select between two ignition scenarios.

[3] If Test B results in only one sprinkler operating, Test C may be skipped.

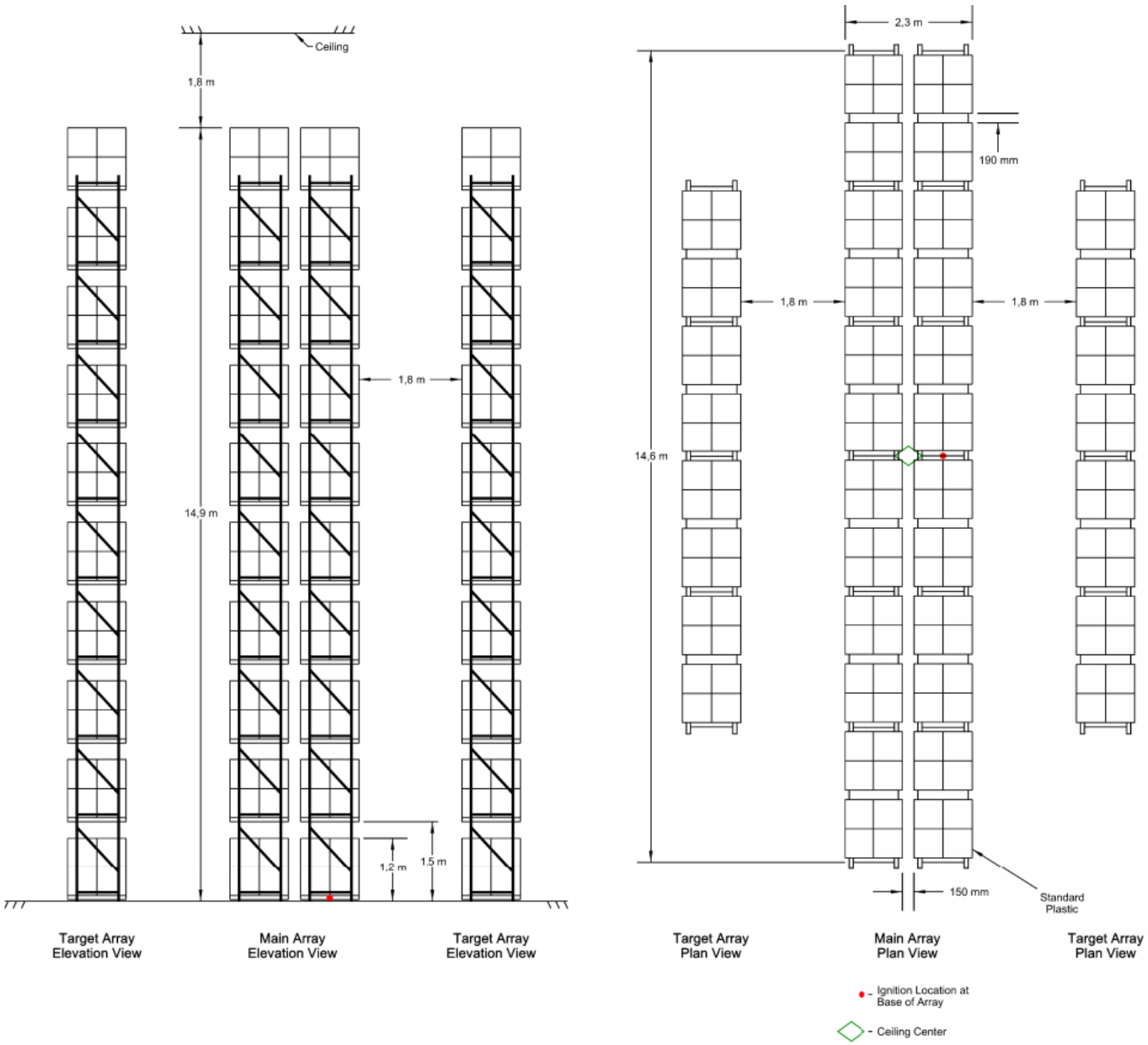


Figure A.5.1 Full scale fire test array for ESFR K480 pendent, Test B and C

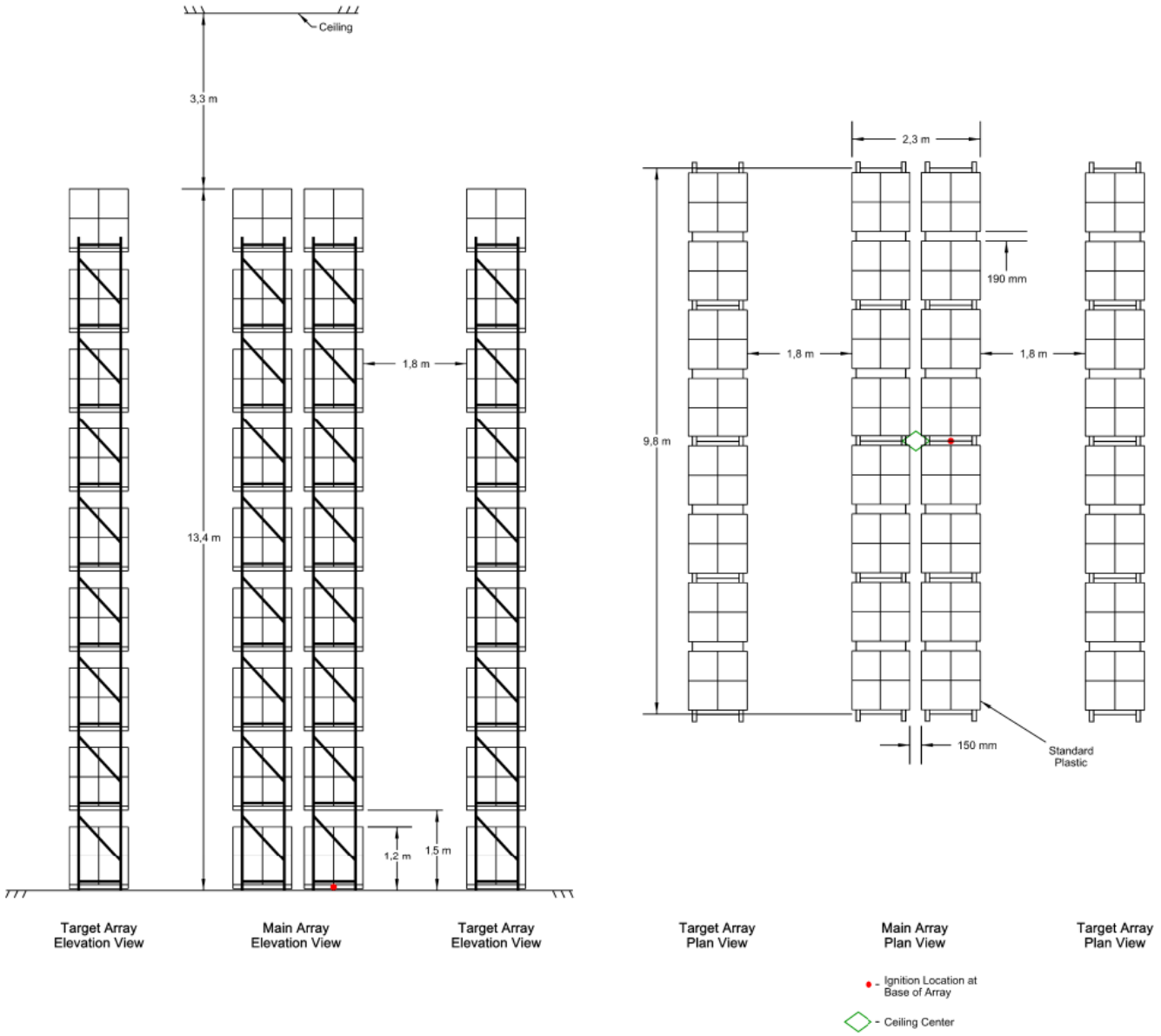


Figure A.5.2 Full scale fire test array for ESFR K480 pendent, Test B and C

A.6 Extinguishing performance assessment for K202 and K240 pendent

The tests detailed in Table A.6 shall be conducted in an indoor fire test facility with an adjustable ceiling suspended above the floor. Sprinklers shall be installed on DN50 diameter pipe with 3,9 mm wall thickness sprinkler pipes.

Ignition for the fire test shall take place at the bottom of the first tier of the test array, located as shown in the applicable figure as referenced in Table A.6. Temperatures shall be monitored by Type ‘k’, mineral insulated, metal clad, sheathed thermocouples located at the ceiling. A typical thermocouple layout is shown in Figure A.1.6. The nominal temperature rating of the sprinklers shall be 74 °C. Metal storage racks shall support the commodity (in accordance with 1.3.4). For fire tests in which aisle jump is specified as a test criterion, a target array shall be located adjacent to the test array, separated by an aisle space 1,8 m ± 0,04 m wide. The commodity type, storage arrangement and height of the target array shall be selected to correspond to the test array.

Table A.6 – K202 and K240 Pendent Test Scenarios

	Test		
	A	B	C[3]
Storage type	Double-row rack (Figure A.6.1)	Double-row rack (Figure A.6.2)	Double-row rack (Figure A.6.2)
Fuel (commodity)	Standard plastic (see 1.3.4)	Standard plastic (see1.3.4)	Standard plastic (see to1.3.4)
Nominal array height in m	7,3	5,8	5,8
Nominal clearance-to-ceiling in m	1,8	3,3	3,3
Heat responsive element to ceiling, pendent sprinklers in mm	330	330	330
Main array size, number of pallet loads (l × w × h)	8 × 2 × 5	8 × 2 × 4	8 × 2 × 4
Target array size, number of pallet loads (l × w × h)	4 × 1 × 5	4 × 1 × 4	4 × 1 × 4
Ignition[1]	Centred between two or four sprinklers[2]	Centred below one sprinkler	Centred below one sprinkler
Sprinkler spacing in m × m	3,0 × 3,0	2,4 × 3,0	3,0 × 3,0
System water pressure, based on K202 L/min/(bar)$^{1/2}$ in bar	3,4	3,4	3,4
System water pressure, based on K240 l/min/(bar)$^{1/2}$ in bar	2,4	2,4	2,4
Test duration in min	30	30	30

[1]Sprinklers shall be arrayed around the ignition point as per the applicable figure.

[2]The ignition location for Test A is based on worst-case scenario determined by ADD testing. If ADD testing is not conducted select between two ignition scenarios.

[3] If Test B results in only one sprinkler operating, Test C may be skipped.

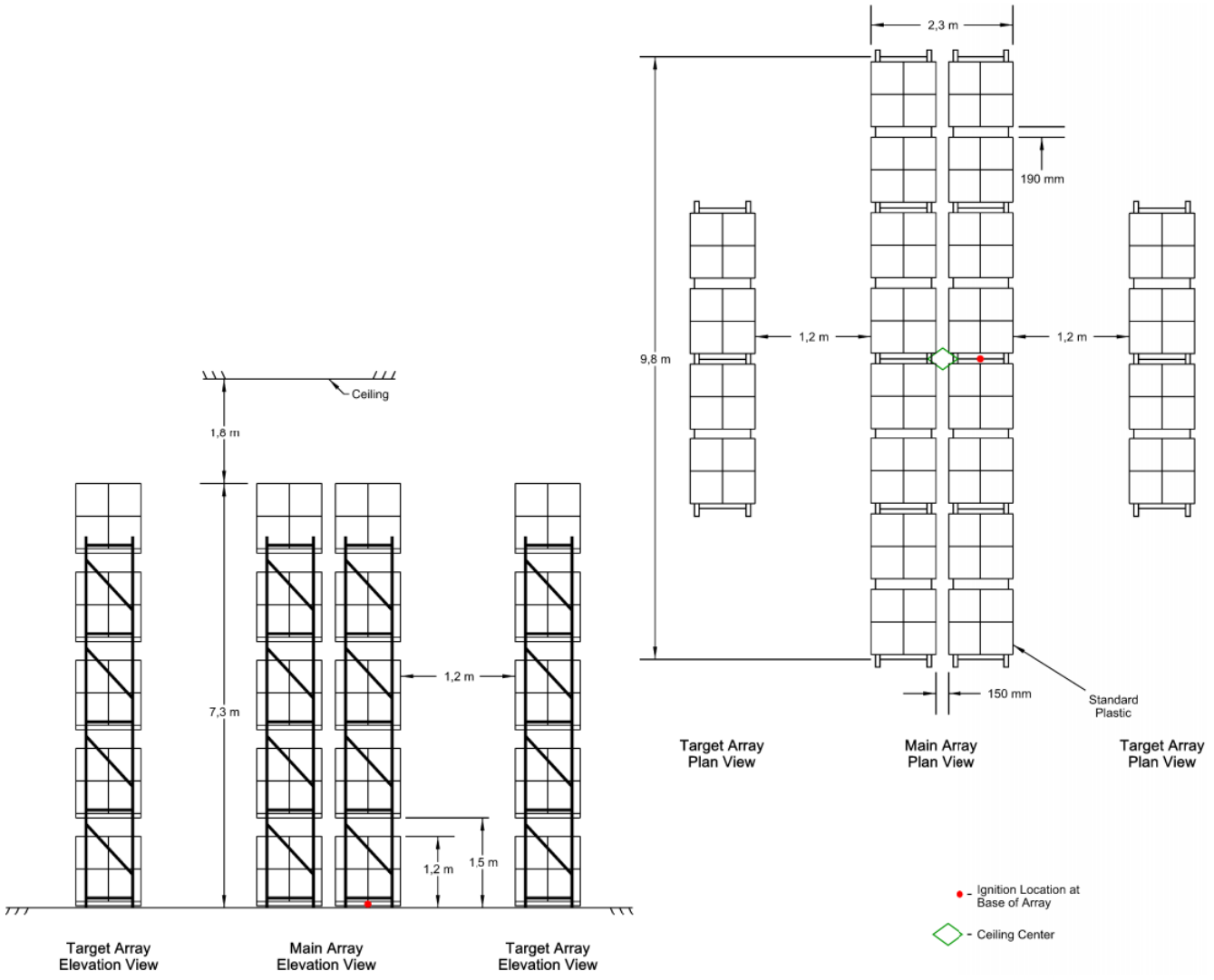


Figure A.6.1 Full scale fire test array for ESFR K202 and K240 pendent, Test A

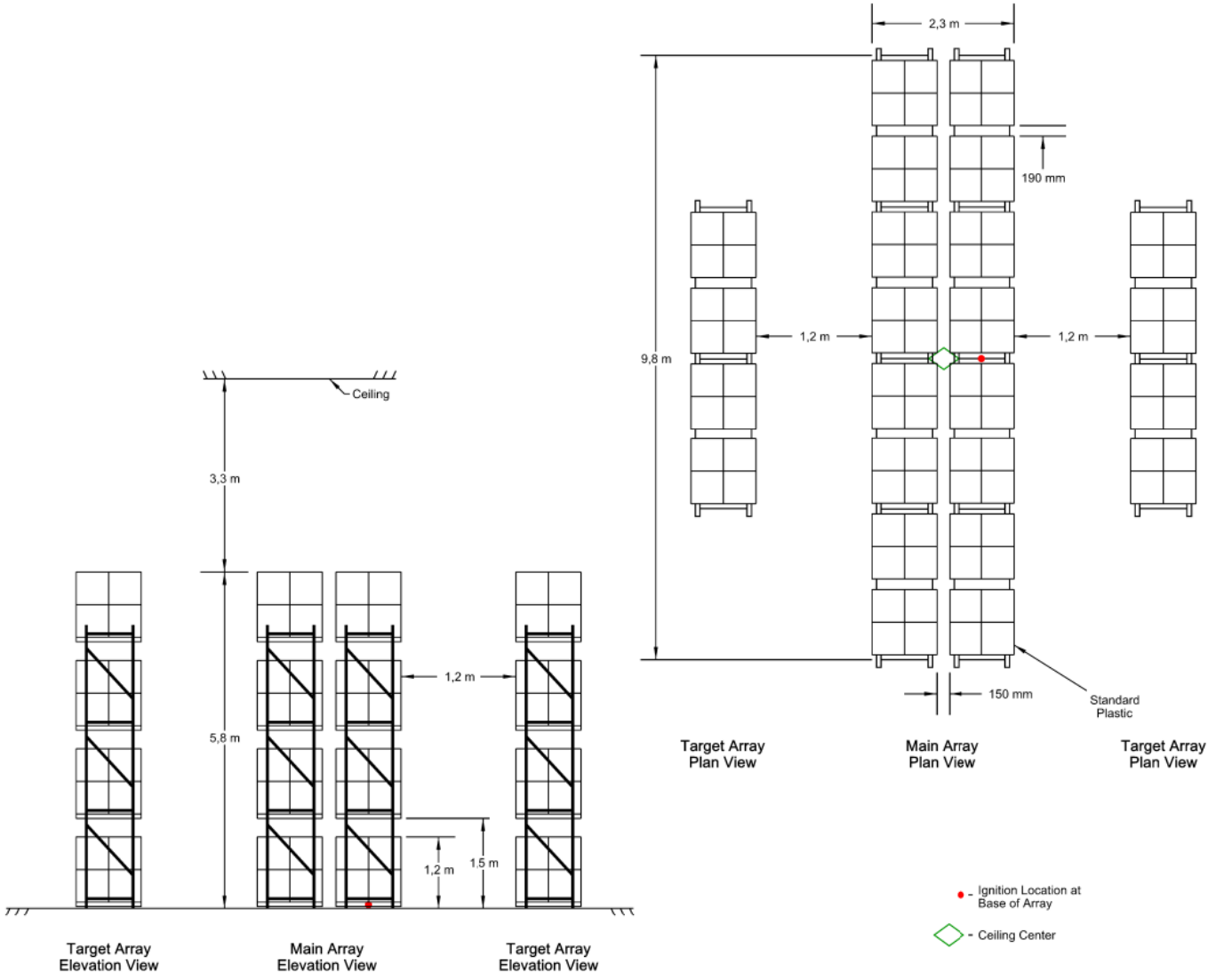


Figure A.6.2 Full scale fire test array for ESFR K202 and K240 pendent, Test B and C

ANNEX B: WATER DISTRIBUTION APPARATUS

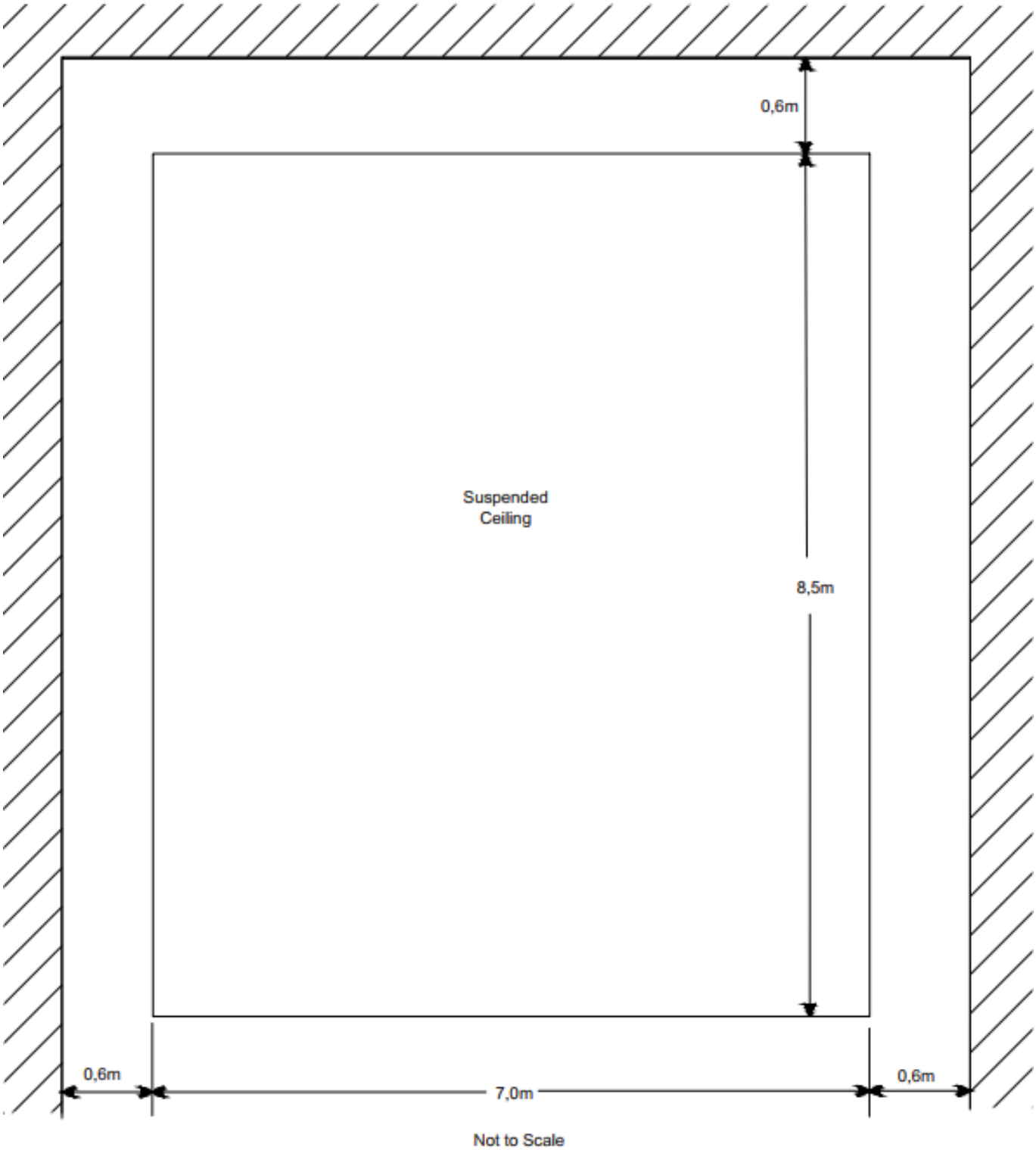
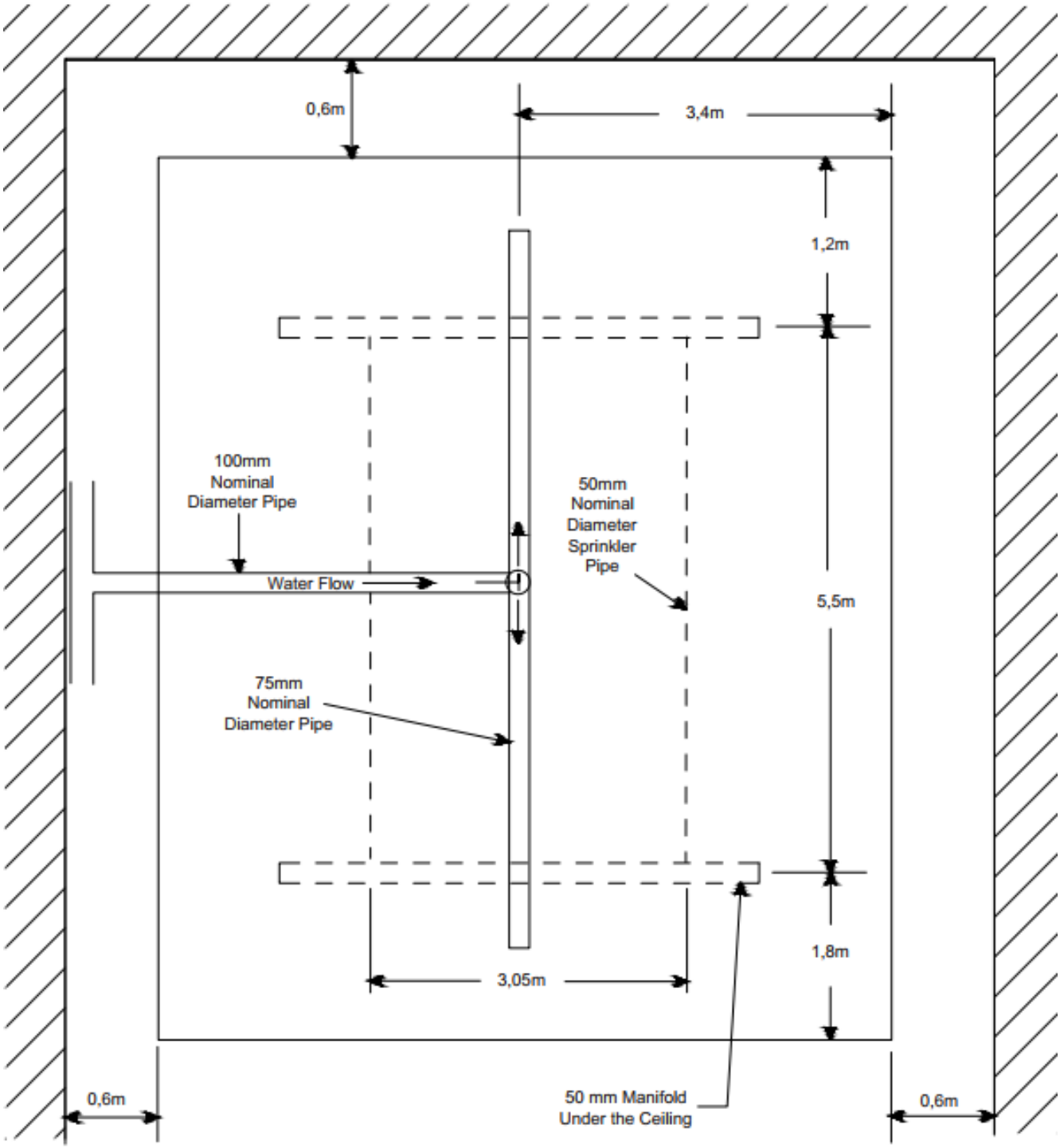


Figure B.1 Water distribution collection apparatus minimum enclosure dimensions (plan view)



Not to Scale

– — — – Indicates piping located below the ceiling

Figure B.2 Water distribution collection apparatus overhead piping configuration (plan view)

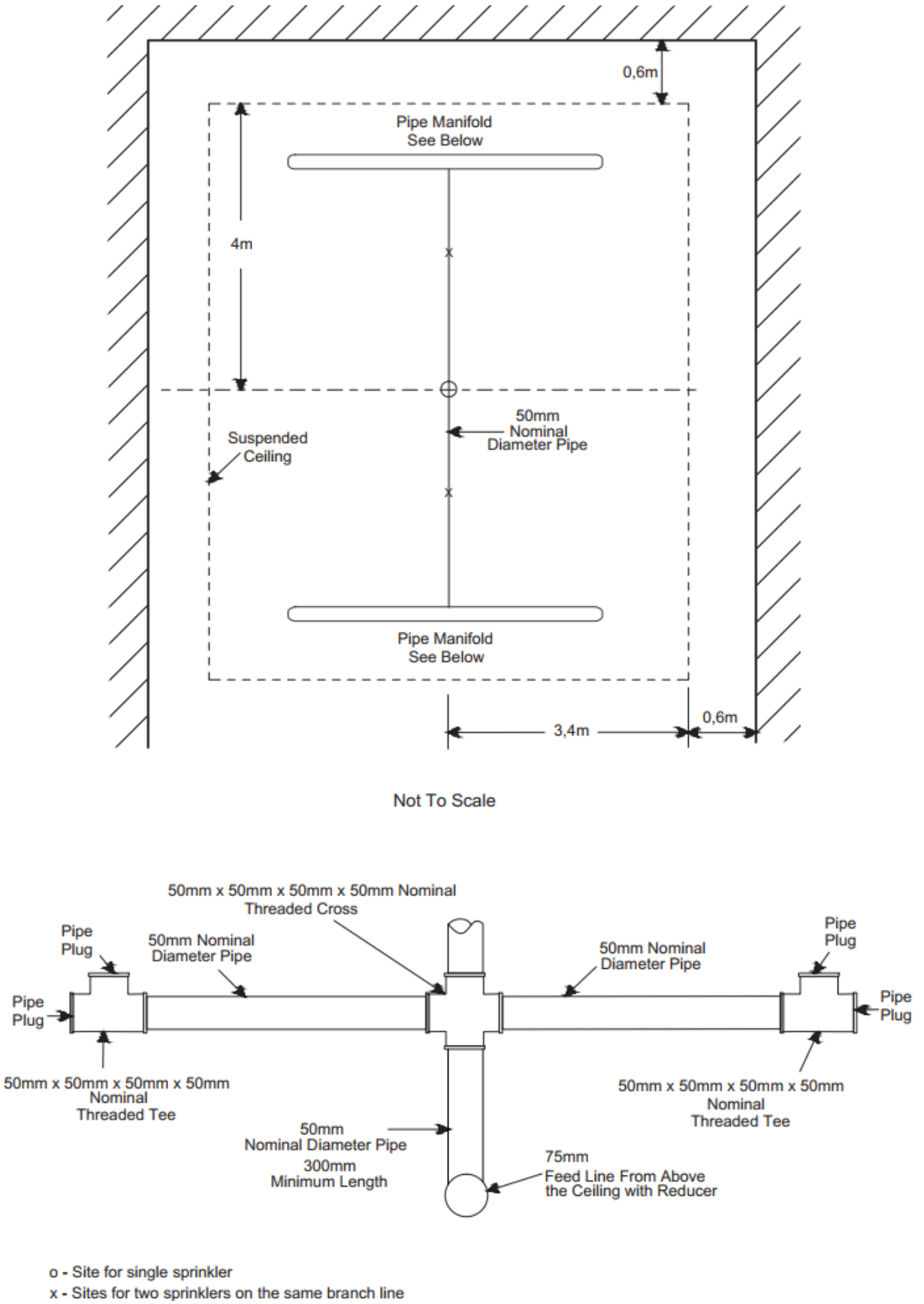


Figure B.3 Water distribution collection apparatus single sprinkler piping configuration (plan view)

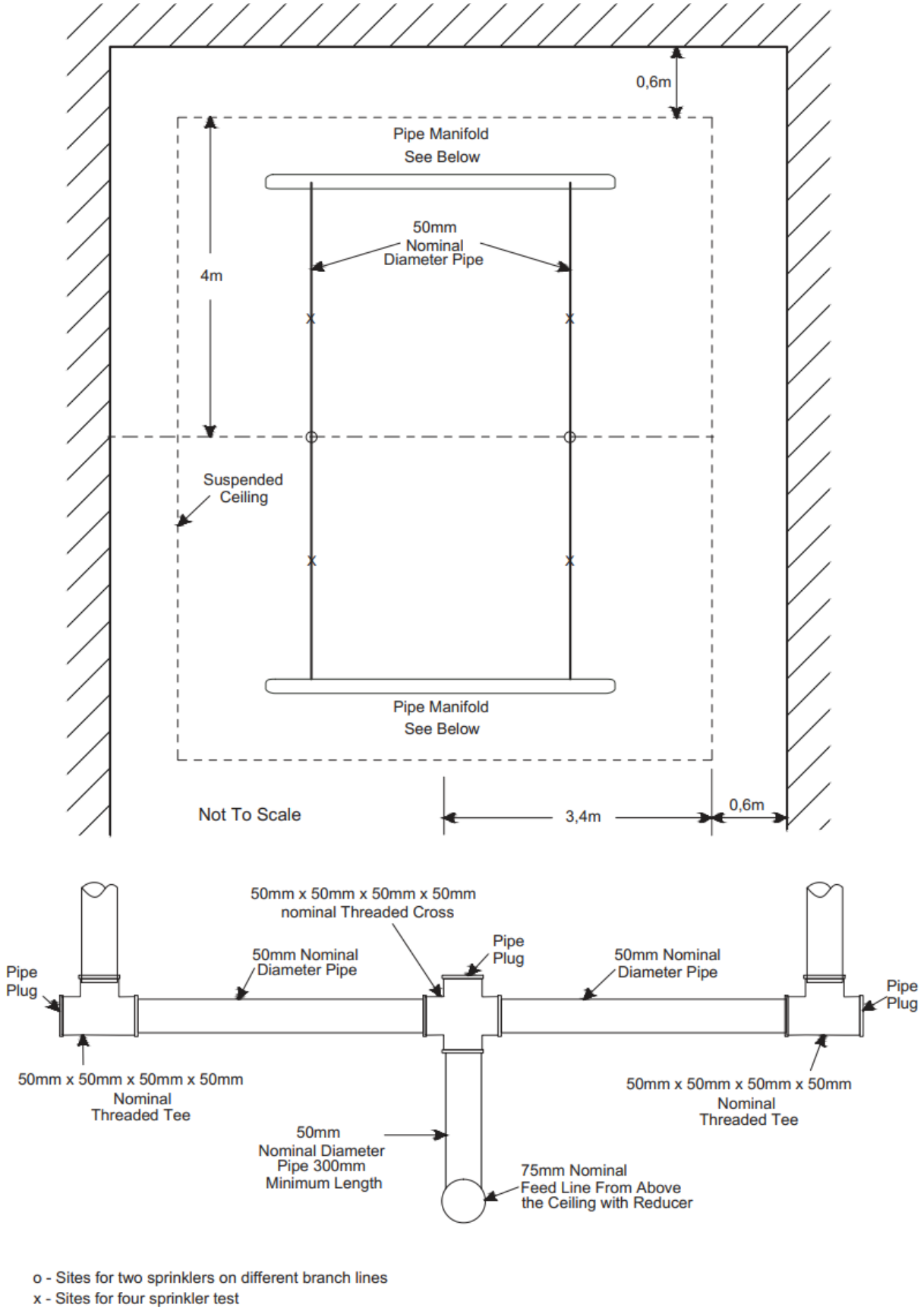


Figure B.4 Water distribution collection apparatus multiple sprinkler piping configuration (plan views)

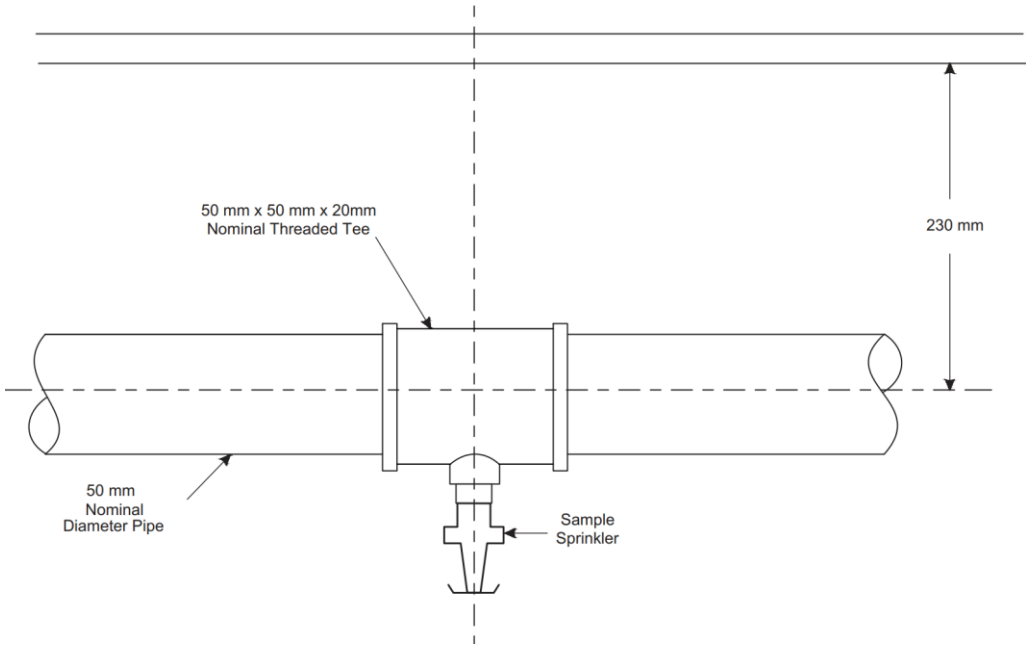


Figure B.5 Water distribution collection apparatus piping detail

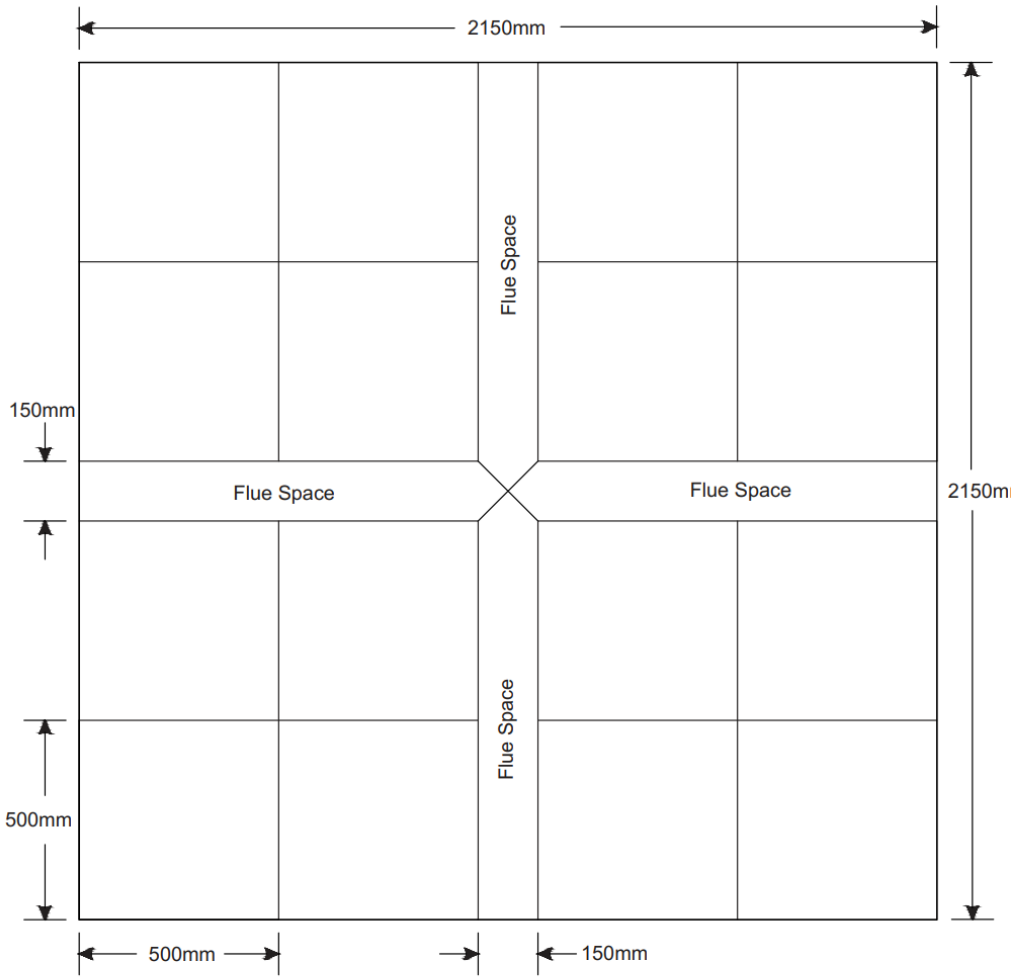
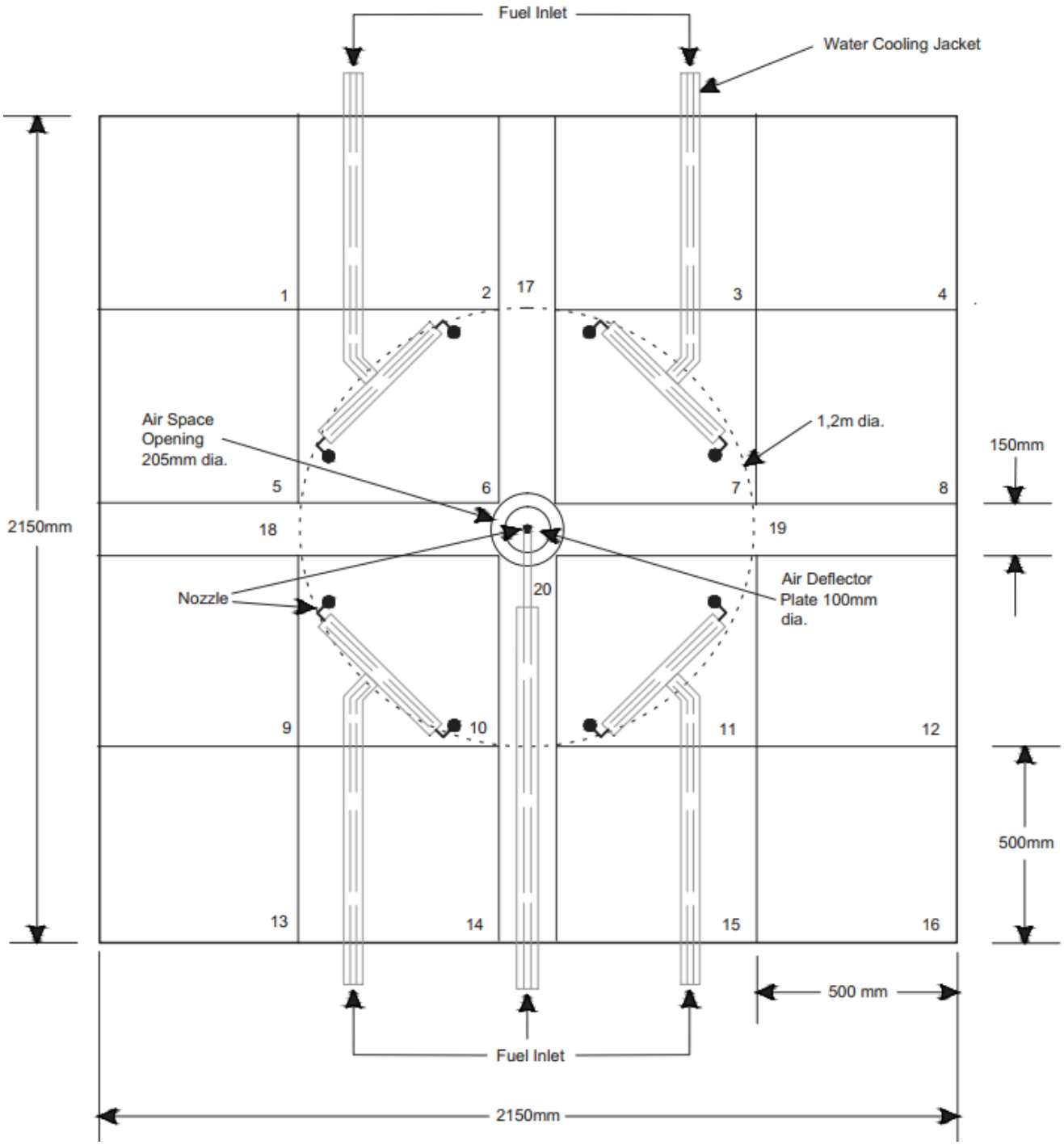


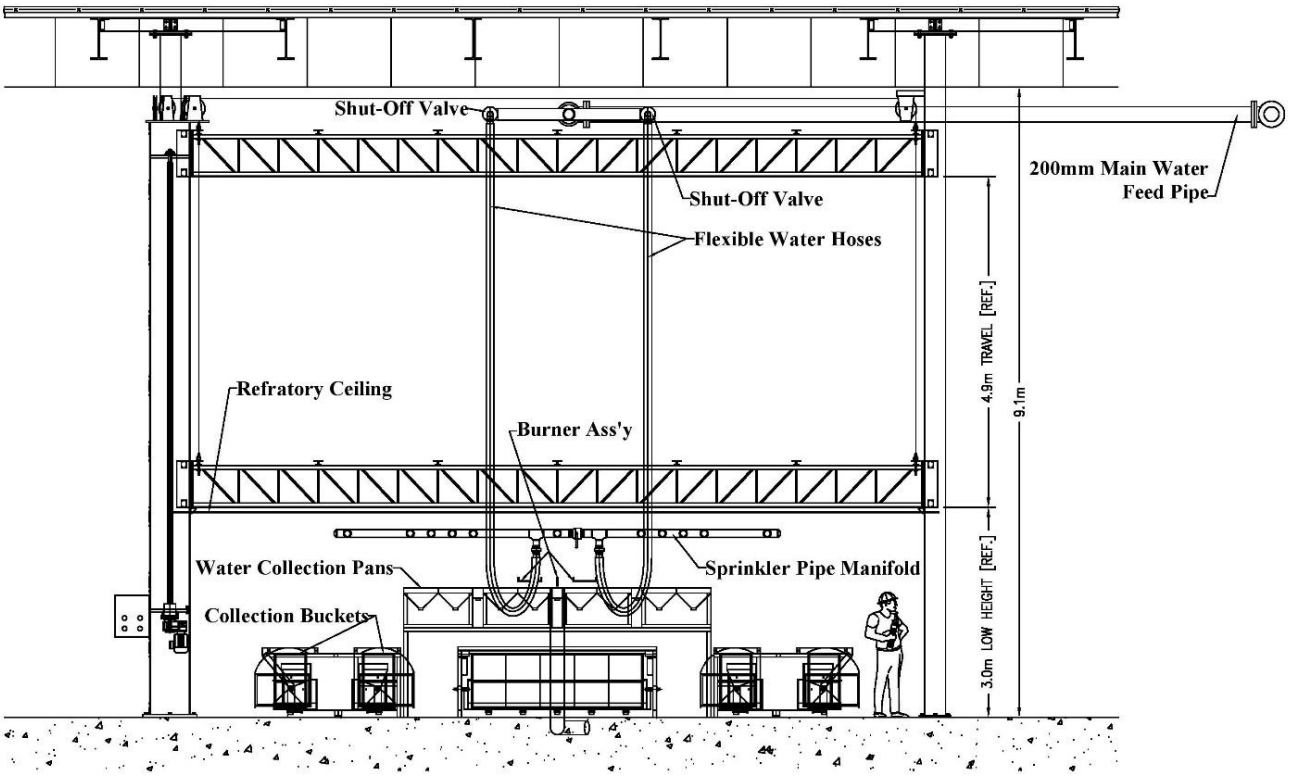
Figure B.6 Water distribution collection apparatus collection pan assembly

ANNEX C: ACTUAL DELIVERED DENSITY APPARATUS



Non-flue pans are numbered 1-16.
Flue pans are numbered 17-20.

Figure C.1 Actual delivered density apparatus – plan view



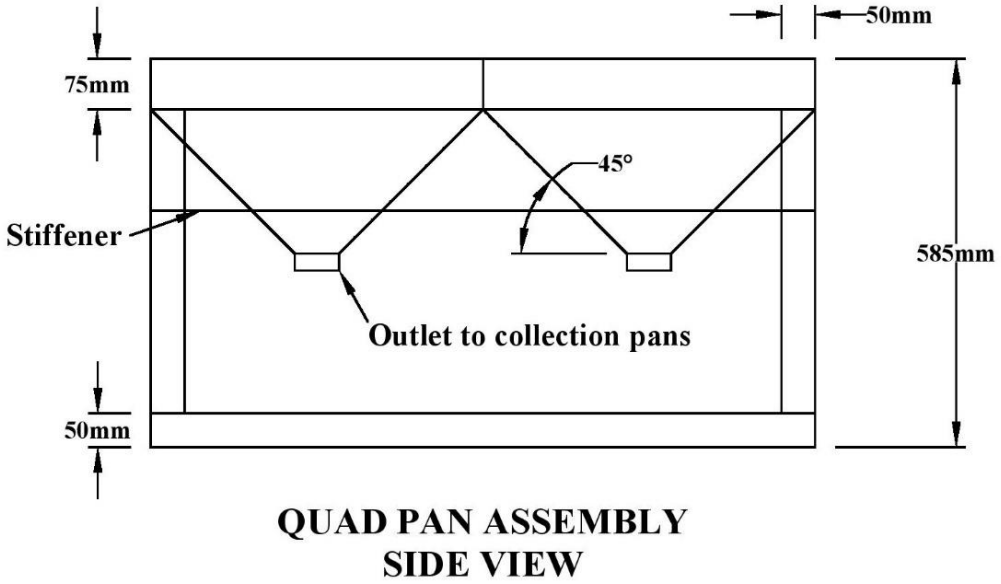


Figure C.2 Actual delivered density apparatus – elevation and side view of a quadrant consisting of four square pans

ANNEX D: TEST APPARATUS FOR MEASURING NOMINAL DISCHARGE COEFFICIENT

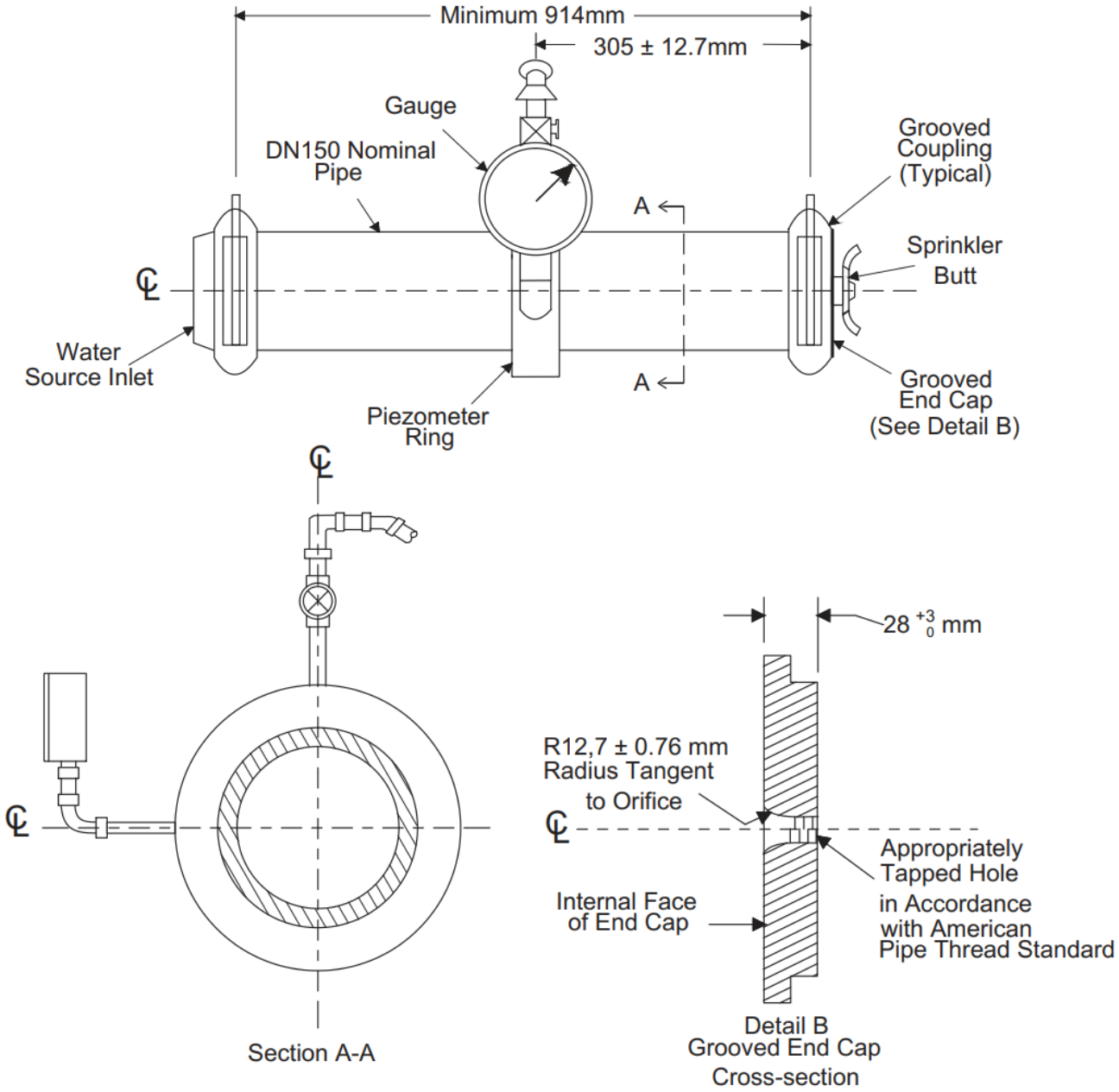
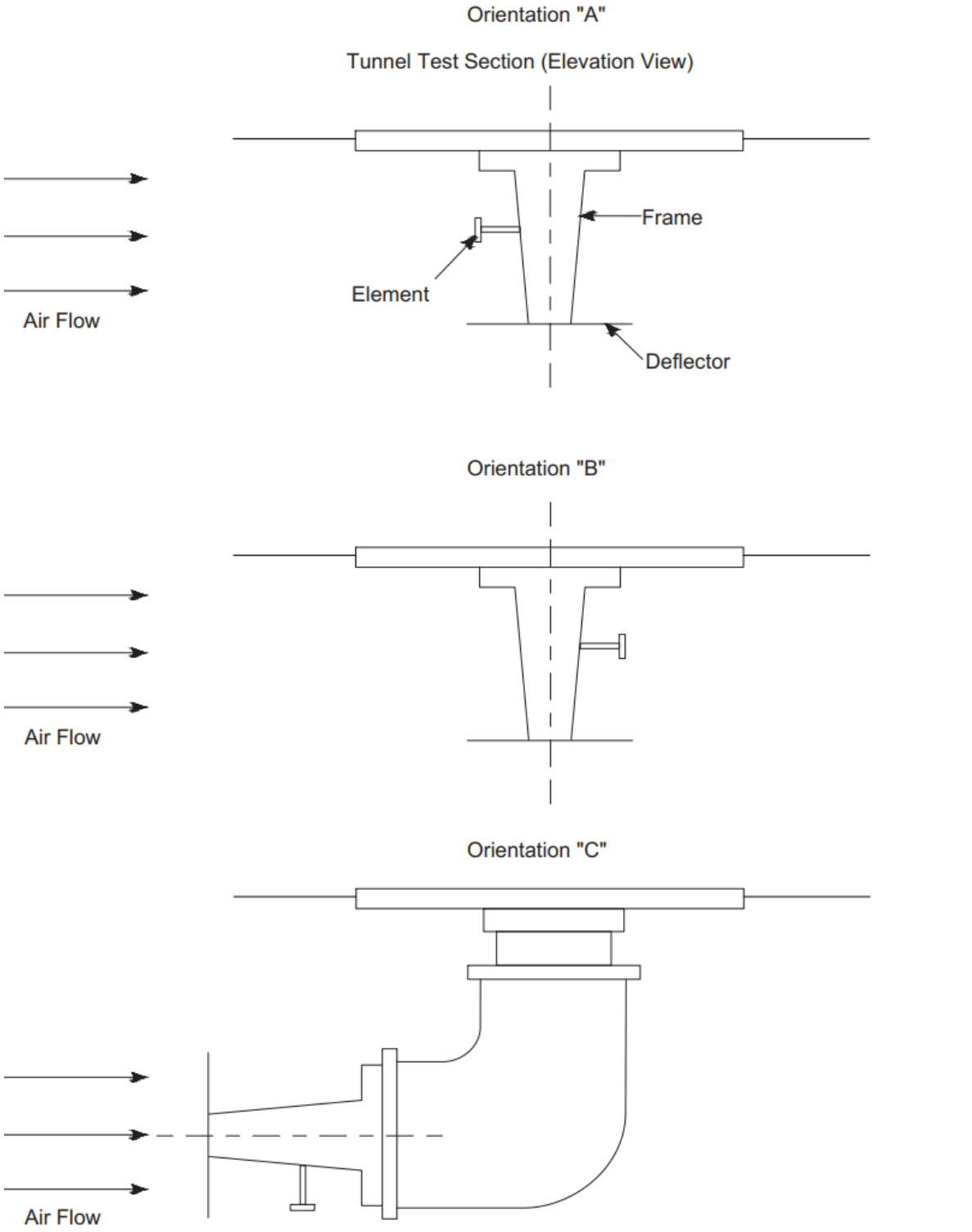


Figure D.1 Test apparatus for measuring nominal discharge coefficient (side and section views)

ANNEX E: RESPONSE DELAY (RESPONSE TIME)



Note: In the case where the sprinkler has a symmetrical heat responsive element and frame, position "A" would be the same as position "B". Testing in both positions is not required.

Figure E.1 Orientations A, B and C

ANNEX F: THRUST MEASUREMENT TEST APPARATUS

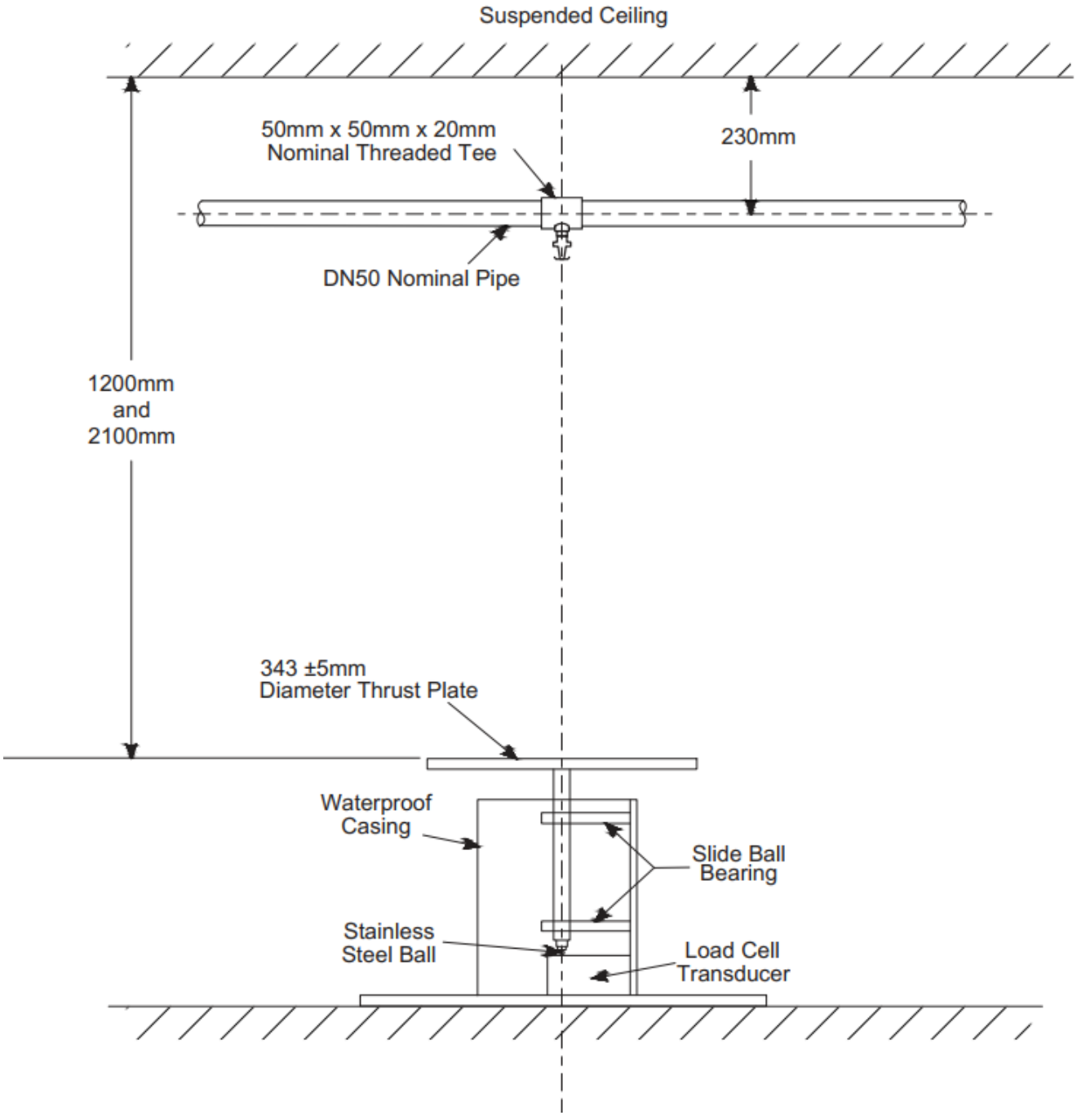


Figure F.1: Thrust measurement test apparatus (side view)