TECHNICAL REPORT

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2022-04

Fire detection and alarm systems —

Part 9: Test fires for fire detectors

Systèmes de détection et d'alarme d'incendie —

Partie 9: Essais sur foyers pour détecteurs d'incendie

Reference number
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Foreword

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

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

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

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

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

This document was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 3, *Fire detection and alarm systems*.

This second edition cancels and replaces the first edition (ISO/TS 7240-9:2012), which has been technically revised.

The main changes are as follows:

— The content has been reworded to include reproductions of clauses from other Parts of the ISO 7240 series so that this document can be considered a catalogue of information.

A list of all parts in the ISO 7240 series can be found on the ISO website.

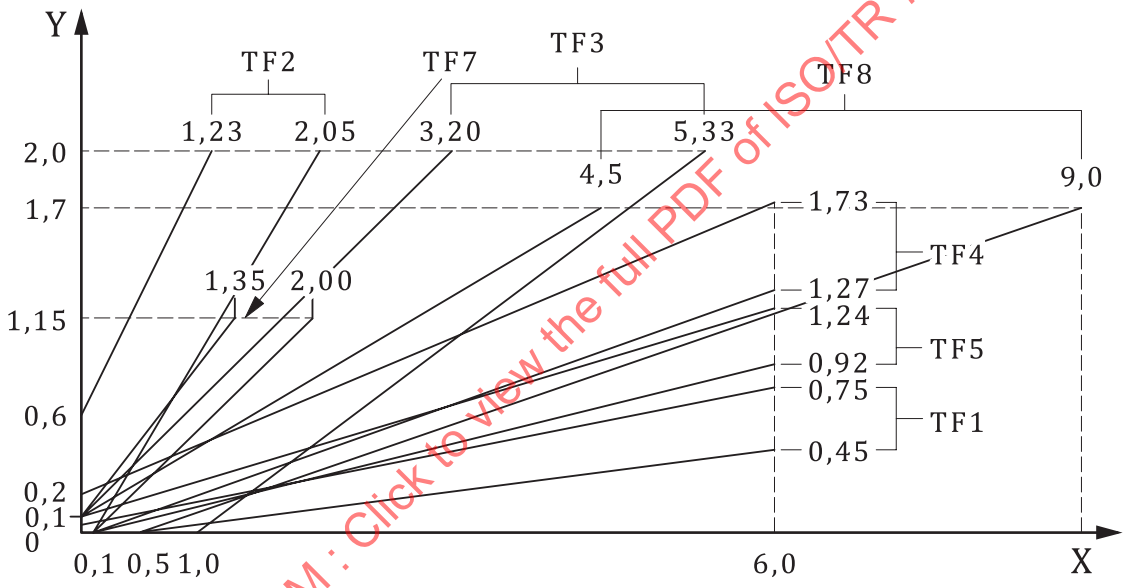
Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document provides a summary of the standard test fires defined in other Parts of the ISO 7240 series and where they are used. It has been published to provide a convenient catalogue of test fires. The formal definition and description of each test fire remains within the individual Parts of the ISO 7240 series. All text which has been reproduced from other Parts of the ISO 7240 series is written in italic font.

The combustibles selected represent a spectrum of large (*m*) and small (*y*) combustion particles for both grey and black smoke. These include burning liquids, plastics and cellulosic (wood) materials, and glowing and smouldering fabrics.

Figure 1 shows the limits of *m* vs *y* where they are defined for the relevant test fires. This figure illustrates how the test fires are designed to represent a reasonable cross–section of fire types and thus ensure that the response characteristics of the detectors being assessed are broadly capable of detecting the majority of common fires that can occur in practice.



Key

X measuring ionization chamber (MIC) reading, *y* (dimensionless)
NOTE *y* is the known function of the concentration of particulates in the smoke or aerosol.

Y absorbance index, *m* (dB/m)

TF1 to TF5, TF7 and TF8 types of test fire which are explained in this document and which have been selected to illustrate a spectrum of large and small combustion particles.

Figure 1 — Composite of ISO test fires TF1 to TF5, TF7 and TF8 profile curves: *m* versus *y*

The test fires described in this document are intended to be applicable for the evaluation of all automatic fire detectors (smoke, heat, flame, etc.). TF7 has completed its original purpose, but has been maintained for reference now and in the future. The test fires described are or have been employed on a selective basis for use in concert with a specified International Standard covering the particular type of detector. For example, test fire TF6, methylated spirits, has been used to evaluate the response of point-type heat detectors. Test fires TF1 through TF5 have been selected to evaluate the response of system-connected smoke detectors. Test fire TF7 has been selected in lieu of test fire TF2 to evaluate the response of smoke alarms intended primarily for installation in residential-type occupancies. Test fires TF2, TF3 and TF9 are suitable for testing the response of a detector to carbon monoxide. Carbon monoxide output curves are also shown for TF4, TF5 and TF8.

Table 1 shows the test fires that are employed in product standards (indicated with a tick).

Note that the test fires are adjusted to meet the characteristics of each detector. Therefore, even if they have the same name, their end-of-test conditions and test validity criteria can differ depending on the applicable product standards. When test fires are applied, they use the conditions and criteria described in the latest relevant product standard.

Based on original test fires (TF1 to TF9), modified test fires have been developed to evaluate new principles of fire detectors such as TF2A and TF2B, etc. The new modified test fires are expected to be added to the series of test fires within a few years.

Table 1 — Test fires employed in product standards

Product standards	TF1	TF2	TF2A	TF2B	TF3	TF3A	TF3B	TF4	TF5	TF5A	TF5B	TF6	TF7	TF8	TF9
ISO 7240-5:2018															
ISO 7240-6:2011		✓			✓										✓
ISO 7240-7:2018		✓			✓			✓	✓						
ISO 7240-8:2014		✓			✓			✓	✓						
ISO 7240-10:2012									✓			✓			
ISO 7240-12:2014		✓			✓			✓	✓						
ISO 7240-15:2014	✓	✓			✓			✓	✓					✓	
ISO 7240-20:2010		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
ISO 7240-22:2017		✓						✓							
ISO 7240-27:2018		✓			✓			✓	✓					✓	
ISO 12239:2010		✓			✓			✓	✓						

Fire detection and alarm systems —

Part 9:
Test fires for fire detectors

1 Scope

This document provides a catalogue of test fires and is intended to enhance comprehensive understanding of fire detection test methods. It describes a series of test fires to which fire detectors, such as smoke, heat and flame detectors, are subjected, as specified in other Parts of the ISO 7240 series.

This document does not specify normative requirements regarding the test methods for the test fires.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7240-1, *Fire detection and alarm systems — Part 1: General and definitions*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7240-1 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
sensitivity
relative degree of response of a smoke detector

Note 1 to entry: A high sensitivity denotes response to a lower concentration of smoke particles than a low sensitivity under identical smoke build-up conditions.

3.2 Abbreviated terms

For the purposes of this document, the following abbreviations apply.

a.s.d. aspirating smoke detector

MIC measuring ionization chamber

TF test fire

4 Characteristics of test fires

Clause 7 describes fifteen test fires which are designated TF1 through TF9. With the exception of TF7, all of these test fires are reproduced from product standards which can be found in other Parts of the ISO 7240 series. Their characteristic features are shown in Table 2.

The test fires are carried out in accordance with the descriptions of Clause 7. It is acceptable for the quantities of fuel used to be slightly varied, if necessary, to produce the required values of fire parameters.

Table 2 — Characteristics of test fires

Designation TF = Test fire	Type of fire	Development of heat	Up-current	Smoke	Aerosol spectrum	Visible portion	Carbon monoxide
TF1	Open cellulosic (wood)	Strong	Strong	Yes	Predominantly invisible	Dark	Very weak
TF2	Rapid smouldering pyrolysis (wood)	Weak	Weak	Yes	Predominantly visible	Light, high scattering	Yes
TF2A	Slow smouldering pyrolysis (wood)	Weak	Weak	Yes	Predominantly visible	Light, high scattering	Yes
TF2B	Smouldering pyrolysis (wood)	Weak	Weak	Yes	Predominantly visible	Light, high scattering	Yes
TF3	Glowing (fast smouldering) cotton	Weak	Very weak	Yes	Partially visible	Light, high scattering	Strong
TF3A	Glowing (slow smouldering) cotton	Weak	Very weak	Yes	Partially visible	Light, high scattering	Strong
TF3B	Glowing (smouldering) cotton	Weak	Very weak	Yes	Partially visible	Light, high scattering	Strong
TF4	Open plastics (polyurethane)	Strong	Strong	Yes	Partially invisible	Very dark	Weak
TF5	Liquid (*n*-heptane)	Strong	Strong	Yes	Predominantly invisible	Very dark	Weak
TF5A	Liquid (*n*-heptane) small	Strong	Strong	Yes	Predominantly invisible	Very dark	Weak
TF5B	Liquid (*n*-heptane) medium	Strong	Strong	Yes	Predominantly invisible	Very dark	Weak
TF6	Liquid (methylated spirit)	Strong	Strong	No	None	None	Very weak
TF7	Slow smouldering (pyrolysis) wood	Weak	Weak	Yes	Predominantly visible	Light, high scattering	Very weak
TF8	Low temperature black smoke (decalin) liquid	Weak	Weak	Yes	Predominantly visible	Dark	Very weak

Table 2 *(continued)*

Designation TF = Test fire	Type of fire	Develop-ment of heat	Up-current	Smoke	Aerosol spectrum	Visible portion	Carbon monoxide
TF9	Deep seated smouldering cotton	Weak	Weak	Yes	Predomi-nantly visible	Light, high scattering	Yes

5 Test laboratory

5.1 General

The test fires are carried out in a standard fire test room.

The dimensions of the fire test room, locations of specimens being tested and measuring instruments are described in ISO 7240-7:2018, Annex F. For cataloguing purposes, these are reproduced in subclause 5.2 of this document.

For aspirating smoke detectors, the relevant dimensions and locations are described in ISO 7240-20:2010, Annex I. For cataloguing purposes, these are reproduced in subclause 5.3 of this document.

In addition to the details described in 5.2 and 5.3, the following points are also widely accepted as being required by manufacturers and test authorities for fire test rooms:

— The ceiling and walls are flat with no obstructions between the fire source and the detectors and instrumentation.

— The fire source is positioned as centrally as possible with respect to the four walls in order to minimize reflection of smoke and/or heat.

— It is permitted to employ fire curtains in order to reduce the room size within specified limits, if necessary.

5.2 Fire test room (for all detectors except aspirating smoke detectors)

NOTE The following text is reproduced for informational purposes from ISO 7240-7:2018, Annex F. The figure numbers have been adapted to ensure continuity of numbering within this document.

The fire sensitivity tests shall be conducted in a rectangular room with a flat horizontal ceiling, and the following dimensions:

Length: *9 m to 11 m;*

Width: *6 m to 8 m;*

Height: *3,8 m to 4,2 m.*

The fire test room shall be equipped with the following measuring instruments:

— *Measuring ionization chamber (MIC);*

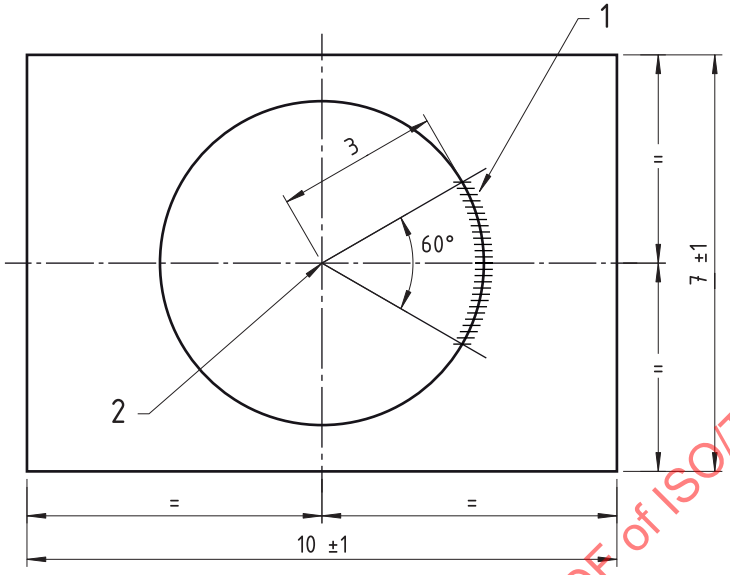
— *Obscuration meter;*

— *Temperature probe.*

The specimens to be tested, the measuring ionization chamber (MIC), the temperature probe and the measuring part of the obscuration meter shall all be located as shown in Figures 2 and 3.

The specimens, the MIC and the mechanical parts of the obscuration meter shall be at least 100 mm apart, measured to the nearest edges. The centre line of the beam of the obscuration meter shall be at least 35 mm below the ceiling.

Dimensions in metres



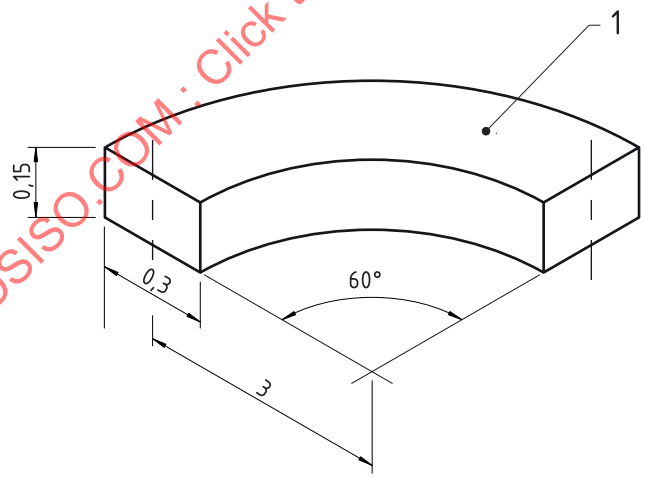
Key

1 specimens and measuring instruments (see Figure 3)

2 position of test fire

Figure 2 — *Plan view of fire test room and position of specimens and monitoring instruments*

Dimensions in metres



Key

1 ceiling

Figure 3 — *Mounting position for instruments and specimens*

5.3 Fire test room and ventilation system (for aspirating smoke detectors)

NOTE The following text is reproduced for informational purposes from ISO 7240-20:2010, Annex I. The figure numbers and cross references have been adapted to ensure continuity of numbering and cross-referencing within this document.

5.3.1 *Fire test room*

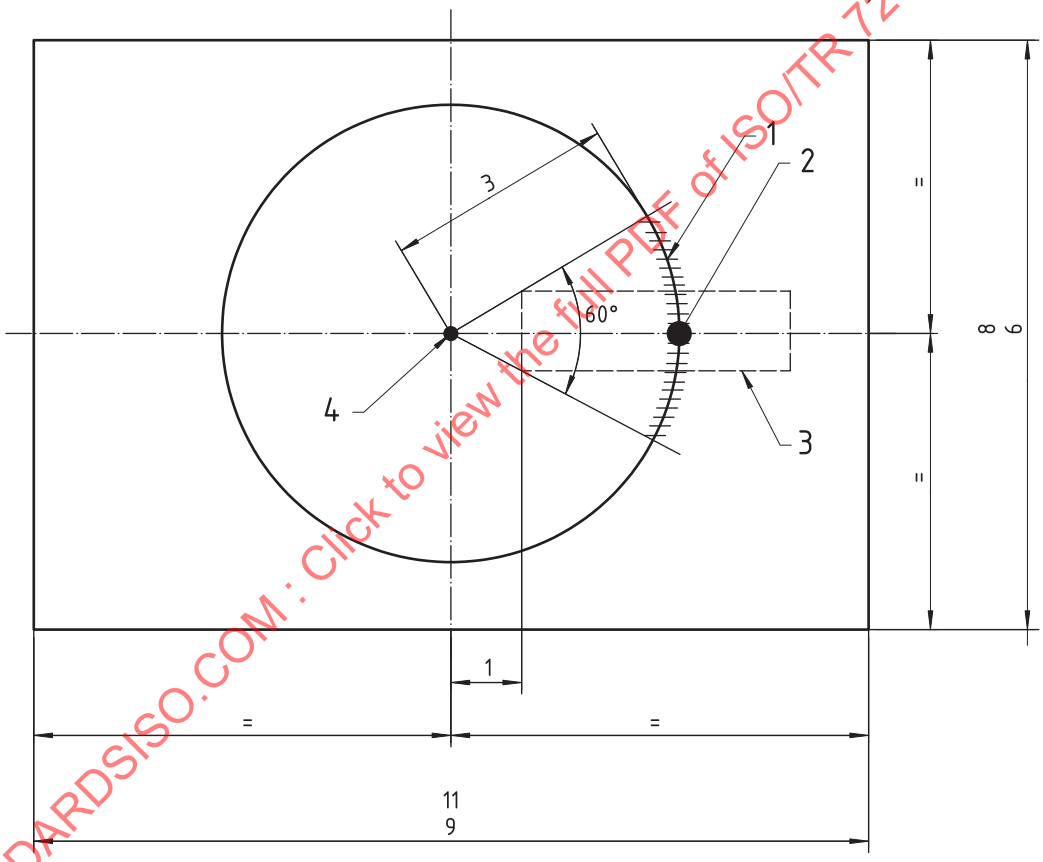
The sampling point, the MIC, the temperature probe and the measuring part of the obscuration meter shall all be located within the volume shown in Figures 4 and 5.

The sampling point shall be located on the 3 m arc (see Figure 4, key item 1). The optimum position is marked as key item 2.

The ventilation system shall be located in the position marked as key item 3 in Figure 4. The direction of the airflow produced by this system shall be toward the test fire (located at the position marked as key item 4 in Figure 4). The description of the ventilation system is given in 5.3.2.

The sampling point, the MIC and the mechanical parts of the obscuration meter shall be at least 100 mm apart, measured to the nearest edges. The centre line of the beam of the obscuration meter shall be at least 35 mm below the ceiling.

Dimensions in metres, unless otherwise indicated

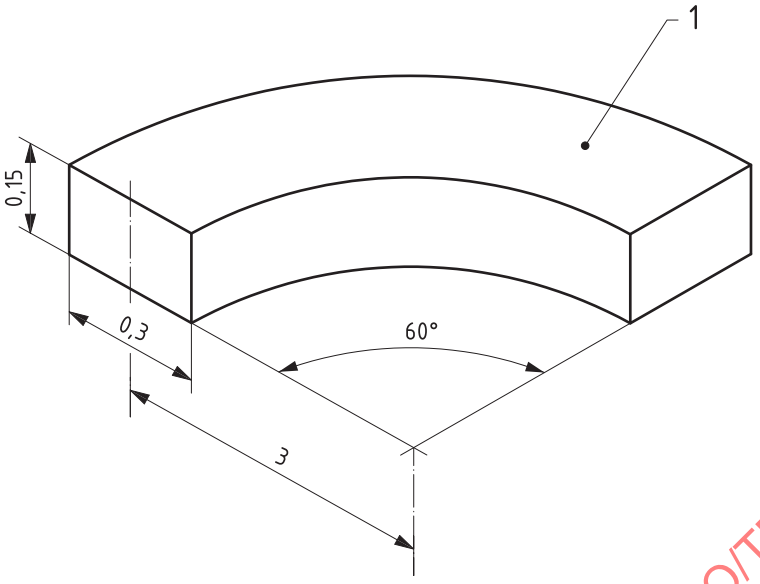


Key

1	*sampling point and measuring instruments (see Figure 5)*	*3*	*ventilation system (see Figure 6)*
2	*optimum position of the sampling point*	*4*	*position of test fire*

Figure 4 — *Plan view of the fire test room*

Dimensions in metres, unless otherwise indicated



Key

1 ceiling

Figure 5 — *Mounting position for instruments and specimens*

5.3.2 *Ventilation system*

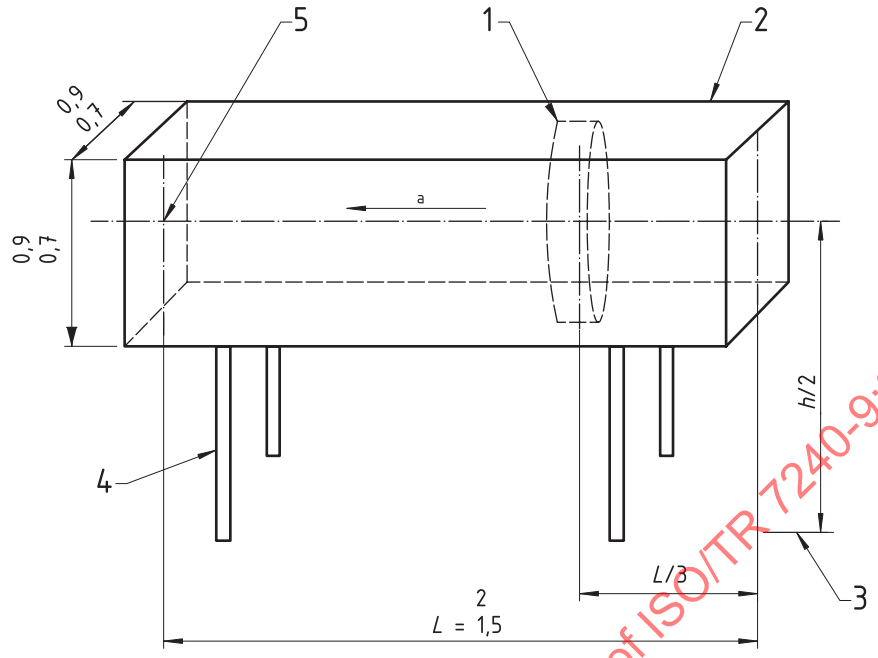
As a consequence of the low quantity of aerosols generated by reduced fire tests, it is necessary, for the reduced fire tests TF2A, TF2B, TF3A, TF3B, TF5A and TF5B, to introduce in the fire test room a ventilation system to increase the homogeneity of the atmosphere close to the sampling points. The following specifies those characteristics of the ventilation system which are of primary importance.

The ventilation system consists of a square duct opened in both extremities (see Figure 6).

A fan is located in the duct as described in Figure 6. The diameter of the fan shall be as close as possible to the dimensions of the sides of the square section of the duct. At the location of the fan, the section of the duct not occupied by the fan shall be closed. The axis of the fan shall be the same as the axis of the square duct.

The ventilation system shall create an airflow at (1,0 ± 0,2) m/s at the output of the duct (the airflow direction is given in Figure 6). Conformity with this requirement shall be regularly verified during the fire tests by measurements at the centre of the duct output section (see key item 5 in Figure 6).

Dimensions in metres



Key

1 *fan*
2 *square duct*
3 *ground*
4 *stand*
5 *location of the flow velocity measurement*
L *length of the duct*
h *height of the fire test room (as described in ISO 7240-7:2018, 5.19.2.1)*
[a] *Air flow.*

Figure 6 — *Ventilation system*

5.4 Ambient test condition

The following ambient conditions are specified in the other Parts of the ISO 7240 series as indicated and applied prior to conducting each test fire:

a) temperature: (23 ± 5) °C except ISO 7240-20, to which $\left(23\ ^{+5}_{-3}\right)$ °C is applied.

It is recommended to ensure less than 2 °C difference between ceiling and floor temperatures for smouldering tests TF2, TF3, TF3A, TF3B and TF7;

b) relative humidity: (25 to 75) %;

c) air pressure: (86 to 106) kPa;

d) air movement: negligible or stable where the re-circulation fan is operational;

e) MIC reading: $y \leq 0{,}05$ except ISO 7240-12, in which $y < 0{,}05$ is applied;

f) optical beam reading: $m \leq 0{,}02$ dB/m except ISO 7240-12, in which $m < 0{,}02$ dB/m is applied;

g) CO concentration: $S \leq 5$ µl/l except ISO 7240-27, to which $S \leq 1{,}5$ µl/l is applied.

NOTE For improved consistency of test fires, the temperature can be controlled to (28 to 25) °C and the relative humidity can be controlled to (45 to 55) %.

5.5 Instruments

5.5.1 General

The measuring instruments or their specification employed during the test fires are described in the corresponding documents shown to the right of each instrument in the following list. These are reproduced in subclauses 5.5.2 to 5.5.4 of this document, with the exception of "spark generator", which is specified in subclause 5.5.5.

—	Obscuration meter;	ISO 7240-7:2018, C.1
—	Measuring ionization chamber (MIC);	ISO 7240-7:2018, C.2
—	CO measuring instrument;	EN 54-26:2015, B.2[10]
—	Spark generator	No reference document

5.5.2 Obscuration meter

5.5.2.1 The response threshold of alarms using scattered light or transmitted light is characterized by the absorbance index (extinction module) of the test aerosol, measured in the proximity of the alarm, at the moment that it generates an alarm signal.

5.5.2.2 The absorbance index is designated *m* and expressed in decibels per metre (dB/m). The absorbance index, *m*, is given by the following formula:

$$m = \frac{10}{d} \log\left(\frac{P_0}{P}\right)$$

where

d is the distance, expressed in metres, travelled by the light in the test aerosol or smoke, from the light source to the light receiver;

P_0 is the radiated power received without test aerosol or smoke;

P is the radiated power received with test aerosol or smoke.

5.5.2.3 For all aerosol or smoke concentrations corresponding to an attenuation of up to 2 dB/m, the measuring error of the obscuration meter is required not exceed 0,02 dB/m + 5 % of the measured attenuation of the aerosol or smoke concentration.

5.5.2.4 The optical system is required to be arranged so that any light scattered more than 3° by the test aerosol or smoke is disregarded by the light detector.

The effective radiated power of the light beam is required to be:

— at least 50 % within a wavelength range from 800 nm to 950 nm;

— not more than 1 % in the wavelength range below 800 nm;

— not more than 10 % in the wavelength range above 1 050 nm.

NOTE The effective radiated power in each wavelength range is the product of the power emitted by the light source, the transmission level of the optical measuring path in clean air and the sensitivity of the receiver within this wavelength range.

Tables B.1 and B.2 show the conversion from *m* value (dB/m) to transmission rate (%) and obscuration rate (%) in several beam lengths.

5.5.3 Measuring ionization chamber (MIC)

5.5.3.1 General

The response threshold of alarms using ionization is characterized by a non-dimensional quantity, *y*, which is derived from the relative change of the current flowing in a measuring ionization chamber, and which is related to the particle concentration of the test aerosol, measured in the proximity of the alarm, at the moment that it generates an alarm condition.

5.5.3.2 Operating method and basic construction

5.5.3.2.1 The mechanical construction of the measuring ionization chamber is given in Annex A.

5.5.3.2.2 The measuring device consists of a measuring chamber, an electronic amplifier and a method of continuously sucking in a sample of the aerosol or smoke to be measured.

5.5.3.2.3 The principle of operation of the measuring ionization chamber is shown in Figure 7. The measuring chamber contains a measuring volume and a suitable means by which the sampled air is sucked in and passes the measuring volume in such a way that the aerosol/smoke particles diffuse into this volume. This diffusion is such that the flow of ions within the measuring volume is not disturbed by air movements.

5.5.3.2.4 The air within the measuring volume is ionized by alpha radiation from an americium radioactive source, such that there is a bipolar flow of ions when an electrical voltage is applied between the electrodes. This flow of ions is affected in a known manner by the aerosol or smoke particles. The ratio of the current in the aerosol-free chamber to that in the presence of an aerosol is a known function of the aerosol or smoke concentration. Thus, the non-dimensional quantity *y*, which is approximately proportional to the particle concentration for a particular type of aerosol or smoke, is used as a measure of the response threshold value for smoke detector using ionization.

5.5.3.2.5 The measuring chamber is dimensioned and operated such that the following relationships apply:

$$Z \times \bar{d} = \eta \times y$$

and

$$y = \left(\frac{I_0}{I}\right) - \left(\frac{I}{I_0}\right)$$

where

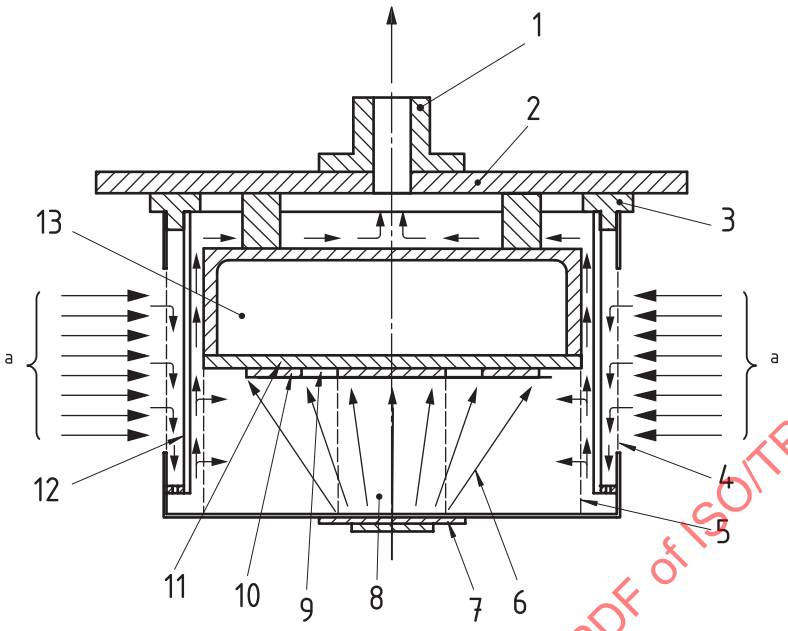
I_0 is the chamber current in air without test aerosol or smoke;

I is the chamber current in air with test aerosol or smoke;

η is the chamber constant;

Z is the particle concentration in particles per cubic metre;

$\bar{d}$ is the average particle diameter.



Key

1	suction nozzle	8	measuring volume
2	assembly plate	9	measuring electrode
3	insulating ring	10	guard ring
4	outer grid	11	insulating material
5	inner grid	12	windshield
6	α rays	13	electronics
7	α source	a	Air/smoke entry.

Figure 7 — Measuring ionization chamber — Method of operation

5.5.3.3 Technical data

a) Radiation source

Isotope:	americium ^{241}Am
Activity:	(130 ± 6,5) kBq
Average energy:	(4,5 ± 0,225) MeV
Mechanical construction:	Americium oxide embedded in gold between two layers of gold, covered with a hard gold alloy. The source is in the form of a circular disc with a diameter of 27 mm, which is mounted in a holder such that no cut edges are accessible.

b) Ionization chamber

The chamber impedance (i.e. the reciprocal of the slope of the current versus voltage characteristic of the chamber in its linear region where the chamber current ≤ 100 pA) is required to be (1,9 ± 0,095) × 10^{11} Ω, when measured in aerosol- and smoke-free air at the following conditions:

Pressure: (101,3 ± 1) kPa

Temperature: (25 ± 2) °C

Relative humidity: (55 ± 20) %

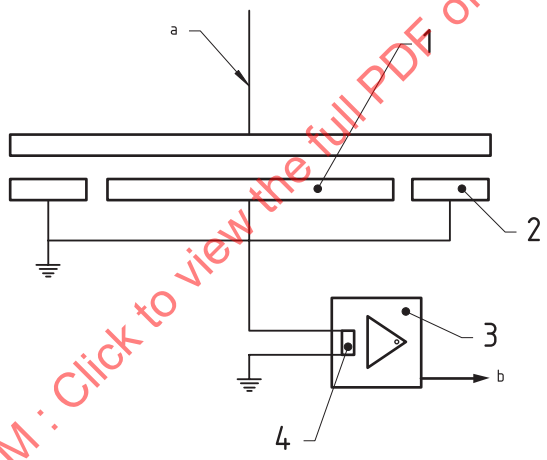
with the potential of the guard ring within ±0,1 V of the voltage of the measuring electrode.

c) Current measuring amplifier

The chamber is operated in the circuit shown in Figure 8, with the supply voltage such that the chamber current between the measuring electrodes is 100 pA in aerosol- or smoke-free air. The input impedance of the current measuring device is required to be < 10^9 Ω.

d) Suction system

The suction system shall draw air through the device at a continuous steady flow of (30 ± 3) l/min at atmospheric pressure.



Key

1 measuring electrode

2 guard ring

3 current measuring amplifier

4 input impedance, Z_{in} < 10^9 Ω

a Supply voltage.

b Output voltage proportional to chamber current.

Figure 8 — Measuring ionization chamber — Operating circuit

Table C.1 shows the conversion from *y* value (dimensionless) to ionization current changing rate (*x* value) (dimensionless) and ionization current (pA).

5.5.4 CO measuring instrument

5.5.4.1 The response time of the instrument is required to be such that it does not cause a measurement error at the highest rate of increase used for measurements greater than 5 µl/l.

5.5.4.2 It is necessary to ensure that the CO measuring instrument used in the fire test room does not respond to fire products other than CO in such a way as to affect the accuracy of the CO measurements.

5.5.5 Spark generator

5.5.5.1 General

The spark generator is to consist of the following or equivalent components. See Figure 9 for an example of one type of equipment presently employed.

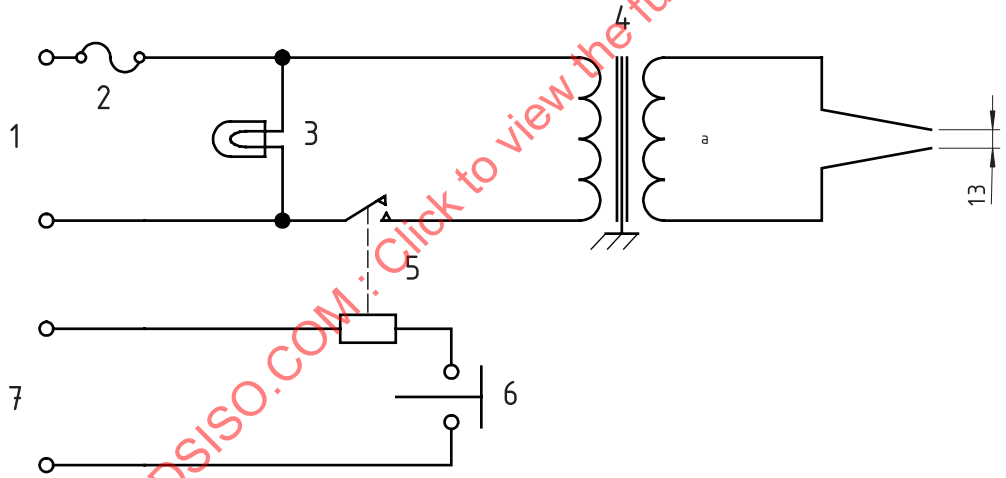
5.5.5.2 Igniter probes

The metal probes, approximately 6 mm diameter and tapered at the ends to form a point and maintained approximately 13 mm apart, are connected to the output leads of a high-voltage transformer. Adjustment and support for the probes is provided by metal clamps affixed to a vertical steel bar integral with assembly.

5.5.5.3 Igniter source

The igniter source consists of a mains voltage primary, 10 000 V, 23 mA secondary oil burner ignition or equivalent transformer, the output of which is to be connected to the igniter probes. The arc used for ignition is to be obtained by the closure of a remote, low-voltage, momentary contact switch, which energizes a relay, whose contacts control the transformer primary.

Dimensions in millimetres



Key

1 mains supply
2 fuse
3 power-on indicator
4 step-up transformer
5 relay (normally open contacts)
6 momentary switch (normally open contacts)
7 extra-low voltage source
[a] 10 kV to 15 kV.

Figure 9 — Spark generator schematic

6 Test method description

6.1 General

Subclauses 6.2 to 6.4 in this document are used by manufacturers and test authorities and are widely accepted.

6.2 Arrangement

For those tests that require ignition inside the test room, the personnel entrusted with the performance of the test are required to leave the test room immediately after igniting the fuel, taking care to prevent air movement, which can affect the development of the test. All doors, windows or other openings are kept closed during the test.

6.3 Measurement parameters

During each test, it is necessary to record the relevant test fire parameters listed in Table 3.

Table 3 — Test fire parameters

Parameter	Symbol	Unit
Temperature	T	°C
Temperature change	ΔT	°C
Time	t	seconds (s) or minutes (min) as required
Smoke density (optical)	m	dB/m
Smoke density (ionization)	y	dimensionless
Carbon monoxide concentration	S	µl/l

See Annexes B and C for tables of m values and y values.

6.4 End-of-test parameters

The values of the fire parameters at the end of the test (T_E, m_E, y_E, t_E, S_E) together with the profile curves are used as the control of the validity and reproducibility of the test fires. The test is considered finished when the specific limits for each test specified in Clause 7 are reached. If a detector responds after the specified end of test fire parameters have been reached, the detector is considered as having failed the test.

7 Test fires

7.1 General

This clause contains a description of the 15 test fires, including type and amount of combustible material required, illustration of 7 test setups, method of ignition, pre-conditioning of combustible material (if needed) and end-of-test parameters.

To permit more flexibility in conducting the tests and interpreting the results, the following guidelines (which are used by manufacturers and test authorities and are widely accepted) can be followed. This ought to also result in a higher success rate for a valid test.

a) Due to variation in smoke build-up that frequently occurs, the build-up curve can occasionally drift out of the limits for a short interval or near the end of the test. The test is to be considered valid

if the detectors being evaluated respond during the time interval when the build-up is within the limits.

1) The following exceptions would apply to the guidelines in a): If the build-up curve drifted to the left of the *m* vs *y* limit, the test could be considered valid if ionization-type detectors actuated during that interval since they respond worse to large particles.

b) The fuels specified are the preferred test materials. Alternate fuels are permitted to be used as substitutes because of the availability of national natural resources. The alternate fuel source is required to exhibit the same characteristics as the preferred fuels, i.e. colour of smoke and particle size distribution (within the profile).

c) Where the detector under test does not contain a carbon monoxide sensor, the profile curves for CO concentration need not apply to the test fire.

7.2 Test fire TF1 — Open cellulosic (wood) fire

7.2.1 General

TF1 is described in ISO 7240-15:2014, Annex G and is reproduced in subclauses 7.2.2 to 7.2.8 of this document. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.2.2 *Fuel*

Approximately 70 dried beechwood sticks, each stick having dimensions of 10 mm × 20 mm × 250 mm.

7.2.3 *Conditioning*

Dry the sticks in a heating oven so the moisture content is less than 3 %.

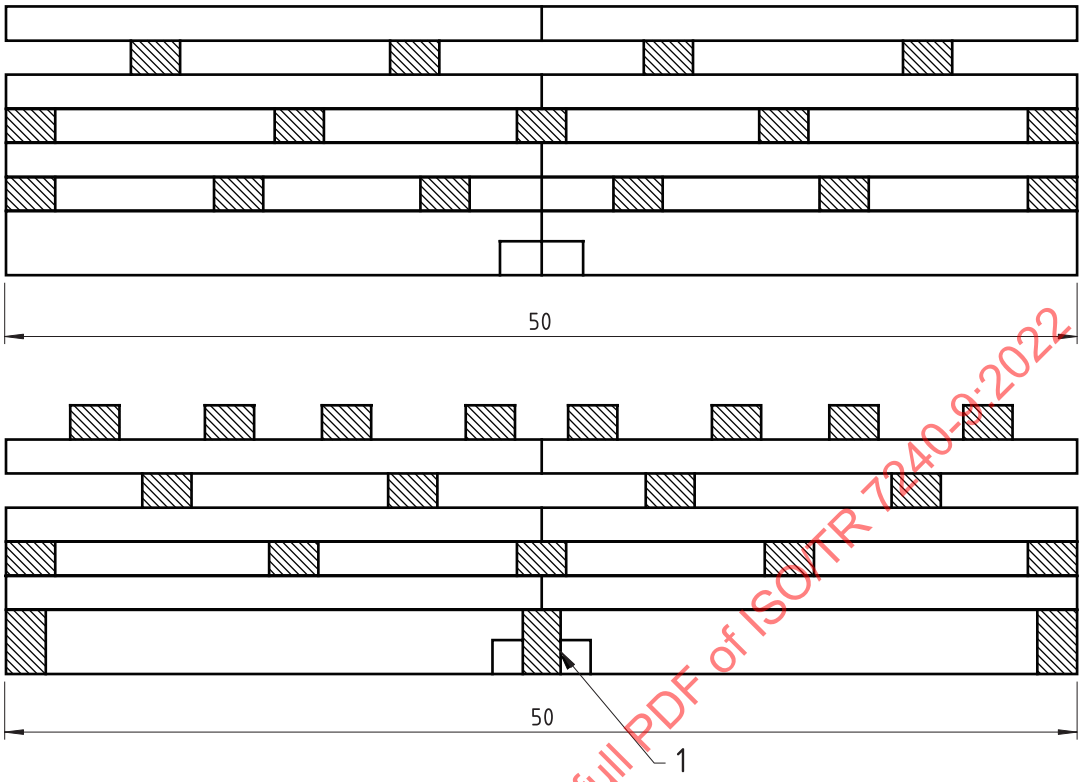
7.2.4 *Preparation*

If necessary, transport the sticks from the oven in a closed plastic bag, and open the bag just prior to laying out the stick in the test arrangement.

7.2.5 *Arrangement*

Superimpose seven layers on a base surface measuring approximately 50 cm wide × 50 cm long × 8 cm high (see Figure 10).

Dimensions in centimetres



Key

1 container for methylated spirits

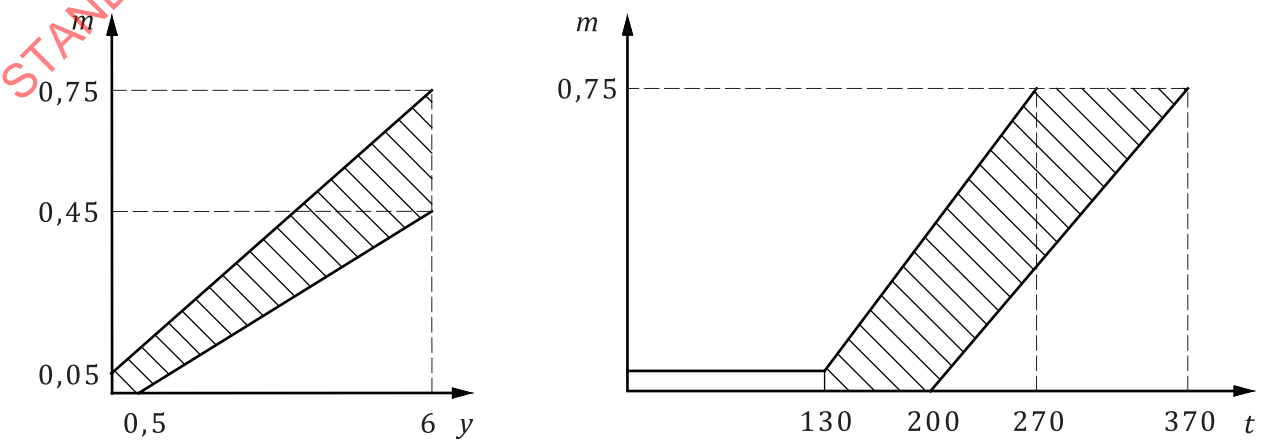
Figure 10 — *Wood arrangement for test fire TF1*

7.2.6 *Ignition starter*

Methylated spirits, 5 cm^3 in a bowl 5 cm in diameter, located in the centre of the base surface, ignited by flame or spark.

7.2.7 *Test validity criteria*

The development of the fire shall be such that the curves of m against y, and m against time, t, fall within the hatched areas shown in Figures 11 and 12. That is, 0,45 dB/m ≤ m ≤ 0,75 dB/m and 270 s ≤ t ≤ 370 s at the end-of-test condition y_E = 6.



Key
m m(dB/m)
y y-value

Figure 11 — Limits for m against y, Fire TF1

Key
m m(dB/m)
t t(s)

Figure 12 — Limits for m against time, t, Fire TF1

7.2.8 *End-of-test conditions*

The end-of-test condition y_E shall be when y = 6, or when all of the specimens have generated an alarm signal, whichever is the earlier.

7.3 Test fire TF2 — Smouldering (pyrolysis) wood fire

7.3.1 General

TF2 is described in ISO 7240-27:2018, Annex F and is reproduced in subclauses 7.3.2 to 7.3.7 of this document. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.3.2 *Fuel*

Approximately 10 dried beechwood sticks (moisture content approximately 5 %), each stick having dimensions of 75 mm × 25 mm × 20 mm.

7.3.3 *Hotplate*

The hotplate shall have a 220 mm diameter grooved surface with eight concentric grooves with a distance of 3 mm between grooves. Each groove shall be 2 mm deep and 5 mm wide, with the outer groove 4 mm from the edge. The hotplate shall have a rating of approximately 2 kW.

The temperature of the hot plate shall be measured by a sensor attached to the fifth groove, counted from the edge of the hotplate, and secured to provide a good thermal contact.

7.3.4 *Arrangement*

The sticks shall be arranged radially on the grooved hotplate surface, with the 20-mm side in contact with the surface such that the temperature probe lies between the sticks and is not covered, as shown in Figure 13.

7.3.5 *Heating rate*

The hotplate shall be powered such that its temperature rises from ambient to 600 °C in approximately 11 min.

7.3.6 End-of-test condition

The end-of-test condition shall be when:

— *m_E = 2 dB/m;*

— *t > 840 s;*

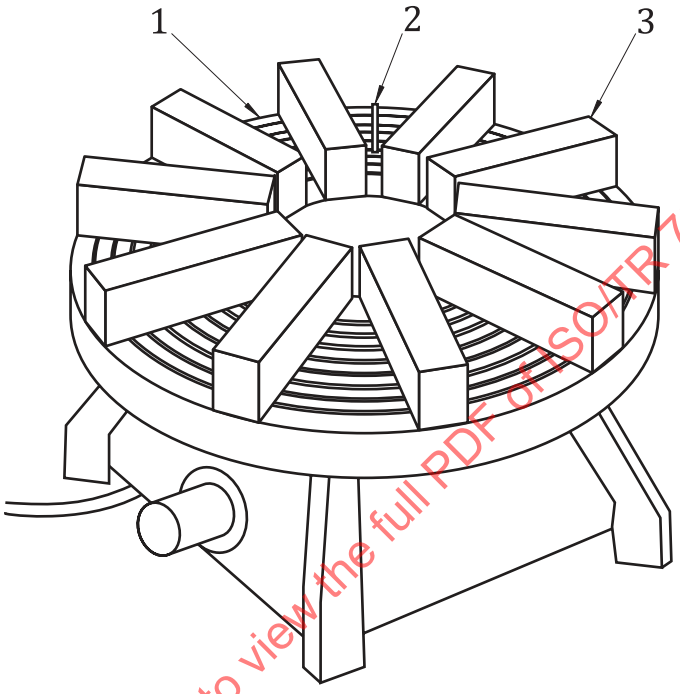
— *S > 100 µl/l; or*

— *all of the specimens have generated an alarm signal, whichever is the earlier.*

7.3.7 *Test validity criteria*

No flaming shall occur before the end-of-test condition has been reached. The development of the fire shall be such that the curves of m against y, and m against time, t, and S against time, t, fall within the limits shown in Figures 14, 15 and 16, respectively. That is, 1,23 ≤ y ≤ 2,05 and 570 ≤ t ≤ 840 at the end-of-test condition m_E = 2 dB/m.

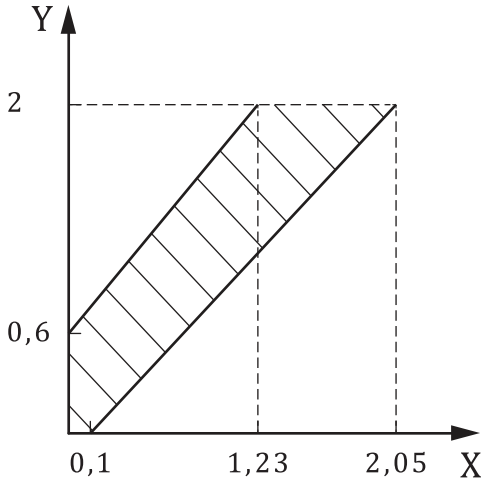
If the end of test condition, m_E = 2 dB/m is reached before all the specimen have responded, then the test is only considered valid if S > 45 µl/l.



Key

1 grooved hotplate
2 temperature sensor
3 wooden sticks

Figure 13 — *Arrangement of sticks on hotplate*

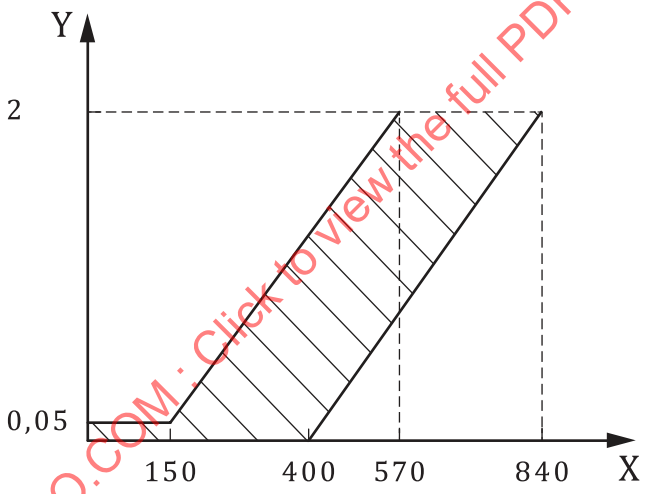


Key

X *y-value*

Y *m-value (dB/m)*

Figure 14 — *Limits for m against y, Fire TF2*

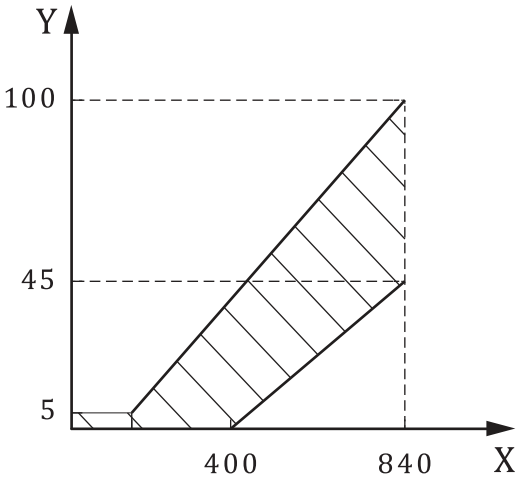


Key

X *time, t (s)*

Y *m-value (dB/m)*

Figure 15 — *Limits for m against time, t, Fire TF2*



Key

X *time, t (s)*

Y *S-value (µI/l)*

Figure 16 — *Limits for S against time, t, Fire TF2*

7.4 Test fire TF2A and TF2B — Reduced smouldering (pyrolysis) wood fire

7.4.1 General

TF2A and TF2B are described in ISO 7240-20:2010, Annex C and are reproduced in subclauses 7.4.2 to 7.4.7 of this document. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.4.2 *Fuel*

The fuel consists of three or more dried beech wood sticks (moisture content ~ 5 %), each stick having dimensions of approximately 75 mm × 25 mm × 20 mm.

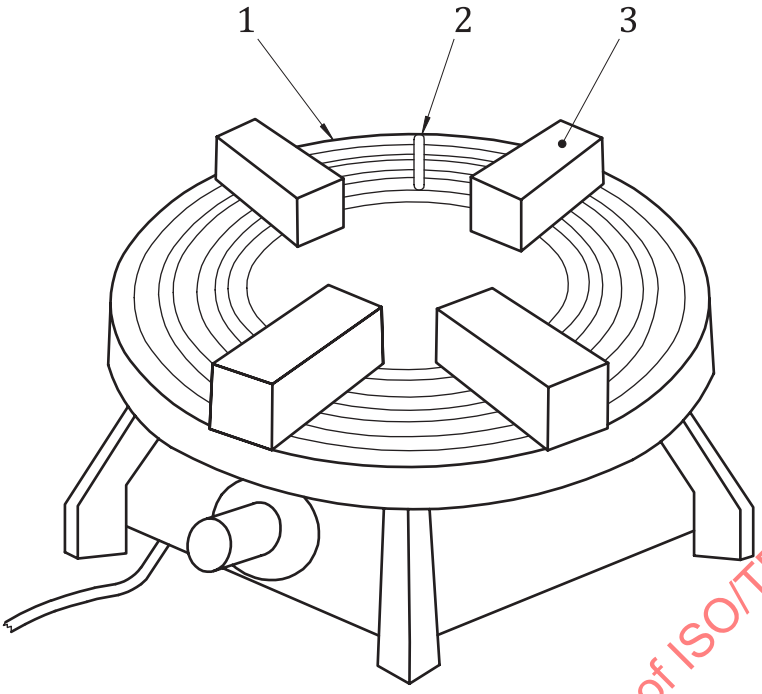
7.4.3 *Hotplate*

The hotplate shall have a 220 mm diameter grooved surface with eight concentric grooves with a distance of 3 mm between grooves. Each groove shall be 2 mm deep and 5 mm wide, with the outer groove 4 mm from the edge. The hotplate shall have a rating of approximately 2 kW.

The temperature of the hotplate shall be measured by a sensor attached to the fifth groove, counted from the edge of the hotplate, and secured to provide a good thermal contact.

7.4.4 *Arrangement*

Arrange the sticks radially on the grooved hotplate surface, with the 20 mm side in contact with the surface such that the temperature probe lies between the sticks and is not covered, as shown in Figure 17.



Key

1 grooved hotplate

2 temperature sensor

3 3 (or more) wooden sticks

Figure 17 — *Arrangement of the sticks on the hotplate*

7.4.5 *Heating rate*

The hotplate shall be powered such that its temperature rises from ambient to 500 °C in approximately 11 min.

NOTE For the TF2 test (used for class C[1] a.s.d.), the target temperature is 600 °C.

7.4.6 *End-of-test condition*

The end-of-test condition, m_E, for class A[2] using TF2A shall be when m = 0,05 dB/m.

The end-of-test condition, m_E, for class B[3] using TF2B shall be when m = 0,15 dB/m.

7.4.7 *Test validity criteria*

No flaming shall occur before the end-of-test condition. The development of the fire shall be such that the curves of m against time for TF2A and TF2B fall within the limits shown in Figures 18 and 19, respectively, up to the time when m equals the end-of-test condition or the specimen has generated an alarm signal, whichever is the earlier.

1) Classification for aspirating smoke detector providing normal sensitivity.

2) Classification for aspirating smoke detector providing very high sensitivity.

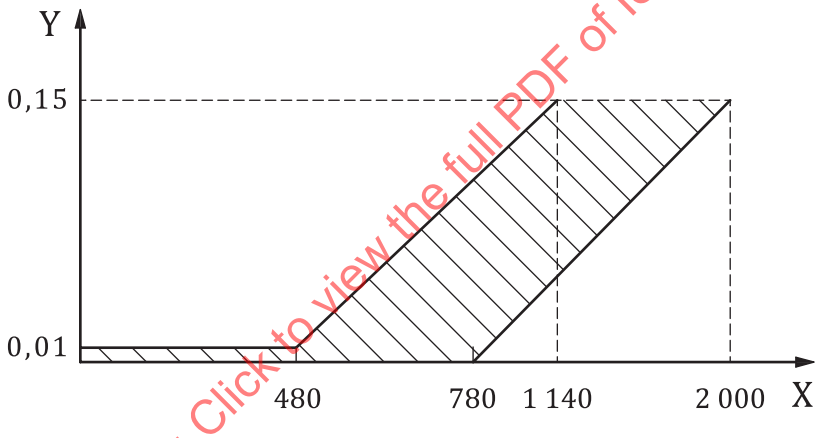
3) Classification for aspirating smoke detector providing enhanced sensitivity.

Key

X *time, t, expressed in seconds*

Y *m-value, expressed in decibels per metre*

Figure 18 — *Limits for* m *against time,* t*, fire TF2A*



Key

X *time, t, expressed in seconds*

Y *m-value, expressed in decibels per metre*

Figure 19 — *Limits for* m *against time,* t*, fire TF2B*

7.5 Test fire TF3 — Glowing smouldering cotton fire

7.5.1 General

TF3 is described in ISO 7240-27:2018, Annex G and is reproduced in subclauses 7.5.2 to 7.5.6 of this document. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.5.2 *Fuel*

Approximately 90 pieces of braided cotton wick, each of length approximately 80 cm and weighing approximately 3 g. The wicks shall be free from any protective coating and shall be washed and dried if necessary.

7.5.3 *Arrangement*

The wicks shall be fastened to a ring approximately 10 cm in diameter and suspended approximately 1 m above a non-combustible plate as shown in Figure 20.

Dimensions in millimetres

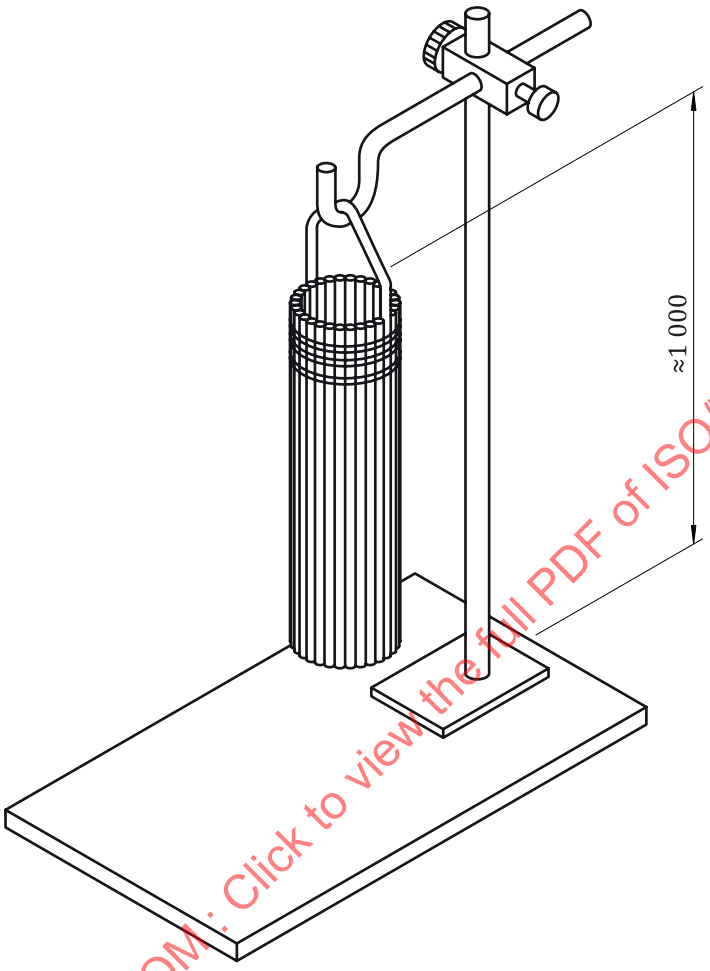


Figure 20 — *Arrangement of cotton wicks*

7.5.4 *Ignition*

The lower end of each wick shall be ignited so that the wicks continue to glow. Any flaming shall be blown out immediately. The test time shall start when all wicks are glowing.

7.5.5 *End-of-test condition*

The end-of-test condition shall be when:

— m_E = 2 dB/m;

— t > 750 s;

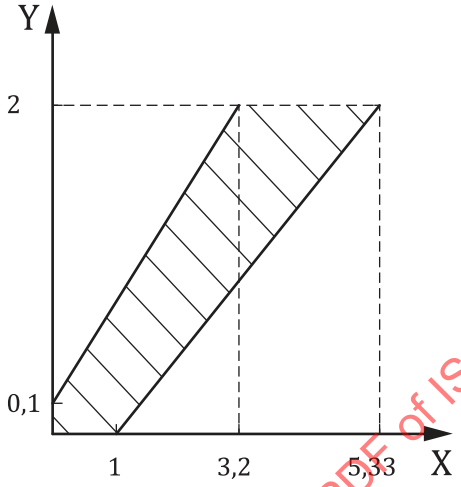
— S > 150 µl/l; or

— *all of the specimens have generated an alarm signal, whichever is the earlier.*

7.5.6 *Test validity criteria*

The development of the fire shall be such that the curves of m against y, and m against time, t, fall within limits shown in Figures 21, 22 and 23, respectively. That is, at the end-of-test condition m_E *= 2 dB/m, 3,2 ≤ y ≤ 5,33 and 280 ≤ t ≤ 750.*

If the end of test condition, y_E *= 6 is reached before all the specimens have responded, then the test is only considered valid if S > 150 µl/l.*

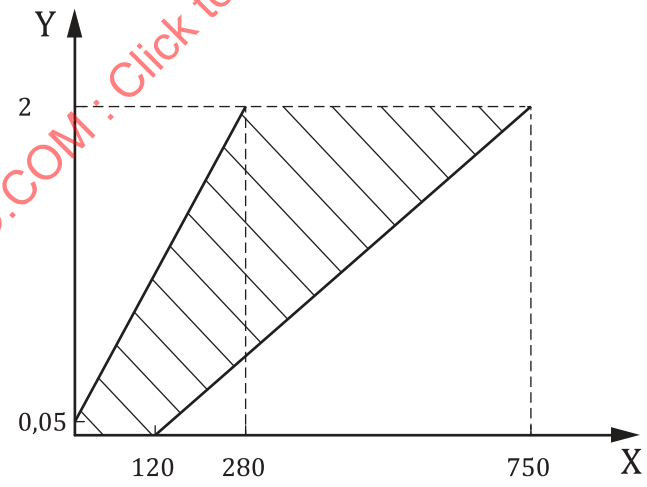


Key

X *y-value*

Y *m-value (dB/m)*

Figure 21 — *Limits for m against y, Fire TF3*

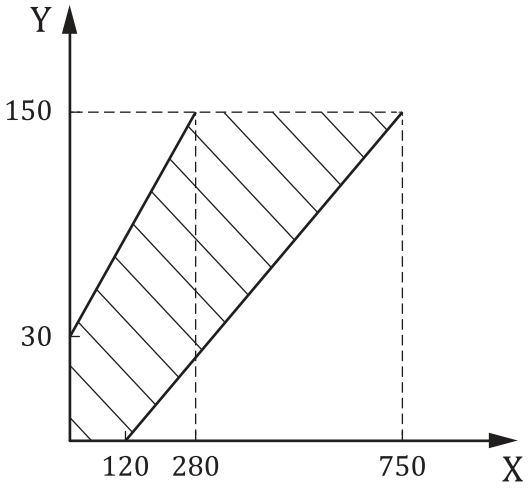


Key

X *time, t (s)*

Y *m-value (dB/m)*

Figure 22 — *Limits for m against time, t, Fire TF3*



Key

X *time, t (S)*

Y *S-value (µI/I)*

Figure 23 — *Limits for S against time, t, Fire TF3*

7.6 Test fire TF3A and TF3B — Reduced glowing smouldering cotton fire

7.6.1 General

TF3A and TF3B are described in ISO 7240-20:2010, Annex E and are reproduced in subclauses 7.6.2 to 7.6.6 of this document. The figure numbers have been adapted to ensure continuity of numbering within this document.

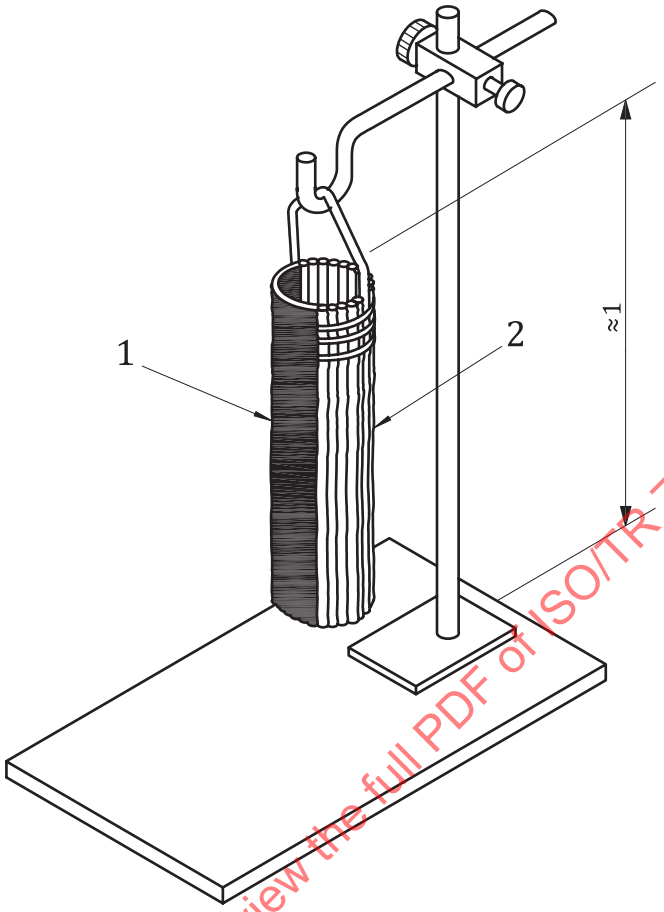
7.6.2 *Fuel*

The fuel consists of approximately 30 or 40 pieces of braided cotton wick, each of length approximately 80 cm and weighing approximately 3 g. The wicks shall be free from any protective coating and shall be washed and dried, if necessary.

7.6.3 *Arrangement*

Fasten the wicks to a ring approximately 10 cm in diameter and suspended approximately 1 m above a non-combustible plate. Position the wicks adjacent to one another and complete the open part of the arc using a curved sheet of non-combustible material to achieve a complete "chimney", as shown in Figure 24.

Dimensions in metres



Key

1 curved sheet of non-combustible material

2 cotton wicks

Figure 24 — *Arrangement of the cotton wicks*

7.6.4 *Ignition*

Ignite the lower end of each wick so that the wicks continue to glow. Blow out any flaming immediately. Start the test time when all wicks are glowing.

7.6.5 *End-of-test condition*

The end-of-test condition, m_E, for class A[4] using TF3A shall be when m = 0,05 dB/m.

The end-of-test condition, m_E, for class B[5] using TF3B shall be when m = 0,15 dB/m.

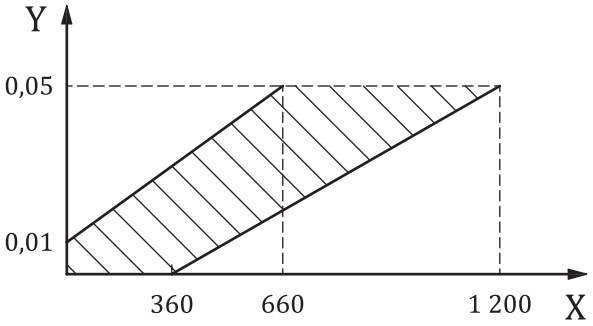
7.6.6 *Test validity criteria*

No flaming shall occur before the end-of-test condition. The development of the fire shall be such that the curves of m against time for TF3A and TF3B fall within the limits shown in Figures 25 and 26, respectively, up to the time when m equals the end-of-test condition or the specimen has generated an alarm signal, whichever is the earliest.

---

4) Classification for aspirating smoke detector providing very high sensitivity.

5) Classification for aspirating smoke detector providing enhanced sensitivity.

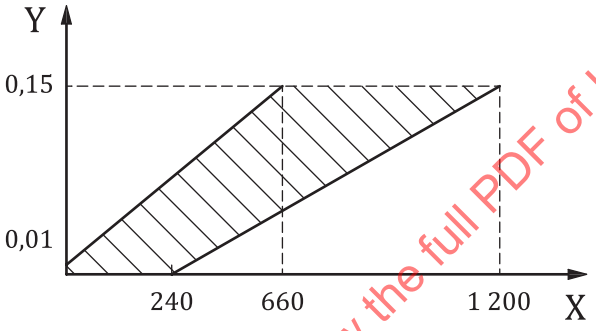


Key

X *time, t, expressed in seconds*

Y *m-value, expressed in decibels per metre*

Figure 25 — *Limits for m against time, t, fire TF3A*



Key

X *time, t, expressed in seconds*

Y *m-value, expressed in decibels per metre*

Figure 26 — *Limits for m against time, t, fire TF3B*

7.7 Test fire TF4 — Flaming plastics (polyurethane) fire

7.7.1 General

TF4 is described in ISO 7240-27:2018, Annex H and is reproduced in subclauses 7.7.2 to 7.7.8 of this document. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.7.2 *Fuel*

Three mats, approximately 50 cm × 50 cm × 2 cm, of soft polyurethane foam, without flame-retardant additives and having a density of approximately 20 kg/m^3, are usually found sufficient. However, the exact quantity of fuel may be adjusted to obtain valid tests.

7.7.3 *Conditioning*

The mats shall be maintained in a humidity not exceeding 50 % at least 48 h prior to test.

7.7.4 *Arrangement*

The mats shall be placed one on top of another on a base formed from aluminium foil with the edges folded up to provide a tray.

7.7.5 *Ignition*

The mats shall normally be ignited at a corner of the lower mat, however the exact position of ignition may be adjusted to obtain a valid test. A small quantity of a clean burning material (e.g. 5 cm^3 of methylated spirit) may be used to assist the ignition.

7.7.6 *Method of ignition*

Ignition shall be by match or spark.

7.7.7 *End-of-test condition*

The end-of-test condition shall be when:

— *y_E = 6,0 for ionization detectors and detectors using scattered or transmitted light with a declared response threshold value band of 0,05 < m < 0,3, or*

— *y_E = 6,5 for detectors using scattered or transmitted light, with a declared response threshold value band of 0,2 < m < 0,6, or*

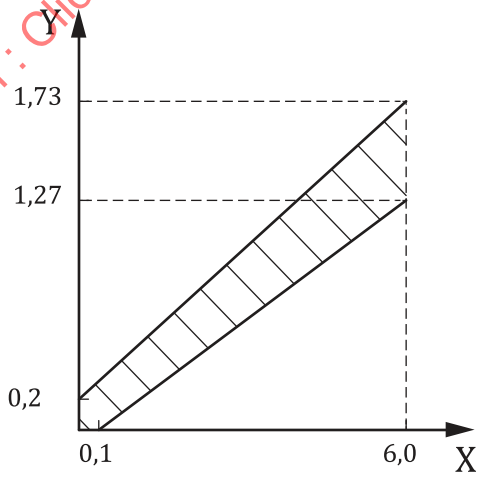
— *all of the specimens have generated an alarm signal, whichever is the earlier.*

7.7.8 *Test validity criteria*

The development of the fire shall be such that the curves of m against y, and m against time, t, and S-value against time, t, fall within the hatched areas shown in Figures 27 or 28, as appropriate for the type of detector tested and Figures 29 and 30, respectively. That is, at the end-of-test condition:

— *y_E = 6,0 and 1,27 ≤ m ≤ 1,73 for ionization detectors and detectors using scattered or transmitted light with a declared response threshold value band of 0,05 < m < 0,3, and 140 ≤ t ≤ 180, or*

— *y_E = 6,5 and 1,38 ≤ m ≤ 1,86 for detectors using scattered or transmitted light, with a declared response threshold value band of 0,2 < m < 0,6, and 150 ≤ t ≤ 193.*

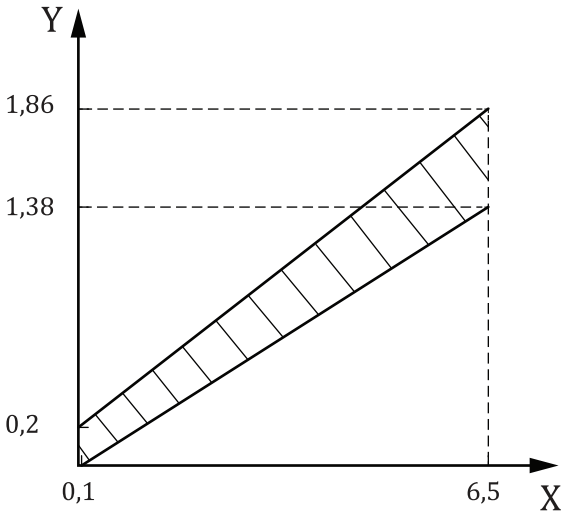


Key

X *y-value*

Y *m-value (dB/m)*

Figure 27 — *Limits for m against y, Fire TF4 — Ionization detectors and detectors using scattered or transmitted light with 0,05 < m < 0,3 declared response threshold value band*

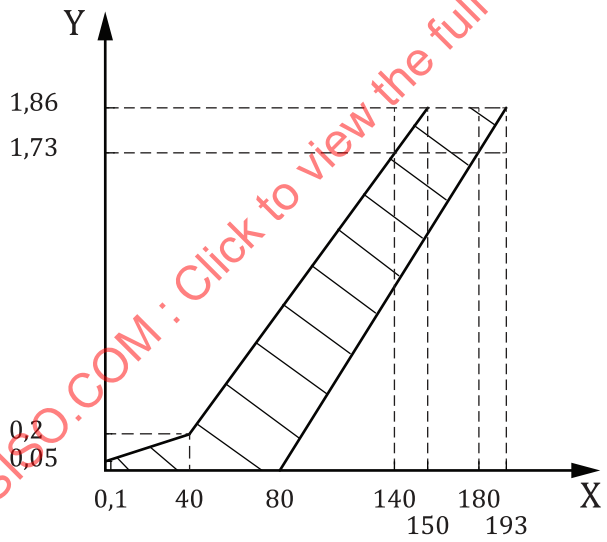


Key

X *y-value*

Y *m-value (dB/m)*

Figure 28 — *Limits for m against y, Fire TF4 — Detectors using scattered or transmitted light with 0,2 < m < 0,6 declared response threshold value band*

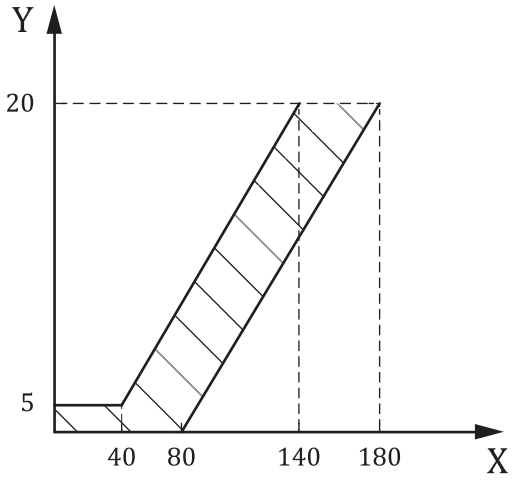


Key

X *t-value (s)*

Y *m-value (dB/m)*

Figure 29 — *Limits for m against time, t, Fire TF4*



Key

X *time, t (s)*

Y *S-value (µl/l)*

Figure 30 — *Limits for S against time, t, Fire TF4*

7.8 Test fire TF5 — Flaming liquid (*n*-heptane) fire

7.8.1 General

TF5 is described in ISO 7240-27:2018, Annex I and is reproduced in subclauses 7.8.2 to 7.8.6 of this document. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.8.2 *Fuel*

Approximately 650 g of a mixture of n-heptane (purity ≥ 99 %) with approximately 3 % of toluene (purity ≥ 99 %), by volume. The precise quantities may be varied to obtain valid tests.

7.8.3 *Arrangement*

The heptane/toluene mixture shall be burnt in a square steel tray with dimensions of approximately 33 cm × 33 cm × 5 cm.

7.8.4 *Ignition*

Ignition shall be by flame or spark.

7.8.5 *End-of-test condition*

The end-of-test condition shall be when:

— y_E *= 6,0 for ionization detectors and detectors using scattered or transmitted light with a declared response threshold value band of 0,05 < m < 0,3, or*

— y_E *= 7,5 for detectors using scattered or transmitted light, with a declared response threshold value band of 0,2 < m < 0,6 , or*

— *S > 16 µl/l, or*

— *all of the specimens have generated an alarm signal, whichever is the earlier.*

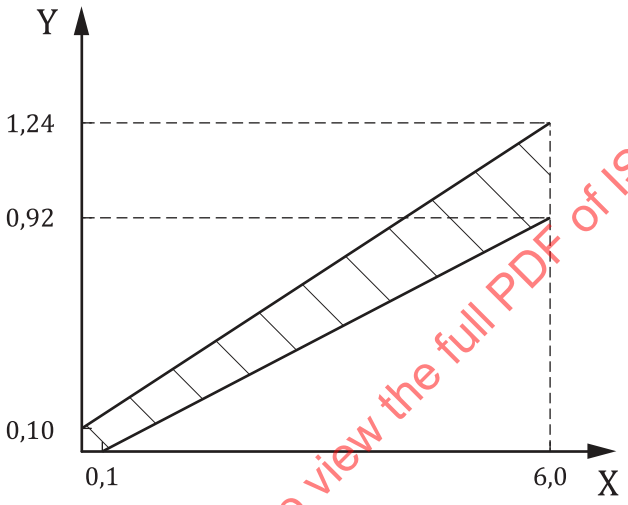
7.8.6 *Test validity criteria*

The development of the fire shall be such that the curves of m against y, m against time, t, and S-value against time, t, fall within the hatched areas shown in Figures 31 or 32, as appropriate for the type of detector tested, and Figures 33 and 34, respectively. That is, at the end-of-test condition:

— *y_E = 6,0 and 0,92 ≤ m ≤ 1,24 for ionization detectors and detectors using scattered or transmitted light with a declared response threshold value band of 0,05 < m < 0,3 , except for the special case above for which m ≤ 1,1, and 120 ≤ t ≤ 240, or*

— *y_E = 7,5 and 1,15 ≤ m ≤ 1,55 for detectors using scattered or transmitted light, with a declared response threshold value band of 0,2 < m < 0,6, except for the special case above for which m ≤ 1,1 and 150 ≤ t ≤ 300 .*

— *If the end of test condition, y_E = 6 is reached before all the specimens have responded, then the test is only considered valid if S > 16 µl/l.*

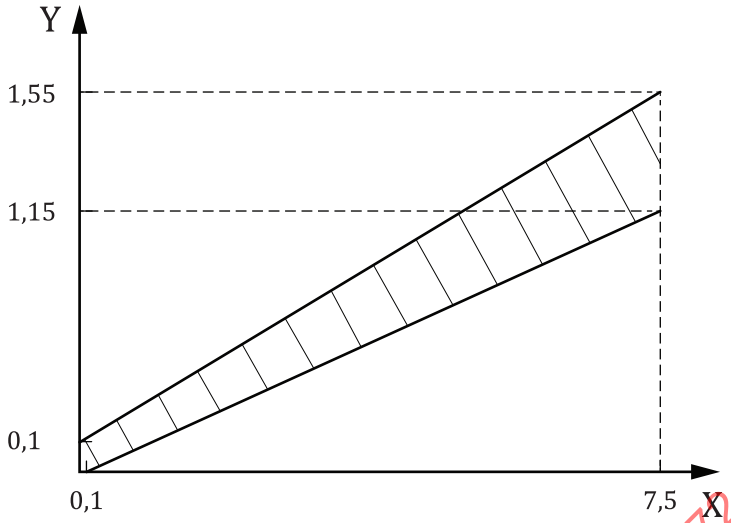


Key

X *y-value*

Y *m-value (dB/m)*

Figure 31 — *Limits for m against y, Fire TF5 — Ionization detectors and detectors using scattered or transmitted light with 0,05 < m < 0,3 declared response threshold value band*

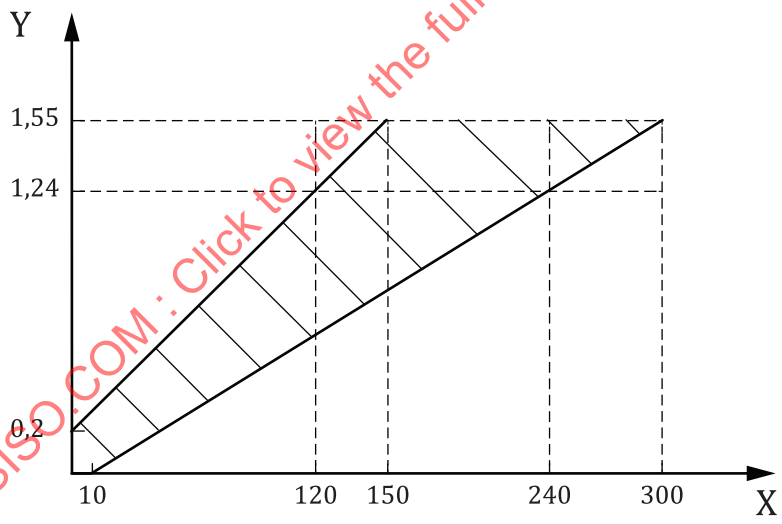


Key

X *y-value*

Y *m-value (dB/m)*

Figure 32 — *Limits for m against y, Fire TF5 — Detectors using scattered or transmitted light with 0,2 < m < 0,6 declared response threshold value band*

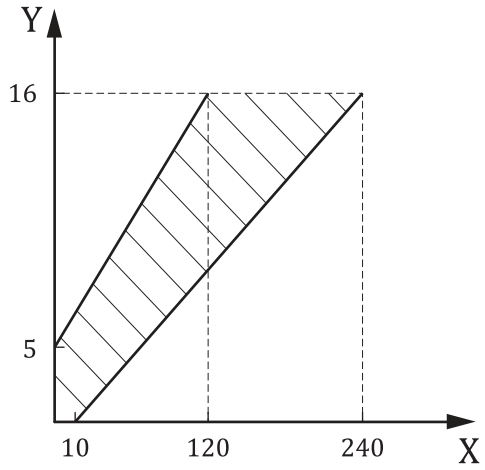


Key

X *t-value (s)*

Y *m-value (dB/m)*

Figure 33 — *Limits for m against time, t, Fire TF5*



Key

X *time, t (s)*

Y *S-value (μI/I)*

Figure 34 — *Limits for S-value against time, t, Fire TF5*

7.9 Test fire TF5A and TF5B — Reduced flaming liquid (n-heptane) fire

7.9.1 General

TF5A and TF5B are described in ISO 7240-20:2010, Annex H and are reproduced in subclauses 7.9.2 to 7.9.6 of this document. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.9.2 *Fuel*

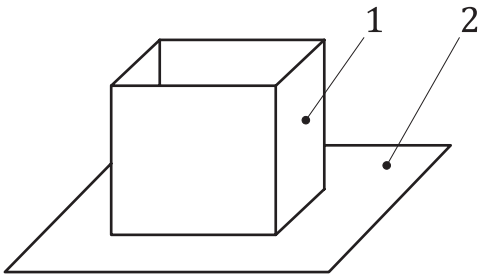
The fuel consists of approximately 200 ml (TF5A) or 300 ml (TF5B) of n-heptane (purity ≥ 99 %), by volume. The precise quantities may be varied to obtain valid tests.

NOTE The use of toluene in the n-heptane is not accepted, since the presence of toluene in the fuel significantly modifies the behaviour of the fire, giving an initial peak burn, which is not suitable for reduced test fires.

7.9.3 *Arrangement*

For TF5A, the n-heptane shall be burnt in a square, 2 mm thick, steel tray with dimensions of approximately 100 mm × 100 mm × 100 mm placed on a 2 mm thick sheet metal base with dimensions of approximately 350 mm × 350 mm, as illustrated in Figure 35.

For TF5B, the n-heptane shall be burnt in a square, 2 mm thick, steel tray with dimensions of approximately 175 mm × 175 mm × 100 mm placed on a 2 mm thick sheet metal base with dimensions of approximately 350 mm × 350 mm, as illustrated in Figure 35.



Key

1 tray

2 base plate

Figure 35 — *Arrangement of the tray for test fires TF5A and TF5B*

The base plate may be the tray used in TF5 and is needed to act as a heat sink to avoid boiling of the small quantities of fuel used in the reduced test fires.

7.9.4 *Ignition*

Ignition shall be by flame or spark, etc.

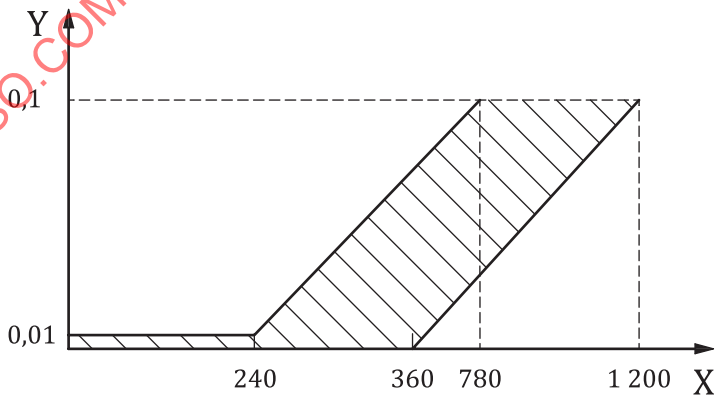
7.9.5 *End-of-test condition*

The end-of-test condition, m_E, for class A[6] using TF5A shall be when m = 0,1 dB/m.

The end-of-test condition, m_E, for class B[7] using TF5B shall be when m = 0,3 dB/m.

7.9.6 *Test validity criteria*

The development of the fire shall be such that the curves of m against time, t, for TF5A and TF5B fall within the limits shown in Figures 36 and 37, respectively, up to the time when m equals the end-of-test condition or the specimen has generated an alarm signal, whichever is the earlier.



Key

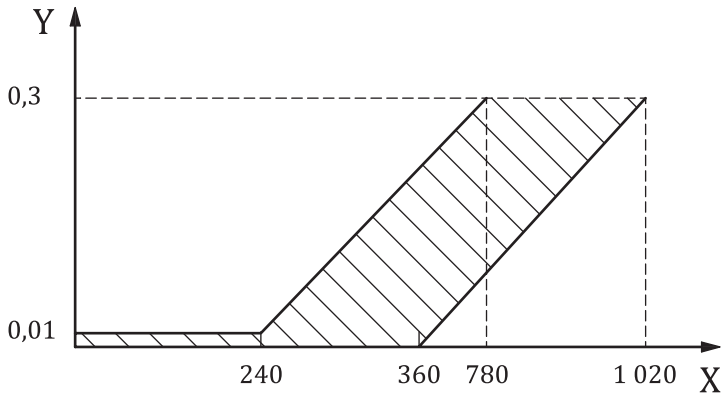
X time, t, expressed in seconds

Y m-value, expressed in decibels per metre

Figure 36 — *Limits for m against time, t, fire TF5A*

6) Classification for aspirating smoke detector providing very high sensitivity.

7) Classification for aspirating smoke detector providing enhanced sensitivity.



Key

X *time, t, expressed in seconds*

Y *m-value, expressed in decibels per metre*

Figure 37 — *Limits for m against time, t, fire TF5B*

7.10 Test fire TF6 — Liquid (methylated spirit) fire

7.10.1 General

TF6 was originally developed to evaluate detectors which have heat sensors. However, at the time of publication, TF6 is used only for point-type flame detectors.

For the purpose of recording the history and future use, subclauses 7.10.2.1 to 7.10.2.5 reproduce the original TF6, which includes test validity criteria and is described in ISO/TS 7240-9:2012, 7.13. Subclauses 7.10.3.1 to 7.10.3.5 reproduce the adjusted TF6, which is described in ISO 7240-10:2012, Annex C. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.10.2 TF6 used for detectors with heat sensor

7.10.2.1 *Fuel*

Methylated spirits, at least 90 % ethanol C_2H_5OH to which has been added 10 % of denaturant impurity (methanol).

7.10.2.2 *Arrangement*

Burn the methylated spirit in a container made from 2 mm thick sheet steel, base surface, 1 900 cm^2 area, dimensions approximately 43,5 cm × 43,5 cm × 5 cm high.

7.10.2.3 *Volume*

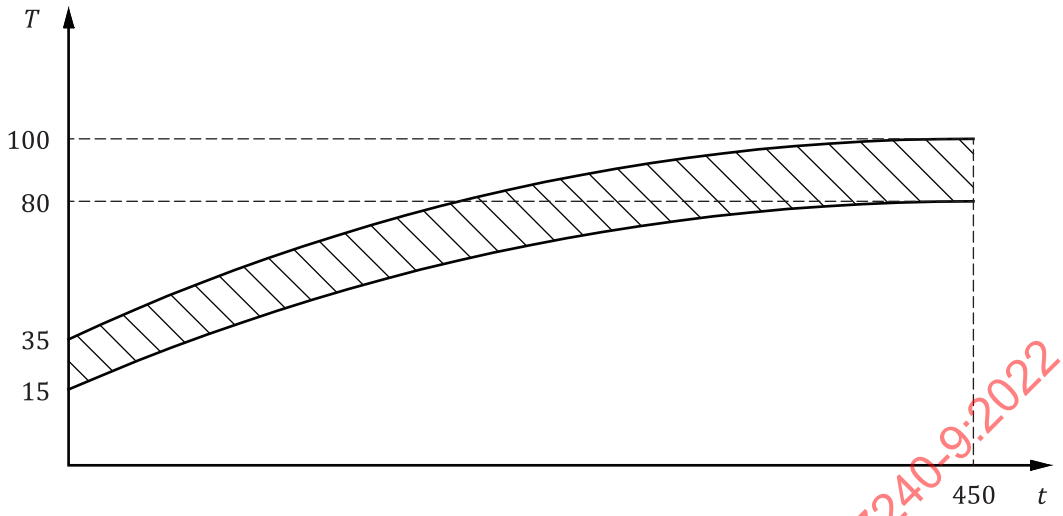
Use approximately 1,5 l of methylated spirit.

7.10.2.4 *Ignition*

Ignite by flame or spark.

7.10.2.5 *Test validity criteria*

The development of the fire shall be such that the curve of temperature, T, against time, t, falls within the hatched areas shown in Figure 38. That is, at the end-of-test condition 80 °C < ΔT < 100 °C and t < 450 s.



Key

t *time (s)*

T *temperature (°C)*

Figure 38 — *Limits for T against t, Fire TF6*

7.10.2.6 *End-of-test condition*

The end-of-test condition shall be when

— *ΔT = 60 °C;*

— *t_E > 450 s; or*

— *all of the specimens have generated an alarm signal, whichever is the earlier.*

7.10.3 TF6 used for Point-type flame detectors

7.10.3.1 *Fuel*

Methylated spirit, at least 90 % ethanol C_2H_5OH, to which has been added 10 % of a denaturant impurity (methanol).

7.10.3.2 *Arrangement*

The methylated spirit shall be burnt in a container made from 2 mm thick sheet steel, with a base surface area of 1 900 cm^2, with dimensions of approximately 43,5 cm × 43,5 cm × 5 cm high.

7.10.3.3 *Volume*

Approximately 1,5 l of methylated spirit shall be used.

7.10.3.4 *Ignition*

Ignition shall be by flame or spark.

7.10.3.5 *End-of-test condition*

30 s after exposure of detectors to the fire.

7.11 Test fire TF7 — Slow smouldering (pyrolysis) wood fire

7.11.1 General

TF7 was originally developed to evaluate smoke alarms but is not in use in ISO 12239 at the time of publication.

For the purpose of recording the history and future use, subclauses 7.11.2 to 7.11.10 reproduce the description of TF7 which was provided in ISO/TS 7240-9:2012, 7.11. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.11.2 *Fuel*

Approximately ten dried beechwood sticks, each stick having dimensions of 75 mm × 25 mm × 20 mm.

7.11.3 *Conditioning*

Dry the sticks in a heating oven so the moisture content is less than 3 %.

7.11.4 *Preparation*

If necessary, transport the sticks from the oven in a closed plastic bag and open the bag just prior to laying out the sticks in the test arrangement.

7.11.5 *Hotplate*

The hotplate shall have a 220 mm diameter grooved surface with eight concentric grooves with a distance of 3 mm between grooves. Each groove shall be 2 mm deep and 5 mm wide, with the outer groove 4 mm from the edge. The hotplate shall have a rating of approximately 2 kW.

Measure the temperature of the hotplate by attaching a sensor to the fifth groove, counted from the edge of the hotplate, and securing the sensor to provide a good thermal contact.

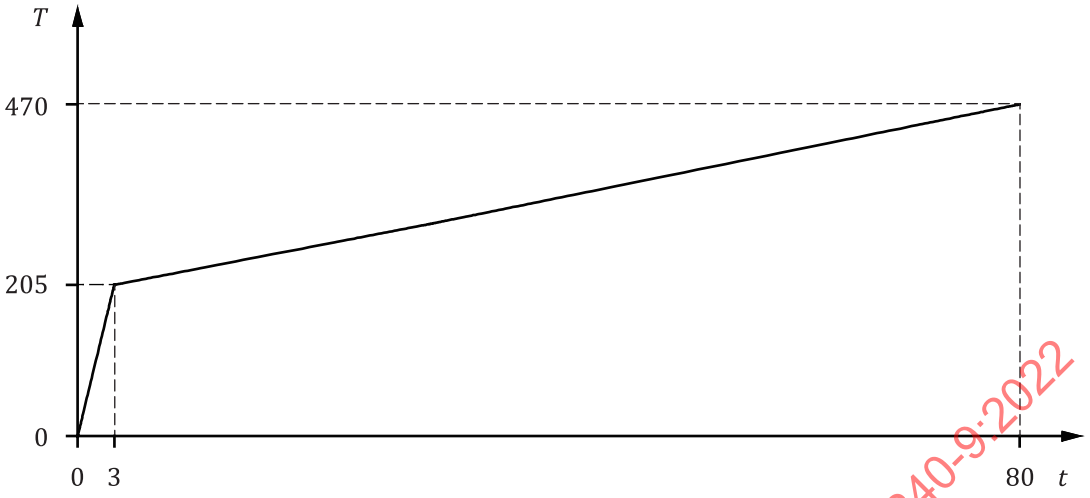
7.11.6 *Arrangement*

Arrange the sticks radially on the grooved hotplate surface, with the 20 mm side in contact with the surface such that the temperature probe lies between the sticks and is not covered, as shown in Figure 13.

The ceiling height of the test laboratory shall be 3 m.

7.11.7 *Heating rate*

Power the hotplate such that its temperature rises in accordance with Figure 39.



Key

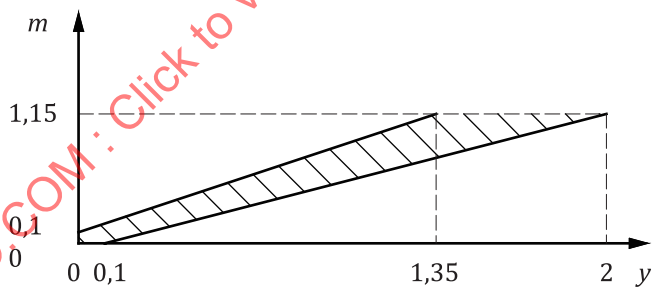
t *time (min)*

T *temperature (°C)*

Figure 39 — *Slow smouldering (pyrolysis) wood fire hotplate temperature vs. time*

7.11.8 *Test validity criteria*

No flaming shall occur before the end-of-test condition has been reached. The development of the fire shall be such that the curves of m against y, and m against time, t, fall within the hatched areas shown in Figures 40 and 41, respectively. That is, 1,35 < y < 2,00 and 50 min < t < 75 min at the end-of-test condition m_E *= 1,15 dB/m.*

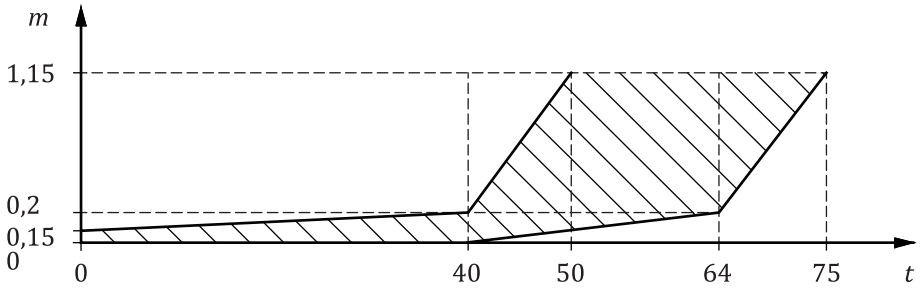


Key

m *m-value(dB/m)*

y *y-value*

Figure 40 — *Limits for* m *against* y*, Fire TF7*



Key

t *time (min)*

m *m-value (dB/m)*

Figure 41 — *Limits for* m *against time, t, Fire TF7*

7.11.9 *Variables*

The number of sticks, the rate of temperature increase of the hotplate and the degree of conditioning of the wood may be varied in order for the test fire to remain within the profile curve limits.

7.11.10 *End-of-test condition*

The end-of-test condition shall be when

— m_E *= 1,15 dB/m;*

— t_E *> 75 min; or*

— *all the specimens have generated an alarm signal.*

7.12 Test fire TF8 — Low-temperature black-smoke liquid (decalin) fire

7.12.1 General

TF8 is described in ISO 7240-27:2018, Annex J and is reproduced in subclauses 7.12.2 to 7.12.7 of this document. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.12.2 *Fuel*

Decalin (decahydronaphtaline for synthesis; a mixture of cis and trans isomers — $C_{10}H_{18}$ – M = 138,25 g/mol – 1 l = 0,88 kg).

7.12.3 *Arrangement*

Burn the decalin in a square steel tray with dimensions approximately 120 mm × 120 mm and 20 mm depth.

7.12.4 *Volume*

Use approximately 170 ml of decalin ($C_{10}H_{18}$).

7.12.5 *Ignition*

Ignite by flame or spark. A small quantity of a clean burning material (5 g of ethanol C_2H_5OH) may be used to assist ignition.

7.12.6 *End-of-test condition*

The end of test condition shall be when:

— $m_E = 1{,}5$ dB m^{-1};

— $t > 445$ s;

— $S > 8$ µl/l; or

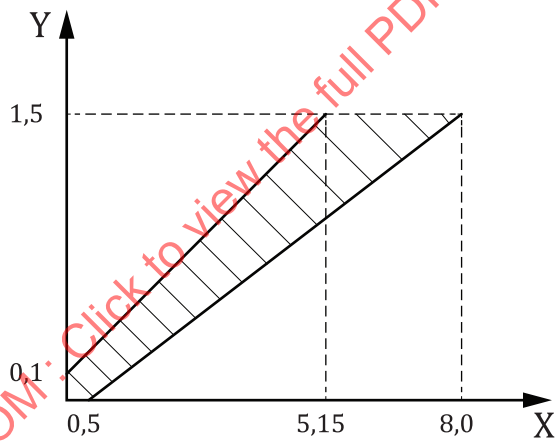
— *all of the specimens have generated an alarm signal, whichever is the earlier.*

7.12.7 *Test validity criteria*

The development of the fire shall be such that the curves of m against y, m against time, t, and S against time, t, fall within the hatched areas shown in Figures 42, 43 and 44, respectively. That is, at the end-of-test condition $m_E = 1{,}7$ dB/m, $4{,}5 < y < 9{,}0$, 4 µl/l < S < 8 µl/l and 550 s < t < 1 000 s.

During the test, the rise in temperature, ΔT, shall not exceed 6 K.

NOTE The test condition can be changed to get the specified profile of test fire if it was not produced. For example, the height of room or the position of fire can be altered to ensure the smoke reaches the ceiling and the tray can be kept cool (e.g. by using heavier grade steel or by placing the tray in an outer bath of cooling water) to ensure T does not rise above 6 K.

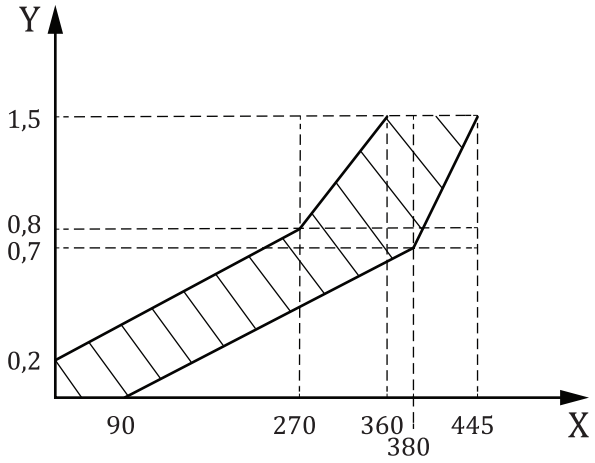


Key

X *y-value*

Y *m-value (dB/m)*

Figure 42 — *Limits for m against y, Fire TF8*

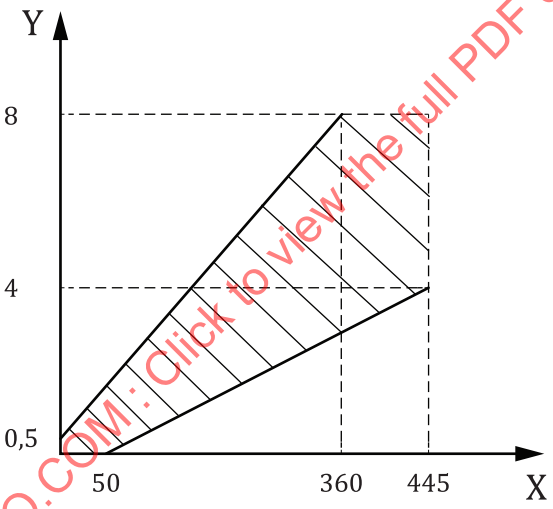


Key

X *time, t (s)*

Y *m-value (dB/m)*

Figure 43 — *Limits for m against time, t, Fire TF8*



Key

X *time, t (s)*

Y *S-value (µI/I)*

Figure 44 — *Limits for S against time, t, Fire TF8*

7.13 Test fire TF9 — Deep-seated smouldering cotton fire

7.13.1 General

TF 9 is described in ISO 7240-6:2011, Annex F and is reproduced in subclauses 7.13.2 to 7.13.6 of this document. The figure numbers have been adapted to ensure continuity of numbering within this document.

7.13.2 *Fuel*

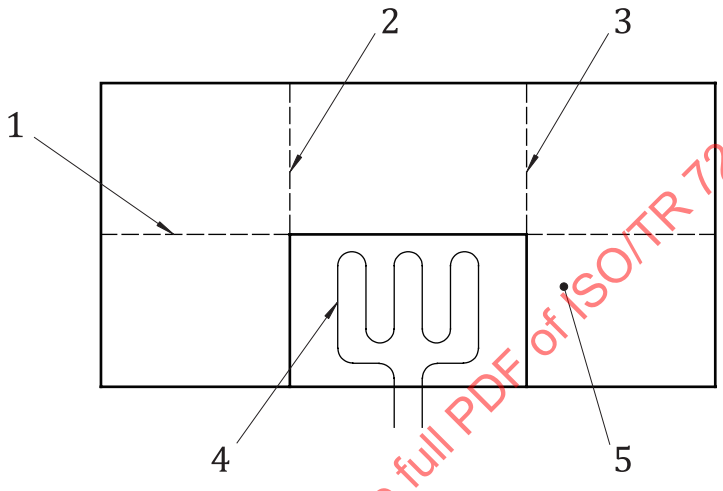
Unused white towel, made from 100 % cotton, having dimensions 50 cm × 100 cm, and a density of 540 g m^{-2}. The fuel shall be dried in an oven at 40 °C for a period of at least 12 h.

7.13.3 *Arrangement*

The towel shall be folded three times to give a rectangle 30 cm × 25 cm, the first fold being on the long dimension. The towel shall be placed on a base formed from aluminium foil with the edges folded up to form a tray.

Approximately 2 m of resistance wire, having a specific resistance of approximately 4 Ω/m, formed as shown in Figure 45, shall be placed on the surface of the towel before it is folded such that, after folding, five layers of the towel cover the resistance wire.

NOTE Nichrome wire is a suitable resistance wire for this test.



Key

1 first fold
2 second fold
3 third fold
4 resistance wire
5 towel, 1 000 mm × 500 mm

Figure 45 — *Arrangement of the cotton towel and ignition source*

7.13.4 *Ignition*

The resistance wire of the ignition source shall be connected to a power supply capable of being adjusted between 18 V and 22 V and capable of delivering at least 2,5 A.

NOTE It can be necessary to adjust the voltage applied to the resistance wire in order to obtain a generation of CO within the defined profile curve (see Figure 47).

The start of the test corresponds with the instant of switching on the supply.

Power shall be supplied to the ignition source throughout the test.

7.13.5 *End-of-test condition*

The end-of-test conditions, S_E and t_E, are when S = 100 µl/l and t > 30 min, or all of the specimens have generated an alarm signal, whichever is the earlier.