TECHNICAL SPECIFICATION

ISO/TS 20885

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Gaseous media fire-extinguishing systems — Area coverage fire test procedure — Engineered and pre-engineered extinguishing units

Systèmes d'extinction d'incendie utilisant des agents gazeux — Mode opératoire de couverture de la zone enflammée — Unités extinctrices centralisées et modulaires

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

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

ISO/TS 20885 was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 8, *Gaseous media fire extinguishing systems*.

Introduction

The need for the tests specified in this Technical Specification arises from the fact that the Class A fire test currently used, which employs wood crib, heptane pan and heptane can test fires in an enclosure of 100 m^3, may not indicate extinguishing concentrations suitable for the protection of plastics fuel hazards such as may be encountered in electronic data processing, telecommunications and process control facilities.

The test protocol which forms the subject of this Technical Specification was developed by a special working group of ISO/TC 21/SC 8. It comprises tests for determination of the extinguishing concentrations and system performance, and is designed to allow individual installers to use their system and to carry out all of the extinguishing tests themselves. Different extinguishing concentrations are proposed that may result from tests involving the same fuel/agent combination; in addition different nozzles and nozzle heights are used in order to reflect various room heights and fire behaviour. Owing to the fact that the given extinguishing concentrations for each agent are only dependent on fuel and not on the type of system, the working group proposes to separate the agent tests (determination of extinguishing concentrations) from the system tests.

In the future, ISO/TC 21/SC 8 intends to restructure the current Annex C of ISO 14520-1:2000, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 1: General requirements* to include polymeric sheet fuel arrays [polymethyl methacrylate (PMMA), polypropylene (PP) and acrylonitrile-butadiene-styrene (ABS)] and polyvinyl chloride (PVC) cable arrays (heptane pan ignited).

Gaseous media fire-extinguishing systems — Area coverage fire test procedure — Engineered and pre-engineered extinguishing units

1 Scope

This Technical Specification specifies a test method for determination of the extinguishing concentrations and system performance of engineered or pre-engineered extinguishing system units designed to mix and distribute the extinguishant, and to totally flood the enclosure.

It is designed to allow individual installers to use their system and to carry out all of the extinguishing tests themselves.

2 Application

2.1 When tested in accordance with the requirements contained in 5.1, 5.2 and 6.2, an extinguishing system unit shall extinguish all visible flaming within 30 s after the end of extinguishant discharge. When tested in accordance with the requirements contained in 6.1 an extinguishing system unit shall extinguish all visible flaming and prevent re-ignition of the fires after a 10 min soak period (also measured from the end of extinguishant discharge). When tested in accordance with the requirements contained in 6.3 and 6.4 an extinguishing system unit shall extinguish all visible flaming within 60 s after the end of extinguishant discharge. The system unit shall also prevent re-ignition of the fires after a 10 min soak period (also measured from the end of extinguishant discharge).

NOTE The 60 s time limit for “no flaming” is provisional. At the time of preparation of this Technical Specification there was no published information providing details of the manner of extinguishment of plastics fires test articles. One laboratory reports that upon discharge of an HFC agent at the same concentration which satisfactorily extinguishes the wood crib test article, the following behaviour of the plastic was observed.

a) The flame size was reduced within 1 min to a very small edge-effect flame measuring approximately 20 mm to 30 mm in size.

b) The time at which the edge-effect flame became extinguished varies but may be longer than 60 s.

c) The edge-effect flame on the plastic test articles is analogous to the persistent smouldering observed to be in effect during the post-flame-out period of the wood crib test (see 6.1.2 to 6.1.4).

d) The 10 min hold period allows the hot test article, wood or plastic, to cool to the point where the low-level combustion reactions cease.

2.2 The tests described in this Technical Specification take into consideration the intended use and limitations of the extinguishing system unit with specific reference to

a) the area coverage for each type of nozzle,

b) the operating temperature range of the system,

c) the location of nozzles in the protected area,

d) either the maximum length and size of piping and number of fittings to each nozzle, or the minimum nozzle pressure,

e) the maximum discharge time,

f) the maximum fill density, and

g) the extinguishing concentrations for specific fuels.

Details of the tests are given in Table 1.

Table 1 — Test objectives and details

Test objective	Enclosure size	Test fires	Subclause
Nozzle distribution verification			
Nozzles minimum height/maximum area coverage	to suit nozzle	heptane test cans	5.1
Nozzles maximum height	⩾100 m^3 no side less than 4 m in height, to suit nozzle	heptane test cans	5.2
Extinguishing concentration	⩾100 m^3 height, h: 3,5 m ⩽ h ⩽ 4 m	a) wood crib	6.1
		b) heptane	6.2
		c) polymeric sheet i) PMMA ii) PP iii) ABS	6.3
		d) PVC cable tray	6.4

3 Extinguishing system

3.1 For the extinguishing tests described in 5.1 and 5.2, the agent containers shall be conditioned to the minimum operating temperature specified in the manufacturer's installation instructions.

The extinguishing system shall be assembled as follows:

a) *pre-engineered-type extinguishing system unit* — using the maximum piping limitations with respect to the number of fittings and length of pipe to the discharge nozzles and nozzle configuration(s) as specified in the manufacturer's design and installation instructions;

b) *engineered-type extinguishing system unit* — using a piping arrangement that results in the minimum nozzle design pressure at 20 °C $^{+2}_{0}$ °C.

3.2 For the extinguishing tests described in 6.1, 6.2, 6.3 and 6.4, the agent containers shall be conditioned at 20 °C ± 2 °C for a minimum period of 16 h prior to conducting the test. In these tests the jet energy from the nozzles shall not influence the development of the fire. Therefore the nozzle(s) shall direct agent parallel to the test enclosure ceiling.

3.3 For all tests, the extinguishing system shall be arranged and dimensioned with regard to the following.

For liquefied extinguishants, the time for the discharge of the pre-liquid gas phase plus the two-phase flow shall be 8 s to 10 s.

For non-liquefied extinguishants, the discharge time shall be 50 s to 60 s, limited by cutting off the discharge with an appropriate means positioned close to the nozzle.

4 Extinguishing concentration

4.1 The extinguishing concentration for each test shall be 76,9 % (i.e. 100 divided by the safety factor, where the safety factor is 1,3) of the intended end use design concentration specified in the manufacturer's design and installation instructions at an ambient temperature of approximately 20 °C within the enclosure. In the tests described in 5.1 and 5.2, the same extinguishing concentration shall be used as in the test described in 6.2.

The quantity to reach the concentration within the enclosure can be established using Equation (1).

4.2 A cold discharge test using the same quantity of extinguishant shall be conducted to verify the actual concentration of extinguishant.

For liquefied extinguishants, the agent concentration shall be measured in the cold discharge test.

For non-liquefied extinguishants, the agent concentration or alternatively the oxygen concentration shall be measured. The extinguishant concentration is then calculated from the oxygen concentration using the following formula:

$$\varphi_{\mathrm{E}} = 100\left(1 - \frac{\varphi_{\mathrm{O_2}}}{20{,}9}\right) \quad (1)$$

where

φ_{E} is the extinguishant concentration, expressed as a volume fraction in percent;

$\varphi_{\mathrm{O_2}}$ is the oxygen concentration measured in the test enclosure, expressed as a volume fraction in percent.

5 Nozzle distribution verification tests

5.1 Nozzles minimum height/maximum area coverage test

5.1.1 Test facility

5.1.1.1 Construction

The test enclosure shall meet the following requirements.

a) The area (ab) and height (h) of the enclosure (see Figure 1) shall correspond to the maximum nozzle area coverage and minimum nozzle height respectively specified by the manufacturer.

b) A means of pressure relief shall be provided.

c) Closable openings shall be provided directly above the test cans to allow for venting prior to system actuation.

d) One baffle shall be installed between the floor and the ceiling (at height h), halfway between the nozzle location and one of the corners of the enclosure (Figure 1 illustrates a 360° nozzle and Figure 2 illustrates a 180° nozzle). The baffle shall be perpendicular to the line connecting the nozzle location and the enclosure corner (see Figures 1 and 2), and shall have a length equal to 20 % of the length of the short wall of the enclosure.

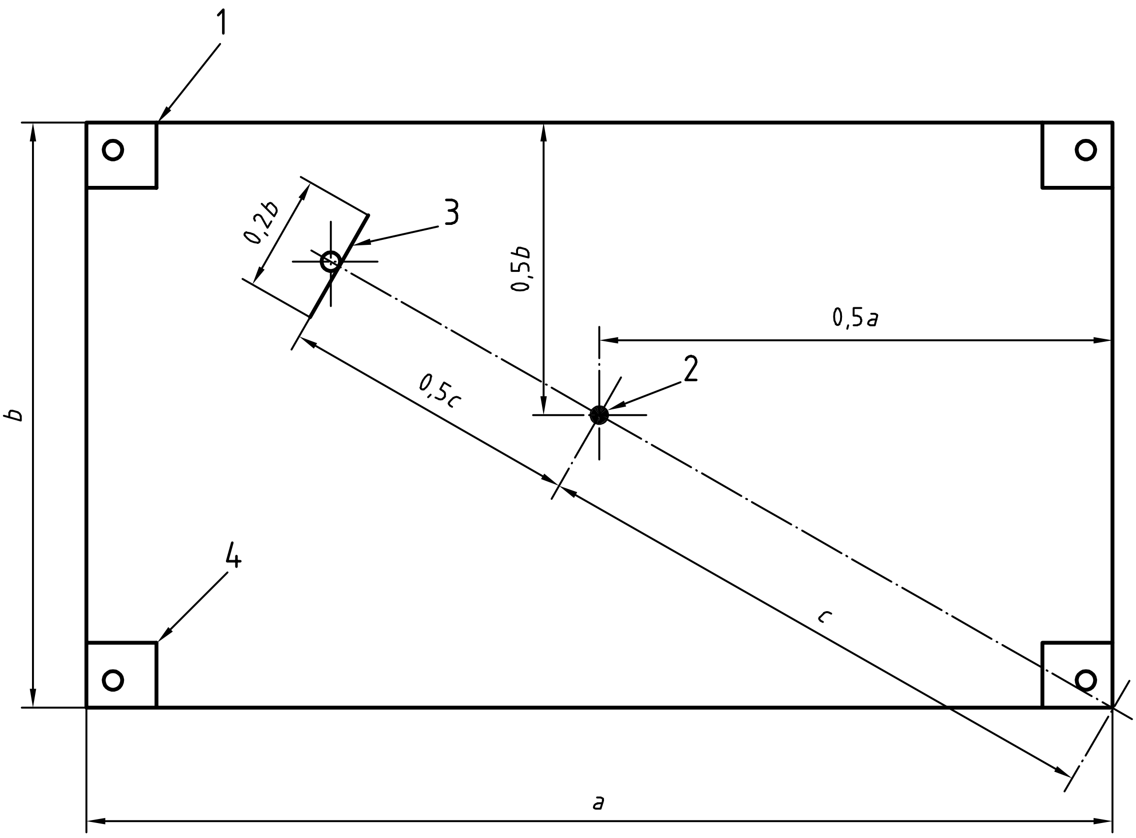
5.1.1.2 Instrumentation

5.1.1.2.1 Oxygen concentration

The sampling and storage of data from the sensors described in this subclause shall occur at a rate of at least 4 Hz.

The oxygen concentration shall be measured using a calibrated oxygen analyser capable of measuring the percentage oxygen to within at least one decimal place (0,1 %). The sensing equipment shall be capable of continuously monitoring and recording the oxygen concentration inside the enclosure throughout the duration of the test. The accuracy of the measuring devices shall not be influenced by any of the fire products.

Three sensors shall be located within the enclosure (see Figure 3). They shall be located at a distance of 850 mm to 1 250 mm from the centre of the room and at the following heights above the floor: 0,1h, 0,5h and 0,9h (where h is the height of the enclosure).



Key

h minimum nozzle height specified by manufacturer

ab maximum nozzle area coverage for a single nozzle

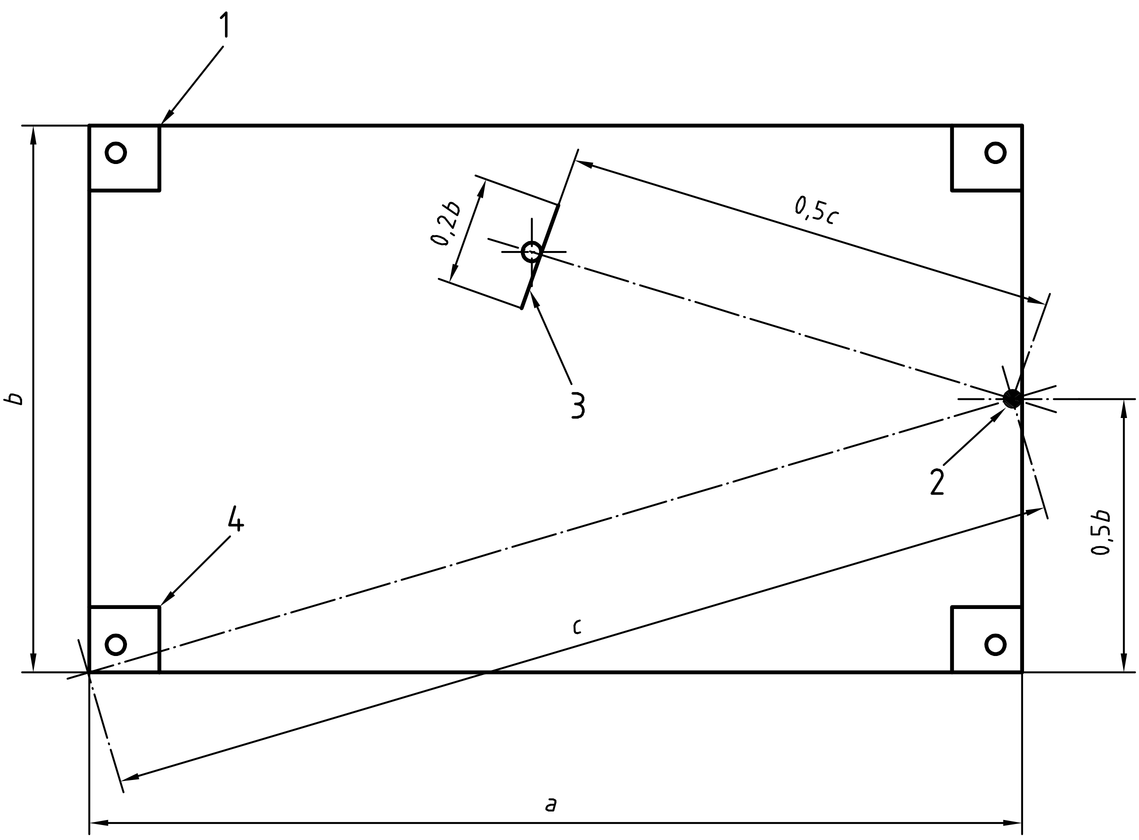
1 test cans

2 nozzle

3 baffle

4 vents

Figure 1 — Example configuration for nozzles minimum height/maximum area coverage test for 360° nozzles



Key

h minimum nozzle height specified by manufacturer

ab maximum nozzle area coverage for a single nozzle

1 test cans

2 nozzle

3 baffle

4 vents

Figure 2 — Example configuration for nozzles minimum height/maximum area coverage test for 180° nozzles

5.1.1.2.2 Carbon dioxide (CO_2) and carbon monoxide (CO) concentration

The CO_2 concentration should be monitored.

Fire products such as CO and CO_2 shall not influence the evaluation of the extinguishing capacity of the investigated extinguishing gas.

5.1.1.2.3 Nozzle pressure

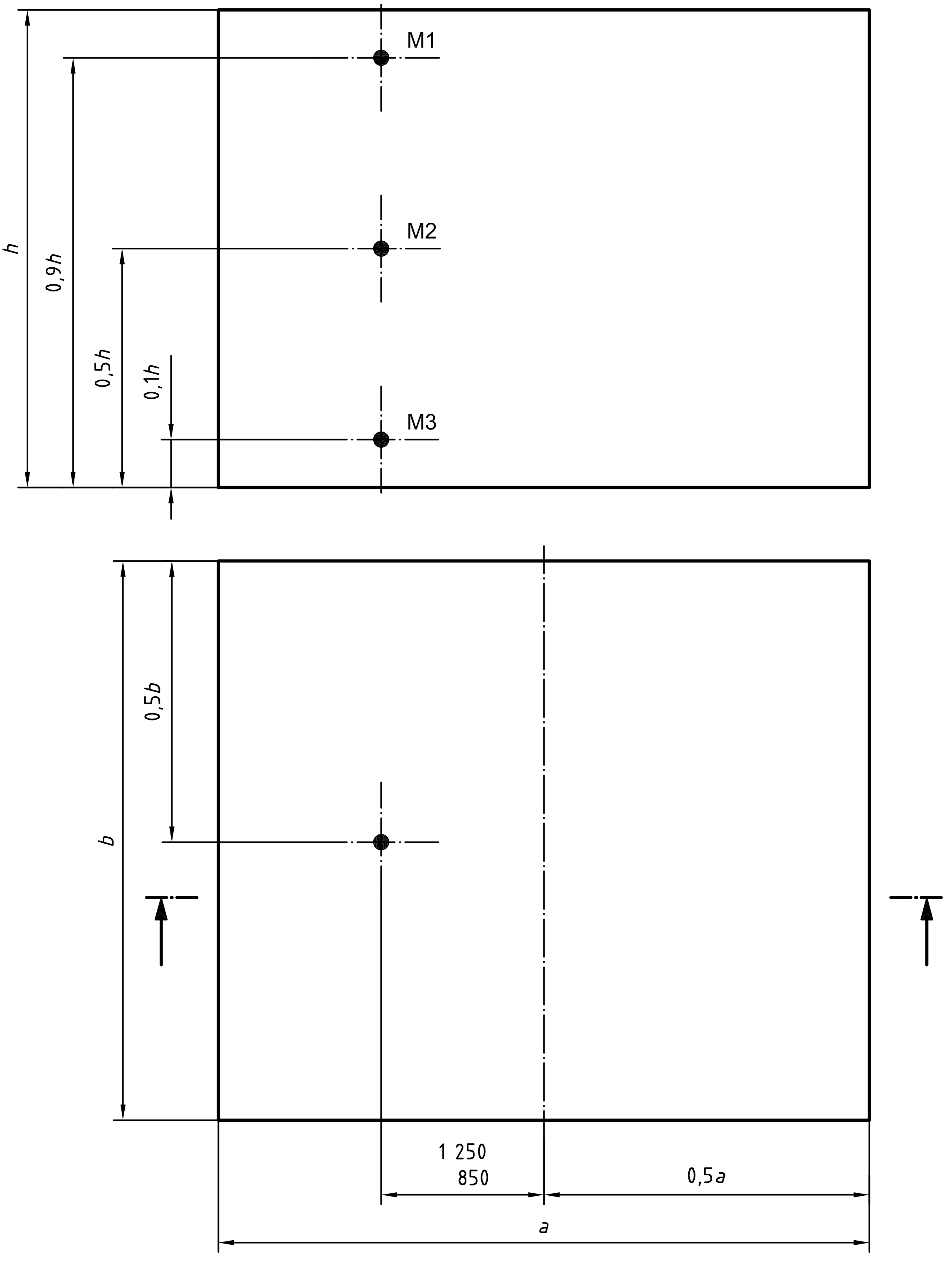
The nozzle pressure during system discharge shall be recorded by a pressure transducer in the pipe work at a distance not greater than 1 m from the nozzle.

5.1.1.2.4 Enclosure temperature

The temperature shall be measure at a position located 850 mm to 1 250 mm horizontally from the centre of the room and at a height 0,5*h* above the floor (see Figure 3).

It is recommended to use K-type thermocouples (Ni-CrNi) of 1 mm diameter.

Dimensions in millimetres



Measuring points:

M1 record O_2 concentration

M2 record O_2 concentration and temperature

M3 record O_2 concentration

Figure 3 — Instrumentation placement for nozzles minimum height/maximum area coverage test

5.1.1.2.5 Nozzle temperature

For liquefied extinguishants, the temperature of the liquid jet just outside the nozzle shall be recorded.

Cameras, e.g. infrared-cameras, or an alternative means of directly viewing the fire can be useful as an aid to determining flame-out times. A thermocouple may be located centrally 30 mm above each test can to provide additional information.

5.1.2 Fuel specification

5.1.2.1 Test cans

The test cans shall be cylindrical, 80 mm ± 5 mm in diameter, at least 100 mm high and made of mild or stainless steel with a thickness of 5 mm to 6 mm.

5.1.2.2 Heptane

The heptane shall be commercial grade with the following characteristics:

a) distillation:

   1) initial boiling point: 90 °C

   2) 50 %: 93 °C

   3) dry point: 96,5 °C

b) density (15,6 °C): 700 kg/m^3 ± 50 kg/m^3

5.1.2.3 Fire configuration and placement

The test cans shall contain either heptane or heptane and water. For test cans containing heptane and water, the heptane shall be at least 50 mm deep. The level of heptane in the cans shall be at least 50 mm below the top of the can.

As a minimum, one test can shall be placed in either the four top or the four bottom corners of the test enclosure at a maximum perpendicular distance of 50 mm to the two adjacent sides and an additional test can shall be positioned directly behind the baffle (see Figures 1 and 2). The cans shall be located vertically within 300 mm of the top or the bottom of the enclosure. If the enclosure permits such placement, two test cans may be placed in each of the corners as specified above; in this case one test can shall be located vertically within 300 mm of the top of the enclosure and the other test can within 300 mm of the bottom.

5.1.3 Test procedure

5.1.3.1 Operation

Prior to commencing the test, analyse the composition of the extinguishing gas.

Ignite the heptane-filled test cans and allow them to burn for 30 s with the closable openings facing upwards in the open position.

After 30 s close all openings and actuate manually the extinguishing system. At the time of actuation of the system, the volume fraction of oxygen within the enclosure shall be not more than 0,5 % lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change more than 1,5 % owing to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the oxygen concentration measured in this test (averaged over the three sensors).

5.1.3.2 Results recording

After the required pre-burn period, record the following data for each test:

a) the calculated discharge time of extinguishant, i.e. the time needed to reach 95 % of the laboratory extinguishant concentration, in seconds;

b) the effective discharge time — for liquefied extinguishants, the time of the pre-liquid gas phase plus the time of the two-phase flow (the discharge time for liquefied extinguishants has to be determined by nozzle pressure, nozzle temperature or a combination of both); for non-liquefied extinguishants, the time from opening the container valve(s) to cutting off the discharge;

c) the time required to achieve extinguishment, in seconds, determined by visual observation or other suitable means;

d) the total mass of extinguishant discharged into the test enclosure.

5.1.4 Determination of distribution performance of the nozzle

Using the extinguishing concentration for heptane, determined in accordance with 6.2.4, all test cans shall be extinguished within 30 s after the end of agent discharge.

As an alternative to the use of the heptane steel cans, the concentration of the extinguishing agent (or for non-liquefied gases, the oxygen concentration) can be measured at the locations specified for steel test cans. The concentration shall be measured at each location and shall be at least the extinguishing concentration, to be reached within 30 s after the end of discharge time.

5.2 Nozzles maximum height test

5.2.1 Test facility

5.2.1.1 Construction

The test enclosure shall meet the following requirements.

a) The test enclosure shall have a minimum volume of 100 m^3. The height shall be at least 3,5 m. The floor dimensions shall be at least 4 m wide by 4 m long. The test enclosure shall have a maximum ceiling height as specified in the manufacturer's installation instructions.

b) A means of pressure relief shall be provided.

c) Closable openings shall be provided directly above the test cans to allow for venting prior to system actuation.

d) One baffle shall be installed between the floor and the ceiling (at height h), halfway between the nozzle location and one of the corners of the enclosure (Figure 1 illustrates a 360° nozzle and Figure 2 illustrates a 180° nozzle). The baffle shall be perpendicular to the line connecting the nozzle location and the enclosure corner (see Figures 1 and 2), and shall have a length equal to 20 % of the length of the short wall of the enclosure.

5.2.1.2 Instrumentation

The instrumentation of the enclosure shall be as described in 5.1.1.2.

5.2.2 Fuel specification

5.2.2.1 Test cans

The test cans shall be as described in 5.1.2.1.

5.2.2.2 Heptane

The heptane shall be commercial grade as specified in 5.1.2.2.

5.2.2.3 Fire configuration and placement

The test can filling requirements and placement within the enclosure shall be as described in 5.1.2.3.

5.2.3 Test procedure

5.2.3.1 Operation

The operation shall be as specified in 5.1.3.1.

5.2.3.2 Results recording

Record the results as specified in 5.1.3.2.

5.2.4 Determination of distribution performance of the nozzle

Determine the distribution performance of the nozzle as specified in 5.1.4.

6 Extinguishing concentration tests

6.1 Wood crib test

6.1.1 Test facility

6.1.1.1 Construction

The test enclosure shall meet the following requirements.

a) The test enclosure shall have a minimum volume of 100 m^3. The height shall be at least 3,5 m, and 4 m maximum. The floor dimensions shall be at least 4 m wide by 4 m long.

b) A means of pressure relief shall be provided.

6.1.1.2 Instrumentation

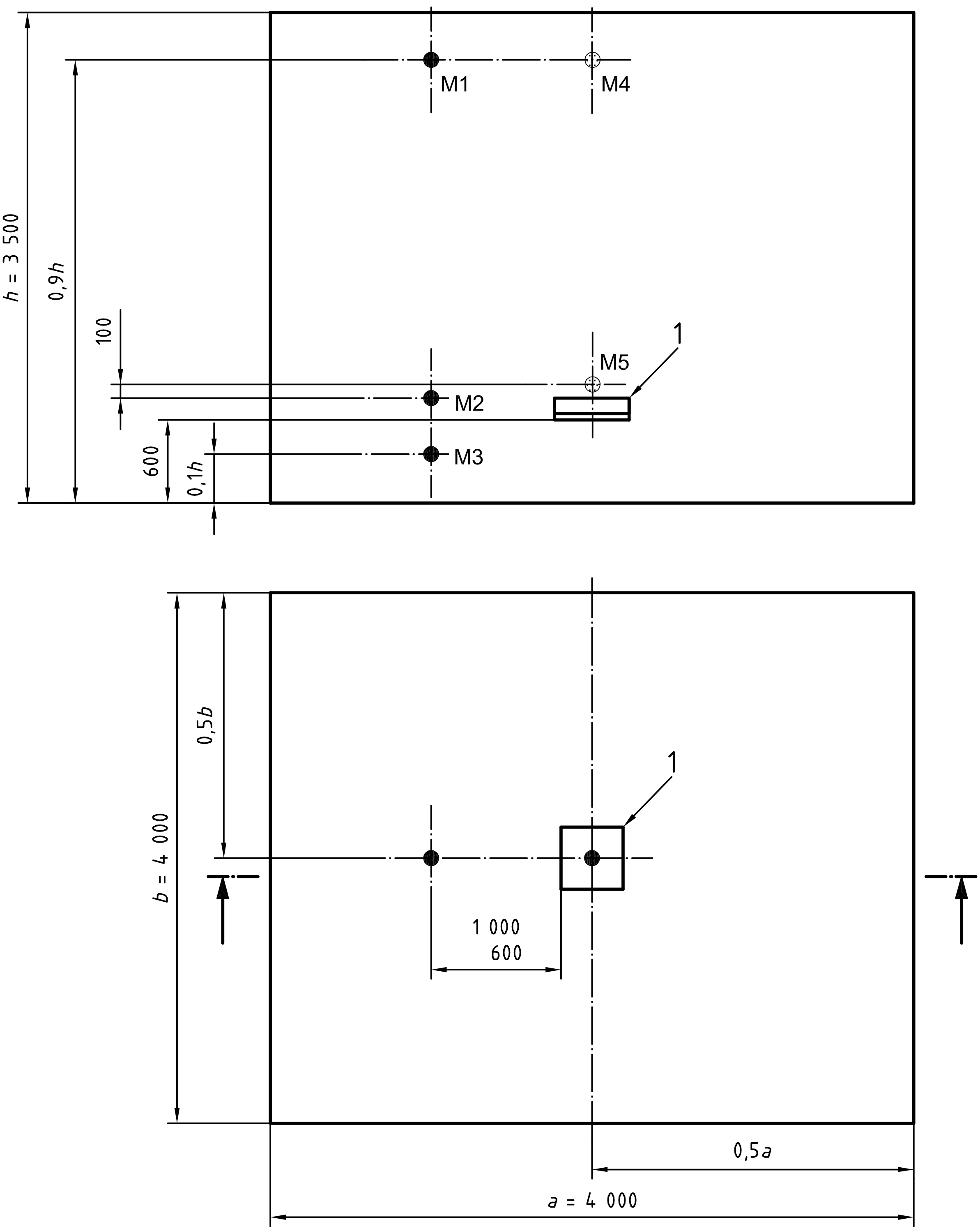
6.1.1.2.1 Oxygen concentrations

The sampling and storage of data from the sensors described in this subclause shall occur at a rate of at least 4 Hz.

The oxygen concentration shall be measured using a calibrated oxygen analyser capable of measuring the percentage oxygen to within at least one decimal place (0,1 %). The sensing equipment shall be capable of continuously monitoring and recording the oxygen concentration inside the enclosure throughout the duration of the test. The accuracy of the measuring devices shall not be influenced by any of the fire products.

Three sensors shall be located within the enclosure (see Figure 4). One sensor shall be located at the equivalent height of the top of the test object from the floor, at a horizontal distance 600 m to 1 000 m from the test object. The other two sensors shall be located at 0,1h and 0,9h (where h is the height of the enclosure) (see Figure 4).

Dimensions in millimetres



Key

1 test object

Measuring points:

M1 record O_2 concentration

M2 record O_2 concentration and temperature

M3 record O_2 concentration

M4 record temperature

M5 record temperature

Figure 4 — Instrumentation placement for the extinguishing concentration test

6.1.1.2.2 CO_2 and CO concentration

The CO_2 concentration should be monitored.

Fire products such as CO and CO_2 shall not influence the evaluation of the extinguishing capacity of the investigated extinguishing gas.

6.1.1.2.3 Nozzle pressure

The nozzle pressure during system discharge shall be recorded by a pressure transducer in the pipe work at a distance not greater than 1 m from the nozzle.

6.1.1.2.4 Enclosure temperature

Two temperature sensors shall be centred above the test object, at a height of 100 mm above the test object and 0,9h (h is the height of the enclosure) above the floor. A third sensor shall be located at the equivalent height of the top of the test object from the floor, at a horizontal distance of 600 m to 1 000 mm from the test object (see Figure 4).

It is recommended to use K-type thermocouples (Ni-CrNi) of 1 mm diameter.

6.1.1.2.5 Near-nozzle temperature

For liquefied extinguishants, the temperature of the liquid jet just outside the nozzle shall be recorded.

Cameras, e.g. infrared-cameras, or an alternative means of directly viewing the fire can be useful as an aid to determining flame-out times.

6.1.2 Fuel specification

6.1.2.1 Crib igniter fuel

Ignition of the crib is achieved by burning 1,5 l of commercial grade heptane (as specified in 5.1.2.2) on a 12,5 l layer of water in a square steel pan 0,25 m^2 in area, 100 mm in height and with a wall thickness of 6 mm (see Figure 5).

6.1.2.2 Fire configuration and placement

The wood crib shall consist of four layers of six, approximately 40 mm × 40 mm by 450 mm ± 50 mm long, kiln spruce or fir lumber having a moisture content between 9 % and 13 %. Place alternate layers of wood members at right angles to one another. Evenly space the individual wood members in each layer, forming a square determined by the specified length of the wood members. Staple or nail together the wood members forming the outside edges of the crib.

The crib shall be pre-burned outside the enclosure on a stand supporting the crib 300 mm above the pan holding the igniter fuel (see 6.1.3.1.2).

After the pre-burn period the crib shall be moved into the enclosure and located on a stand supporting the crib centrally within the enclosure with the base of the crib 600 mm above the floor (see 6.1.3.1.3).

6.1.3 Test procedure

6.1.3.1 Operation

6.1.3.1.1 Prior to commencing the test, analyse the composition of the extinguishing gas. Record the weight and the moisture content of the crib prior to the test.

Dimensions in millimetres

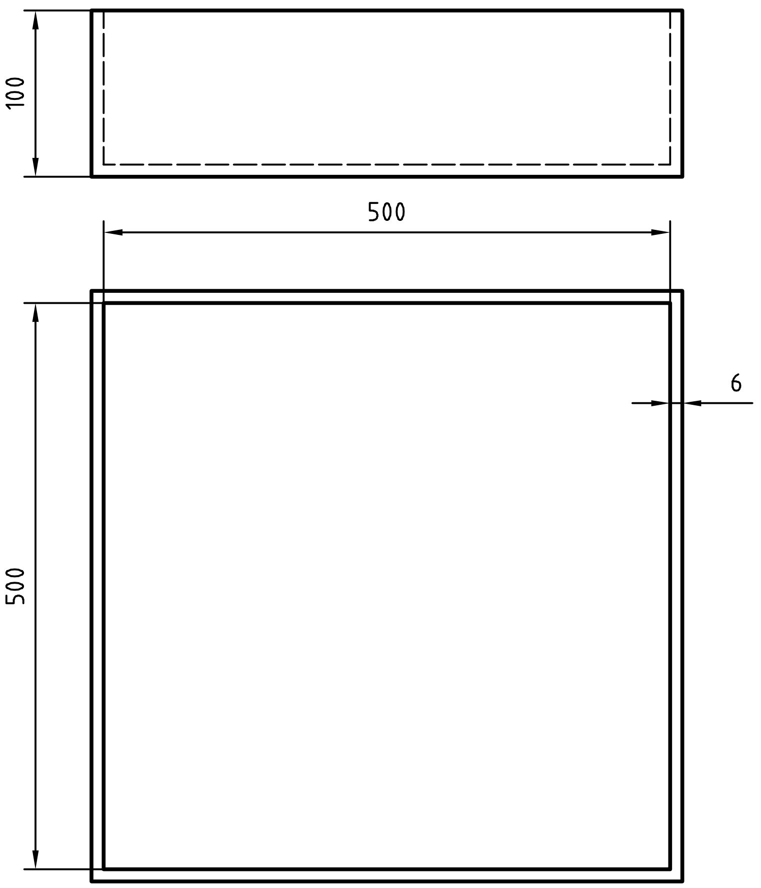


Figure 5 — Pan dimensions for wood crib and heptane pan fire test

6.1.3.1.2 Centre the crib with the bottom of the crib approximately 300 mm above the top of the pan on a test stand constructed so as to allow for the bottom of the crib to be exposed to the atmosphere. Carry out the pre-burning outside the enclosure, if possible in a sufficiently dimensioned room (at least five times the volume of the enclosure). Ensure that the pre-burning is not influenced by weather conditions such as rain, wind, sun, etc. The maximum wind speed in the proximity of the fire shall be 3 m/s. If necessary, use adequate means for protection against wind, etc. Record the weather conditions, including the location of the pre-burn, and the air temperature, humidity and wind speed.

Ignite the heptane and allow the crib to burn freely. The 1,5 l of heptane will provide a burn time of approximately 3 min. After the heptane is exhausted, allow the crib to burn freely for an additional period of 3 min, resulting in a total pre-burn time of 6 min $^{+10}_{\ 0}$ s outside the test enclosure.

6.1.3.1.3 Just prior to the end of the pre-burn period, move the crib into the test enclosure and place it on a stand such that the bottom of the crib is 600 mm above the floor. Seal the enclosure and actuate the system. The time required to position the burning crib in the enclosure and the actuation of the system discharge shall not exceed 15 s.

6.1.3.1.4 At the time of actuation of the system, the volume fraction of oxygen within the enclosure at the level of the crib shall be not more than 0,5 % lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change more than 1,5 % owing to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the oxygen concentration measured in this test (averaged values).

6.1.3.1.5 From the end of system discharge, leave the enclosure sealed for a total of 10 min. After the soak period, remove the crib from the enclosure and observe whether sufficient fuel remains to sustain combustion and check for signs of re-ignition. Record the following:

a) the presence and location of burning embers,

b) whether or not the glowing embers or crib re-ignites;

c) the weight of the crib after the test.

6.1.3.1.6 If necessary, amend the extinguishant concentration and repeat the experimental programme until three successive successful extinguishments are achieved.

6.1.3.2 Results recording

After the required pre-burn period, record the following data for each test:

a) the calculated discharge time of extinguishant, i.e. the time needed to reach 95 % of the laboratory extinguishant concentration, in seconds;

b) the effective discharge time — for liquefied extinguishants, the time of the pre-liquid gas phase plus the time of the two-phase flow (the discharge time for liquefied extinguishants has to be determined by nozzle pressure, nozzle temperature or a combination of both); for non-liquefied extinguishants, the time from opening the container valve(s) to cutting off the discharge;

c) the time required to achieve extinguishment, in seconds, determined by visual observation or other suitable means;

d) the total mass of extinguishant discharged into the test enclosure;

e) the soaking time (the time from the end of system discharge until the opening of the test enclosure).

It is recommended to record the temperature profile of the wood crib, using an infrared camera.

6.1.4 Determination of design extinguishant concentration

The laboratory extinguishant concentration is that concentration which achieves satisfactory extinguishment of the fire over three successive tests (no re-ignition or existence of burning embers after 10 min after end of discharge). The design concentration is the laboratory concentration multiplied by an appropriate safety factor.

6.2 Heptane pan test

6.2.1 Test facility

6.2.1.1 Construction

The test enclosure shall be constructed as described in 6.1.1.1.

6.2.1.2 Instrumentation

The instrumentation of the enclosure shall be as described in 6.1.1.2.

6.2.2 Fuel specification

6.2.2.1 Heptane

The heptane shall be commercial grade as specified in 5.1.2.2.

6.2.2.2 Fire configuration and placement

The fire shall comprise a square steel pan of 0,25 m^2 in area, 100 mm in height with a wall thickness of 6 mm as specified in 6.1.2.1. The test pan shall contain 12,5 l of heptane. The heptane surface is then 50 mm below the top of the test pan.

The steel pan shall be located in the centre of the test enclosure with the bottom 600 mm above the floor of the test enclosure.

6.2.3 Test procedure

6.2.3.1 Operation

Prior to commencing the test, analyse the composition of the extinguishing gas.

Ignite the heptane and allow it to burn for 30 s.

After 30 s close all openings and actuate manually the extinguishing system. At the time of actuation of the system, the volume fraction of oxygen within the enclosure shall be not more than 0,5 % lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change more than 1,5 % owing to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the oxygen concentration measured in this test (averaged values).

If necessary, amend the extinguishant concentration and repeat the experimental programme until three successive successful extinguishments are achieved.

6.2.3.2 Results recording

Record the results as specified in 6.1.3.2 a) to d).

6.2.4 Determination of design extinguishant concentration

The laboratory extinguishant concentration is that concentration which achieves satisfactory extinguishment of the fire over three successive tests (no flaming 30 s after the end of extinguishant discharge). The design concentration is the laboratory concentration multiplied by an appropriate safety factor.

NOTE Practitioners of this test method are invited to comment on the need to retain the flame-out time as a pass-fail criterion, and if so to advise what flame-out time is deemed appropriate.

6.3 Polymeric sheet fire test

6.3.1 Test facility

6.3.1.1 Construction

The test enclosure shall be constructed as described in 6.1.1.1.

6.3.1.2 Instrumentation

The instrumentation of the enclosure shall be as described in 6.1.1.2.

6.3.2 Fuel specification

6.3.2.1 Igniter fuel

The ignition source shall be a heptane pan (constructed of 2 mm thick mild or stainless steel), 51 mm × 112 mm and 21 mm deep, centred 12 mm below the bottom of the plastic sheets (see Figure 6). The 51 mm side of the pan shall be orientated parallel to the sheets of polymeric fuel. The pan shall be filled with 6 ml of commercial grade heptane (as specified in 5.1.2.2) on a water base of 40 ml.

6.3.2.2 Polymeric fuel

Tests shall be conducted with three plastics fuels:

- polymethyl methacrylate (PMMA);
- polypropylene (PP);
- acrylonitrile-butadiene-styrene polymer (ABS).

The plastics properties are given in Table 2.

Table 2 — Plastics properties for 25 kW/m^2 exposure in cone calorimeter

Fuel	Colour	Density	Ignition time, s		180 s average Heat release rate, kW/m^2		Effective Heat of combustion, MJ/kg	
		g/cm^3	nom.	tol.	nom.	tol.	nom.	tol.
PMMA	Black	1,19	77	± 30 %	286	25 %	23,3	± 25 %
PP	Natural (white)	0,905	91	± 30 %	225	25 %	39,6	± 25 %
ABS	Natural (cream)	1,04	115	± 30 %	484	25 %	29,1	± 25 %

6.3.2.3 Polymeric fuel array

The polymeric fuel array shall consist of four sheets of polymer, 9,5 mm thick, 405 mm high, and 200 mm wide. The sheets shall be spaced and located as shown in Figure 6. The bottom of the fuel array shall be located 203 mm from the floor. The fuel sheets shall be fixed mechanically at the required spacing. The sheets of plastic shall not bend significantly during the test.

The fuel array shall be located centrally within the enclosure.

6.3.2.4 Fuel shield

A fuel shield consisting of a metal frame made from sheet metal on the top (610 mm × 380 mm) and two sides (610 mm wide × 850 mm high) shall be provided around the fuel array as illustrated in Figure 6. The two remaining sides and bottom shall be open.

The sheet metal shall be aluminium with a thickness of 2 mm to 3 mm.

The fuel array is oriented in the fuel shield such that the 200 mm dimension of the fuel array is parallel to the 610 mm side of the fuel shield.

6.3.2.5 External baffles

External baffles, constructed as shown in Figure 7, shall be located around the exterior of the fuel shield. The baffles shall be placed 90 mm above the floor. The top baffle shall be rotated 45° with respect to the bottom baffle.

6.3.3 Test procedure

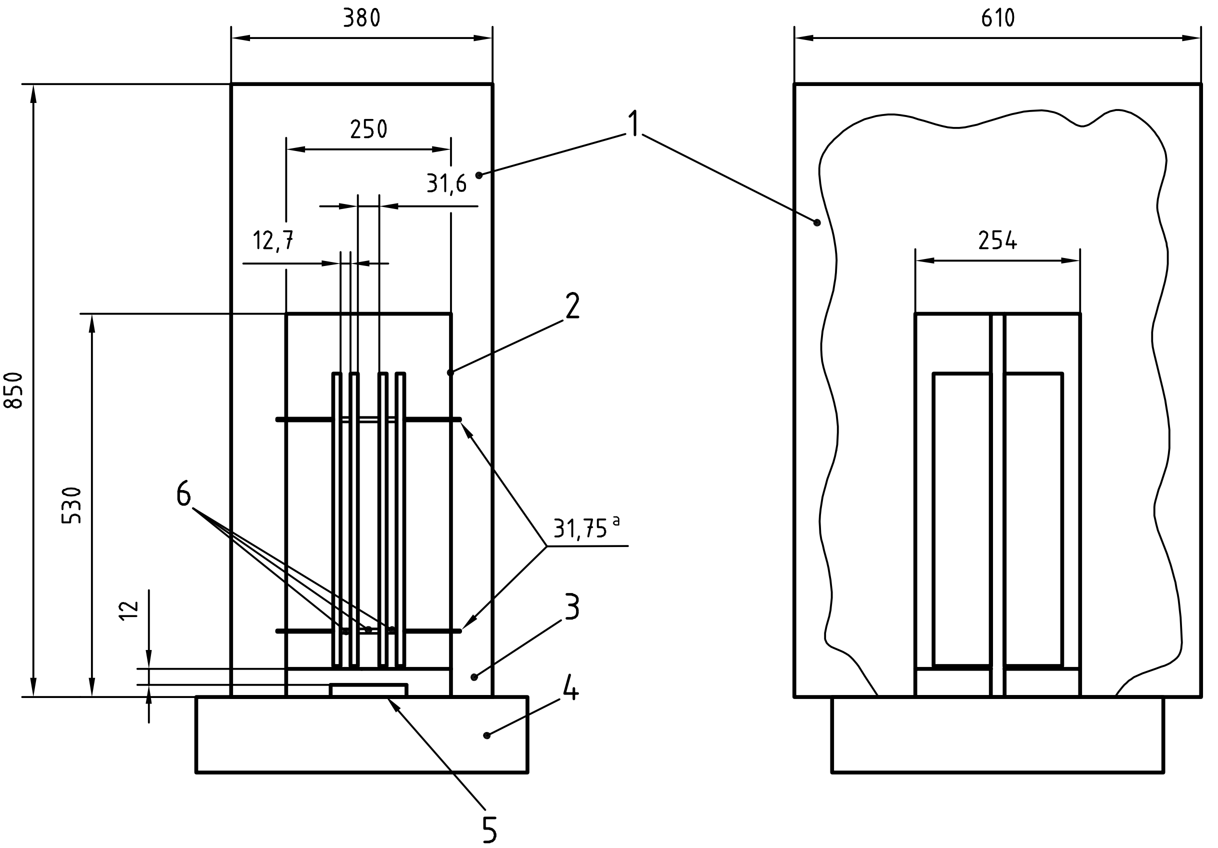
6.3.3.1 Operation

Prior to commencing the test, analyse the composition of the extinguishing gas. Record the weight of the plastic sheets prior to the test.

Ignite the heptane and allow it to burn completely. Close all enclosure openings 210 s after ignition of the heptane, and actuate manually the extinguishing system.

At the time of actuation of the system, the volume fraction of oxygen within the enclosure at the level of the fuel shall not be more than 0,5 % lower than the normal atmospheric oxygen concentration. During the test, the volume fraction of oxygen shall not change more than 1,5 % owing to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the oxygen concentration measured in this test (averaged values).

Dimensions in millimetres



Key

1 fuel shield: channel metal frame covered with metal sheet on top and two sides

2 metal angle frame

3 drip tray

4 load cell

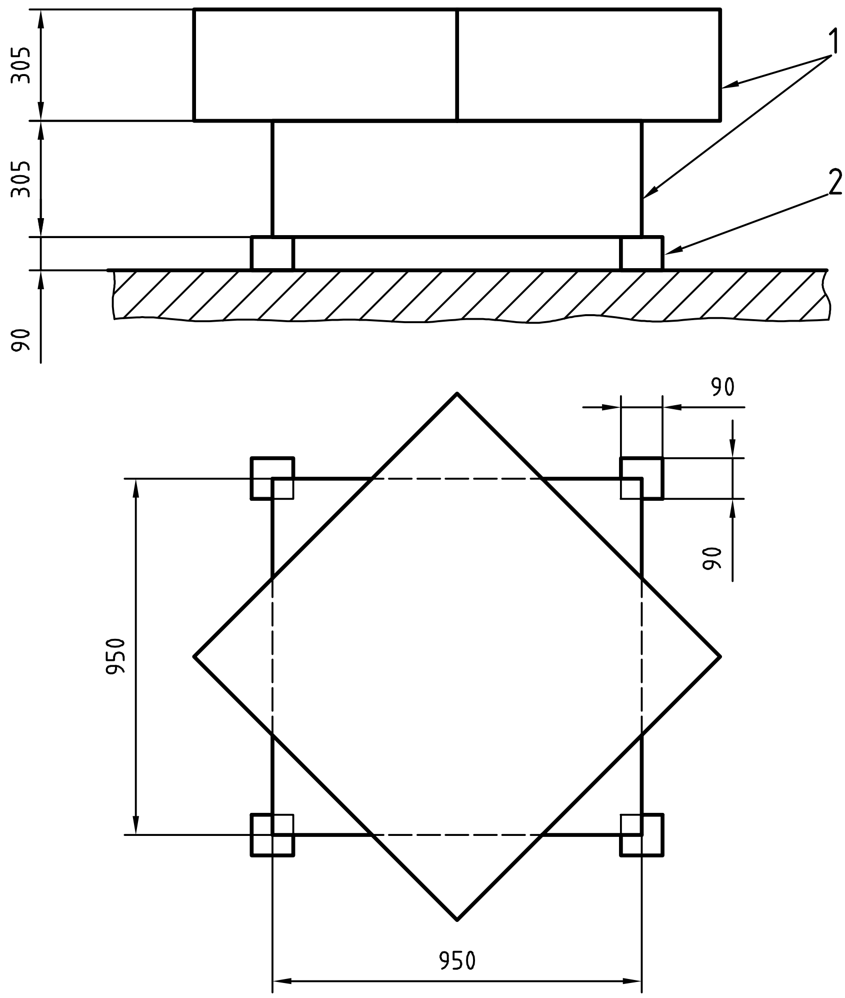
5 heptane pan

6 spacer

a fully threaded rod fuel support

Figure 6 — Polymeric sheet fire fuel array and fuel shield

Dimensions in millimetres



Key

1 polycarbonate or metal baffles

2 cinder block

Figure 7 — Polymeric fire baffle arrangement

From the end of system discharge, leave the enclosure sealed for a total of 10 min. After the soak period, ventilate the enclosure and observe whether sufficient fuel remains to sustain combustion and check for signs of re-ignition. Record the following:

a) the presence and location of burning fuel;

b) whether or not the fire re-ignites;

c) the weight of the fire structure after the test.

If necessary, amend the extinguishant concentration and repeat the experimental programme until three successive successful extinguishments are achieved.

6.3.3.2 Results recording

After the required pre-burn period, record the following data for each test:

a) the calculated discharge time of extinguishant, i.e. the time needed to reach 95 % of the laboratory extinguishant concentration, in seconds;

b) the effective discharge time — for liquefied extinguishants, the time of the pre-liquid gas phase plus the time of the two-phase flow (the discharge time for liquefied extinguishants has to be determined by nozzle pressure, nozzle temperature or a combination of both); for non-liquefied extinguishants, the time from opening the container valve(s) to cutting off the discharge;

c) the time required to achieve extinguishment, in seconds, determined by visual observation or other suitable means;

d) the total mass of extinguishant discharged into the test enclosure;

e) the soaking time (the time from the end of system discharge until the opening of the test enclosure).

6.3.4 Determination of design extinguishant concentration

The laboratory extinguishant concentration for each fuel is that concentration which achieves satisfactory extinguishment of the fire over three successive tests (no flaming 60 s after end of extinguishant discharge and no re-ignition after 10 min from the end of discharge). The design concentration is the highest of the laboratory concentrations for the three fuels (see 6.3.3.2) multiplied by an appropriate safety factor, if the three laboratory concentrations are higher than the laboratory concentration according to 6.4.4.

NOTE 1 The 60 s time limit for "no flaming" is provisional. At the time of preparation of this Technical Specification there was no published information providing details of the manner of extinguishment of plastics fires test articles. One laboratory reports that upon discharge of an HFC agent at the same concentration which satisfactorily extinguishes the wood crib test article, the following behaviour of the plastic was observed.

a) The flame size was reduced within 1 min to a very small edge-effect flame measuring approximately 20 mm to 30 mm in size.

b) The time at which the edge-effect flame became extinguished varies but may be longer than 60 s.

c) The edge-effect flame on the plastic test articles is analogous to the persistent smouldering observed to be in effect during the post-flame-out period of the wood crib test (see 6.1.2 to 6.1.4).

d) The 10 min hold period allows the hot test article, wood or plastic, to cool to the point where the low-level combustion reactions cease.

NOTE 2 Practitioners of this test method are invited to comment on the need to retain the flame-out time as a pass-fail criterion, and if so to advise what flame-out time is deemed appropriate.

6.4 PVC cable tray fire test

6.4.1 Test facility

6.4.1.1 Construction

The test enclosure shall be constructed as described in 6.1.1.1.

6.4.1.2 Instrumentation

The instrumentation of the enclosure shall be as described in 6.1.1.2.

6.4.2 Fuel specification

6.4.2.1 Igniter fuel

The ignition source shall be a heptane pan (made from stainless steel), 200 mm × 200 mm and 20 mm deep, centred 75 mm below the lowest cable tray (see Figure 8). The pan shall be filled with 100 ml of commercial grade heptane (as specified in 5.1.2.2) without a water layer.

The quantity of heptane may be increased to ensure a burning time (checked with the cable tray) of 90 s.

6.4.2.2 PVC cables

The test shall use surface wiring cables conforming to Table 3. The cables shall be of the surface way type, PVC sheeted, with two insulated conductors and one exposed earth continuity conductor.

Table 3 — Properties of PVC cable for cable tray fire test

Cable part	**Linear density**, g/m	**Mass fraction**, %
External sheathing	75	32,5
Internal sheathing	35	15,2
Internal copper wire	100	43,6
Copper core	20	8,7

6.4.2.3 Cable tray details

The test shall use a cable tray complying with the specifications given in Table 4.

6.4.2.4 Fire configuration and placement

The cable array shall consist of six cable tray layers, each layer having ten evenly spaced cables on it. The dimensions and arrangement of the cables shall be as specified in Table 4 and Figure 8. The bottom of the fuel array shall be located 100 mm from the floor.

The fuel array shall be located centrally within the enclosure.

Table 4 — Specification of the PVC cable tray fire

Parameter	**Measurement**
Cable tray length	750 mm
Cable tray width	230 mm
Cable length	650 mm
Number of cables per layer	10
Cable separation (distance between centres)	20 mm
Cable tray porosity	20,3 %
Cable tray thickness	1 mm
Cable tray separation	20 mm
Starter fuel (*n*-heptane) quantity	100 ml
Height of fire above base of starter fuel tray	75 mm

Dimensions in millimetres

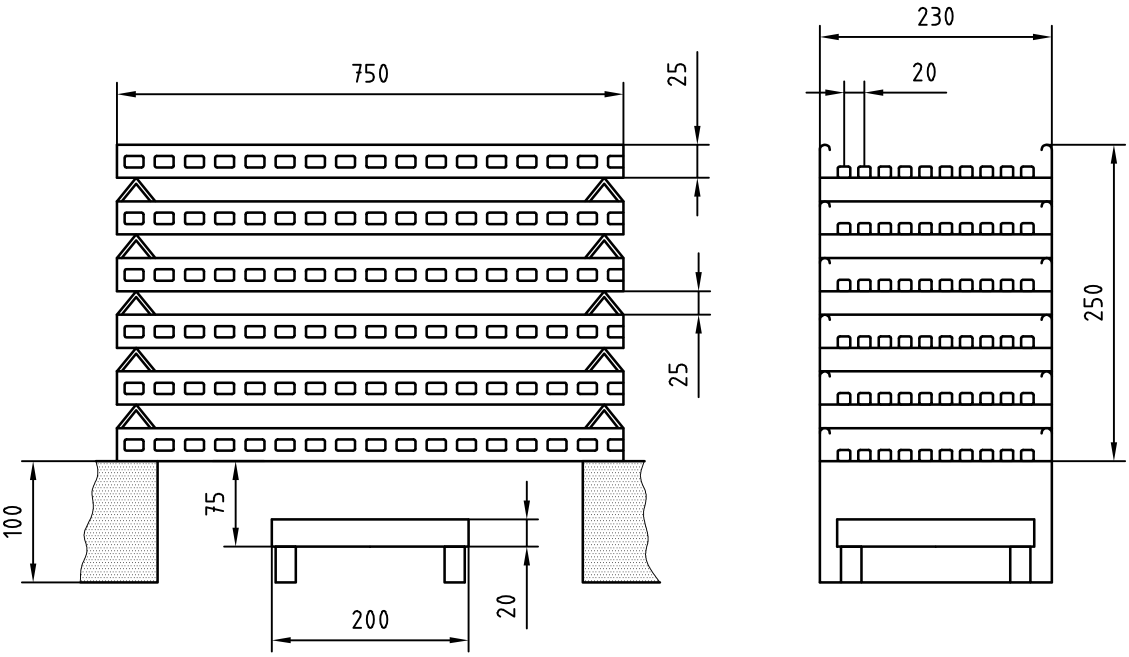


Figure 8 — PVC cable tray fire

6.4.3 Test procedure

6.4.3.1 Operation

Prior to commencing the test, analyse the composition of the extinguishing gas. Record the weight of the cables prior to the test.

Ignite the heptane and allowed it to burn completely. Close all openings 270 s after ignition of the heptane, and actuate manually the extinguishing system.

NOTE At that time the heat release rate of the cable array is between 20 kW and 25 kW.

At the time of actuation of the system, the volume fraction of oxygen within the enclosure at the level of the fuel shall not be more than 0,5 % lower than the normal atmospheric oxygen concentration. During the test, the volume fraction of oxygen shall not change more than 1,5 % owing to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the oxygen concentration measured in this test (averaged values).

From the end of discharge, leave the enclosure sealed for a total of 10 min. After the soak period, ventilate the enclosure and observe whether sufficient fuel remains to sustain combustion and check for signs of re-ignition. record the following:

a) the presence and location of burning fuel;

b) whether or not the cables re-ignite;

c) the weight of the cables after the test.

If necessary, amend the extinguishant concentration and repeat the experimental programme until three successive successful extinguishments are achieved.

6.4.3.2 Results recording

After the required pre-burn period, record the following data for each test:

a) the calculated discharge time of extinguishant, i.e. the time needed to reach 95 % of the laboratory extinguishant concentration, in seconds;

b) the effective discharge time — for liquefied extinguishants, the time of the pre-liquid gas phase plus the time of the two-phase flow (the discharge time for liquefied extinguishants has to be determined by nozzle pressure, nozzle temperature or a combination of both); for non-liquefied extinguishants, the time from opening the container valve(s) to cutting off the discharge;

c) the time required to achieve extinguishment, in seconds, determined by visual observation or other suitable means;

d) the total mass of extinguishant discharged into the test enclosure;

e) the soaking time (the time from the end of system discharge until the opening of the test enclosure);

f) the fuel mass loss from 60 s after end of discharge until the end of the soaking time.

6.4.4 Determination of design extinguishant concentration

The laboratory extinguishant concentration is that concentration which achieves satisfactory extinguishment of the fire over three successive tests (no flaming 60 s after end of extinguishant discharge and no re-ignition after 10 min from the end of the discharge).

NOTE 1 The 60 s time limit for “no flaming” is provisional. At the time of preparation of this Technical Specification there was no published information providing details of the manner of extinguishment of plastics fires test articles. One laboratory reports that upon discharge of an HFC agent at the same concentration which satisfactorily extinguishes the wood crib test article, the following behaviour of the plastic was observed.

a) The flame size was reduced within 1 min to a very small edge-effect flame measuring approximately 20 mm to 30 mm in size.

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c) The edge-effect flame on the plastic test articles is analogous to the persistent smouldering observed to be in effect during the post-flame-out period of the wood crib test (see 6.1.2 to 6.1.4).

d) The 10 min hold period allows the hot test article, wood or plastic, to cool to the point where the low-level combustion reactions cease.

NOTE 2 Practitioners of this test method are invited to comment on the need to retain the flame-out time as a pass-fail criterion, and if so to advise what flame-out time is deemed appropriate.

The design concentration is the laboratory concentration multiplied by an appropriate safety factor.

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