INTERNATIONAL STANDARD

ISO 7240-7

Second edition
2011-08-01

Fire detection and alarm systems —

Part 7:
Point-type smoke detectors using scattered light, transmitted light or ionization

Systèmes de détection et d'alarme d'incendie —

Partie 7: Détecteurs de fumée ponctuels utilisant le principe de la diffusion de la lumière, de la transmission de la lumière ou de l'ionisation

Reference number
ISO 7240-7:2011(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

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 7240-7 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 7240-7:2003), which has been technically revised.

ISO 7240 consists of the following parts, under the general title *Fire detection and alarm systems*:

— *Part 1: General and definitions*

— *Part 2: Control and indicating equipment*

— *Part 3: Audible alarm devices*

— *Part 4: Power supply equipment*

— *Part 5: Point-type heat detectors*

— *Part 6: Carbon monoxide fire detectors using electro-chemical cells*

— *Part 7: Point-type smoke detectors using scattered light, transmitted light or ionization*

— *Part 8: Carbon monoxide fire detectors using an electro-chemical cell in combination with a heat sensor*

— *Part 9: Test fires for fire detectors* [Technical Specification]

— *Part 10: Point-type flame detectors*

— *Part 11: Manual call points*

— *Part 12: Line type smoke detectors using a transmitted optical beam*

— *Part 13: Compatibility assessment of system components*

- *Part 14: Guidelines for drafting codes of practice for design, installation and use of fire detection and fire alarm systems in and around buildings* [Technical Report]
- *Part 15: Point type fire detectors using scattered light, transmitted light or ionization sensors in combination with a heat sensor*
- *Part 16: Sound system control and indicating equipment*
- *Part 17: Short-circuit isolators*
- *Part 18: Input/output devices*
- *Part 19: Design, installation, commissioning and service of sound systems for emergency purposes*
- *Part 20: Aspirating smoke detectors*
- *Part 21: Routing equipment*
- *Part 22: Smoke-detection equipment for ducts*
- *Part 24: Sound-system loudspeakers*
- *Part 25: Components using radio transmission paths*
- *Part 27: Point-type fire detectors using a scattered-light, transmitted-light or ionization smoke sensor, an electrochemical-cell carbon-monoxide sensor and a heat sensor*
- *Part 28: Fire protection control equipment*

A part 23 dealing with visual alarm devices and a part 29 dealing with video fire detectors are under development.

Introduction

This part of ISO 7240, drawn up by ISO/TC 21/SC 3, is based on a draft prepared by the European Committee for Standardization's CEN/TC 72, *Automatic fire detection systems*.

A fire detection and alarm system is required to function satisfactorily not only in the event of fire, but also during and after exposure to conditions it is likely to meet in practice, including corrosion, vibration, direct impact, indirect shock and electromagnetic interference. Specific tests are intended to assess the performance of the smoke detectors under such conditions.

This part of ISO 7240 is not intended to place any other restrictions on the design and construction of such detectors.

This edition of ISO 7240-7 introduces a requirement that smoke detectors that operate on the scattered or transmitted light principle be marked with one of two possible nominal response threshold value bands. This marking provides for a clearer choice of response values so that the risk of unwanted alarms can be decreased in installations where unfavourable environmental conditions are present.

NOTE For some test fires, smoke detectors that operate on the scattered or transmitted light principle and that have been factory set to the upper response threshold value band can fall outside one of the classification limits given in ISO/TS 7240-9.

This edition of ISO 7240-7 introduces additional requirements for smoke detectors with more than one smoke sensor.

Fire detection and alarm systems —

Part 7: Point-type smoke detectors using scattered light, transmitted light or ionization

1 Scope

This part of ISO 7240 specifies requirements, test methods and performance criteria for point-type smoke detectors that operate using scattered light, transmitted light or ionization, for use in fire detection and alarm systems installed in buildings (see ISO 7240-1). This part of ISO 7240 also covers point smoke detectors that incorporate more than one smoke sensor operating on these principles. Additional requirements and test methods for such detectors are given in Annex N.

For the testing of other types of smoke detectors, or smoke detectors working on different principles, this part of ISO 7240 can be used only for guidance. Smoke detectors with special characteristics, developed for specific risks, are not covered.

NOTE Certain types of detector contain radioactive materials. The national requirements for radiation protection differ from country to country and are not specified in this part of ISO 7240.

2 Normative references

The following referenced documents are indispensable for the application 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 209, *Aluminium and aluminium alloys — Chemical composition*

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

IEC 60068-1, *Environmental testing — Part 1: General and guidance*

IEC 60068-2-1, *Environmental testing — Part 2-1: Tests — Test A: Cold*

IEC 60068-2-2, *Environmental testing — Part 2-2: Tests — Test B: Dry heat*

IEC 60068-2-6, *Environmental testing — Part 2-6: Tests — Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27, *Environmental testing — Part 2-27: Tests — Test Ea and guidance: Shock*

IEC 60068-2-42, *Environmental testing — Part 2-42: Tests — Test Kc: Sulphur dioxide test for contacts and connections*

IEC 60068-2-78, *Environmental testing — Part 2-78: Tests — Test Cab: Damp heat, steady state*

EN 50130-4:1995 + A1:1998 + A2:2003, *Alarm systems — Part 4: Electromagnetic compatibility — Product family standard: Immunity requirements for components of fire, intruder and social alarm systems*

3 Terms and definitions

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

3.1
aerosol density
smoke density
number of particulates per volume as described operationally by one of two parameters:

— m (3.3), an absorbance index, used in the testing of smoke detectors using scattered or transmitted light;

— y (3.5), a dimensionless variable, used in the testing of smoke detectors using ionization

NOTE These parameters are not concentrations *sensu stricto*, but represent values which are proportional to the concentration and have been shown to function in lieu of a true concentration value for the purposes of these tests.

3.2
least sensitive orientation
point of rotation, relative to air flow, about the vertical axis where a detector produces the maximum response threshold value

3.3
m
absorbance index
measured light attenuation characterizing the concentration of particulates in smoke or an aerosol

NOTE The equation for m is given in Annex C.

3.4
response threshold value
A_{th}
⟨smoke detector⟩ aerosol density in the proximity of the specimen at the moment that it generates an alarm signal, when tested as specified in 5.1.5

NOTE The response threshold value can depend on signal processing in the detector and in the control and indicating equipment.

3.5
y
dimensionless variable, reflecting the change in the current flowing in an ionization chamber as a known function of the concentration of particulates in the smoke or aerosol

NOTE The equation for y is given in Annex C.

4 General requirements

4.1 Compliance

In order to comply with this part of ISO 7240, the detector shall meet the requirements of this clause, which shall be verified by visual inspection or engineering assessment, shall be tested as specified in Clause 5 (and, for detectors with more than one smoke sensor, Annex N) and shall meet the requirements of the tests.

4.2 Response threshold value of detectors using scattered or transmitted light

Detectors using scattered or transmitted light shall conform to one of the two response threshold value bands specified in Table 1 and the corresponding end-of-test conditions for the test fires specified in 5.18.

Table 1 — Response threshold value for detectors using scattered or transmitted light

Response threshold value in smoke tunnel (aerosol) dB/m		**Test fires end-of-test conditions**			
		TF2 dB/m	**TF3** dB/m	**TF4** dimensionless	**TF5** dimensionless
1	0,05 < m < 0,3	m = 2	m = 2	y = 6	y = 6
2	0,2 < m < 0,6	m = 2	m = 2	y = 6,5	y = 7,5
NOTE The smaller the m value, the higher the sensitivity of the detectors.					

4.3 Individual alarm indication

Each detector shall be provided with an integral red visual indicator by which the individual detector releasing an alarm can be identified, until the alarm condition is reset. Where other conditions of the detector may be visually indicated, these shall be clearly distinguishable from the alarm indication, except when the detector is switched into a service mode. For detachable detectors, the indicator may be integral with the base or the detector head.

NOTE The alarm condition is reset manually at the control and indicating equipment (see EN 54-2).

The visual indicator shall be visible from a distance of 6 m in an ambient light intensity up to 500 lx at an angle of up to

a) 5° from the axis of the detector in any direction,

b) 45° from the axis of the detector in at least one direction.

4.4 Connection of ancillary devices

The detector may provide for connections to ancillary devices (remote indicators, control relays, etc.), but open- or short-circuit failures of these connections shall not prevent the correct operation of the detector.

4.5 Monitoring of detachable detectors

For detachable detectors, a means shall be provided for a remote monitoring system (e.g. the control and indicating equipment) to detect the removal of the head from the base, in order to give a fault signal.

4.6 Manufacturer's adjustments

It shall not be possible to change the manufacturer's settings except by special means (e.g. the use of a special code or tool), or by breaking or removing a seal.

4.7 On-site adjustment of response behaviour

If there is provision for on-site adjustment of the response behaviour of the detector, then

a) for all of the settings at which the manufacturer claims compliance, the detector shall comply with the requirements of this part of ISO 7240 and access to the adjustment means shall be possible only by the use of a code or special tool, or by removing the detector from its base or mounting,

b) any setting or settings at which the manufacturer does not claim compliance with this part of ISO 7240 shall be accessible only by the use of a code or special tool, and it shall be clearly marked on the detector or in the associated data that if this setting or these settings are used, the detector does not comply with this part of ISO 7240.

These adjustments may be carried out at the detector or at the control and indicating equipment.

4.8 Protection against the ingress of foreign bodies

The detector shall be so designed that a sphere of diameter greater than (1,3 ± 0,05) mm cannot pass into the sensor chamber or chambers.

NOTE 1 This requirement is intended to restrict the access of insects into the sensitive parts of the detector. It is known that this requirement is not sufficient to prevent the access of all insects; however, it is considered that extreme restrictions on the size of access holes can introduce the danger of clogging by dust, etc. It can, therefore, be necessary to take other precautions against false alarms due to the entry of small insects.

NOTE 2 For detectors that do not have physical protection against ingress of foreign bodies, the resistance of the detector against the adverse effect of such ingress needs to be proven by the manufacturer.

4.9 Response to slowly developing fires

The provision of "drift compensation" (e.g. to compensate for sensor drift due to the build-up of dirt in the detector) shall not lead to a significant reduction in the sensitivity of the detector to slowly developing fires (see Annex L).

Since it is not practical to make tests with very slow increases in smoke density, an assessment of the response of the detector to slow increases in smoke density shall be made by analysis of the circuit/software, and/or physical tests and simulations.

The detector shall be deemed to meet the requirements of this subclause if this assessment shows the following:

a) that for any rate of increase in smoke density R, which is greater than 25 % of the initial uncompensated response threshold value of the detector, $A_{\text{th,u}}$, per hour, the time for the detector to give an alarm does not exceed $1{,}6 \times (A_{\text{th,u}}:R)$ by more than 100 s;

b) that the total compensation C_{t} is limited such that $C_{\text{t}} < 0{,}6\,A_{\text{th,u}}$ throughout this range, and that the fully compensated response threshold value $A_{\text{th,c}}$ does not exceed its initial value $A_{\text{th,u}}$ by a factor greater than 1,6.

4.10 Marking

Each detector shall be clearly marked with the following information:

a) reference to this part of ISO 7240 (i.e. ISO 7240-7);

b) name or trademark of the manufacturer or supplier;

c) model designation (type or number);

d) for detectors using scattered or transmitted light, the response threshold value band,

EXAMPLE (0,05 to 0,3) dB/m or (0,2 to 0,6) dB/m.

e) wiring terminal designations;

f) some mark(s) or code(s) (e.g. serial number or batch code) by which the manufacturer can identify, at least, the date or batch and place of manufacture, and the version number(s) of any software contained within the detector.

For detachable detectors, the detector head shall be marked with a), b), c) and f), and the base shall be marked with, at least, c) and e).

Where any marking on the device uses symbols or abbreviations not in common use, these should be explained in the data supplied with the device.

The markings shall be visible during installation of the detector and shall be accessible during maintenance.

The markings shall not be placed on screws or other easily removable parts.

4.11 Data

Either detector shall be supplied with sufficient technical, installation and maintenance data to enable their correct installation and operation or, if all of these data are not supplied with each detector, reference to the appropriate data sheet shall be given on, or with, each detector.

To enable correct operation of the detectors, these data should describe the requirements for the correct processing of the signals from the detector. This may be in the form of a full technical specification of these signals, a reference to the appropriate signalling protocol or a reference to suitable types of control and indicating equipment, etc.

Installation and maintenance data shall include reference to an *in situ* test method to ensure that detectors operate correctly when installed.

NOTE Additional information can be required by organizations certifying that detectors produced by a manufacturer conform to the requirements of this part of ISO 7240.

4.12 Requirements for software-controlled detectors

4.12.1 General

The requirements of 4.12.2, 4.12.3 and 4.12.4 shall be met for detectors that rely on software control in order to fulfil the requirements of this part of ISO 7240.

4.12.2 Software documentation

4.12.2.1 The manufacturer shall submit documentation that gives an overview of the software design. This documentation shall be in sufficient detail for inspection of the design for compliance with this part of ISO 7240 and shall include at least the following:

a) functional description of the main program flow (e.g. as a flow diagram or structogram), including

   1) a brief description of the modules and the functions that they perform,

   2) the way in which the modules interact,

   3) the overall hierarchy of the program,

   4) the way in which the software interacts with the hardware of the detector,

   5) the way in which the modules are called, including any interrupt processing;

b) description of those areas of memory used for the various purposes (e.g. the program, site-specific data and running data);

c) designation by which the software and its version can be uniquely identified.

4.12.2.2 The manufacturer shall prepare and maintain detailed design documentation. This shall be available for inspection in a manner that respects the manufacturers' rights for confidentiality. It shall be comprised of at least the following:

a) overview of the whole system configuration, including all software and hardware components;

b) description of each module of the program, containing at least

   1) the name of the module,

   2) a description of the tasks performed,

   3) a description of the interfaces, including the type of data transfer, the valid data range and the checking for valid data;

c) full source code listings, as hard copy or in machine-readable form (e.g. ASCII-code), including all global and local variables, constants and labels used, and sufficient comment for recognizing the program flow;

d) details of any software tools used in the design and implementation phase (CASE-Tools, Compilers, etc.).

NOTE This detailed design documentation can be reviewed at the manufacturers' premises.

4.12.3 Software design

In order to ensure the reliability of the detector, the following requirements for software design apply.

a) The software shall have a modular structure.

b) The design of the interfaces for manually and automatically generated data shall not permit invalid data to cause error in the program operation.

c) The software shall be designed to avoid the occurrence of deadlock of the program flow.

4.12.4 Storage of programs and data

The program necessary to comply with this part of ISO 7240 and any preset data, such as manufacturer's settings, shall be held in non-volatile memory. Writing to areas of memory containing this program and data shall be possible only by the use of some special tool or code and shall not be possible during normal operation of the detector.

Site-specific data shall be held in memory that can retain data for at least two weeks without external power to the detector, unless provision is made for the automatic renewal of such data, following loss of power, within 1 h of power being restored.

5 Tests

5.1 General

5.1.1 Atmospheric conditions for tests

Unless otherwise stated in a test procedure, carry out the testing after the test specimen has been allowed to stabilize in the standard atmospheric conditions for testing in accordance with IEC 60068-1 as follows:

— temperature: (15 to 35) °C;

— relative humidity: (25 to 75) %;

— air pressure: (86 to 106) kPa.

The temperature and humidity shall be substantially constant for each environmental test where the standard atmospheric conditions are applied.

5.1.2 Operating conditions for tests

If a test method requires a specimen to be operational, then connect the specimen to suitable supply and monitoring equipment having the characteristics required by the manufacturer's data. Unless otherwise specified in the test method, the supply parameters applied to the specimen shall be set within the manufacturer's specified range(s) and shall remain substantially constant throughout the tests. The value chosen for each parameter shall normally be the nominal value, or the mean of the specified range. If a test procedure requires a specimen to be monitored to detect any alarm or fault signals, then connections shall be made to any necessary ancillary devices (e.g. through wiring to an end-of-line device for conventional detectors) to allow a fault signal to be recognized.

The details of the supply and monitoring equipment and the alarm criteria used shall be given in the test report (Clause 6).

5.1.3 Mounting arrangements

Mount the specimen by its normal means of attachment in accordance with the manufacturer's instructions. If these instructions describe more than one method of mounting, then choose the method considered to be most unfavourable for each test.

5.1.4 Tolerances

Unless otherwise stated, the tolerances for the environmental test parameters shall be as given in the basic reference standards for the test (e.g. the relevant part of IEC 60068).

If a specific tolerance or deviation limit is not specified in a requirement or test procedure, then a tolerance of ± 5 % shall be applied.

5.1.5 Measurement of response threshold value

Install the specimen for which the response threshold value, A_{th}, is to be measured in the smoke tunnel, described in Annex A, in its normal operating position, by its normal means of attachment. The orientation of the specimen, relative to the direction of air flow, shall be the least sensitive orientation, as determined in the directional dependence test, unless otherwise specified in the test procedure.

Before commencing each measurement, purge the smoke tunnel to ensure that the tunnel and the specimen are free from the test aerosol.

The air velocity in the proximity of the specimen shall be (0,2 ± 0,04) m/s during the measurement, unless otherwise specified in the test procedure.

Unless otherwise specified in the test procedure, the air temperature in the tunnel shall be (23 ± 5) °C and shall not vary by more than 5 °C for all the measurements on a particular detector type.

Connect the specimen to its supply and monitoring equipment as specified in 5.1.2, and allow it to stabilize for a period of at least 15 min, unless otherwise specified by the manufacturer.

Introduce the test aerosol, as specified in Annex B, into the tunnel such that the rate of increase of aerosol density is as follows:

— for detectors using scattered or transmitted light, in decibels per metre per minute:

$$0{,}015 \le \frac{\Delta m}{\Delta t} \le 0{,}1;$$

— for detectors using ionization, per minute:

$$0{,}05 \le \frac{\Delta y}{\Delta t} \le 0{,}3\ .$$

NOTE These ranges are intended to allow the selection of a convenient rate, depending upon the sensitivity of the detector, so that a response can be obtained in a reasonable time.

The initially selected rate of increase in aerosol density shall be similar for all measurements on a particular detector type.

The response threshold value is the aerosol density (m or y) at the moment that the specimen gives an alarm. This shall be recorded as m, expressed in decibels per metre, for detectors using scattered or transmitted light, or as y for detectors using ionization (see Annex C).

5.1.6 Provision for tests

Provide the following for testing compliance with this part of ISO 7240:

a) for detachable detectors, 20 detector heads and bases; for non-detachable detectors, 20 specimens;

b) data specified in 4.11.

NOTE Detachable detectors are comprised of at least two parts: a base (socket) and a head (body). If the specimens are detachable detectors, then the two or more parts together are regarded as a complete detector.

The specimens submitted shall be deemed representative of the manufacturer's normal production with regard to their construction and calibration. This implies that the mean response threshold value of the 20 specimens found in the reproducibility test (5.4) should also represent the production mean, and that the limits specified in the reproducibility test should also be applicable to the manufacturer's production.

5.1.7 Test schedule

Test the specimens in accordance with the test schedule in Table 2. After the reproducibility test, number the four least sensitive specimens (i.e. those with the highest response thresholds) 17 to 20 and the others 1 to 16 arbitrarily.

5.1.8 Test report

The test results shall be reported in accordance with Clause 6.

Table 2 — Test schedule

Test	Subclause	Specimen No.(s)
Repeatability	5.2	One chosen arbitrarily
Directional dependence	5.3	One chosen arbitrarily
Reproducibility	5.4	All specimens
Variation of supply parameters	5.5	1
Air movement	5.6	2
Dazzling[a]	5.7	3
Dry heat (operational)	5.8	4
Cold (operational)	5.9	5
Damp heat, steady state (operational)	5.10	6
Damp heat, steady state (endurance)	5.11	7
Sulfur dioxide (SO_2) corrosion (endurance)	5.12	8
Shock (operational)	5.13	9
Impact (operational)	5.14	10
Vibration, sinusoidal (operational)	5.15	11
Vibration, sinusoidal (endurance)	5.16	11
Electrostatic discharge (operational)	5.17	12[b]
Radiated electromagnetic fields (operational)	5.17	13[b]
Conducted disturbances induced by electromagnetic fields (operational)	5.17	14[b]
Fast transient bursts (operational)	5.17	15[b]
Slow high-energy voltage surge (operational)	5.17	16[b]
Fire sensitivity	5.18	17, 18, 19 and 20

[a] This test only applies to detectors using a scattered or transmitted light principle of operation.

[b] In the interests of test economy, it is permitted to use the same specimen for more than one EMC test. In that case, intermediate functional test(s) on the specimen(s) used for more than one test can be deleted, and the full functional test conducted at the end of the sequence of tests. However, it should be noted that in the event of a failure, it might not be possible to identify which test exposure caused the failure.

5.2 Repeatability

5.2.1 Object of test

The object of the test is to show that the detector has stable behaviour with respect to its sensitivity even after a number of alarm conditions.

5.2.2 Test procedure

Measure the response threshold value of the specimen to be tested six times as specified in 5.1.5.

The orientation of the specimen relative to the direction of air flow is arbitrary, but it shall be the same for all six measurements.

Designate the maximum response threshold value as y_{max} or m_{max} and the minimum value as y_{min} or m_{min}.

5.2.3 Requirements

The ratio of the response threshold values $y_{max} : y_{min}$ or $m_{max} : m_{min}$ shall be not greater than 1,6.

The lower response threshold value, y_{min}, shall be not less than 0,2.

The lower response threshold value, m_{min}, shall be not less than

— 0,05 dB/m for detectors with a declared response threshold value band of $0{,}05 < m < 0{,}3$, or

— 0,2 dB/m for detectors with a declared response threshold value band of $0{,}2 < m < 0{,}6$.

The higher response threshold value, $m_{max,}$ shall be not greater than

— 0,3 dB/m for detectors with a declared response threshold value band of $0{,}05 < m < 0{,}3$, or

— 0,6 dB/m for detectors with a declared response threshold value band of $0{,}2 < m < 0{,}6$.

5.3 Directional dependence

5.3.1 Object of test

The object of the test is to confirm that the sensitivity of the detector is not unduly dependent on the direction of air flow around the detector.

5.3.2 Test procedure

Measure the response threshold value of the specimen to be tested eight times as specified in 5.1.5, with the specimen being rotated 45° about its vertical axis between each measurement, so that the measurements are taken for eight different orientations relative to the direction of air flow.

Designate the maximum response threshold value as y_{max} or m_{max} and the minimum value as y_{min} or m_{min}.

Record the least sensitive and the most sensitive orientations. The orientation for which the maximum response threshold is measured is referred to as the *least sensitive* orientation, and the orientation for which the minimum response threshold is measured is referred to as the *most sensitive* orientation.

5.3.3 Requirements

The ratio of the response threshold values $y_{max} : y_{min}$ or $m_{max} : m_{min}$ shall be not greater than 1,6.

The lower response threshold value, y_{min}, shall be not less than 0,2.

The lower response threshold value, m_{min}, shall be not less than

— 0,05 dB/m for detectors with a declared response threshold value band of $0{,}05 < m < 0{,}3$, or

— 0,2 dB/m for detectors with a declared response threshold value band of $0{,}2 < m < 0{,}6$.

The higher response threshold value, m_{max}, shall be not greater than

— 0 dB/m for detectors with a declared response threshold value band of $0{,}05 < m < 0{,}3$, or

— 0,6 dB/m for detectors with a declared response threshold value band of $0{,}2 < m < 0{,}6$.

5.4 Reproducibility

5.4.1 Object of test

The object of the test is to show that the sensitivity of the detector does not vary unduly from specimen to specimen and to establish response threshold value data for comparison with the response threshold values measured after the environmental tests.

5.4.2 Test procedure

Measure the response threshold value of each of the test specimens as specified in 5.1.5.

Calculate the mean of these response threshold values, which shall be designated $\overline{y}$ or $\overline{m}$.

Designate the maximum response threshold value as y_{max} or m_{max} and the minimum value as y_{min} or m_{min}.

5.4.3 Requirements

The ratio of the response threshold values $y_{max} : \overline{y}$ or $m_{max} : \overline{m}$ shall be not greater than 1,33, and the ratio of the response threshold values $\overline{y} : y_{min}$ or $\overline{m} : m_{min}$ shall be not greater than 1,5.

The lower response threshold value, y_{min}, shall be not less than 0,2.

The lower response threshold value, m_{min}, shall be not less than

— 0,05 dB/m for detectors with a declared response threshold value band of $0{,}05 < m < 0{,}3$, or

— 0,2 dB/m for detectors with a declared response threshold value band of $0{,}2 < m < 0{,}6$.

The higher response threshold value, m_{max}, shall be not greater than

— 0,3 dB/m for detectors with a declared response threshold value band of $0{,}05 < m < 0{,}3$, or

— 0,6 dB/m for detectors with a declared response threshold value band of $0{,}2 < m < 0{,}6$.

5.5 Variation in supply parameters

5.5.1 Object of test

The object of the test is to show that, within the specified range(s) of the supply parameters (e.g. voltage), the sensitivity of the detector is not unduly dependent on those parameters.

5.5.2 Test procedure

Measure the response threshold value of the specimen as specified in 5.1.5, at the upper and lower limits of the supply parameter (e.g. voltage) range(s) specified by the manufacturer.

Designate the maximum response threshold value as y_{max} or m_{max} and the minimum value as y_{min} or m_{min}.

NOTE For some detectors, the only relevant supply parameter can be the d.c. voltage applied to the detector. For other types of detectors (e.g. analogue addressable), it can be necessary to consider signal levels and timing. If necessary, the manufacturer can be requested to provide suitable supply equipment to allow the supply parameters to be changed as required.

5.5.3 Requirements

The ratio of the response threshold values $y_{max} : y_{min}$ or $m_{max} : m_{min}$ shall be not greater than 1,6.

The lower response threshold value, y_{min}, shall be not less than 0,2.

The lower response threshold value, m_{min}, shall be not less than

— 0,05 dB/m for detectors with a declared response threshold value band of 0,05 $< m <$ 0,3, or

— 0,2 dB/m for detectors with a declared response threshold value band of 0,2 $< m <$ 0,6.

The higher response threshold value, m_{max}, shall be not greater than

— 0,3 dB/m for detectors with a declared response threshold value band of 0,05 $< m <$ 0,3, or

— 0,6 dB/m for detectors with a declared response threshold value band of 0,2 $< m <$ 0,6.

5.6 Air movement

5.6.1 Object of test

The object of the test is to show that the sensitivity of the detector is not unduly affected by the rate of the air flow, and that it is not unduly prone to false alarms in draughts or in short gusts.

5.6.2 Test procedure

Measure the response threshold value of the specimen to be tested as specified in 5.1.5 in the most and least sensitive orientations, as determined in 5.3.

Designate these appropriately as $y_{(0,2)max}$ and $y_{(0,2)min}$ or $m_{(0,2)max}$ and $m_{(0,2)min}$.

Repeat these measurements, but with an air velocity in the proximity of the detector of (1 ± 0,2) m/s.

Designate the response threshold values in these tests as $y_{(1,0)max}$ and $y_{(1,0)min}$, or $m_{(1,0)max}$ and $m_{(1,0)min}$.

Additionally, for detectors using ionization, subject the specimen to be tested, in its most sensitive orientation, to an aerosol-free air flow at a velocity of (5 ± 0,5) m/s for a period of not less than 5 min and not more than 7 min, and then, at least 10 min later, to a gust at a velocity of (10 ± 1) m/s for a period of not less than 2 s and not more than 4 s.

NOTE These exposures can be generated by plunging the specimen being tested into an air flow with the appropriate velocity for the required time.

Any signal emitted shall be recorded.

5.6.3 Requirements

For detectors using ionization, the following shall apply:

$$0{,}625 \leq \frac{y_{(0,2)max} + y_{(0,2)min}}{y_{(1,0)max} + y_{(1,0)min}} \leq 1{,}6$$

For detectors using scattered or transmitted light, the following shall apply:

$$0{,}625 \leq \frac{m_{(0,2)\text{max}} + m_{(0,2)\text{min}}}{m_{(1,0)\text{max}} + m_{(1,0)\text{min}}} \leq 1{,}6$$

Moreover, the detector shall not emit either a fault signal or an alarm signal during the test with aerosol-free air.

5.7 Dazzling

5.7.1 Object of test

The object of the test is to show that the sensitivity of the detector is not unduly influenced by the close proximity of artificial light sources. This test is applied only to detectors using scattered light or transmitted light, as detectors using ionization are considered unlikely to be influenced.

5.7.2 Test procedure

Install the dazzling apparatus (see Annex D) in the smoke tunnel (see Annex A). Install the specimen in the dazzling apparatus in the least sensitive orientation and connect it to its supply and monitoring equipment. Perform the following procedure.

a) Measure the response threshold value as specified in 5.1.5.

b) Switch the four lamps ON simultaneously for 10 s and then OFF for 10 s. Repeat this ten times.

c) Switch the four lamps ON again and, after at least 1 min, measure the response threshold value as specified in 5.1.5, with the lamps ON.

d) Then switch the four lamps OFF.

Repeat a) to d), but with the detector rotated 90° in one direction (either direction may be chosen), from the least sensitive orientation.

For each orientation, designate the maximum response threshold value as m_{max} and the minimum response threshold value as m_{min}.

5.7.3 Requirements

During the periods when the lamps are being switched ON and OFF, and when the lamps are ON before the response threshold value is measured, the specimen shall not emit either an alarm or a fault signal.

For each orientation, the ratio of the response thresholds $m_{\text{max}} : m_{\text{min}}$ shall be not greater than 1,6.

5.8 Dry heat (operational)

5.8.1 Object of test

The object of the test is to demonstrate the ability of the detector to function correctly at high ambient temperatures that can occur for short periods in the service environment.

5.8.2 Test procedure

5.8.2.1 Reference

Use the test apparatus and perform the procedure in accordance with IEC 60068-2-2, Test Bb, and with 5.8.2.2 to 5.8.2.4.

5.8.2.2 State of specimen during conditioning

Mount the specimen being tested as specified in 5.1.3 in the smoke tunnel (see Annex A), in its least sensitive orientation, and connect it to its supply and monitoring equipment as specified in 5.1.2.

5.8.2.3 Conditioning

Apply the following conditioning:

— temperature: starting at an initial air temperature of (23 ± 5) °C, increase the air temperature to (55 ± 2) °C;

— duration: maintain this temperature for 2 h.

NOTE Test Bb specifies rates of change of temperature of ≤ 1 K/min for the transitions to and from the conditioning temperature.

5.8.2.4 Measurements during conditioning

Monitor the specimen during the conditioning period to detect any alarm or fault signals.

5.8.2.5 Final measurements

Measure the response threshold value as specified in 5.1.5, but at a temperature of (55 ± 2) °C.

Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.8.3 Requirements

No alarm or fault signals shall be given during the period that the temperature is increasing to the conditioning temperature or during the conditioning period until the response threshold value is measured.

The ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} shall be not greater than 1,6.

5.9 Cold (operational)

5.9.1 Object of test

The object of the test is to demonstrate the ability of the detector to function correctly at low ambient temperatures appropriate to the anticipated service environment.

5.9.2 Test procedure

5.9.2.1 Reference

Use the test apparatus and perform the procedure in accordance with IEC 60068-2-1, Test Ab, and with 5.9.2.2 to 5.9.2.5.

5.9.2.2 State of specimen during conditioning

Mount the specimen as specified in 5.1.3 and connect it to supply and monitoring equipment as specified in 5.1.2.

5.9.2.3 Conditioning

Apply the following conditioning:

- temperature: (−10 ± 3) °C;
- duration: 16 h.

NOTE Test Ab specifies rates of change of temperature of ≤ 1 K/min for the transitions to and from the conditioning temperature.

5.9.2.4 Measurements during conditioning

Monitor the specimen during the conditioning period to detect any alarm or fault signals.

5.9.2.5 Final measurements

After a recovery period of at least 1 h at the standard laboratory conditions, measure the response threshold value as specified in 5.1.5.

Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.9.3 Requirements

No alarm or fault signals shall be given during the transition to or the period at the conditioning temperature.

The ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} shall not be greater than 1,6.

5.10 Damp heat, steady state (operational)

5.10.1 Object of test

The object of the test is to demonstrate the ability of the detector to function correctly at high relative humidity (without condensation), that can occur for short periods in the anticipated service environment.

5.10.2 Test procedure

5.10.2.1 Reference

Use the test apparatus and perform the procedure in accordance with IEC 60068-2-78, Test Cab, and with 5.10.2.2 to 5.10.2.5.

5.10.2.2 State of the specimen during conditioning

Mount the specimen as specified in 5.1.3 and connect it to supply and monitoring equipment as specified in 5.1.2.

5.10.2.3 Conditioning

Apply the following conditioning:

- temperature: (40 ± 2) °C;
- relative humidity: (93 ± 3) %;
- duration: 4 d.

5.10.2.4 Measurements during conditioning

Monitor the specimen during the conditioning period to detect any alarm or fault signals.

5.10.2.5 Final measurements

After a recovery period of at least 1 h at the standard laboratory conditions, measure the response threshold value as specified in 5.1.5.

Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.10.3 Requirements

No alarm or fault signals shall be given during the conditioning.

The ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} shall be not greater than 1,6.

5.11 Damp heat, steady state (endurance)

5.11.1 Object of test

The object of the test is to demonstrate the ability of the detector to withstand the long-term effects of humidity in the service environment (e.g. changes in electrical properties of materials, chemical reactions involving moisture, galvanic corrosion).

5.11.2 Test procedure

5.11.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-78, Test Cab, and with 5.11.2.2 to 5.11.2.4.

5.11.2.2 State of the specimen during conditioning

Mount the specimen as specified in 5.1.3. Do not supply it with power during the conditioning.

5.11.2.3 Conditioning

Apply the following conditioning:

- temperature: (40 ± 2) °C;
- relative humidity: (93 ± 3) %;
- duration: 21 d.

5.11.2.4 Final measurements

After a recovery period of at least 1 h in standard laboratory conditions, measure the response threshold value as specified in 5.1.5.

Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max}, and the lesser as y_{min} or m_{min}.

5.11.3 Requirements

No fault signal attributable to the endurance conditioning shall be given on reconnection of the specimen.

The ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} shall be not greater than 1,6.

5.12 Sulfur dioxide (SO2) corrosion (endurance)

5.12.1 Object of test

The object of the test is to demonstrate the ability of the detector to withstand the corrosive effects of sulfur dioxide as an atmospheric pollutant.

5.12.2 Test procedure

5.12.2.1 Reference

Use the test apparatus and perform the procedure in accordance with IEC 60068-2-42, Test Kc, but carry out the conditioning in accordance with 5.12.2.3.

5.12.2.2 State of specimen during conditioning

Mount the specimen as specified in 5.1.3. Do not supply it with power during the conditioning, but equip it with untinned copper wires of the appropriate diameter, connected to a sufficient number of terminals to allow the final measurement to be made without making further connections to the specimen.

5.12.2.3 Conditioning

Apply the following conditioning:

— temperature: (25 ± 2) °C;

— relative humidity: (93 ± 3) %;

— SO_2 concentration: (25 ± 5) µl/l;

— duration: 21 d.

5.12.2.4 Final measurements

Immediately after the conditioning, subject the specimen to a drying period of 16 h at (40 ± 2) °C, ≤ 50 % RH, followed by a recovery period of at least 1 h at the standard laboratory conditions. After this, measure the response threshold value as specified in 5.1.5.

Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.12.3 Requirements

No fault signal attributable to the endurance conditioning shall be given on reconnection of the specimen.

The ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} shall be not greater than 1,6.

5.13 Shock (operational)

5.13.1 Object of test

The object of the test is to demonstrate the immunity of the detector to mechanical shocks that are likely to occur, albeit infrequently, in the anticipated service environment.

5.13.2 Test procedure

5.13.2.1 Reference

Use the test apparatus and perform the procedure generally in accordance with IEC 60068-2-27, Test Ea, but carry out the conditioning in accordance with 5.13.2.3.

5.13.2.2 State of specimen during conditioning

Mount the specimen as specified in 5.1.3 to a rigid fixture, and connect it to its supply and monitoring equipment as specified in 5.1.2.

5.13.2.3 Conditioning

For specimens with a mass ≤ 4,75 kg, apply the following conditioning:

— shock pulse type: half sine;

— pulse duration: 6 ms;

— peak acceleration: 10 × (100 − 20M) m/s2 (where M is the mass of the specimen in kilograms);

— number of directions: 6;

— pulses per direction: 3.

Do not test specimens with a mass > 4,75 kg.

5.13.2.4 Measurements during conditioning

Monitor the specimen during the conditioning period and for a further 2 min to detect any alarm or fault signals.

5.13.2.5 Final measurements

After the conditioning, measure the response threshold value as specified in 5.1.5.

Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.13.3 Requirements

No alarm or fault signals shall be given during the conditioning period or the additional 2 min.

The ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} shall be not greater than 1,6.

5.14 Impact (operational)

5.14.1 Object of test

The object of the test is to demonstrate the immunity of the smoke detectors to mechanical impacts upon its surface, which it can sustain in the normal shipping, installation, and service environments, and which it can reasonably be expected to withstand.

5.14.2 Test procedure

5.14.2.1 Apparatus

The test apparatus (Annex E) shall consist of a swinging hammer incorporating a rectangular-section aluminium alloy head (aluminium alloy Al Cu4SiMg complying with ISO 209, solution- and precipitation-treated condition) with the plane-impact face chamfered to an angle of 60° to the horizontal when in the striking position (i.e. when the hammer shaft is vertical). The hammer head shall be (50 ± 2,5) mm high, (76 ± 3,8) mm wide and (80 ± 4) mm long at mid-height.

5.14.2.2 State of specimen during conditioning

Mount the specimen rigidly to the apparatus by its normal mounting means and position it so that it is struck by the upper half of the impact face when the hammer is in the vertical position (i.e. when the hammerhead is moving horizontally). Choose the azimuthal direction and the position of impact relative to the specimen as that most likely to impair the normal functioning of the specimen. Connect the specimen to its supply and monitoring equipment as specified in 5.1.2.

5.14.2.3 Conditioning

Use the following test parameters during the conditioning:

- impact energy: (1,9 ± 0,1) J;
- hammer velocity: (1,5 ± 0,13) m/s;
- number of impacts: one.

5.14.2.4 Measurements during conditioning

Monitor the specimen during the conditioning period and for a further 2 min to detect any alarm or fault signals.

5.14.2.5 Final measurements

After the conditioning, measure the response threshold value as specified in 5.1.5.

Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.14.3 Requirements

No alarm or fault signals shall be given during the conditioning period or the additional 2 min.

The impact shall not detach the specimen from its base, or the base from the mounting.

The ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} shall be not greater than 1,6.

5.15 Vibration, sinusoidal (operational)

5.15.1 Object of test

The object of the test is to demonstrate the immunity of the detector to vibration at levels considered appropriate to the normal service environment.

5.15.2 Test procedure

5.15.2.1 Reference

Use the test apparatus and perform the procedure in accordance with IEC 60068-2-6, Test Fc, and with 5.15.2.2 to 5.15.2.5.

5.15.2.2 State of specimen during conditioning

Mount the specimen on a rigid fixture as specified in 5.1.3 and connect it to its supply and monitoring equipment as specified in 5.1.2. Apply the vibration in each of three mutually perpendicular axes in turn, and so that one of the three axes is perpendicular to the normal mounting plane of the specimen.

5.15.2.3 Conditioning

Apply the following conditioning:

- frequency range: (10 to 150) Hz;
- acceleration amplitude: 5 m/s2 (≈ 0,5 gn);
- number of axes: 3;
- sweep rate: 1 octave/min;
- number of sweep cycles: 1/axis.

The vibration operational and endurance tests may be combined such that the specimen is subjected to the operational test conditioning followed by the endurance test conditioning in one axis before changing to the next axis. Only one final measurement need be made.

5.15.2.4 Measurements during conditioning

Monitor the specimen during the conditioning period to detect any alarm or fault signals.

5.15.2.5 Final measurements

After the conditioning, visually inspect the specimen for mechanical damage both internally and externally. Then measure the response threshold value as specified in 5.1.5.

NOTE The final measurements are normally made after the vibration endurance test and it is necessary to make them here only if the operational test is conducted in isolation.

Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.15.3 Requirements

No alarm or fault signals shall be given during the conditioning. No mechanical damage, either internally or externally, shall result.

The ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} shall be not greater than 1,6.

5.16 Vibration, sinusoidal (endurance)

5.16.1 Object of test

The object of the test is to demonstrate the ability of the detector to withstand the long-term effects of vibration at levels appropriate to the shipping, installation, and service environment.

5.16.2 Test procedure

5.16.2.1 Reference

Use the test apparatus and perform the procedure in accordance with IEC 60068-2-6, Test Fc, and with 5.16.2.2 to 5.16.2.4.

5.16.2.2 State of specimen during conditioning

Mount the specimen on a rigid fixture as specified in 5.1.3, but do not supply it with power during conditioning. Apply the vibration in each of three mutually perpendicular axes in turn, and so that one of the three axes is perpendicular to the normal mounting axis of the specimen.

5.16.2.3 Conditioning

Apply the following conditioning:

— frequency range: (10 to 150) Hz;

— acceleration amplitude: 10 m/s2 (≈1,0 gn);

— number of axes: 3;

— sweep rate: 1 octave/min;

— number of sweep cycles: 20/axis.

The vibration operational and endurance tests may be combined such that the specimen is subjected to the operational test conditioning followed by the endurance test conditioning in one axis before changing to the next axis. It is necessary to make only one final measurement.

5.16.2.4 Final measurements

After the conditioning, measure the response threshold value as specified in 5.1.5.

Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.16.3 Requirements

No fault signal, attributable to the endurance conditioning, shall be given on reconnection of the specimen.

The ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} shall be not greater than 1,6.

5.17 Electromagnetic compatibility (EMC) immunity tests (operational)

5.17.1 The following EMC immunity tests shall be carried out in accordance with EN 50130-4:

a) electrostatic discharge;

b) radiated electromagnetic fields;

c) conducted disturbances induced by electromagnetic fields;

d) fast transient bursts;

e) slow, high-energy voltage surges.

5.17.2 For these tests, the criteria for compliance as specified in EN 50130-4 and the following shall apply.

a) The functional test, called for in the initial and final measurements, shall be as follows.

— Measure the response threshold value as specified in 5.1.5.

— Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

b) The required operating condition shall be as specified in 5.1.2.

c) The acceptance criteria for the functional test after the conditioning shall be that the ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} shall not be greater than 1,6.

5.18 Fire sensitivity

5.18.1 Object of test

The object of the test is to show that the detector has adequate sensitivity to a broad spectrum of smoke types as required for general application in fire detection systems for buildings.

5.18.2 Test procedure

5.18.2.1 Principle of test

The specimens are mounted in a standard fire test room (see Annex F) and exposed to a series of test fires designed to produce smoke representative of a wide spectrum of types of smoke and smoke flow conditions.

5.18.2.2 Test fires

Subject the specimens to the four test fires TF2 to TF5[1]. The type, quantity and arrangement of the fuel and the method of ignition are specified in Annexes G to J for each test fire, along with the end-of-test condition and the required profile curve limits.

In order for a test fire to be valid, the development of the fire shall be such that the profile curves of m against y and m against time, t, fall within the specified limits, up to the time when all of the specimens have generated an alarm signal or the end-of-test condition is reached, whichever is the earlier. If these conditions are not met, then the test is invalid and shall be repeated. It is permissible, and can be necessary, to adjust the quantity, condition (e.g. moisture content) and arrangement of the fuel to obtain valid test fires.

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1) The test fire 1 (TF1) is not considered applicable to this part of ISO 7240.

5.18.2.3 Mounting of specimens

Mount the four specimens (Nos. 17, 18, 19 and 20) on the fire test room ceiling in the designated area (see Annex F) in accordance with the manufacturer's instructions, such that they are in the least sensitive orientation relative to an assumed air flow from the centre of the room to the specimen.

Connect each specimen to its supply and monitoring equipment, as specified in 5.1.2, and allow it to stabilize in its quiescent condition before the start of each test fire.

Detectors that dynamically modify their sensitivity in response to varying ambient conditions can require special reset procedures and/or stabilization times. The manufacturer's guidance should be sought in such cases to ensure that the state of the detectors at the start of each test is representative of their normal quiescent state.

5.18.2.4 Initial conditions

IMPORTANT — The stability of the air and temperature affects the smoke flow within the room. This is particularly important for the test fires that produce low thermal lift for the smoke (e.g. TF2 and TF3). Therefore, the difference between the temperature near the floor and the ceiling should be < 2 °C, and local heat sources that can cause convection currents (e.g. lights and heaters) should be avoided. If it is necessary for people to be in the room at the beginning of a test fire, they should leave as soon as possible, taking care to produce the minimum disturbance to the air.

Before each test fire, ventilate the room with clean air until it is free from smoke, so that the conditions given below can be obtained.

Switch off the ventilation system and close all doors, windows and other openings. Then allow the air in the room to stabilize and the following conditions to be obtained before the test is started:

— air temperature: $T = (23 \pm 5)$ °C;

— air movement: negligible;

— smoke density (ionization): $y \leq 0{,}05$;

— smoke density (optical): $m \leq 0{,}02$ dB/m.

5.18.2.5 Recording of the fire parameters and response values

During each test fire, record the fire parameters in Table 3 as a function of time from the start of the test. Record each parameter continuously or at least once per second.

Table 3 — Fire parameters

Parameter	Symbol	Unit
Temperature change	ΔT	°C
Smoke density (ionization)	y	(dimensionless)
Smoke density (optical)	m	dB/m

The alarm signal given by the supply and monitoring equipment shall be taken as the indication that a specimen has responded to the test fire.

Record the time of response (alarm signal) of each specimen, along with ΔT_a, y_a and m_a, the fire parameters at the moment of response. A response of the specimen after the end-of-test condition is ignored.

5.18.3 Requirements

All four specimens shall generate an alarm signal, in each test fire, before the specified end-of-test condition is reached.

6 Test report

The test report shall contain, as a minimum, the following information:

a) identification of the alarm tested;

b) reference to this part of ISO 7240 (i.e. ISO 7240-7:2011);

c) results of the test: the individual response threshold values and the minimum, maximum, and arithmetic mean values, where appropriate;

d) conditioning period and the conditioning atmosphere;

e) temperature and the relative humidity in the test room throughout the test;

f) details of the supply and monitoring equipment and the alarm criteria;

g) details of any deviation from this part of ISO 7240 or from the International Standards to which reference is made, and details of any operations regarded as optional.

Annex A
(normative)

Smoke tunnel for response threshold value measurements

This annex specifies those properties of the smoke tunnel that are of primary importance for making repeatable and reproducible measurements of response threshold values of smoke detectors. However, since it is not practical to specify and measure all parameters that can influence the measurements, the background information in Annex L should be carefully considered and taken into account when a smoke tunnel is designed and used to make measurements as specified in this part of ISO 7240.

The smoke tunnel shall have a horizontal working section containing a working volume. The working volume is a defined part of the working section where the air temperature and air flow are within the required test conditions. Conformance with this requirement shall be regularly verified under static conditions, by measurements at an adequate number of points distributed within and on the imaginary boundaries of the working volume. The working volume shall be large enough to fully enclose the detector to be tested and the sensing parts of the measuring equipment. The working section shall be designed to allow the dazzling apparatus specified in Annex D to be inserted. The alarm being tested shall be mounted in its normal operating position on the underside of a flat board aligned with the air flow in the working volume. The board shall be of such dimensions that its edge or edges are at least 20 mm from any part of the detector. The alarm mounting arrangement shall not unduly obstruct the air flow between the board and the tunnel ceiling.

Means shall be provided for creating an essentially laminar air flow at the required velocities [i.e. (0,2 ± 0,04) m/s or (1,0 ± 0,2) m/s] through the working volume. It shall be possible to control the temperature at the required values and to increase the temperature at a rate not exceeding 1 K/min to 55 °C.

Both aerosol density measurements, m in decibels per metre for alarms using scattered or transmitted light and y (dimensionless) for alarms using ionization, shall be made in the working volume in the proximity of the detector.

Means shall be provided for the introduction of the test aerosol such that a homogeneous aerosol density is obtained in the working volume.

Only one alarm shall be mounted in the tunnel, unless it has been demonstrated that measurements made simultaneously on more than one alarm are in close agreement with measurements made by testing alarms individually. In the event of a dispute, the value obtained by individual testing shall be accepted.

Annex B
(normative)

Test aerosol for response threshold value measurements

A polydispersive aerosol shall be used as the test aerosol to measure the response threshold values. The bulk of the particles comprising the aerosol shall have a particle diameter between 0,5 µm and 1 µm and a refractive index of approximately 1,4.

The test aerosol shall be reproducible and stable with regard to the following parameters:

— particle mass distribution;

— optical constants of the particles;

— particle shape;

— particle structure.

The stability of the aerosol should be ensured. One possible method to do this is to measure and monitor the stability of the ratio $m:y$.

It is recommended that an aerosol generator using pharmaceutical-grade paraffin oil be used to generate the test aerosol.

Annex C
(normative)

Smoke-measuring instruments

C.1 Obscuration meter

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.

The absorbance index is designated m and expressed in decibels per metre (dB/m). The absorbance index m is given by Equation (C.1):

$$m = \frac{10}{d} \log\left(\frac{P_0}{P}\right) \tag{C.1}$$

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.

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

The optical system shall 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 shall 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.

C.2 Measuring ionization chamber (MIC)

C.2.1 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.

C.2.2 Operating method and basic construction

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

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.

The principle of operation of the measuring ionization chamber is shown in Figure C.1. 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.

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 detectors using ionization.

The measuring chamber is so dimensioned and operated that Equations (C.2) and (C.3) apply:

$$Z \times \bar{d} = \eta \times y \qquad \text{(C.2)}$$

$$y = \left(\frac{I_0}{I}\right) - \left(\frac{I}{I_0}\right) \qquad \text{(C.3)}$$

where

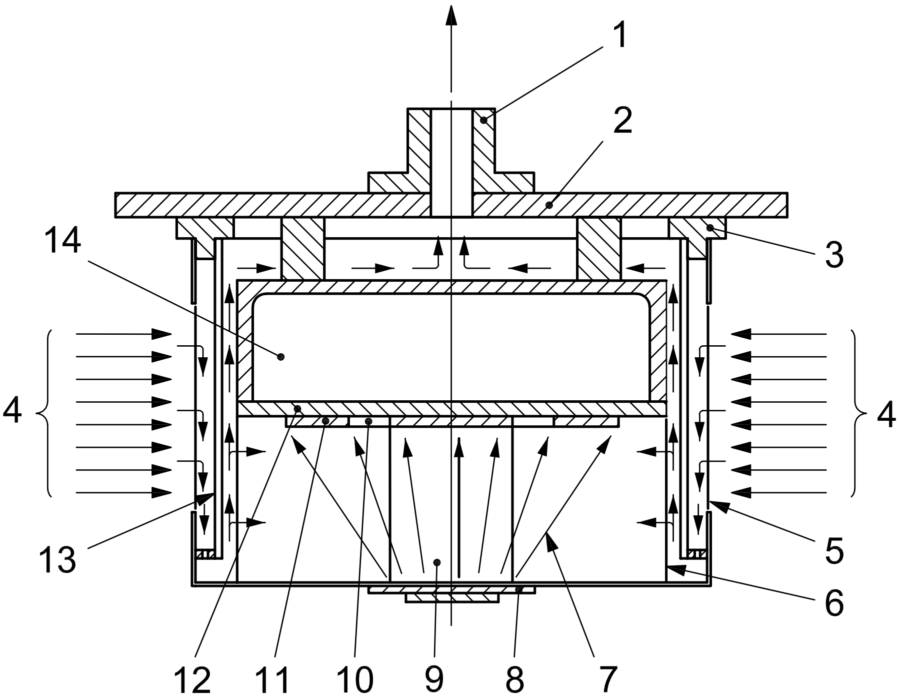
η is the chamber constant;

Z is the particle concentration in particles per cubic metre;

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

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.



Key

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

Figure C.1 — Measuring ionization chamber — Method of operation

C.2.3 Technical data

a) Radiation source:

isotope: ^{241}Am (americium);

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) shall be $(1{,}9 \pm 0{,}095) \times 10^{11}$ Ω, when measured in aerosol- and smoke-free air at the following conditions with the potential of the guard ring within ± 0,1 V of the voltage of the measuring electrode:

pressure: (101,3 ± 1) kPa;

temperature: (25 ± 2) °C;

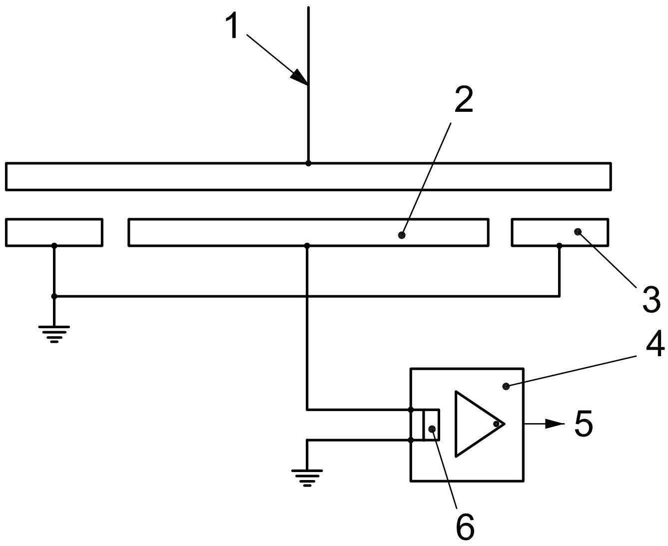
relative humidity: (55 ± 20) %.

c) Current measuring amplifier

The chamber is operated in the circuit shown in Figure C.2, 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 shall be $< 10^9\,\Omega$.

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 supply voltage

2 measuring electrode

3 guard ring

4 current measuring amplifier

5 output voltage proportional to chamber current

6 input impedance, $Z_{in} < 0^9\,\Omega$

Figure C.2 — Measuring ionization chamber — Operating circuit

Annex D
(normative)

Apparatus for dazzling test

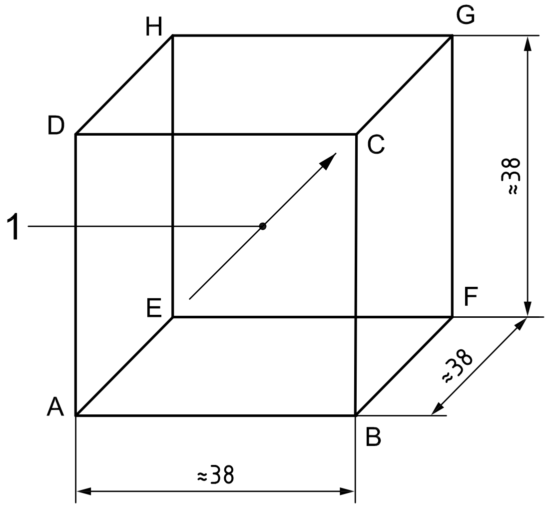
The dazzling apparatus [see Figure D.1 a)] shall be constructed so that it can be inserted in the working section of the smoke tunnel. The apparatus is cube-shaped, with four of the cube faces (ABFE, AEHD, BFGC and DCGH) closed and lined on the inside with high-gloss aluminium foil. The other two opposing cube faces (ABCD and EFGH) are open to allow for the flow of test aerosol through the device.

A circular fluorescent lamp [32 W, “warm white”, approximate colour temperature: 2 800K; see Figure D.1 b)] with a diameter of approximately 30 cm is mounted on each of the four closed surfaces of the cube. The lights should not cause turbulence in the tunnel. To obtain a stable light output, the tubes should be aged for 100 h and discarded at 2 000 h.

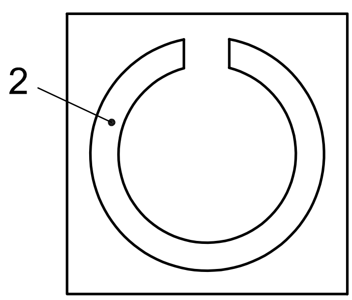
The specimen being tested shall be installed in the centre of the upper cube face [see Figure D.1 a)] so that light can play on it from all directions.

The electrical connections to the fluorescent lamps shall be such that there can be no interference with the detection system through electrical signals.

Dimensions in centimetres



a)



b)

Key

1 stream of aerosol

2 fluorescent lamp

Figure D.1 — Dazzling apparatus a) and lamp b)

Annex E
(normative)

Apparatus for impact test

The apparatus (see Figure E.1) consists essentially of a swinging hammer comprising a rectangular section head (striker) with a chamfered impact face, mounted on a tubular steel shaft. The hammer is fixed into a steel boss, which runs on ball bearings on a fixed steel shaft mounted in a rigid steel frame, so that the hammer can rotate freely about the axis of the fixed shaft. The design of the rigid frame is such as to allow complete rotation of the hammer assembly when the specimen is not present.

The striker has overall dimensions of 76 mm (width) × 50 mm (depth) × 94 mm (length) and is manufactured from aluminium alloy (Al Cu4SiMg as specified in ISO 209), which has been solution- and precipitation-treated. It has a plane-impact face chamfered at (60 ± 1)° to the long axis of the head. The tubular steel shaft has an outside diameter of (25 ± 0,1) mm with a wall thickness of (1,6 ± 0,1) mm.

The striker is mounted on the shaft so that its long axis is at a radial distance of 305 mm from the axis of rotation of the assembly, the two axes being mutually perpendicular. The central boss is 102 mm in outside diameter and 200 mm long, and is mounted coaxially on the fixed steel pivot shaft, which is approximately 25 mm in diameter; however, the precise diameter of the shaft will depend on the bearings used.

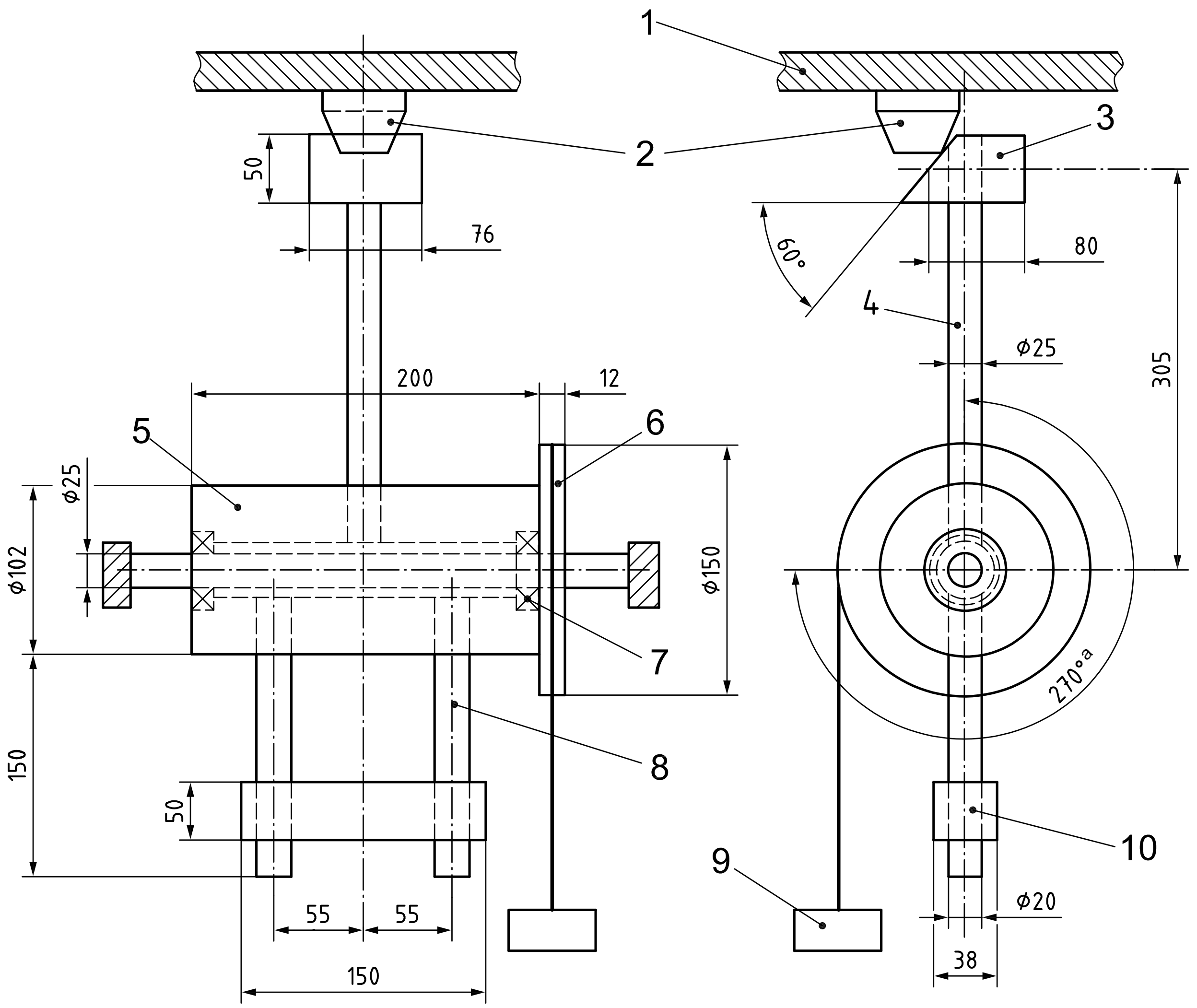
Diametrically opposite the hammer shaft are two steel counter-balance arms, each 20 mm in outside diameter and 185 mm long. These arms are screwed into the boss so that a length of 150 mm protrudes. A steel counter-balance weight is mounted on the arms so that its position can be adjusted to balance the weight of the striker and arms, as in Figure E.1. On the end of the central boss is mounted a 150 mm diameter aluminium alloy pulley, 12 mm wide, and around this is wound an inextensible cable, with one end fixed to the pulley. The other end of the cable supports the operating weight.

The rigid frame also supports the mounting board on which the specimen is mounted by its normal fixings. The mounting board is adjustable vertically so that the upper half of the impact face of the hammer strikes the specimen when the hammer is moving horizontally, as shown in Figure E.1.

To operate the apparatus, the position of the mounting board with the specimen is first adjusted as shown in Figure E.1 and the mounting board is then secured rigidly to the frame. The hammer assembly is then balanced carefully by adjustment of the counter-balance weight with the operating weight removed. The hammer arm is then drawn back to the horizontal position ready for release and the operating weight is reinstated. On release of the assembly, the operating weight spins the hammer and arm through an angle of $3\pi/2$ rad to strike the specimen. The mass, in kilograms, of the operating weight to produce the required impact energy of 1,9 J equals $0{,}388/(3\pi r)$ kg, where r is the effective radius of the pulley, in metres. This equals approximately 0,55 kg for a pulley radius of 75 mm.

As this part of ISO 7240 requires a hammer velocity at impact of (1,5 ± 0,13) m/s, it is necessary to reduce the mass of the hammer head by drilling the back face sufficiently to obtain this velocity. It is estimated that a head with a mass of about 0,79 kg is required to obtain the specified velocity, but it is necessary to determine this by trial and error.

Dimensions in millimetres unless otherwise specified



Key

1 mounting board
2 detector
3 striker
4 striker shaft
5 boss
6 pulley
7 ball bearings
8 counter-balance arms
9 operating weight
10 counter-balance weight

[a] Angle of movement.

NOTE The dimensions shown are for guidance, apart from those relating to the hammer head.

Figure E.1 — Impact apparatus

Annex F
(normative)

Fire test room

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);

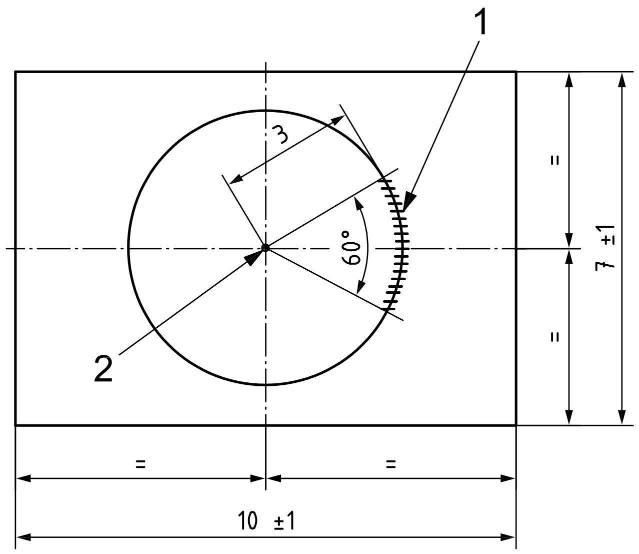
— obscuration meter;

— temperature probe.

The specimens being tested, the MIC, the temperature probe and the measuring part of the obscuration meter shall all be located as shown in Figures F.1 and F.2.

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 unless otherwise specified



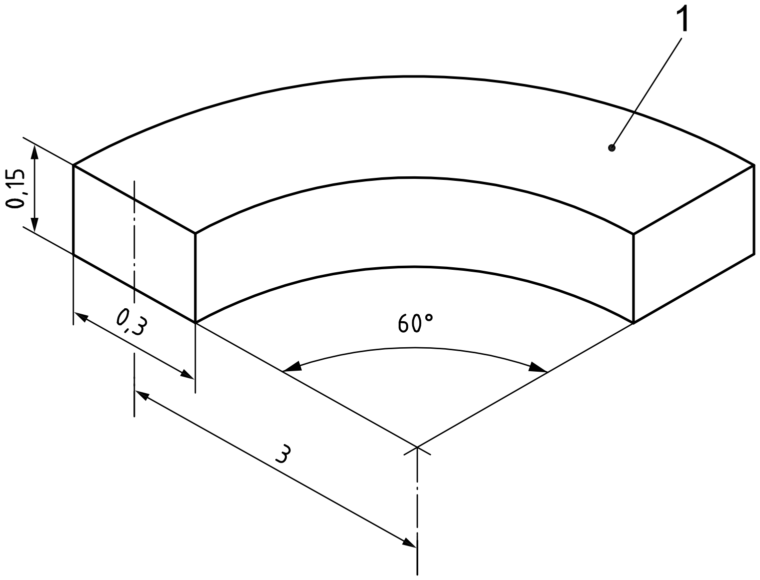
Key

1 specimens and measuring instruments (see Figure F.2)

2 position of test fire

Figure F.1 — Plan view of fire test room and position of specimens and monitoring instruments

Dimensions in metres unless otherwise specified



Key

1 ceiling

Figure F.2 — Mounting position for instruments and specimens

Annex G
(normative)

Smouldering (pyrolysis) wood fire (TF2)

G.1 Material

G.1.1 Fuel, approximately 10 dried beechwood sticks (moisture content ≈ 5 %), each stick having dimensions of 75 mm × 25 mm × 20 mm.

G.2 Aparatus

G.2.1 Hotplate, with 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.

G.3 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 G.1.

G.4 Heating rate

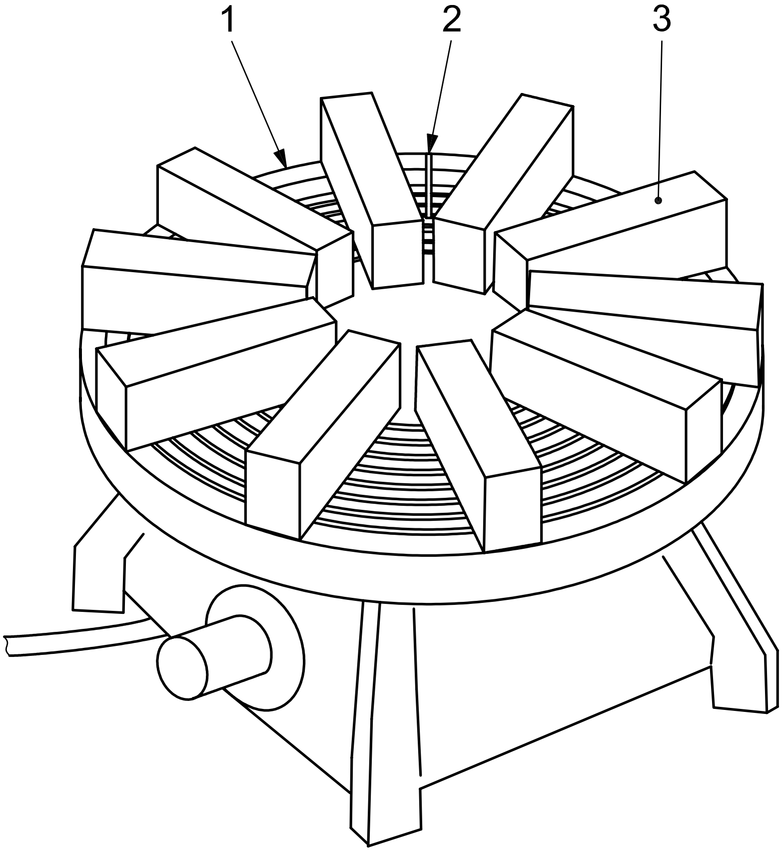
The hotplate shall be powered such that its temperature rises from ambient to 600 °C in approximately 11 min.

G.5 End-of-test condition

The end-of-test condition, m_E, shall be when $m = 2$ dB/m or all of the specimens have generated an alarm signal, whichever is the earlier.

G.6 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 G.2 and G.3, respectively. That is, $1{,}23 \le y \le 2{,}05$ and $570 \le t \le 840$ at the end-of-test condition $m_E = 2$ dB/m.



Key

1 grooved hotplate
2 temperature sensor
3 wooden sticks

Figure G.1 — Arrangement of sticks on hotplate

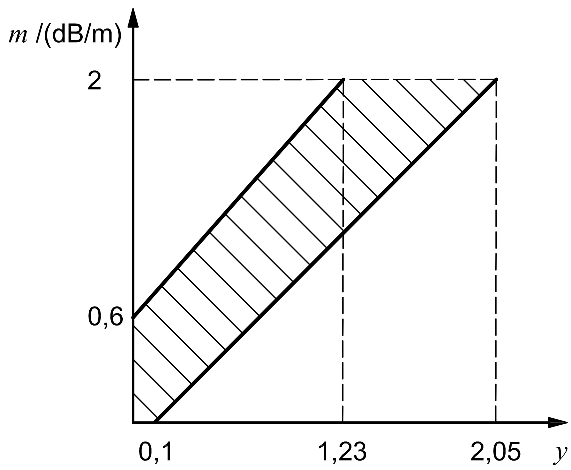


Figure G.2 — Limits for *m* against *y*, Fire TF2

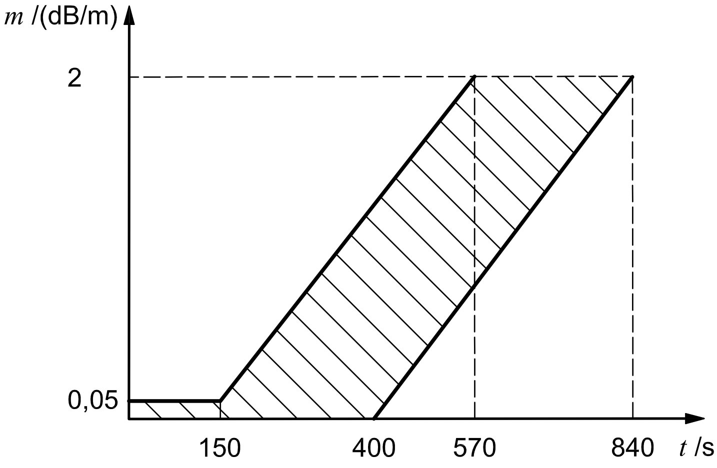


Figure G.3 — Limits for *m* against time, *t*, Fire TF2

Annex H
(normative)

Glowing smouldering cotton fire (TF3)

H.1 Material

H.1.1 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.

H.2 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 H.1.

Dimensions in metres

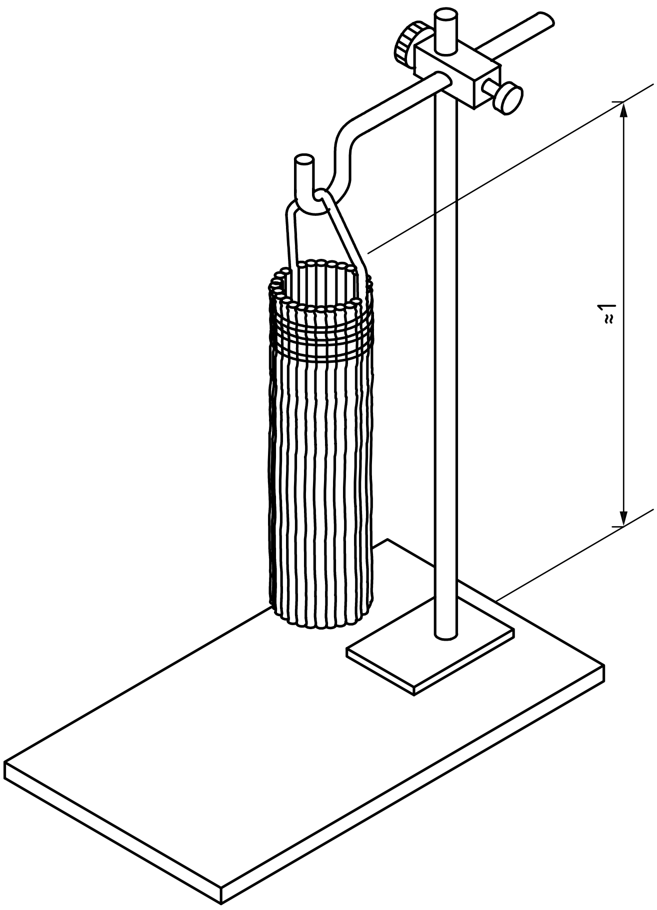


Figure H.1 — Arrangement of cotton wicks

H.3 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.

H.4 End-of-test condition

The end-of-test condition, m_E, shall be when $m = 2$ dB/m or all of the specimens have generated an alarm signal, whichever is the earlier.

H.5 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 H.2 and H.3, respectively. That is, at the end-of-test condition $m_E = 2$ dB/m, $3{,}2 \leq y \leq 5{,}33$ and $280 \leq t \leq 750$.

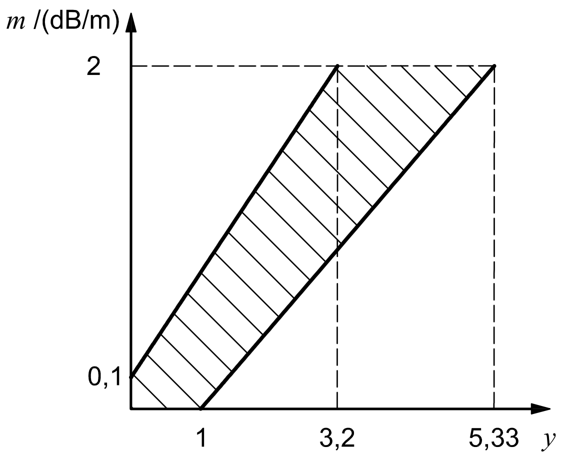


Figure H.2 — Limits for m against y, Fire TF3

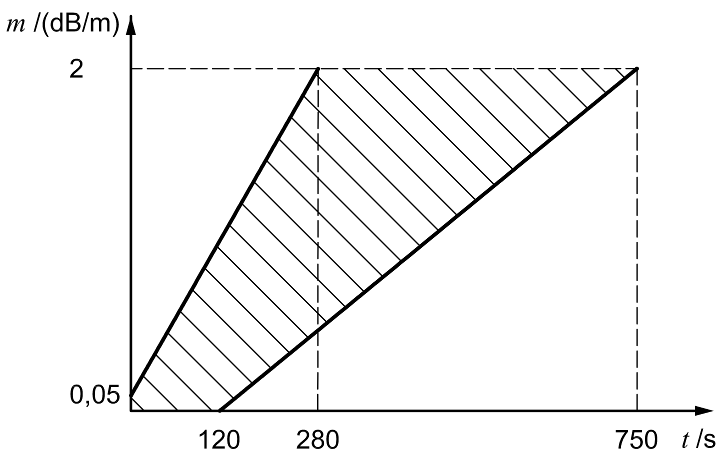


Figure H.3 — Limits for m against time, t, Fire TF3

Annex I
(normative)

Flaming plastics (polyurethane) fire (TF4)

I.1 Material

I.1.1 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.

I.2 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.

I.3 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.

I.4 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 $0{,}05 < m < 0{,}3$,

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

— all of the specimens have generated an alarm signal, if the alarm signal is generated before y_E is reached.

I.5 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 I.1 or I.2, as appropriate for the type of detector tested and I.3, respectively. That is, at the end-of-test condition:

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

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

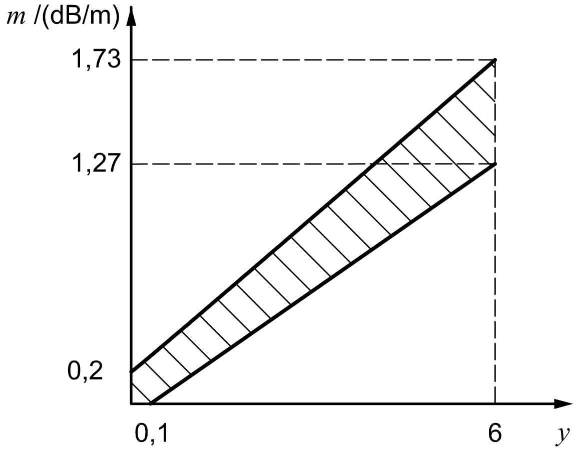


Figure I.1 — Limits for *m* against *y*, Fire TF4 — Ionization detectors and detectors using scattered or transmitted light with 0,05 < *m* < 0,3 declared response threshold value band

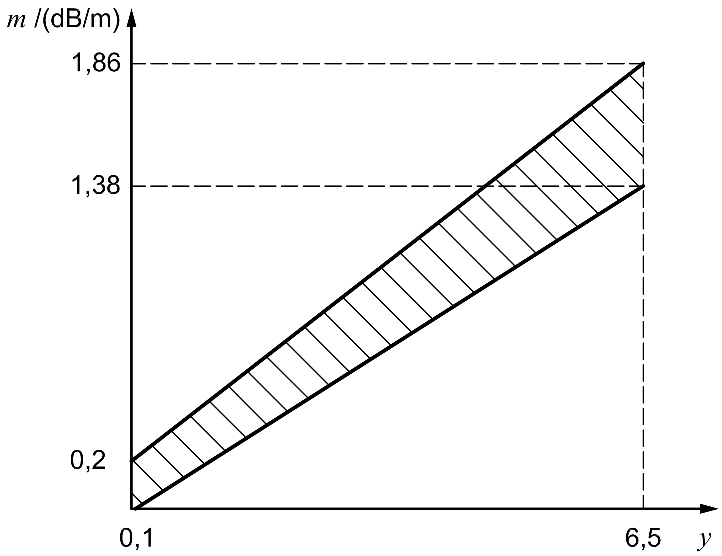


Figure I.2 — Limits for *m* against *y*, Fire TF4 — Detectors using scattered or transmitted light with 0,2 < *m* < 0,6 declared response threshold value band

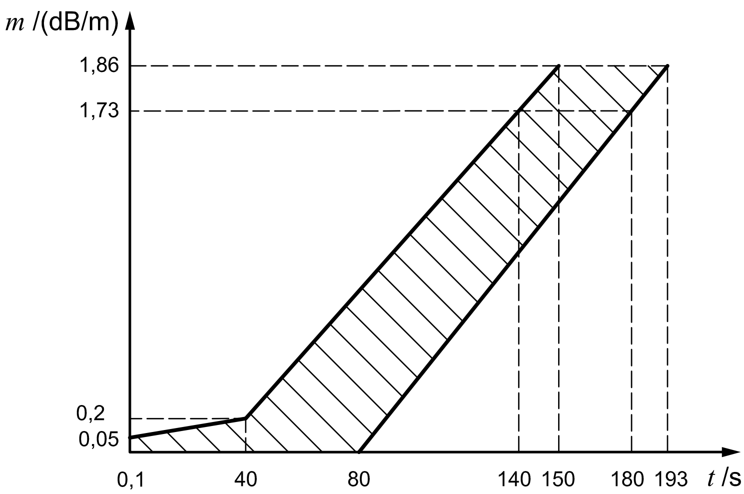


Figure I.3 — Limits for *m* against time, *t*, Fire TF4

Annex J
(normative)

Flaming liquid (*n*-heptane) fire (TF5)

J.1 Material

J.1.1 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.

J.2 Arrangement

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

J.3 Ignition

Ignition shall be by flame or spark, etc.

J.4 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 $0{,}05 < m < 0{,}3$,

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

— all of the specimens have generated an alarm signal, if the alarm signal is generated before y_E is reached.

If, however, the end-of-test condition, $y_F = 6$, is reached before all the specimens of detectors using scattered or transmitted light have responded, then the test is only considered valid if $m \leq 1{,}1$ dB/m has been reached.

J.5 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 J.1 or J.2, as appropriate for the type of detector tested, and J.3, respectively. That is, at the end-of-test condition

— $y_E = 6{,}0$ and $0{,}92 \leq m \leq 1{,}24$ 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 $m \leq 1{,}1$, and $120 \leq t \leq 240$, or

— $y_E = 7{,}5$ and $1{,}15 \leq m \leq 1{,}55$ 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 $m \leq 1{,}1$ and $150 \leq t \leq 300$.

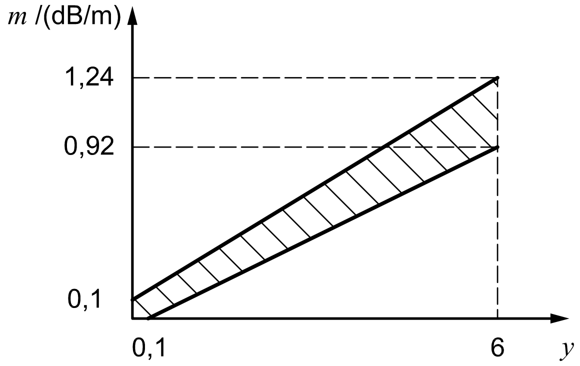


Figure J.1 — Limits for *m* against *y*, Fire TF5 — Ionization detectors and detectors using scattered or transmitted light with $0,05 < m < 0,3$ **declared response threshold value band**

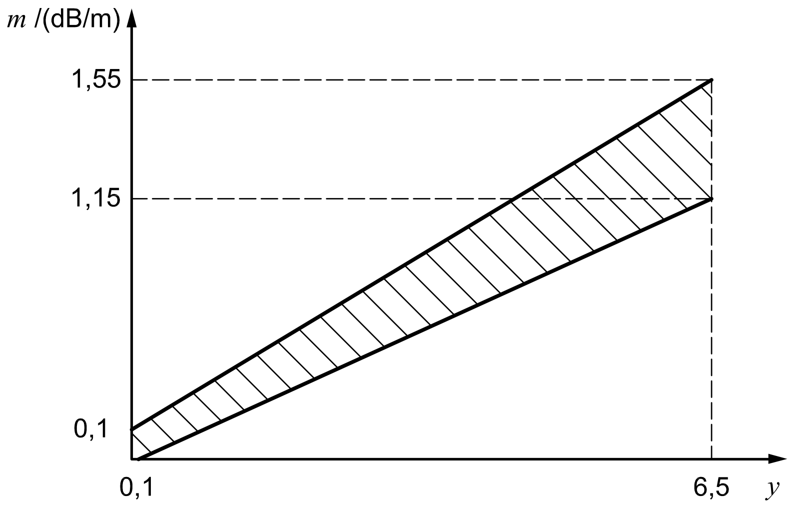


Figure J.2 — Limits for *m* against *y*, Fire TF5 — Detectors using scattered or transmitted light with $0,2 < m < 0,6$ **declared response threshold value band**

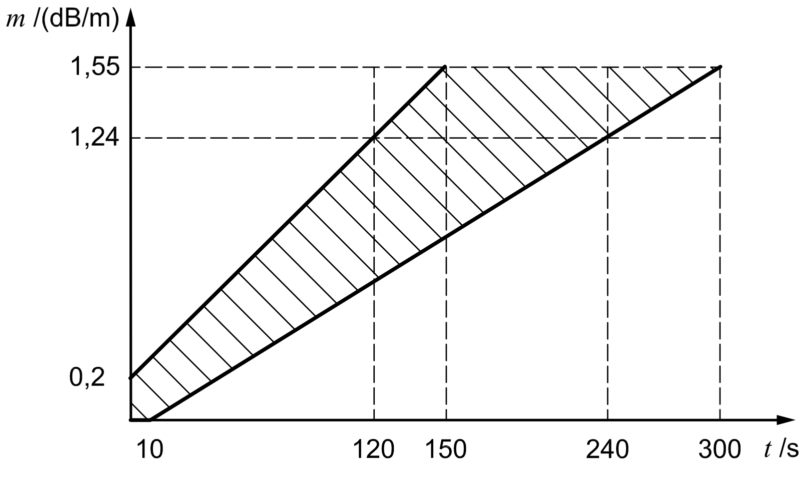


Figure J.3 — Limits for *m* against time, *t*, Fire TF5

Annex K
(informative)

Information concerning the construction of the smoke tunnel

Smoke detectors respond when the signal or signals from one or more smoke sensors fulfil certain criteria. The smoke concentration at the sensor or sensors is related to the smoke concentration surrounding the detector, but the relation is usually complex and dependent on several factors, such as orientation, mounting, air velocity, turbulence and rate of rise of aerosol density. The relative change of the response threshold value measured in the smoke tunnel is the main parameter considered when the stability of smoke detectors is evaluated by testing in accordance with this part of ISO 7240.

Many different smoke tunnel designs are suitable for the tests specified in this part of ISO 7240 but the following points should be considered when designing and characterizing a smoke tunnel.

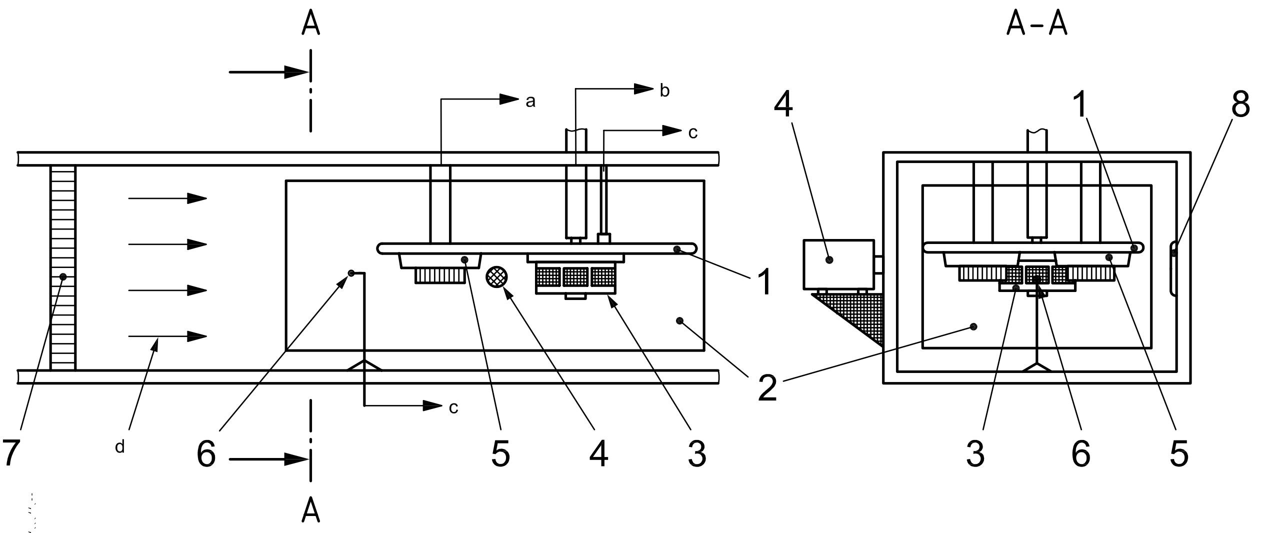
The response threshold value measurements require increasing aerosol density until the alarm responds. This may be facilitated in a closed-circuit smoke tunnel. A purging system is required to purge the smoke tunnel after each aerosol exposure.

The air flow created by a fan in the tunnel is turbulent, and it is necessary to pass it through an air turbulence reducer to create a nearly laminar and uniform air flow in the working volume (see Figure K.1). This may be facilitated by using a filter, honeycomb or both, in line with, and upstream of, the working section of the tunnel. If a filter is used, it should be coarse enough to let the aerosol pass. Care should be taken to ensure that the air flow is well mixed to give a uniform temperature and aerosol density before entering the flow turbulence reducer. Efficient mixing may be obtained by feeding the aerosol to the tunnel upstream of the fan.

A means for heating the air before it enters the working section is required. The tunnel should have a system capable of controlling the heating so as to achieve the specified temperatures and temperature profiles in the working volume. Heating should be achieved by means of low-temperature heaters to avoid the production of extraneous aerosols or alteration of the test aerosol.

Special attention should be given to the arrangement of the elements in the working volume in order to avoid disturbance of the test conditions, e.g. due to turbulence. The suction through the MIC creates a mean air velocity of approximately 0,04 m/s in the plane of the inlet openings in the chamber housing. However, the effect of the suction is negligible if the MIC is placed 10 cm to 15 cm downstream of the detector position.

The smoke tunnel may be designed for aerosol-free wind exposures at velocities of 5 m/s and 10 m/s, provided this does not interfere with the operation when the tunnel is used for response threshold value measurements.



Key

1 mounting board
2 working volume
3 measuring ionization chamber (MIC)
4 obscuration meter
5 detector(s) under test
6 temperature sensor
7 flow turbulence reducer
8 reflector for obscuration meter

[a] Supply and monitoring equipment.

[b] MIC suction.

[c] Control and measuring equipment.

[d] Air flow.

Figure K.1 — Smoke tunnel — Working section

Annex L
(informative)

Compensation for detector drift

L.1 Principles of compensation for detector drift

A simple detector operates by comparing the signal from the sensor with a certain fixed threshold (alarm threshold). When the sensor signal reaches the threshold, the detector generates an alarm signal. The smoke density at which this occurs is the response threshold value for the detector. In this simple detector, the alarm threshold is fixed and does not depend on the rate of change of sensor signal with time.

It is known that the sensor signal in clean air can change over the life of the detector. Such changes can be caused, for example, by contamination of the sensing chamber with dust or by other long-term effects such as component ageing. This drift can, in time, lead to increased sensitivity and eventually to false alarms.

It can be considered beneficial, therefore, to provide compensation for such drift in order to maintain a more constant level of response threshold value with time. For the purposes of this discussion, it is assumed that the compensation is achieved by increasing the alarm threshold to offset some or all of the upward drift in the sensor output.

Any compensation for drift will reduce the sensitivity of the detector to slow changes in the sensor output even if these changes are caused by a real, but gradual, increase in smoke level. The objective of 4.8 and this annex is to ensure that the compensation does not reduce the sensitivity to a slowly developing fire to an unacceptable degree.

For the purposes of 4.8 and this annex, it is assumed that the development of any fire which presents a serious danger to life or property is such that the sensor output changes at a rate of at least 25 % of the initial uncompensated response threshold value of the detector, $A_{\text{th,u}}$, per hour. At the minimum rate for which this specification applies, e.g. 0,25 $A_{\text{th,u}}$ per hour, the maximum time to alarm without compensation is 4 h. The response to rates of change less than 0,25 $A_{\text{th,u}}$ per hour is not specified in 4.8 and this annex, and so there is no requirement for the detector to respond to these slower rates of change.

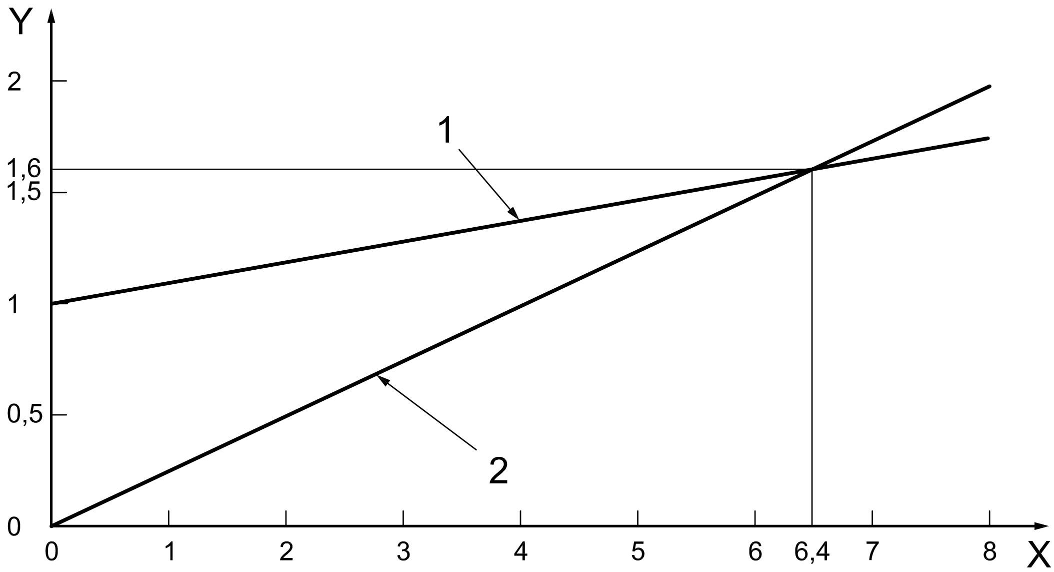
In order not to restrict the way in which compensation is achieved, 4.8 requires only that the time to alarm, for all rates of change greater than 0,25 $A_{\text{th,u}}$ per hour, not exceed 1,6 times the time to alarm if the compensation were not present. Thus, at the minimum rate for which this specification applies, e.g. 0,25 $A_{\text{th,u}}$ per hour, the maximum time to alarm for a compensated alarm is 1,6 × 4 h, or 6,4 h.

L.2 Linear compensation

If the threshold increases in a linear fashion with time in response to a rise in the sensor signal, and if the extent of the compensation is not limited, then the maximum rate of allowable compensation per hour, as can be seen from Figure L.1, is described by Equation (L.1):

$$\frac{0{,}6 \times A_{\text{th,u}}}{6{,}4} = 0{,}094\, A_{\text{th,u}} \qquad \text{(L.1)}$$

At this compensation rate, the sensor output reaches the compensated threshold in exactly 6,4 h.



Key

X time, t, expressed in hours

Y alarm threshold relative to $A_{th,u}$

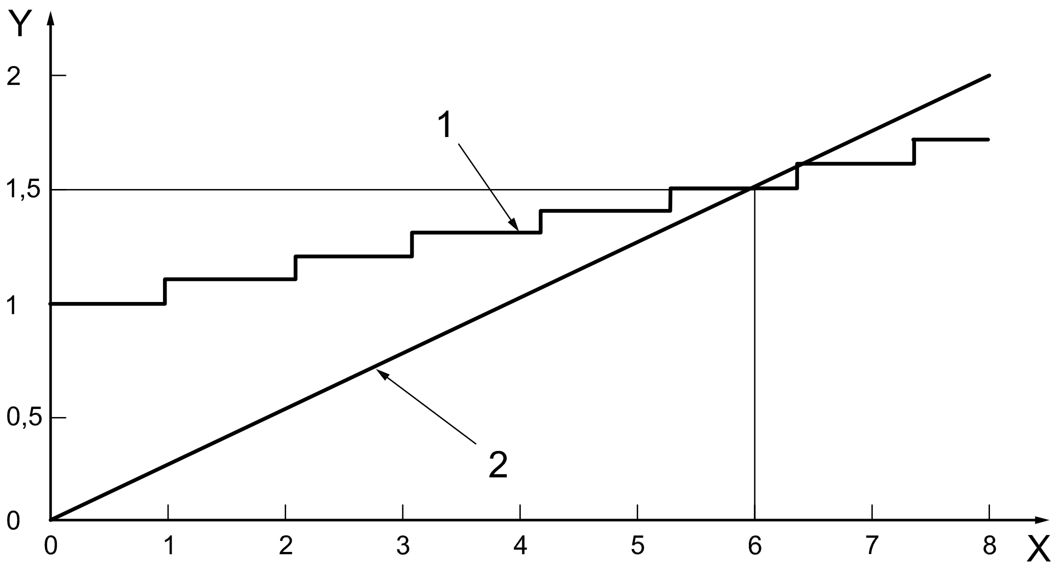
1 alarm threshold, for linear compensation at 0,094 $A_{th,u}$ per hour

2 sensor output, 0,25 $A_{th,u}$ per hour

Figure L.1 — Linear compensation — Limiting case

L.3 Stepwise compensation

Although it has been assumed above that the threshold is compensated linearly and continuously, it is not necessary that the process be either linear or continuous. For example, the stepwise adjustment shown in Figure L.2 also meets the requirement since, in this case, an alarm is reached in 6 h, which is less than the limiting value of 6,4 h.



Key

X time, t, expressed in hours

Y alarm threshold relative to $A_{th,u}$

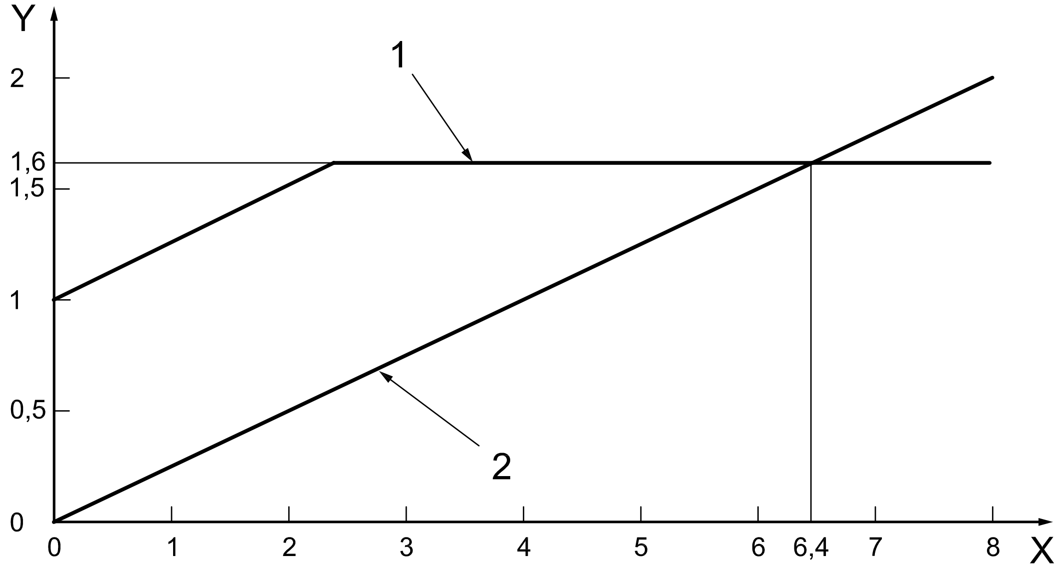
1 alarm threshold, for stepwise compensation

2 sensor output, 0,25 $A_{th,u}$ per hour

Figure L.2 — Stepwise compensation — Limiting case

L.4 High-rate compensation

It is not necessary that the rate of compensation be limited to 0,094 $A_{th,u}$ per hour if the total extent of the compensation is restricted to 0,6 $A_{th,u}$. A relatively rapid rate of compensation balanced by a slower or zero rate, as shown in Figure L.3, also meets the requirement in reaching an alarm condition in 6,4 h or less. In this case, the maximum rate of compensation is limited only by the requirements of the test fires.



Key

X time, t, expressed in hours

Y alarm threshold relative to $A_{th,u}$

1 alarm threshold, high-rate, limited-extent compensated

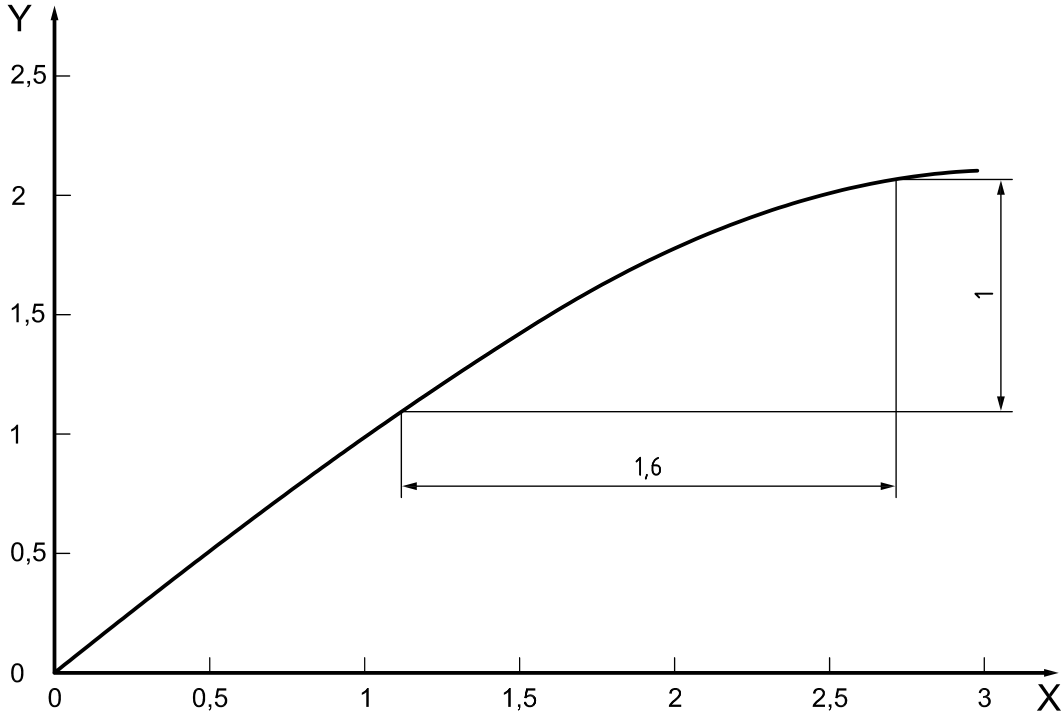
2 sensor output, 0,25 $A_{th,u}$ per hour

Figure L.3 — High-rate, limited-extent compensation

L.5 Avoidance of the non-linear region

The requirements of 4.8 allow considerable freedom in the ways of compensating for slow changes in detector sensitivity. However, it is recognized that in an actual detector, the range over which the output of the sensor is linearly related to smoke (or other stimulus that is equivalent to smoke) is finite. If the range of compensation takes the sensor output into this non-linear region, then the sensitivity of the detector can become degraded to an unacceptable degree.

As an example, consider a detector having the transfer characteristic shown in Figure L.4, in which both axes are expressed in terms of response threshold value $A_{th,u}$. The non-linearity of the characteristic causes the effective sensitivity to be reduced at higher values of stimulus. In this instance, the compensation should be limited to less than $1{,}1 \times A_{th,u}$, since in order to produce a change in output of $A_{th,u}$, the stimulus should increase from $1{,}1 \times A_{th,u}$ to $2{,}7 \times A_{th,u}$. This reduction in sensitivity by a factor of 1,6 is the maximum allowed by 4.8.



Key

X stimulus

Y output

Figure L.4 — Example of non-linear transfer characteristic

Annex M
(informative)

Information concerning the construction of the measuring ionization chamber (MIC)

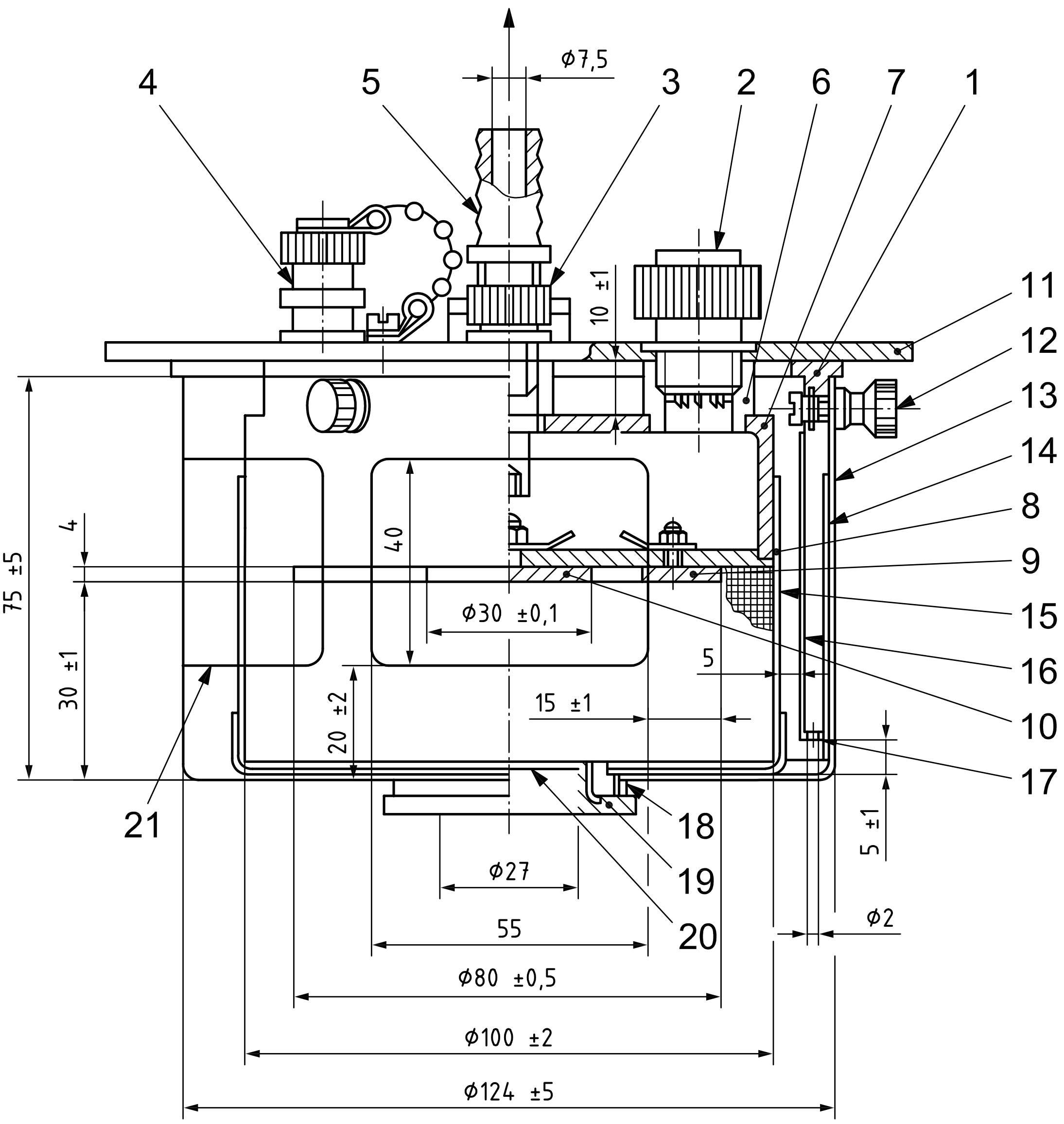
The mechanical construction of the MIC is shown in Figure M.1. The functionally important dimensions are marked with their tolerances. Further details of the various parts of the device are given in Table M.1.

NOTE The MIC is fully described in Reference [2].

Table M.1 — List of parts of the MIC

Reference No.	Item	Number provided	Dimensions, special features	Material
1	Insulating ring	1		Polyamide
2	Multipole socket	1	10-pole	
3	Measuring electrode terminal	1	To chamber supply	
4	Measuring electrode terminal	1	To amplifier or current measuring device	
5	Suction nozzle	1		
6	Guide socket	4		Polyamide
7	Housing	1		Aluminium
8	Insulating plate	1		Polycarbonate
9	Guard ring	1		Stainless steel
10	Measuring electrode	1		Stainless steel
11	Assembly plate	1		Aluminium
12	Fixing screw with milled nut	3	M3	Nickel plated brass
13	Cover	1	Six openings	Stainless steel
14	Outer grid	1	Wire, 0,2 mm in diameter; internal mesh width, 0,8 mm	Stainless steel
15	Inner grid	1	Wire, 0,4 mm in diameter; internal mesh width, 1,6 mm	Stainless steel
16	Windshield	1		Stainless steel
17	Intermediate ring	1	With 72 equispaced holes, each 2 mm in diameter	
18	Threaded ring	1		Nickel plated brass
19	Source holder	1		Nickel plated brass
20	^{241}Am source	1	27 mm diameter	See C.2.3
21	Openings on the periphery	6		

Dimensions in millimetres



NOTE 1 See Table M.1 for the list of parts.

NOTE 2 Dimensions without a tolerance marked are recommended dimensions.

Figure M.1 — Mechanical construction of measuring ionization chamber

Annex N
(normative)

Detectors with more than one smoke sensor

N.1 General

In addition to the testing described in the other clauses and annexes of this part of ISO 7240, smoke detectors with more than one smoke sensor shall be tested as described in this annex to demonstrate the stability of each smoke sensor and its associated circuitry.

N.2 Measurement of the response threshold value for smoke detectors with more than one smoke sensor

The response threshold values of smoke detectors with more than one sensor shall be measured as described in 5.1.5, in the same manner as for smoke detectors with a single smoke sensor, but with the following taken into account.

— If the smoke detector incorporates at least one scattered light or transmitted light sensor and at least one ionization sensor, then in the tests contained in 5.2 to 5.17, the response threshold value shall be recorded consistently as either m or y, at the choice of the manufacturer.

— If the smoke detector incorporates only scattered light or transmitted light sensors, then in tests 5.2 to 5.17, the response threshold value shall be recorded as m.

— If the smoke detector incorporates only ionization sensors, then in the tests contained in 5.2 to 5.17, the response threshold value shall be recorded as y.

N.3 Assessment of sensor stability

In addition to the measurements of response threshold values made for the smoke detector in the tests contained in 5.2 to 5.17, response values shall be recorded for each smoke sensor. The response value for a particular smoke sensor shall be the aerosol density (expressed as m for sensors using scattered or transmitted light or y for sensors using ionization) in the proximity of the detector at the moment that a predetermined event associated with that sensor occurs. The manufacturer may choose the predetermined event as either the moment the detector signals an alarm due to the effect on that sensor only or the moment the sensor, with its associated circuitry, produces a predetermined signal.

The manufacturer shall provide a measurement technique that allows an individual assessment of the response of each sensor with its associated circuitry (e.g. the detector may provide outputs of the response data for each sensor or a method may be provided for switching off each sensor independently).

To facilitate making reliable measurements, it is recommended that the predetermined signal be normally produced by the sensor when the aerosol density in the proximity of the detector is within ± 50 % of $\bar{m}$ or $\bar{y}$ as determined in 5.4.

If possible, these response measurements may be made at the same time as the response threshold value measurements made on the detectors, or they may be made in separate tests on additional detectors or detectors, specially prepared to allow monitoring of the predetermined events or signals mentioned above, or by a combination of these.

In the interest of test economy, the additional or specially prepared detectors may be used for more than one test. In that case, the final measurements of the sensor response between tests on the same detector may be deleted and the final measurement made at the end of a test sequence on a detector. However, it should be noted that in the event of a failure, it might not be possible to identify which test exposure caused the failure.

These response measurements, for individual sensors, shall meet the ratio requirements specified for the response threshold values in tests 5.2 to 5.17.

NOTE The requirements specifying minimum response threshold values are not applicable to these response measurements made on the individual sensors.

Bibliography

[1] ISO/TS 7240-9, *Fire detection and alarm systems — Test fires for fire detectors*

[2] *Investigation of ionization chamber for reference measurements of smoke density*, by M. Avlund, published by DELTA Electronics, Venlighedsvej 4 DK-2970 Hørsholm, Denmark

[3] EN 542:2003, *Adhesives — Determination of density*

ICS 13.220.20

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