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Fire detection and alarm systems —

Part 15:
Point-type fire detectors using smoke and heat sensors

Systèmes de détection et d'alarme d'incendie —

Partie 15: Détecteurs linéaires de fumée utilisant une transmission par faisceaux lumineux

Reference number
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Foreword

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

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

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

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is 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 7240-15:2004), 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: Design, installation, commissioning and service of fire detection and fire alarm systems in and around buildings*
- *Part 15: Point-type fire detectors using smoke and heat sensors*
- *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 23: Visual alarm devices*
- *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*

The following part is under preparation:

- *Part 29: Video fire detectors*

Introduction

This part of ISO 7240 is prepared by ISO/TC 21/SC 3, the secretariat of which is held by SA, and is based on ISO 7240-15:2004.

Point-type fire detectors using smoke and heat sensors are general purpose fire detectors for installation in and around buildings. Multi-sensor detectors respond to a broad range of fires and can be designed to achieve high stability against deceptive phenomena that can result in unwanted alarms.

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 detectors under such conditions.

This edition introduces a requirement that smoke sensors that operate on the principle of scattered or transmitted light to be marked with one of two possible nominal response threshold bands. The availability of two of response threshold bands provides installation designers with a detector selection choice to further reduce the risk of unwanted alarms in installations where unfavourable environmental conditions are present.

This edition introduces additional requirements for smoke detectors with more than one smoke sensor.

Fire detection and alarm systems —

Part 15:
Point-type fire detectors using smoke and heat sensors

1 Scope

This part of ISO 7240 specifies requirements, test methods, and performance criteria for point-type fire detectors using smoke and heat sensors, incorporating in one mechanical enclosure at least one smoke sensor and at least one other sensor which responds to heat, and in which the signal(s) of the smoke sensor(s) is (are) combined with the signal(s) of the heat sensor(s).

The performance of a single sensor within the detector covered by this part of ISO 7240 cannot be sufficient for conformity to other parts of ISO 7240 for the single sensor detector.

Certain types of detectors can contain radioactive materials. The national requirements for radiation protection differ from country to country and they are not therefore specified in this standard. However, such detectors are expected to conform to the national requirements and be in line with the recommendations of the Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development (OECD)[1].

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

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

ISO 7240-5:2012, *Fire detection and alarm systems — Part 5: Point-type heat detectors*

ISO 7240-7, *Fire detection and alarm systems — Part 7: Point-type smoke detectors using scattered light, transmitted light or ionization*

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

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

IEC 60068-2-2, *Environmental testing — Part 2-2: Tests. Tests 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 60068-2-30, *Environmental testingPart 2-30: Tests. Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

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[1] OECD, *Recommendations for ionization smoke detectors in implementation of radiation protection standards. Nuclear Energy Agency, Organisation for economic Co-operation and Development, Paris, France*

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, *Alarm systems — Part 4: Electromagnetic compatibility — Product family standard: Immunity requirements for components of fire, intruder and social alarm systems*

3 Terms, definitions, and abbreviations

3.1 Terms and definitions

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

3.2 Abbreviated terms

FDCIE	fire detection control and indicating equipment

4 Requirements

4.1 Compliance

In order to comply with this part of ISO 7240, the detector shall meet the following requirements.

a) Clause 4, which shall be verified by visual inspection or engineering assessment, shall be tested in accordance with Clause 5 and shall meet the requirements of the tests.

b) Clauses 7 and 8, which shall be verified by visual inspection.

4.2 Design considerations

Detectors shall be so designed that the signal(s) from the smoke sensor(s), combined with the signal(s) from the heat sensor(s), release an alarm signal.

NOTE In some cases, an alarm signal can result from only one element, but the overall fire performance is dependent on signals from more than one sensor being combined in some form of signal processing.

4.3 Smoke-response 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 5.22.

Table 1 — Smoke-response value for detectors using scattered or transmitted light

Smoke-response value in smoke tunnel (aerosol) dB/m		**Test fires end-of-test conditions**					
		TF1 dB/m	**TF2** dB/m	**TF3** dB/m	**TF4** dimensionless	**TF5** dimensionless	**TF8** dB/m
1	$0{,}05 < m < 0{,}3$	$m = 2$	$m = 2$	$m = 2$	$y = 6$	$y = 6$	$m = 1{,}7$
2	$0{,}2 < m < 0{,}6$	$m = 2$	$m = 2$	$m = 2$	$y = 6{,}5$	$y = 7{,}5$	$m = 1{,}7$
NOTE The smaller the m value, the higher the sensitivity of the detectors.							

4.4 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 can be visually indicated, they shall be clearly distinguishable from the alarm condition, except when the detector is switched into a service mode. For detachable detectors, the indicator can be integral with the base or the detector head.

NOTE The alarm condition is reset manually at the FDCIE.

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

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

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

4.5 Indication of other conditions

Where the detector visually indicates other status conditions, they shall be clearly distinguishable from the alarm indication.

4.6 Connection of ancillary devices

Where the detector provides for connections to ancillary devices (e.g. remote indicators, control relays), open- or short-circuit failures of these connections shall not prevent the correct operation of the detector.

4.7 Monitoring of detachable detectors

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

4.8 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.

4.9 On-site adjustment of response behaviour

4.9.1 If there is provision for on-site adjustment of the response value 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, and

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 these setting or settings are used, the detector does not comply with this part of ISO 7240.

4.9.2 Adjustments can be carried out at the detector or at the FDCIE.

4.9.3 Where means are provided (remotely or internally) to switch off signals from a sensing element or to change the sensitivity of the detector so that it no longer meets the requirements of this part of ISO 7240, this change in status shall be made available to the FDCIE.

4.10 Response to slowly developing fires

4.10.1 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 A).

4.10.2 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.

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

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

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

4.11 Protection against ingress of foreign bodies

4.11.1 The detector shall be so designed that a sphere of diameter larger than (1,3 ± 0,05) mm cannot pass into the smoke measuring chamber.

NOTE This requirement is intended to restrict the access of insects into the smoke measuring chamber 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 might therefore be necessary to take other precautions against false alarms due to the entry of small insects.

4.11.2 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 shall be proven by the manufacturer.

4.12 Software-controlled detectors

4.12.1 General requirements

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 prepare documentation which gives an overview of the software design. This documentation shall be in sufficient detail for the design to be inspected 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, and

    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 detailed design documentation. This shall be available for inspection in a manner that respects the manufacturer's rights of confidentiality. It shall comprise at least the following:

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

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

    1) the name of the module,

    2) a description of the tasks performed, and

    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 the program flow to be recognized;

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

NOTE This detailed 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

4.12.4.1 The program necessary to comply with this part of ISO 7240 and any present 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.

4.12.4.2 Site-specific data shall be held in memory which will 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

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

- temperature: 15 °C to 35 °C;
- relative humidity: 25 % to 75 %;
- air pressure: 86 kPa to 106 kPa.

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

5.1.2 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 the method considered to be most unfavourable for each test shall be chosen.

5.1.3 Operating conditions for tests

5.1.3.1 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, set the supply parameters applied to the specimen within the manufacturer’s specified range(s) and maintain them 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 connect the specimen to any necessary ancillary devices (e.g. through wiring to an end-of-line device for non-addressable detectors) to allow a fault signal to be recognized.

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

5.1.4 Tolerances

5.1.4.1 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).

5.1.4.2 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 the smoke-response value

5.1.5.1 Install the specimen for which the smoke-response value, A_{sr}, is to be measured in a smoke tunnel, described in Annex B, 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 of smoke response test (5.3), unless otherwise specified in the test procedure.

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

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

5.1.5.4 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 K and not faster than 0,2 K/min for all the measurements on a specimen.

5.1.5.5 Connect the specimen to its supply and monitoring equipment as described in 5.1.3, and allow it to stabilize for at least 15 min, unless otherwise specified by the manufacturer.

5.1.5.6 Introduce the test aerosol as specified in B.3 into the tunnel at such a rate that the increase of aerosol density is as follows:

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

$$0{,}015 \leq \frac{\vartriangle m}{\vartriangle t} \leq 0{,}1$$

where

m is the aerosol density in dB/m;

t is the time in min.

— for detectors using ionization, per minute:

$$0{,}05 \leq \frac{\vartriangle y}{\vartriangle t} \leq 0{,}3$$

where

y is a dimensionless variable;

t is the time in min.

NOTE These ranges are intended to allow the selection of a convenient rate, depending upon the sensitivity of the detector, to get a response in a reasonable time.

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

5.1.5.8 Record the aerosol density (m or y) at the moment the specimen gives an alarm. This shall be taken as the smoke-response value.

5.1.6 Measurement of the heat-response value

5.1.6.1 Install the specimen for which the heat-response value is to be measured in a heat tunnel, as specified in Annex C, 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 one as determined in the directional dependence of heat response test (5.4), unless otherwise specified in the test procedure.

5.1.6.2 Connect the specimen to its supply and monitoring equipment as specified in 5.1.3, and allow it to stabilize for at least 15 min, unless otherwise specified by the manufacturer.

5.1.6.3 Before the test, stabilize the temperature of the air stream and the specimen at (25 ± 2) °C. The air flow shall be maintained at a constant mass flow equivalent to a velocity of (0,8 ± 0,1) m/s at 25 °C.

5.1.6.4 Raise the air temperature until the heat sensor produces a signal (this might be a fire signal), as specified by the manufacturer. The rate of rise of the air temperature and the associated tolerances shall correspond to one of the values, except for 0,2 K/min, 1 K/min and 30 K/min, as specified in ISO 7240-5. The choice of the rate within the range of 3 K/min to 20 K/min shall be specified by the manufacturer.

5.1.6.5 For this purposes of this test, the manufacturer can supply specimens with special outputs or specially modified software to indicate when the air temperature has caused an internal threshold to be reached. However, it is essential that the output signal be routed through the amplification path of the detector.

5.1.6.6 Record the temperature at which this signal is produced, T (s). This shall be taken as the heat-response value.

5.1.7 Provision for tests

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

- for detachable detectors: 23 detector heads and bases;
- for non-detachable detectors: 23 specimens;
- the data specified in Clause 7 and Clause 8.

5.1.7.2 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 smoke-response value of the specimens as measured in the reproducibility of smoke response test (5.5) should also represent the production mean, and that the deviation limits specified for the reproducibility test should also be applicable to the manufacturer’s production.

5.1.8 Test schedule

Test the specimens as specified in Table 2. After the reproducibility of smoke response test (5.5), number the four specimens with the least sensitive smoke response (i.e. those with the highest smoke response value) 18 to 23. Number the others 1 to 17 arbitrarily.

Table 2 — Test schedule

Test	Subclause	Specimen no(s). to be tested
Repeatability of smoke response	5.2	one chosen arbitrarily
Directional dependence of smoke response	5.3	one chosen arbitrarily
Directional dependence of heat response	5.4	one chosen arbitrarily
Reproducibility of smoke response	5.5	all specimens

[a] This test applies only 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 cannot be possible to identify which test exposure caused the failure.

[c] This test defines measurement and assessment changes that apply to other tests if the detector has more than one smoke sensor

Table 2 *(continued)*

Test	Subclause	Specimen no(s). to be tested
Reproducibility of heat response	5.6	all specimens
Lower limit of heat response	5.7	1
Air movement	5.8	2
Dazzling[a]	5.9	3
Variation of supply parameters	5.10	3
Dry heat (operational)	5.11	4
Cold (operational)	5.12	5
Damp heat, cyclic (operational)	5.13	6
Damp heat, steady state (endurance)	5.14	7
Sulfur dioxide (SO_2) corrosion (endurance)	5.15	8
Shock (operational)	5.16	9
Impact (operational)	5.17	10
Vibration, sinusoidal (operational)	5.18	11
Vibration, sinusoidal (endurance)	5.19	11
Electrostatic discharge (operational)	5.20	12[b]
Radiated electromagnetic fields (operational)	5.20	13[b]
Conducted disturbances induced by electromagnetic fields (operational)	5.20	14[b]
Fast transient bursts (operational)	5.20	15[b]
Slow high energy voltage surge (operational)	5.20	16[b]
Detectors with more than one smoke sensor – Optional test[c]	5.21	17
Fire sensitivity	5.22	18, 19, 20, 21, 22, 23

[a] This test applies only 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 cannot be possible to identify which test exposure caused the failure.

[c] This test defines measurement and assessment changes that apply to other tests if the detector has more than one smoke sensor

5.1.9 Test report

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

5.2 Repeatability of smoke response

5.2.1 Object of test

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

5.2.2.1 Mount the specimen in accordance with 5.1.2 and connect it to supply and monitoring equipment in accordance with 5.1.3.

5.2.2.2 Measure the smoke-response value of the specimen 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.

5.2.2.3 Designate the maximum of the measured smoke-response values as $y_{\max}$ or $m_{\max}$ and the minimum value as $y_{\min}$ or $m_{\min}$.

5.2.3 Requirements

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

5.2.3.2 The lower smoke-response value $y_{\min}$ shall be not less than 0,2.

5.2.3.3 The lower smoke-response value, $m_{\min}$, shall be not less than

- 0,05 dB/m for detectors with a declared smoke-response value band of $0{,}05 < m < 0{,}3$, or
- 0,2 dB/m for detectors with a declared smoke-response value band of $0{,}2 < m < 0{,}6$.

5.2.3.4 The higher smoke-response value, $m_{\max,}$ shall be not greater than

- 0,3 dB/m for detectors with a declared smoke-response value band of $0{,}05 < m < 0{,}3$, or
- 0,6 dB/m for detectors with a declared smoke-response value band of 0,2 < m < 0,6.

5.3 Directional dependence of smoke response

5.3.1 Object of test

To show that the sensitivity of the detector is not unduly dependent on the direction of air flow around the detector.

5.3.2 Test procedure

5.3.2.1 Mount the specimen in accordance with 5.1.2 and connect it to supply and monitoring equipment in accordance with 5.1.3.

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

5.3.2.3 Designate the maximum of the measured smoke-response values as $y_{\max}$ or $m_{\max}$ and the minimum value as $y_{\min}$ or $m_{\min}$.

5.3.2.4 Record the orientations for which the maximum and minimum smoke-response values were measured.

5.3.3 Requirements

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

5.3.3.2 The lower smoke-response value $y_{\min}$ shall be not less than 0,2.

5.3.3.3 The lower smoke-response value, $m_{\min}$, shall be not less than

- 0,05 dB/m for detectors with a declared smoke-response value band of $0,05 < m < 0,3$, or
- 0,2 dB/m for detectors with a declared smoke-response value band of $0,2 < m < 0,6$.

5.3.3.4 The higher smoke-response value, $m_{\max}$, shall be not greater than

- 0,3 dB/m for detectors with a declared smoke-response value band of $0,05 < m < 0,3$, or
- 0,6 dB/m for detectors with a declared smoke-response value band of 0,2 < m < 0,6.

5.4 Directional dependence of heat response

5.4.1 Object of test

To show that the sensitivity of the detector is not unduly dependent on the direction of air flow around the detector.

5.4.2 Test procedure

5.4.2.1 Mount the specimen in accordance with 5.1.2 and connect it to supply and monitoring equipment in accordance with 5.1.3.

5.4.2.2 Stabilize the specimen at 25 °C before each measurement.

5.4.2.3 Measure the heat-response value of the specimen eight times as specified in 5.1.6, at a rate of rise of 10 K/min, the specimen being rotated 45° about its vertical axis between each measurement, so that the measurements are taken at eight different orientations relative to the direction of air flow.

5.4.2.4 Record the heat-response value at each of the eight orientations.

5.4.2.5 Designate the maximum of the measured heat-response value as $T_{\max}$ and the minimum value as $T_{\min}$.

5.4.2.6 Record the orientations for which the maximum and minimum heat-response values were measured. The orientation for which the maximum response time was measured is referred to as the *least sensitive* heat orientation. The orientation for which the minimum response time was measured is referred to as the *most sensitive* heat orientation.

5.4.3 Requirements

The ratio of $(T_{\max} - 25):(T_{\min} - 25)$ shall be not greater than 1,6.

5.5 Reproducibility of smoke response

5.5.1 Object of test

To show that the smoke sensitivity of the detector does not vary unduly from specimen to specimen.

5.5.2 Test procedure

5.5.2.1 Mount the specimen in accordance with 5.1.2 and connect it to supply and monitoring equipment in accordance with 5.1.3.

5.5.2.2 Measure the smoke-response value of each specimen as specified in 5.1.5.

5.5.2.3 Calculate the mean of these smoke-response values and designate it as $\bar{y}$ or $\bar{m}$ as appropriate.

5.5.2.4 Designate the maximum of the measured smoke-response values as $y_{\max}$ or $m_{\max}$ and the minimum value as $y_{\min}$ or $m_{\min}$.

5.5.3 Requirements

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

5.5.3.2 The lower smoke-response value $y_{\min}$ shall be not less than 0,2.

5.5.3.3 The lower smoke-response value, $m_{\min}$, shall be not less than

- 0,05 dB/m for detectors with a declared smoke-response value band of $0{,}05 < m < 0{,}3$, or
- 0,2 dB/m for detectors with a declared smoke-response value band of $0{,}2 < m < 0{,}6$.

5.5.3.4 The higher smoke-response value, $m_{\max}$, shall be not greater than

- 0,3 dB/m for detectors with a declared smoke-response value band of $0{,}05 < m < 0{,}3$, or
- 0,6 dB/m for detectors with a declared smoke-response value band of 0,2 < m < 0,6.

5.6 Reproducibility of heat response

5.6.1 Object of test

To show that the heat sensitivity of the detector does not vary unduly from specimen to specimen.

5.6.2 Test procedure

5.6.2.1 Mount the specimen in accordance with 5.1.2 and connect it to supply and monitoring equipment in accordance with 5.1.3.

5.6.2.2 Stabilize the specimen at 25 °C.

5.6.2.3 Measure the heat-response value of the specimen as specified in 5.1.6, at a rate of rise of 20 K/min.

5.6.2.4 Designate the maximum of the measured heat-response value as $T_{\max}$ and the minimum value as $T_{\min}$.

5.6.3 Requirements

The ratio of $T_{\max}$: $T_{\min}$ shall be not greater than 1,3.

5.7 Lower limit of heat response

5.7.1 Object of the test

To show that detectors in the absence of smoke, are not more sensitive to heat alone, than is permitted in ISO 7240-5.

5.7.2 Test procedure

5.7.2.1 Mount the specimen in accordance with 5.1.2 and connect it to supply and monitoring equipment in accordance with 5.1.3.

5.7.2.2 Measure the heat-response value of the specimen in its most sensitive orientation, using the methods described in 5.3 and ISO 7240-5:2012, 5.4. For the purposes of these tests, use the test parameters for class A1 detectors according to ISO 7240-5:2012.

NOTE The minimum static response temperature needs to be greater than that which is required to comply with the dry heat (operational) test (5.11).

5.7.3 Requirements

5.7.3.1 In the test for static response temperature (5.3 of ISO 7240-5:2012), the specimen shall not give an alarm signal at a temperature less than the minimum static response temperature specified in Table 1 of ISO 7240-5:2012 for a class A1 detectors according to ISO 7240-5:2012.

5.7.3.2 The specimen shall not give an alarm signal at each rate of rise of air temperature in a time less than the lower response time limits specified in Table 4 of ISO 7240-5:2012 for a class A1 detector according to ISO 7240-5:2012.

5.8 Air movement

5.8.1 Object of test

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.

5.8.2 Test procedure

5.8.2.1 Mount the specimen in accordance with 5.1.2 and connect it to supply and monitoring equipment in accordance with 5.1.3.

5.8.2.2 Measure the smoke-response value of the specimen as described in 5.1.5 in the most and the least sensitive orientation. Designate these appropriately as $y_{(0,2)\mathrm{max}}$ and $y_{(0,2)\mathrm{min}}$ or $m_{(0,2)\mathrm{max}}$ and $m_{(0,2)\mathrm{min}}$.

5.8.2.3 Repeat these measurements but with an air velocity in the proximity of the detector of (1 ± 0,2) m/s. Designate the smoke-response values in these tests as $y_{(1,0)\mathrm{max}}$ and $y_{(1,0)\mathrm{min}}$ or $m_{(1,0)\mathrm{max}}$ and $m_{(1,0)\mathrm{min}}$.

5.8.2.4 Additionally, for detectors containing an ionization chamber, 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.

5.8.2.4 Record any signal that is emitted.

5.8.3 Requirements

5.8.3.1 One of the following relationships shall apply:

— for detectors using scattered or transmitted light: $0{,}625 < \frac{\left[m_{(0,2)\max} + m_{(0,2)\min}\right]}{\left[m_{(1,0)\max} + m_{(1,0)\min}\right]} < 1{,}6$;

— for detectors using ionization: $0{,}625 < \frac{\left[y_{(0,2)\max} + y_{(0,2)\min}\right]}{\left[y_{(1,0)\max} + y_{(1,0)\min}\right]} < 1{,}6$.

5.8.3.2 For ionization-chamber detectors, the detector shall not emit either a fault signal or an alarm signal during the test with aerosol free-air.

5.9 Dazzling

5.9.1 Object of test

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

5.9.2 Test procedure

5.9.2.1 Mount the apparatus for the dazzling test (see Annex D) in the smoke tunnel as specified in B.1.

5.9.2.2 Install the specimen in the apparatus in the least sensitive orientation and connect it to its supply and monitoring equipment in accordance with 5.1.3.

5.9.2.3 Measure the smoke-response value of the specimen as specified in 5.1.5.

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

5.9.2.5 Switch the four lamps ON again and, after at least 1 min, measure the smoke-response value as specified in 5.1.5, with the lamps ON.

5.9.2.6 Switch the four lamps OFF.

5.9.2.7 Repeat 5.9.2.3 to 5.9.2.6, but with the detector rotated 90° in one direction (either direction can be chosen), from the least sensitive orientation.

5.9.2.8 For each orientation, designate the maximum smoke-response value as $m_{\max}$ and the minimum smoke-response value as $m_{\min}$.

5.9.3 Requirements

During the periods when the switching sequences are being conducted and when the lamps are all ON for at least 1 min, the specimen shall not emit either an alarm or fault signal.

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

5.10 Variation in supply parameters (voltage)

5.10.1 Object of test

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 these parameters.

5.10.2 Test procedure

5.10.2.1 Measure the smoke-response 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.

5.10.2.2 Designate the maximum of the measured smoke-response values as y_{max} or m_{max} and the minimum value as y_{min} or m_{min}.

5.10.2.3 Measure the heat-response value of the specimen as specified in 5.1.6, at a rate of rise of 20 K/min, at the upper and lower limits of the supply parameter (e.g. voltage) range(s) specified by the manufacturer.

5.10.2.4 Designate the maximum of the measured heat-response value as T_{max} and the minimum value as T_{min}.

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

5.10.3 Requirements

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

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

5.10.3.3 The lower smoke-response value, m_{min}, shall be not less than

- 0,05 dB/m for detectors with a declared smoke-response value band of $0{,}05 < m < 0{,}3$, or
- 0,2 dB/m for detectors with a declared smoke-response value band of $0{,}2 < m < 0{,}6$.

5.10.3.4 The higher smoke-response value, m_{max}, shall be not greater than

- 0,3 dB/m for detectors with a declared smoke-response value band of $0{,}05 < m < 0{,}3$, or
- 0,6 dB/m for detectors with a declared smoke-response value band of 0,2 < m < 0,6.

5.10.3.5 The ratio of T_{max}: T_{min} shall be not greater than 1,3.

5.11 Dry heat (operational)

5.11.1 Object of test

To demonstrate the ability of the detector to function correctly at high ambient temperatures.

5.11.2 Test procedure

5.11.2.1 Reference

Use the test apparatus and conduct the procedure in accordance with IEC 60068-2-2, Test Bb, and with 5.11.2.2 to 5.11.2.5.

5.11.2.2 State of the specimen during conditioning

Mount the specimen to be tested in the smoke tunnel as specified in B.1, in its least sensitive orientation, with an initial air temperature of (25 ± 5) °C, and connect it to its supply and monitoring equipment in accordance with 5.1.3.

5.11.2.3 Conditioning

Apply the following conditioning:

- temperature: starting at an initial air temperature of (23 ± 5) °C, increase the air temperature to (55 ± 2) °C at a rate not exceeding 1 K/min;
- duration: maintain the maximum temperature for 2 h.

5.11.2.4 Measurements during conditioning

Monitor the specimen to detect any alarm or fault signals.

5.11.2.5 Final measurements

5.11.2.5.1 Measure the smoke-response value in accordance with 5.1.5, but at a temperature of (55 ± 2) °C.

5.11.2.5.2 Of the two smoke-response values measured for the specimen in this test and in the reproducibility test (5.5), designate the greater as $y_{\max}$ or $m_{\max}$ and the lesser as $y_{\min}$ or $m_{\min}$.

NOTE For this test, the minimum static response of the heat sensor needs to be greater than (55 ± 2) °C.

5.11.3 Requirements

5.11.3.1 No alarm or fault signals shall be produced during conditioning, until the smoke-response value is measured.

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

5.12 Cold (operational)

5.12.1 Object of test

To demonstrate the ability of the detector to function correctly at low ambient temperatures appropriate to the anticipated service environment.

5.12.2 Test procedure

5.12.2.1 Reference

Use the test apparatus and conduct the procedures as specified in IEC 60068-2-1, Test Ab, but carry out the conditioning procedure as specified in 5.12.2.2 to 5.12.2.5.

5.12.2.2 State of the specimen during conditioning

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

5.12.2.3 Conditioning

Apply the following conditioning:

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

5.12.2.4 Measurements during conditioning

Monitor the specimen to detect any alarm or fault signals.

5.12.2.5 Final measurements

5.12.2.5.1 After the recovery period of between 1 h and 2 h at standard atmospheric conditions, measure the smoke-response value as specified in 5.1.5.

5.12.2.5.2 Designate the greater of the smoke response values measured in this test and for the same specimen in the reproducibility test (5.5) as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.12.2.5.3 Measure the heat-response value as specified in 5.1.6, at a rate of rise of 20 K/min.

5.12.2.5.4 Designate the greater of the heat-response values measured in this test and for the same specimen in the reproducibility test (5.6) as T_{max} and the lesser as T_{min}.

5.12.3 Requirements

5.12.3.1 No alarm or fault signals shall be produced during the conditioning.

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

5.12.3.3 The ratio of T_{max}: T_{min} shall be not greater than 1,3.

5.13 Damp heat, cyclic (operational)

5.13.1 Object of test

To demonstrate the ability of the detector to function correctly at high relative humidity (with condensation), which can occur for short periods in the anticipated service environment.

5.13.2 Test procedure

5.13.2.1 Reference

Use the test apparatus and conduct the procedure as specified in IEC 60068-2-30, Test Db, using the Variant 1 test cycle and with 5.13.2.2 to 5.13.2.5.

5.13.2.2 State of the specimen during conditioning

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

5.13.2.3 Conditioning

Apply the following conditioning:

- lower temperature: (25 ± 2) °C;
- upper temperature: (40 ± 2) °C;
- relative humidity:
  - at lower temperature ≥95 %;
  - at upper temperature (93 ± 3) %;
- number of cycles: 2.

5.13.2.4 Measurements during conditioning

Monitor the specimen to detect any alarm or fault signals.

5.13.2.5 Final measurements

5.13.2.5.1 After the recovery period of between 1 h and 2 h at standard atmospheric conditions, measure the smoke-response value as specified in 5.1.5.

5.13.2.5.2 Designate the greater of the smoke-response values measured in this test and for the same specimen in the reproducibility test (5.5) as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.13.2.5.3 Measure the heat-response value as specified in 5.1.6, at a rate of rise of 20 K/min.

5.13.2.5.4 Designate the greater of the heat-response values measured in this test and for the same specimen in the reproducibility test (5.6) as T_{max} and the lesser as T_{min}.

5.13.3 Requirements

5.13.3.1 No alarm or fault signals shall be produced during the conditioning.

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

5.13.3.3 The ratio of T_{max}: T_{min} shall be not greater than 1,3.

5.14 Damp heat, steady-state (endurance)

5.14.1 Object of test

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

5.14.2 Test procedure

5.14.2.1 Reference

Use the test apparatus and conduct the procedure as specified in IEC 60068-2-78, but carry out the conditioning procedure specified in 5.14.2.2 to 5.14.2.3.

5.14.2.2 State of the specimen during conditioning

Mount the specimen as specified in 5.1.2, but do not supply it with power during the conditioning.

5.14.2.3 Conditioning

Apply the following conditioning:

— temperature: (40 ± 2) °C;

— relative humidity: (93 ± 3) %;

— duration: 21 d.

5.14.2.4 Final measurements

5.14.2.4.1 After the recovery period of between 1 h and 2 h at standard atmospheric conditions, measure the smoke-response value as specified in 5.1.5.

5.14.2.4.2 Designate the greater of the smoke response values measured in this test and for the same specimen in the reproducibility test (5.5) as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.14.2.4.3 Measure the heat-response value as specified in 5.1.6, at a rate of rise of 20 K/min.

5.14.2.4.4 Designate the greater of the heat-response values measured in this test and for the same specimen in the reproducibility test (5.6) as T_{max} and the lesser as $T_{min.}$

5.14.3 Requirements

5.14.3.1 No alarm of fault signal shall be attributable to the endurance conditioning when the specimen is connected to the supply and monitoring equipment.

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

5.14.3.3 The ratio of T_{max}: T_{min} shall be not greater than 1,3.

5.15 Sulfur dioxide (SO_2) corrosion (endurance)

5.15.1 Object of test

To demonstrate the ability of the detector to withstand the corrosive effects of sulfur dioxide as an atmospheric pollutant.

5.15.2 Test procedure

5.15.2.1 Reference

Use the test apparatus and conduct the procedure generally as specified in IEC 60068-2-42, Test Kc, but carry out the conditioning specified in 5.15.2.2 to 5.15.2.3.

5.15.2.2 State of the specimen during conditioning

Mount the specimen as specified in 5.1.2. Do not supply it with power during the conditioning, but equip it with untinned copper wires of the appropriate diameter, connected to sufficient terminals to allow the final measurements to be made without making further connections to the specimen.

5.15.2.3 Conditioning

Apply the following conditioning:

- temperature: (25 ± 2) °C;
- relative humidity: (93 ± 3) %;
- SO_2 concentration: (25 ± 5) μl/l;
- Duration: 21 d.

5.15.2.4 Final measurements

5.15.2.4.1 Immediately after the conditioning, subject the specimen to a drying period of 16 h at 40 °C, ≤ 50 % RH, followed by a recovery period of 1 h to 2 h at standard laboratory conditions.

5.15.2.4.2 After the recovery period, measure the smoke-response value as specified in 5.1.5.

5.15.2.4.3 Designate the greater of the smoke response values measured in this test and for the same specimen in the reproducibility test (5.5) as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.15.2.4.4 Measure the heat-response value as specified in 5.1.6.

Designate the greater of the heat-response value measured in this test and for the same specimen in the reproducibility test (5.6) as T_{max} and the lesser as T_{min}.

5.15.3 Requirements

5.15.3.1 No alarm of fault signal shall be attributable to the endurance conditioning when the specimen is connected to the supply and monitoring equipment.

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

5.15.3.3 The ratio of T_{max}: T_{min} shall be not greater than 1,3.

5.16 Shock (operational)

5.16.1 Object of test

To demonstrate the immunity of the detector to such mechanical shocks that are likely to occur, albeit infrequently, in the anticipated service environment.

5.16.2 Test procedure

5.16.2.1 Reference

Use the test apparatus and perform the procedure generally as specified in IEC 60068-2-27, Test Ea, but carry out the conditioning as specified in 5.16.2.2 to 5.16.2.4.

5.16.2.2 State of the specimen during conditioning

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

5.16.2.3 Conditioning

5.16.2.3.1 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/s^2 (where M is the mass of the specimen, in kilograms);
- number of directions: 6;
- pulses per direction: 3.

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

5.16.2.4 Measurements during conditioning

Monitor the specimen to detect any alarm or fault signals.

5.16.2.5 Final measurements

5.16.2.5.1 After the conditioning, measure the smoke-response value as specified in 5.1.5.

5.16.2.5.2 Designate the greater of the smoke response values measured in this test and for the same specimen in the reproducibility test (5.5) as $y_{\max}$ or $m_{\max}$ and the lesser as $y_{\min}$ or $m_{\min}$.

5.16.2.4.3 Measure the heat-response value as specified in 5.1.6.

5.16.2.4.4 Designate the greater of the heat-response value measured in this test and for the same specimen in the reproducibility test (5.6) as $T_{\max}$ and the lesser as $T_{\min}$.

5.16.3 Requirements

5.16.3.1 No alarm or fault signals shall be produced during the conditioning.

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

5.16.3.3 The ratio of $T_{\max}$: $T_{\min}$ shall be not greater than 1,3.

5.17 Impact (operational)

5.17.1 Object of test

To demonstrate the immunity of the detector to mechanical impacts upon its surface, which it can sustain in the normal service environment, and which it can reasonably be expected to withstand.

5.17.2 Test procedure

5.17.2.1 Apparatus

The test apparatus 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). A suitable apparatus is specified in Annex E.

5.17.2.2 State of the specimen during conditioning

5.17.2.2.1 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 position of impact relative to the specimen as that most likely to impair the normal functioning of the specimen.

5.17.2.2.2 Connect the specimen to its supply and monitoring equipment as specified in 5.1.3.

5.17.2.3 Conditioning

Apply the following conditioning:

- impact energy: (1,9 ± 0,1) J;
- hammer velocity: (1,5 ± 0,125) m/s;
- number of impacts: 1.

5.17.2.4 Measurements during conditioning

Monitor the specimen to detect any alarm or fault signals.

5.17.2.5 Final measurements

5.17.2.5.1 After the conditioning, measure the smoke-response value as specified in 5.1.5.

5.17.2.5.2 Designate the greater of the smoke-response values measured in this test and for the same specimen in the reproducibility test (5.5) as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.17.2.5.3 Measure the heat-response value as specified in 5.1.6.

5.17.2.5.4 Designate the greater of the heat-response value measured in this test and for the same specimen in the reproducibility test (5.6) as T_{max} and the lesser as T_{min}.

5.17.3 Requirements

5.17.3.1 No alarm or fault signals shall be produced during the conditioning.

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

5.17.3.3 The ratio of T_{max}: T_{min} shall be not greater than 1,3.

5.18 Vibration, sinusoidal (operational)

5.18.1 Object of test

To demonstrate the immunity of the detector to vibration at levels considered appropriate to the normal service environment.

5.18.2 Test procedure

5.18.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-6, Test Fc, but carry out the conditioning specified in 5.18.2.2 to 5.18.2.4.

5.18.2.2 State of the specimen during conditioning

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

5.18.2.2.2 Apply the vibration in turn to each of three mutually perpendicular axes, and so that one of the three axes is perpendicular to the normal mounting plane of the specimen.

5.18.2.3 Conditioning

5.18.2.3.1 Apply the following conditioning:

- frequency range: 10 Hz to150 Hz;
- acceleration amplitude: 4,905 m/s^2 (= 0,5 g_n);
- number of axes: 3;
- sweep rate: 1 octave/min;
- number of sweep cycles: 1/axis.

5.18.2.3.2 The vibration operational and endurance tests can 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 then be made.

5.18.2.4 Measurements during conditioning

Monitor the specimen to detect any alarm or fault signals.

5.18.2.5 Final measurements

5.18.2.5.1 After the conditioning, measure the smoke-response value as specified in 5.1.5. Designate the greater of the smoke-response values measured in this test and for the same specimen in the reproducibility test (5.5) as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.18.2.5.2 Measure the heat-response value as specified in 5.1.6.

5.18.2.5.3 Designate the greater of the heat-response value measured in this test and for the same specimen in the reproducibility test (5.6) as T_{max} and the lesser as T_{min}.

5.18.3 Requirements

5.18.3.1 No alarm or fault signals shall be produced during the conditioning.

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

5.18.3.3 The ratio of T_{max}: T_{min} shall be not greater than 1,3.

5.19 Vibration, sinusoidal (endurance)

5.19.1 Object of test

To demonstrate the ability of the detector to withstand the long-term effects of vibration at levels appropriate to the service environment.

5.19.2 Test procedure

5.19.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-6, Test Fc, but carry out the conditioning specified in 5.19.2.2 to 5.19.2.3.

5.19.2.2 State of the specimen during conditioning

5.19.2.2.1 Mount the specimen as specified in 5.1.2, but do not supply it with power during conditioning.

5.19.2.2.2 Apply the vibration in turn to each of three mutually perpendicular axes, and so that one of the three axes is perpendicular to the normal mounting axis of the specimen.

5.19.2.3 Conditioning

5.19.2.3.1 Apply the following conditioning:

- frequency range: 10 Hz to 150 Hz;
- acceleration amplitude: 9,81 m/s^2 (= 1,0 g_n);
- number of axes: 3;
- sweep rate: 1 octave/min;
- number of sweep cycles: 20/axis.

5.19.2.3.2 The vibration operational and endurance tests can 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 then be made.

5.19.2.4 Final measurements

5.19.2.4.1 After the conditioning, measure the smoke-response value as specified in 5.1.5.

5.19.2.4.2 Designate the greater of the smoke-response values measured in this test and for the same specimen in the reproducibility test (5.5) as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.19.2.4.3 Measure the heat-response value as specified in 5.1.6.

5.19.2.4.4 Designate the greater of the heat-response values measured in this test and for the same specimen in the reproducibility test (5.6) as T_{max} and the lesser as T_{min}.

5.19.3 Requirements

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

5.19.3.2 The ratio of T_{max}: T_{min} shall be not greater than 1,3.

5.20 Electromagnetic compatibility (EMC)

5.20.1 Conduct out the following EMC immunity tests as described in EN 50130-4:

a) electrostatic discharge;

b) radiated electromagnetic fields;

c) conducted disturbances induced by electromagnetic fields (operational);

d) fast transient bursts (operational);

e) slow high-energy voltage surges (operational).

5.20.2 For these tests, the criteria for compliance 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:

   1) measure the smoke response value as described in 5.1.5;

   2) designate the greater of the smoke-response value measured in this test and for the same specimen in the reproducibility test (5.5) as y_{max} or m_{max} and the lesser as y_{min} or m_{min};

   3) measure the heat-response value as specified in 5.1.6;

   4) designate the greater of the heat-response values measured in this test and for the same specimen in the reproducibility test (5.6) as T_{max} and the lesser as T_{min};

b) The required operating condition shall be as described in 5.1.3;

c) The acceptance criteria for the functional test after the conditioning shall be that:

   1) the ratio of the smoke response values y_{max}: y_{min} or m_{max}: m_{min} shall not be greater than 1,6;

   2) the ratio of T_{max}: T_{min} shall be not greater than 1,3.

5.21 Detectors with more than one smoke sensor — Optional test

5.21.1 Object of test

To demonstrate the stability of each smoke sensor and its associated circuitry.

5.21.1.1 Reference

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

NOTE 1 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 the reproducibility of smoke response test (5.5). If possible, these response measurements should be made at the same time as the smoke-response value measurements, or they can be made in separate tests on additional detectors or detectors, specially prepared to allow monitoring of the predetermined events or signals, or by a combination of these.

NOTE 2 In the interest of test economy, the additional or specially prepared detectors can be used for more than one test. In that case, the final measurements of the sensor response between tests on the same detector can be deleted and the final measurement made at the end of a test sequence on a detector. However, in the event of a failure, it might not be possible to identify which test exposure caused the failure.

5.21.2 Test procedure

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

5.21.2.2 Measure the smoke-response value as specified in 5.1.5, making the following adjustments to the procedure as required.

- If the smoke detector incorporates at least one scattered light or transmitted light sensor and at least one ionization sensor, then the smoke-response value shall be recorded consistently as either *m* or *y*, at the choice of the manufacture, for the tests in 5.2, 5.3, 5.5, and 5.8 to 5.20.
- If the smoke detector incorporates only scattered light or transmitted light sensors, then the smoke-response value shall be recorded as *m* for the tests in 5.2, 5.3, 5.5, and 5.8 to 5.20.
- If the smoke detector incorporates only ionization sensors, then the smoke-response value shall be recorded as *y* for the tests in 5.2, 5.3, 5.5, and 5.8 to 5.20.

5.21.2.3 In addition to the measurements of smoke-response values made for the smoke detector for the tests in 5.2, 5.3, 5.5, and 5.8 to 5.20, record smoke-response values for each smoke sensor. The smoke-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 can 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.

5.21.3 Requirements

Response measurements for individual sensors shall meet the ratio requirements specified for the smoke-response values for the tests in 5.2, 5.3, 5.5, and 5.8 to 5.20.

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

5.22 Fire sensitivity

5.22.1 Object of test

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

5.22.2 Principle

The specimens are mounted in a standard fire test room (see Annex F) and are exposed to a series of test fires designed to produce smoke and heat.

5.22.3 Test procedure

5.22.3.1 Test fires

5.22.3.1.1 Subject the specimens to the six test fires TF1, TF2, TF3, TF4, TF5, and TF8, as specified in Annexes G to L.

5.22.3.1.2 In order to be a valid test fire, 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 in order to obtain valid test fires.

5.22.3.2 Mounting of the specimens

5.22.3.2.1 Mount the six specimens (Nos. 18 to 23) 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.

5.22.3.2.2 Connect each specimen to its supply and monitoring equipment, as specified in 5.1.3, and allow it to stabilize in its quiescent condition before the start of each test fire.

5.22.3.2.3 Detectors which dynamically modify their sensitivity in response to varying ambient conditions might 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.

5.22.3.3 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, which 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.

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

5.22.3.3.2 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 ± 5) °C;
- air movement: negligible;
- smoke density (ionization): $y \leq 0{,}05$;
- smoke density (optical): $m \leq 0{,}02$ dB/m.

5.22.3.4 Recording of the fire parameters and response values

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

Table 3 — Fire parameters

Parameter	Symbol	Units
Temperature change	ΔT	K
Smoke density (ionization)	y	(dimensionless)
Smoke density (optical)	m	dB/m

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

5.22.3.4.3 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 detector after the end-of-test condition has been reached shall be ignored.

5.22.4 Requirements

All six 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 detector tested;

b) a reference to this part of ISO 7240 (i.e. ISO 7240-15);

c) assessment of requirements specified in Clause 4;

d) results of the tests specified in Clause 5, including:

  1) the individual smoke-response values, heat-response values, and the minimum, maximum, and arithmetic mean values where appropriate,

  2) conditioning period and the conditioning atmosphere,

  3) temperature and the relative humidity in the test room throughout the test,

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

e) assessment of marking requirements specified in Clause 7;

f) assessment of data requirements specified in Clause 8;

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.

7 Marking

7.1 Each detector shall be clearly marked with the following information:

a) a reference to this part of ISO 7240 (i.e. ISO 7240-15);

b) the name or trademark of the manufacturer or supplier;

c) the model designation (type or number)

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

e) wiring terminal designations;

f) some mark or code by which the manufacturer can identify, at least, the date or batch of manufacture (e.g. a serial number or batch code).

7.2 For detachable detectors, the marking of the detector head shall include items a), b), c), d), and f) and the base shall be marked with at least items c) and e).

7.3 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.

7.4 The marking shall be visible during installation and shall be accessible during maintenance.

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

7.6 For detectors containing radioactive materials, attention is drawn to the marking provisions of the relevant national requirements and OECD recommendations.

8 Data

8.1 Detectors shall be supplied with sufficient technical, installation and maintenance documentation to enable their correct handling, 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.

8.2 To enable correct operation of the detectors, these data should describe the requirements for the correct processing of the signals from the detector. This can 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 FDCIE, etc.

8.3 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.

Annex A
(normative)

Compensation for detector drift

A.1 Principles of compensation for detector drift

A.1.1 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 smoke response 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.

A.1.2 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.

A.1.3 It could be considered beneficial, therefore, to provide compensation for such drift in order to maintain a more constant level of smoke response 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.

A.1.4 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 5.9 and this Annex is to ensure that the compensation does not reduce the sensitivity to a slowly developing fire to an unacceptable degree.

A.1.5 For the purposes of 4.10 and this annex, it is assumed that the development of any fire which presents a serious danger to life or property will be such that the sensor output will change at a rate of at least 25 % of the initial uncompensated smoke response value of the detector, $A_{\mathrm{sr,u}}$, per hour. At the minimum rate for which this specification applies, e.g. 0,25 $A_{\mathrm{sr,u}}$ per hour, the maximum time to alarm without compensation is 4 h. The response to rates of change less than 0,25 $A_{\mathrm{sr,u}}$ per hour is not specified in 4.10 and this Annex, and so there is no requirement for the detector to respond to these slower rates of change.

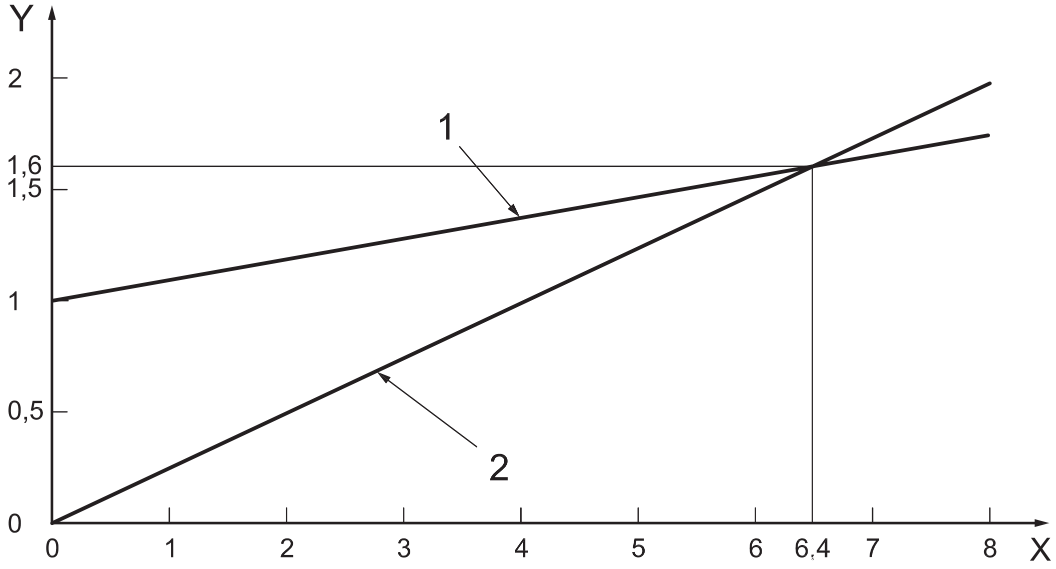
A.1.6 In order not to restrict the way in which compensation is achieved, 4.10 requires only that the time to alarm, for all rates of change greater than 0,25 $A_{\mathrm{sr,u}}$ per hour, not exceed (1,6 · the time to alarm) if the compensation were not present. Thus, at the minimum rate for which this specification applies, e.g. 0,25 $A_{\mathrm{sr,u}}$ per h, the maximum time to alarm for a compensated alarm is (1,6 · 4 h), or 6,4 h.

A.2 Linear compensation

A.2.1 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 compensation allowed, as can be seen from Figure A.1, is described by Formula (A.1)

$$0{,}6 \times A_{\mathrm{sr,u}} / 6{,}4 = 0{,}094\, A_{\mathrm{sr,u}} \qquad \text{(A.1)}$$

A.2.2 At this compensation rate the sensor output will reach the compensated threshold in exactly 6,4 h.



Key

X time, t, expressed in hours

Y alarm threshold relative to $A_{\text{sr,u}}$

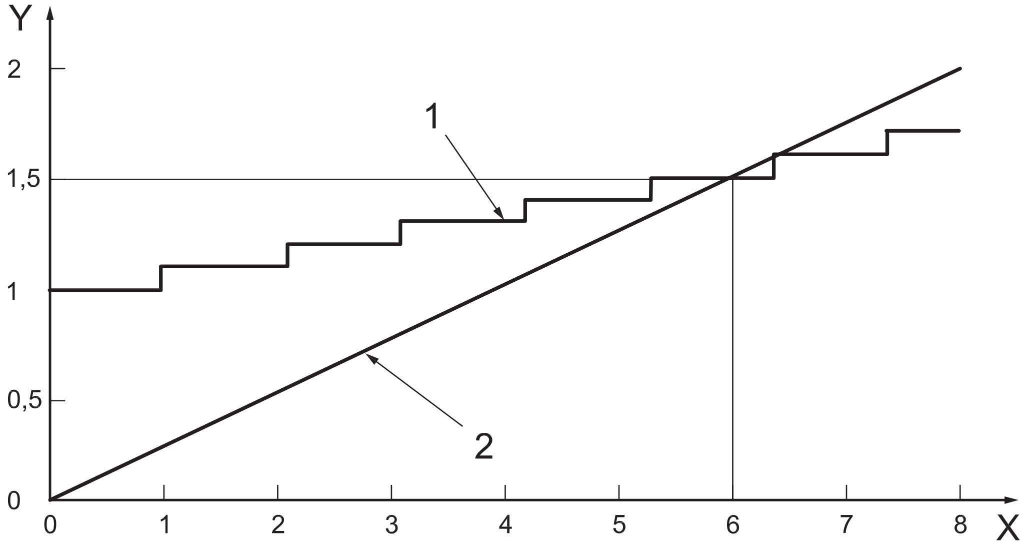
1 alarm threshold, for linear compensation at 0,094 $A_{\text{sr,u}}$ per hour

2 sensor output, 0,25 $A_{\text{sr,u}}$ per hour

Figure A.1 — Linear compensation — Limiting case

A.3 Stepwise compensation

Although it has been assumed above that the threshold is compensated linearly and continuously, the process need not be either linear or continuous. For example, the stepwise adjustment shown in Figure A.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.



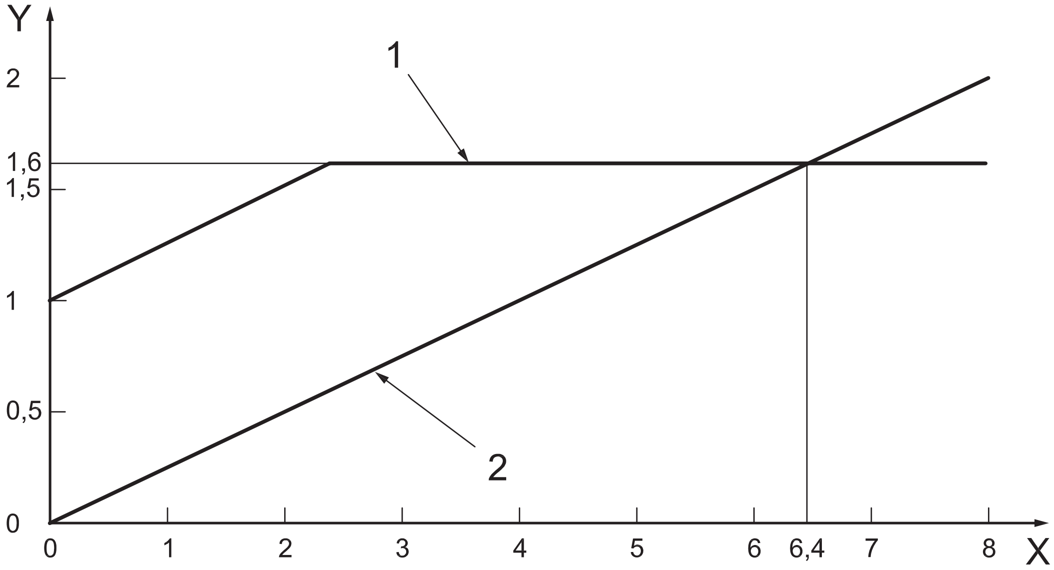
Key

X	time, *t*, expressed in hours
Y	alarm threshold relative to $A_{\mathrm{sr,u}}$
1	alarm threshold, for stepwise compensation
2	sensor output, 0,25 $A_{\mathrm{sr,u}}$ per hour

Figure A.2 — Stepwise compensation — Limiting case

A.4 High-rate compensation

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



Key

X time, *t*, expressed in hours

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

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

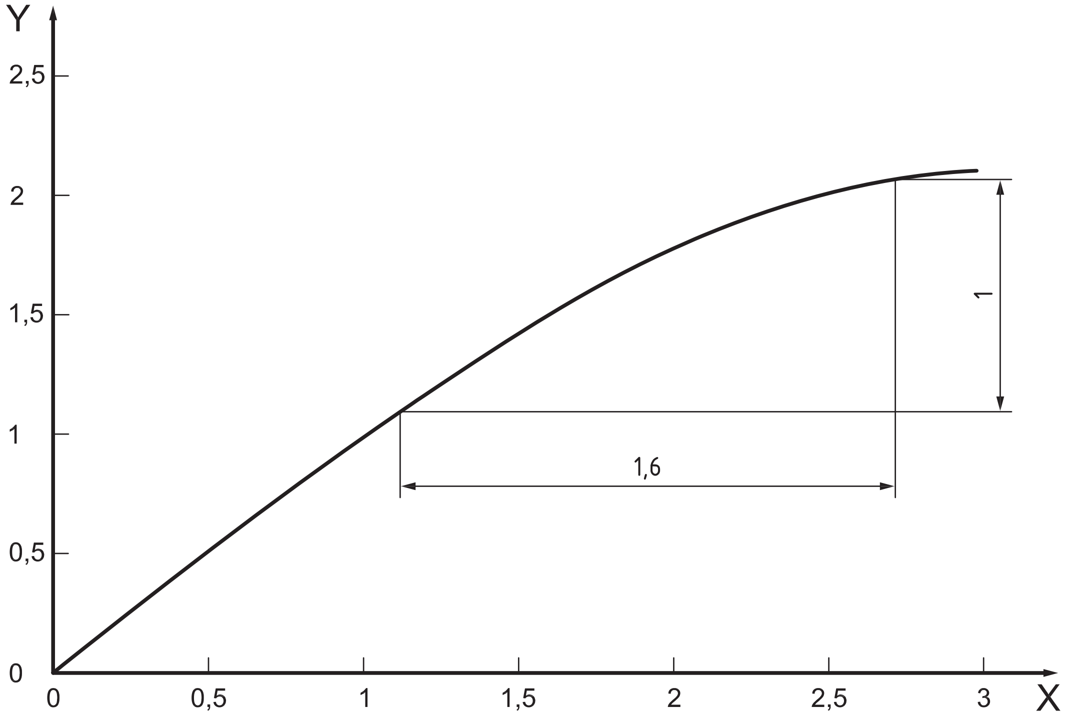
2 sensor output, 0,25 $A_{sr,u}$ per hour

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

A.5 Avoidance of the nonlinear region

A.5.1 The requirements of 4.10 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 which is equivalent to smoke) is finite. If the range of compensation takes the sensor output into this nonlinear region, then the sensitivity of the detector could become degraded to an unacceptable degree.

A.5.2 As an example, consider a detector having the transfer characteristic shown in Figure A.4, in which both axes are expressed in terms of response threshold value $A_{sr,u}$. The nonlinearity of the characteristic causes the effective sensitivity to be reduced at higher values of stimulus. In this instance, the compensation shall be limited to less than 1,1 × $A_{sr,u}$, since in order to produce a change in output of $A_{sr,u}$, the stimulus shall increase from 1,1 × $A_{sr,u}$ to 2,7 × $A_{sr,u}$. This reduction in sensitivity by a factor of 1,6 is the maximum allowed in 4.10.



Key

X stimulus

Y output

Figure A.4 — Example of nonlinear transfer characteristic

Annex B
(normative)

Smoke tunnel for smoke-response value measurements

B.1 Smoke-response value measurements

B.1.1 This annex specifies those properties of the smoke tunnel which are of primary importance for making repeatable and reproducible measurements of smoke-response values of smoke detectors. However, since it is not practical to specify and measure all parameters which can influence the measurements, the background information in B.2 should be carefully considered and taken into account when a smoke tunnel is designed and used to make measurements in accordance with this part of ISO 7240.

B.1.2 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 to be 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 the edge or edges of the board 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.

B.1.3 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.

B.1.4 Both aerosol density measurements, m in decibels per metre, for detectors using scattered or transmitted light, and y (dimensionless) for detectors using ionization, shall be made in the working volume in the proximity of the detector.

B.1.5 Means shall be provided for the introduction of the test aerosol such that a homogeneous aerosol density is obtained in the working volume.

B.1.6 Only one detector shall be mounted in the tunnel, unless it has been demonstrated that measurements made simultaneously on more than one detector are in close agreement with measurements made by testing detectors individually. In the event of a dispute, the value obtained by individual testing shall be accepted.

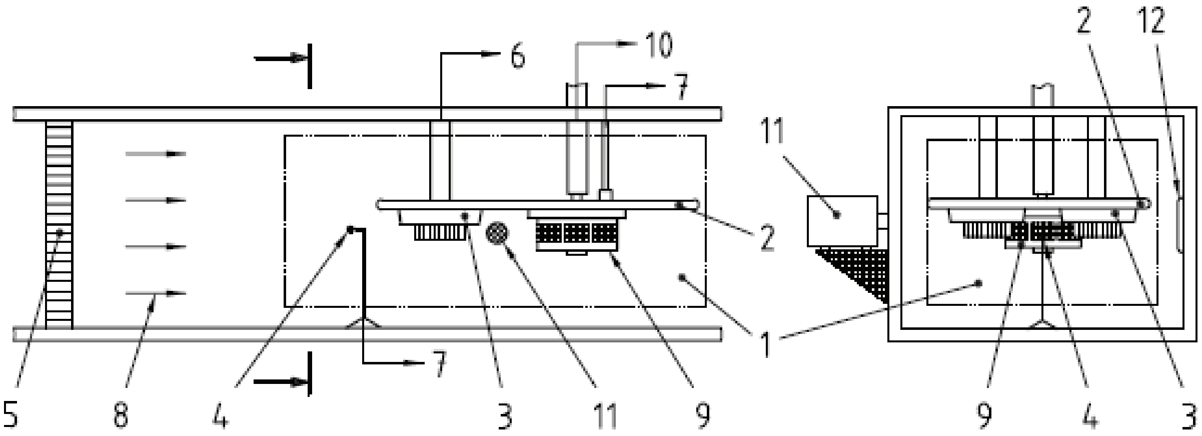
B.2 Construction of the smoke tunnel

B.2.1 Smoke detectors respond when the signal or signals from one or more smoke detectors 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 smoke-response 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.

B.2.2 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.

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

b) The air flow created by a fan in the tunnel will be turbulent, and needs to pass through an air turbulence reducer to create a nearly laminar and uniform air flow in the working volume (see Figure B.1). This can 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 can be obtained by feeding the aerosol to the tunnel upstream the fan.



Key

1	working volume
2	mounting board
3	detector(s) under test
4	temperature sensor
5	flow turbulence reducer
6	supply and monitoring equipment
7	control and measuring equipment
8	air flow
9	measuring ionization chamber (MIC)
10	MIC suction
11	obscuration meter
12	reflector for obscuration meter

Figure B.1 — Smoke tunnel — Working section side view and cross-section

c) 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.

d) 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 measuring ionization chamber (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 will be negligible if the MIC is placed 10 cm to 15 cm downstream of the detector position.

e) The smoke tunnel can 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 smoke-response value measurements.

B.3 Test aerosol for smoke-response measurements

B.3.1 A polydispersive aerosol shall be used as the test aerosol to measure the smoke-response 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.

B.3.2 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.

B.3.3 The stability of the aerosol should be ensured. One possible method to do this is to measure and monitor the stability of the ratio $m : y$.

B.3.4 It is recommended that an aerosol generator using pharmaceutical-grade paraffin oil be used to generate the test aerosol.

B.4 Aerosol-measuring instruments

B.4.1 Obscuration method

B.4.1.1 Obscuration meter

B.4.1.1.1 The smoke-response value of detectors using scattered light or transmitted light is characterized by the absorbance index (extinction module) of the test aerosol, measured in the proximity of the detector, at the moment that it generates an alarm signal.

B.4.1.1.2 The absorbance index is designated m and expressed in decibels per metre (dB/m). The absorbance index m is given by the Formula B.1.

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

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.

B.4.1.1.3 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.

B.4.1.1.4 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.

B.4.1.1.5 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.

B.4.2 Measuring ionization chamber (MIC)

B.4.2.1 General

The smoke-response value of detectors 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.

B.4.2.2 Operating method and basic construction

B.4.2.2.1 The mechanical construction of the measuring ionization chamber is given in Annex M.

B.4.2.2.2 The measuring device consists of a measuring chamber, an electronic amplifier and a method of continuously sucking in a sample of the aerosol or smoke to be measured.

B.4.2.2.3 The principle of operation of the measuring ionization chamber is shown in Figure B.2. 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.

B.4.2.2.4 The air within the measuring volume is ionized by alpha radiation from an americium radioactive source, such that there is a bipolar flow of ions when an electrical voltage is applied between the electrodes. This flow of ions is affected in a known manner by the aerosol or smoke particles. The ratio of the current in the aerosol-free chamber to that in the presence of an aerosol is a known function of the aerosol or smoke concentration. Thus, the non-dimensional quantity *y*, which is approximately proportional to the particle concentration for a particular type of aerosol or smoke, is used as a measure of the smoke-response value for smoke detectors using ionization.

B.4.2.2.5 The measuring chamber is so dimensioned and operated that the following relationships apply:

$$Z \times \bar{d} = \eta \times y \text{ and } y = \left(\frac{I_0}{I}\right) - \left(\frac{I}{I_0}\right) \tag{B.2}$$

where

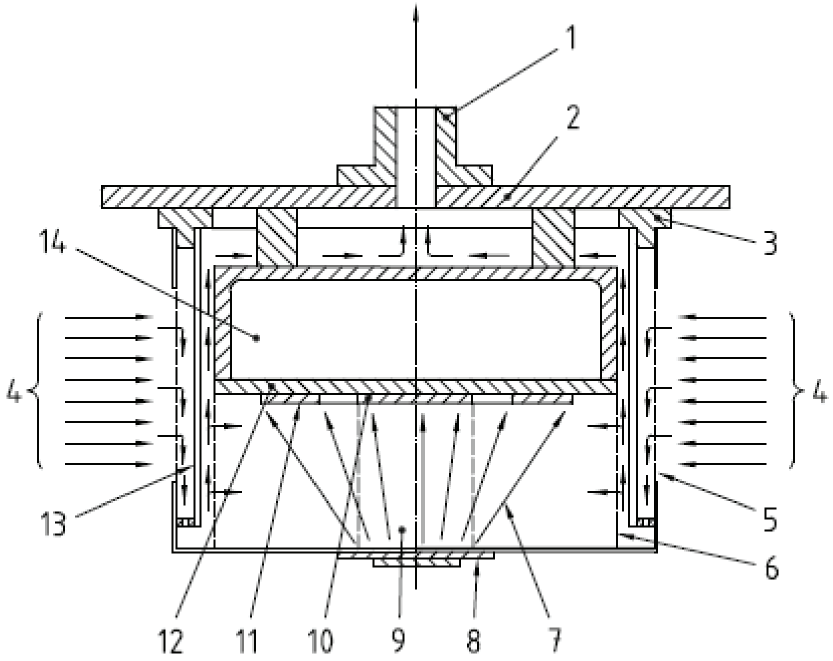
I_0 is the chamber current in air without test aerosol or smoke;

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

η is the chamber constant;

Z is the particle concentration, in particles per cubic metre;

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



Key

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

Figure B.2 — Measuring ionization chamber — Method of operation

Annex C
(normative)

Heat tunnel for heat-response value measurements

C.1 This annex specifies those properties of the heat tunnel which are of primary importance for making repeatable and reproducible measurements of response time and static response temperature of heat detectors. However, since it is not practical to specify and measure all parameters, which can influence the measurements, the background information in Annex N should be carefully considered and taken into account when a heat tunnel is designed and used to make measurements in accordance with this part of ISO 7240.

C.2 The heat tunnel shall meet the following requirements for each class of heat detector it is used to test.

a) The heat 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 conditions are within ±2 K and ±0,1 m/s, respectively, of the nominal test conditions. Conformance with this requirement shall be regularly verified under both static and rate-of-rise 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(s) to be tested, the required amount of mounting board and the temperature measuring sensor.

b) Mount the detector to be tested 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 (5 ± 1) mm thick and of such dimensions that the edge(s) of the board are at least 20 mm from any part of the detector. The edge(s) of the board shall have a semi-circular form and the air flow between the board and the tunnel ceiling shall not be unduly obstructed. The material from which the board is made shall have a thermal conductivity not greater than 0,52 W/(m·K).

c) If two or more detectors are to be mounted in the working volume and tested simultaneously, then previous tests shall have been conducted which confirm that response time measurements made simultaneously on more than one detector are in close agreement with measurements made by testing detectors individually. In the event of a dispute, the value obtained by individual testing shall be accepted.

d) Means shall be provided for creating a stream of air through the working volume at the constant temperature and rate of rise of air temperature specified for each class of detector to be tested. This air stream shall be essentially laminar and maintained at a constant mass flow equivalent to (0,8 ± 0,1) m/s at 25 °C.

e) The temperature sensor shall be positioned at least 50 mm upstream of the detector and at least 25 mm below the lower surface of the mounting board. The air temperature shall be controlled to within ±2 K of the nominal temperature required at any time during the test.

f) The air-temperature measuring system shall have an overall time constant of not greater than 2 s, when measured in air with a mass flow equivalent to (0,8 ± 0,1) m/s at 25 °C.

g) Means shall be provided for measuring the response time of the detector under test to an accuracy of ±1 s.

Annex D
(normative)

Apparatus for the dazzling test

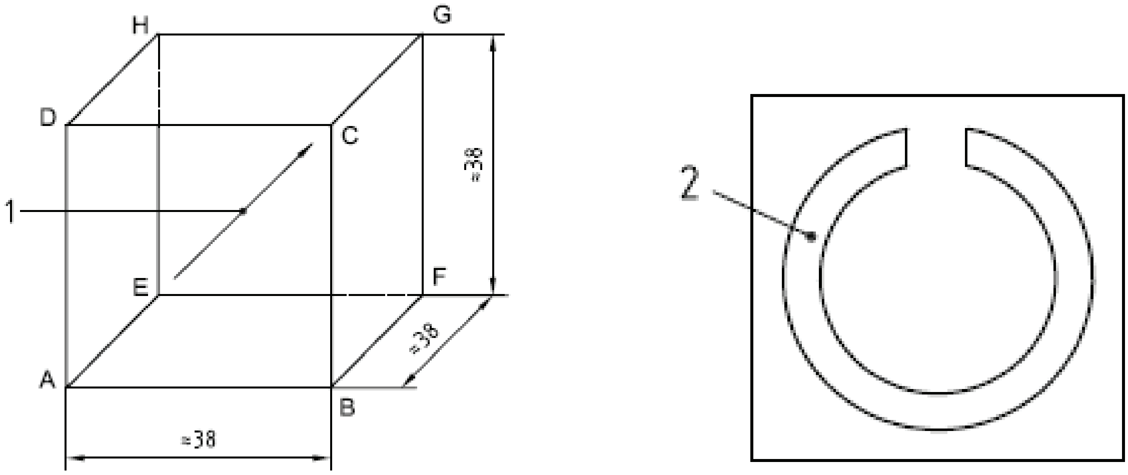
D.1 The dazzling apparatus [see Figure D.1 a)] shall be constructed so that it can be inserted in the working section of the smoke tunnel. The apparatus is cube-shaped, with four of the cube faces (ABFE, AEHD, BFGH and EFGH) closed and lined on the inside with high-gloss aluminium foil. The other two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

D.2 A circular fluorescent lamp [32 W, “warm white”, approximate colour temperature: 2 800 K; 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.

D.3 The detector to be 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.

D.4 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) Dazzling apparatus

b) Lamp

Key

1 stream of aerosol

2 fluorescent lamp

Figure D.1 — Dazzling apparatus and lamp

Annex E
(normative)

Apparatus for the impact test

E.1 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.

E.2 The striker with 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.

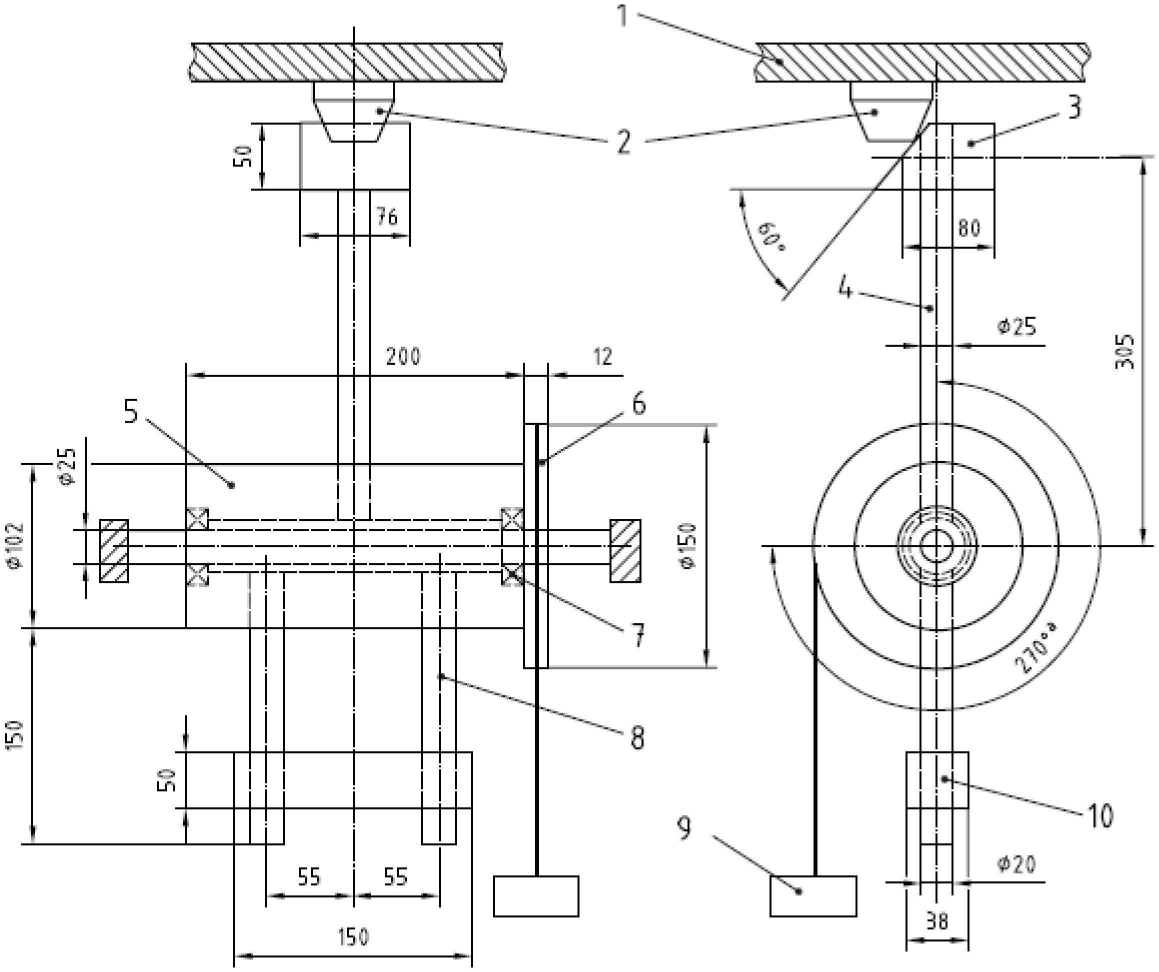
E.3 The striker is mounted on the shaft so that its long axis is at a radial distance of 305 mm from the axis of rotation of the assembly, the two axes being mutually perpendicular. The central boss is 102 mm in outside diameter and 200 mm long, and is mounted coaxially on the fixed steel pivot shaft, which is approximately 25 mm in diameter; however the precise diameter of the shaft will depend on the bearings used.

E.4 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 the 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 mass 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.

E.5 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 will strike the specimen when the hammer is moving horizontally, as shown in Figure E.1.

E.6 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 will spin 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.

E.7 As this part of ISO 7240 requires a hammer velocity at impact of (1,5 ± 0,13) m/s, the mass of the hammer head will need to be reduced by drilling the back face sufficiently to obtain this velocity. It is estimated that a head of mass of about 0,79 kg will be required to obtain the specified velocity, but this will have to be determined by trial and error.



Key

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

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

Figure E.1 — Impact apparatus

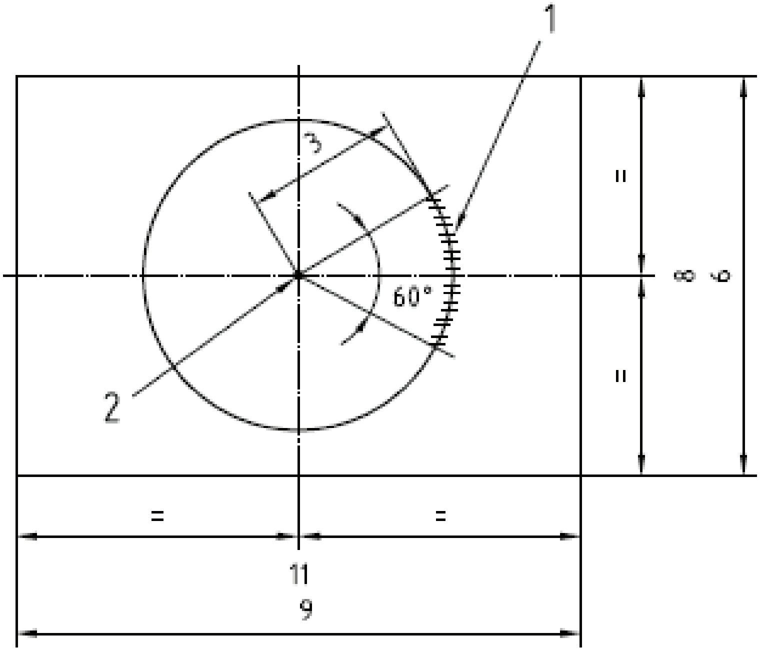
Annex F
(normative)

Fire test room

F.1 The specimens to be tested, the measuring ionization chamber (MIC), the temperature probe and the measuring part of the obscuration meter shall all be located within the volume shown in Figures F.1 and F.2.

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 centreline of the beam of the obscuration meter shall be at least 35 mm below the ceiling.

Dimensions in metres

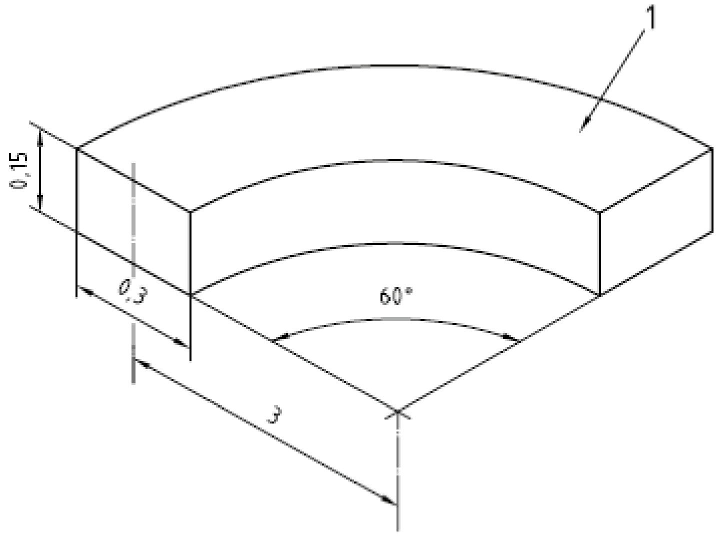


Key

1	specimens and measuring instruments (see Figure 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



Key

1 ceiling

Figure F.2 — Mounting positions for instruments and specimens

Annex G
(normative)

Open cellulosic (wood) fire (TF1)

G.1 Fuel

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

G.2 Conditioning

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

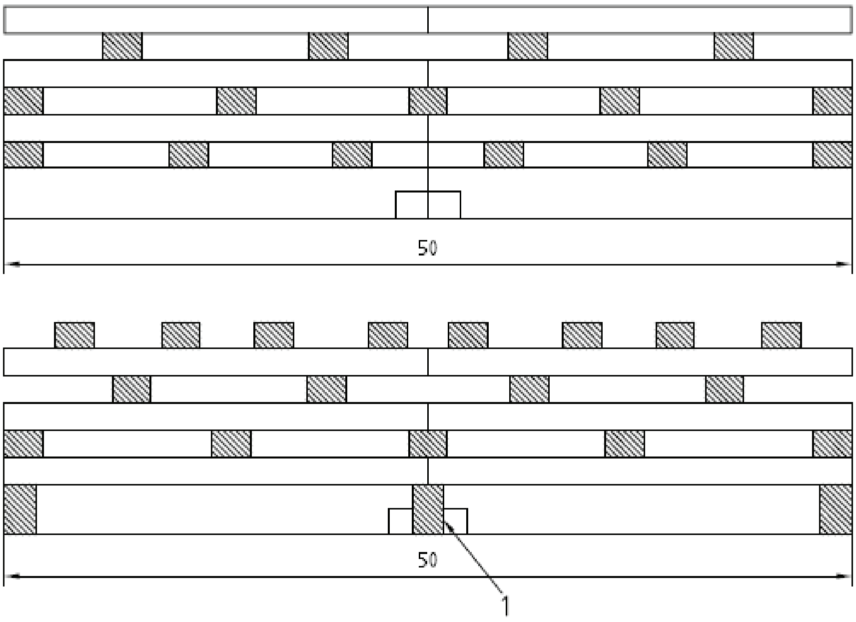
G.3 Preparation

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

G.4 Arrangement

Superimpose seven layers on a base surface measuring approximately 50 cm wide × 50 cm long by 8 cm high (see Figure G.1).

Dimensions in centimetres



Key

1 container for methylated spirits

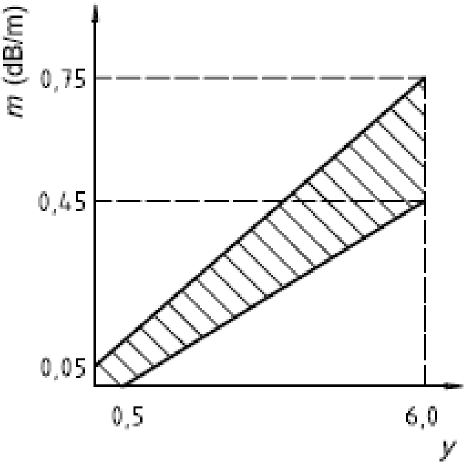
Figure G.1 — Wood arrangement for test fire TF1

G.5 Ignition starter

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

G.6 Test validity criteria

The development of the fire shall be such that the curves of *m* against *y*, and *m* against time, *t*, fall within the hatched areas shown in Figures G.2 and G.3. That is, 0,45 dB/m ≤ m ≤ 0,75 dB/m and 270 s ≤ t ≤ 370 s at the end-of-test condition $y_E = 6$.



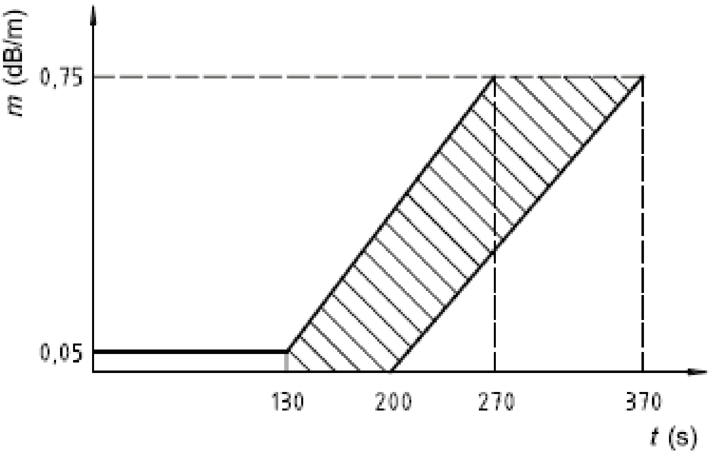


Figure G.2 — Limits for *m* against *y*, Fire TF1

Figure G.3 — Limits for *m* against time, *t*, Fire TF1

G.7 End-of-test conditions

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

Annex H

(normative)

Smouldering (pyrolysis) wood fire (TF2)

H.1 Fuel

Approximately 10 dried beechwood sticks, each stick having dimensions of 75 mm × 25 mm × 20 mm.

H.2 Conditioning

Dry the sticks in a heating oven so the moisture content is approximately 5 %.

H.3 Preparation

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

H.4 Hotplate

H.4.1 The hotplate shall have a 220 mm diameter grooved surface with eight concentric grooves with a distance of 3 mm between grooves. Each groove shall be 2 mm deep and 5 mm wide, with the outer groove 4 mm from the edge. The hotplate shall have a rating of approximately 2 kW.

H.4.2 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.

H.5 Arrangement

The sticks shall be arranged radially on the grooved hotplate surface, with the 20-mm side of the stick in contact with the surface such that the temperature probe lies between the sticks and is not covered, as shown in Figure H.1.

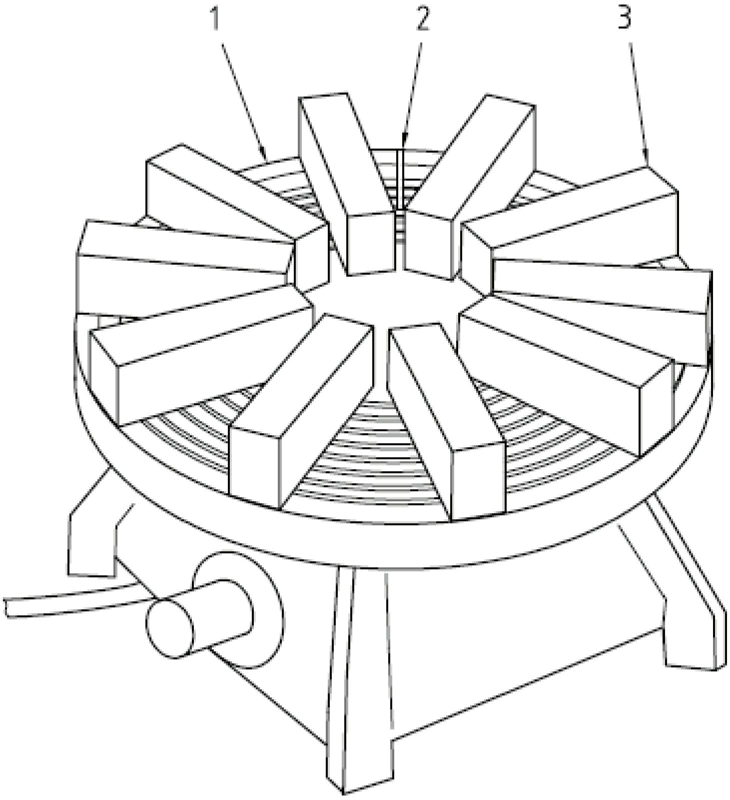
H.6 Heating rate

Power the hotplate such that its temperature rises from ambient to 600 °C in approximately 11 min, and is maintained for the duration of the test.

H.7 Test validity criteria

H.7.1 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 Figure H.2 and Figure H.3, respectively.

H.7.2 For detectors using ionization, if the end of test condition, $m_E = 2$ dB/m, is reached before all the specimens have responded, then the test is only considered valid if $y \geq 1{,}6$.



Key

1 grooved hotplate

2 temperature sensor

3 wooden sticks

Figure H.1 — Arrangement of sticks on the hotplate

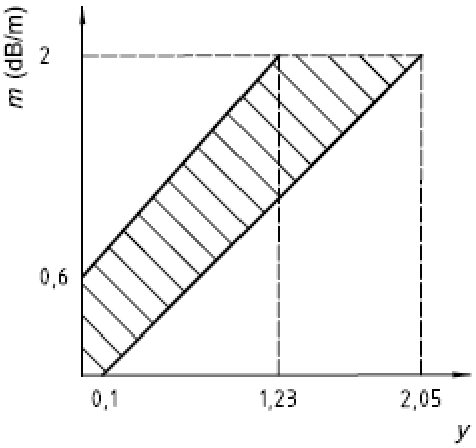


Figure H.2 — Limits for *m* against *y*, Fire TF2

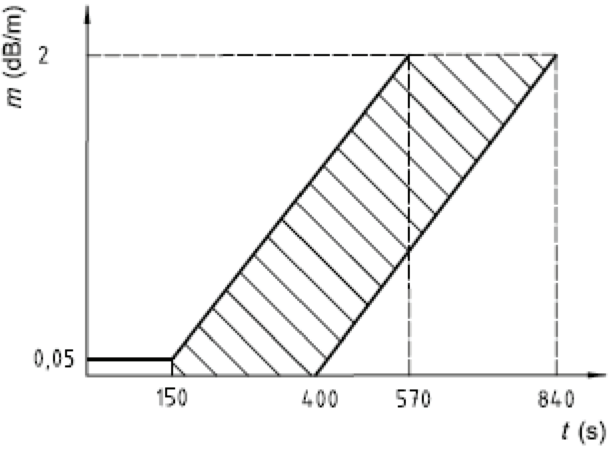


Figure H.3 — Limits for *m* against time, *t*, Fire TF2

H.8 Variables

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

H.9 End-of-test conditions

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

Annex I
(normative)

Glowing smouldering cotton fire (TF3)

I.1 Fuel

Approximately 90 pieces of braided cotton wick, each of length approximately 80 cm and weighing approximately 3 g.

I.2 Conditioning

Wash and dry the wicks if they have a protective coating. Store the wicks in an environment of no more than 50 % humidity prior to being ignited.

I.3 Arrangement

Fasten the wicks to a ring approximately 10 cm in diameter and suspended approximately 1 m above a non-combustible plate as shown in Figure I.1.

Dimensions in metres

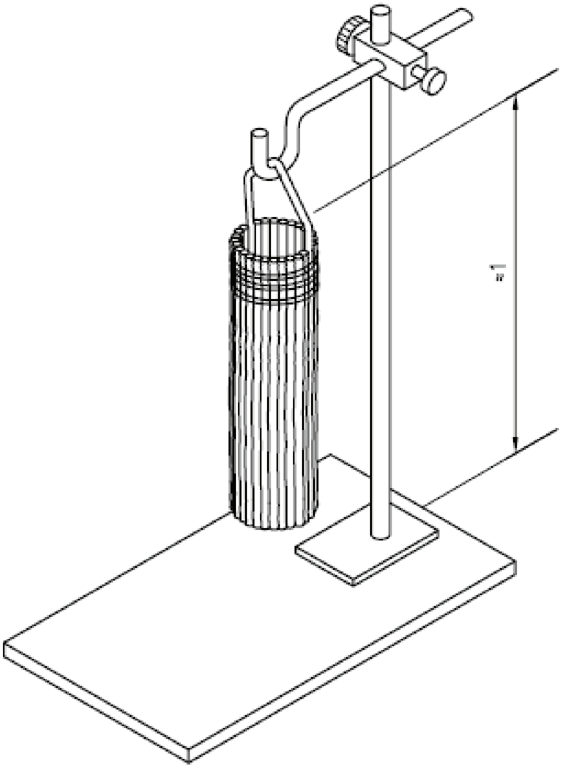


Figure I.1 — Arrangement of the cotton wicks

I.4 Ignition

Ignite by match or torch. Ignite the lower end of each wick so that the wicks continue to glow. Immediately blow out any flaming. Start the test time when all wicks are glowing.

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

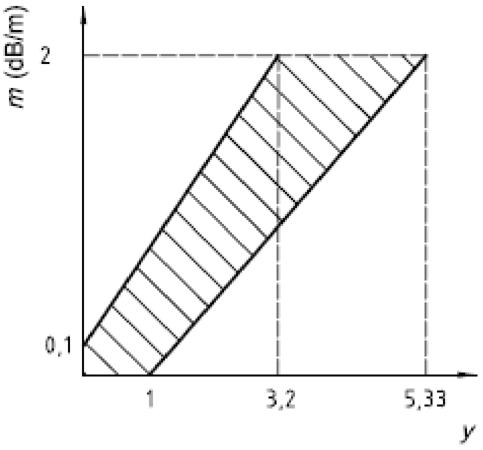


Figure I.2 — Limits for *m* against *y*, Fire TF3

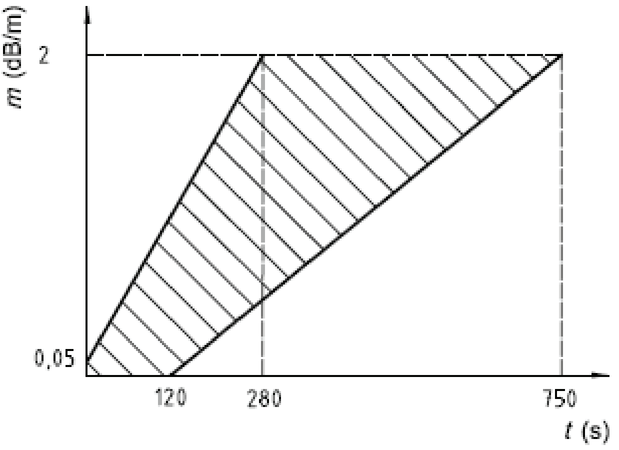


Figure I.3 — Limits for *m* against time, *t*, Fire TF3

I.6 End-of-test conditions

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

Annex J
(normative)

Flaming plastics (polyurethane) fire (TF4)

J.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 can be adjusted to obtain valid tests.

J.2 Conditioning

Maintain the mats in a humidity not exceeding 50 % at least 48 h prior to test.

J.3 Arrangement

Place the mats one on top of another, on a base formed from aluminium foil with the edges folded up to provide a tray.

J.4 Ignition

Ignite by match or spark. Ignite the mats at a corner of the lower mat. Adjust the exact position of ignition to obtain a valid test. A small quantity of a clean-burning material (e.g. 5 cm^3 of methylated spirit) can be used to assist the ignition.

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 $1{,}27 \text{ dB/m} \leq m \leq 1{,}73 \text{ dB/m}$ for ionization detectors and detectors using scattered or transmitted light with a declared smoke-response value band of $0{,}05 \text{ dB/m} < m < 0{,}3 \text{ dB/m}$, and $140 \text{ s} \leq t \leq 180 \text{ s}$; or

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

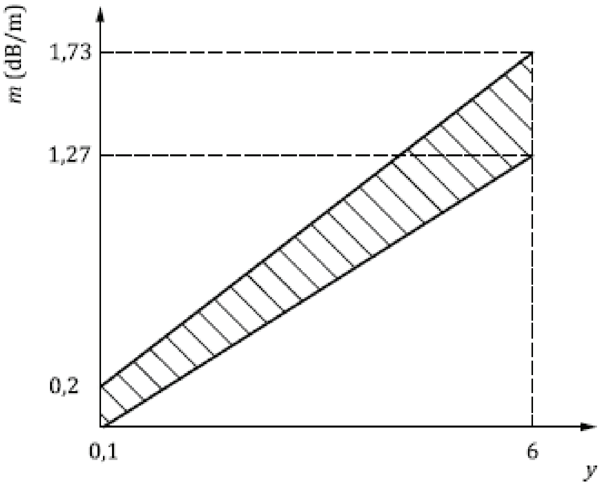


Figure J.1 — Limits for *m* against *y*, Fire TF4 — Ionization detectors and detectors using scattered or transmitted light with 0,05 dB/m < *m* < 0,3 dB/m declared smoke-response value band

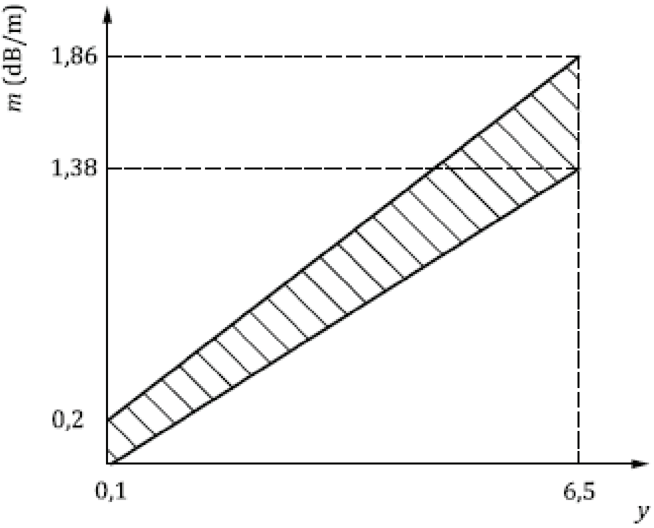


Figure J.2 — Limits for *m* against *y*, Fire TF4 — Detectors using scattered or transmitted light with 0,2 dB/m < *m* < 0,6 dB/m declared smoke-response value band

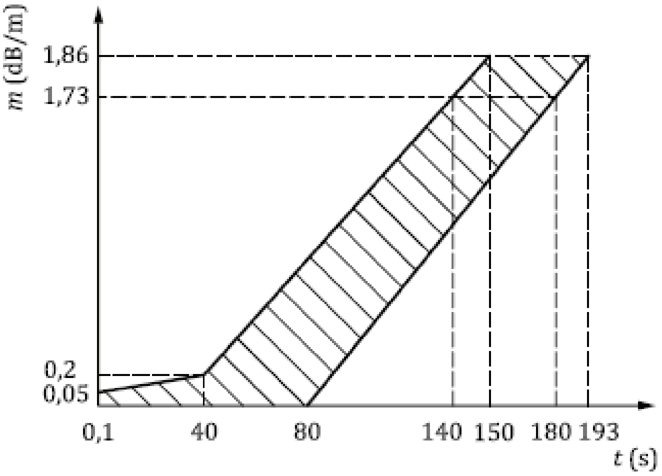


Figure J.3 — Limits for *m* against time, *t*, Fire TF4

J.6 End-of-test conditions

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 smoke-response value band of 0,05 dB/m < m < 0,3 dB/m;
- — $y_E = 6{,}5$ for detectors using scattered or transmitted light, with a declared smoke-response value band of 0,2 dB/m < m < 0,6 dB/m;
- — all of the specimens have generated an alarm signal, if the alarm signal is generated before y_E is reached.

Annex K
(normative)

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

K.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 can be varied to obtain valid tests.

K.2 Arrangement

Burn the heptane/toluene mixture in a square 2 mm thick steel tray with dimensions of approximately 330 mm × 330 mm × 50 mm.

K.3 Ignition

Ignite by flame or spark.

K.4 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 K.1 or K.2, as appropriate for the type of detector tested, and K.3, respectively. That is, at the end-of-test condition:

— $y_E = 6{,}0$ and $0{,}92 \text{ dB/m} \le m \le 1{,}24 \text{ dB/m}$ for ionization detectors and detectors using scattered or transmitted light with a declared smoke-response value band of $0{,}05 \text{ dB/m} < m < 0{,}3 \text{ dB/m}$, except for the special case above for which $m \le 1{,}1 \text{ dB/m}$, and $120 \text{ s} \le t \le 240 \text{ s}$, or

— $y_E = 7{,}5$ and $1{,}15 \text{ dB/m} \le m \le 1{,}55 \text{ dB/m}$ for detectors using scattered or transmitted light, with a declared smoke-response value band of $0{,}2 \text{ dB/m} < m < 0{,}6 \text{ dB/m}$, except for the special case above for which $m \le 1{,}1 \text{ dB/m}$ and $150 \text{ s} \le t \le 300 \text{ s}$.

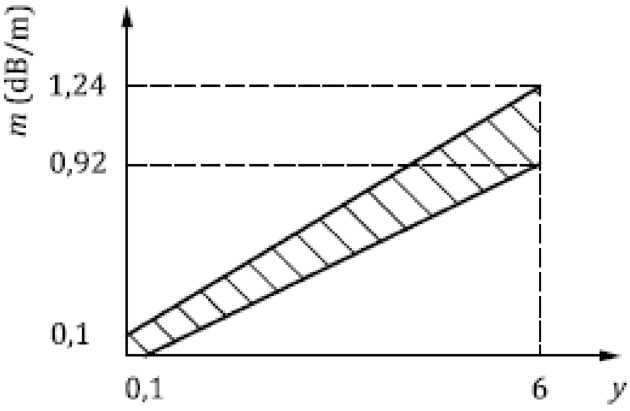


Figure K.1 — Limits for *m* against *y*, Fire TF5 — Detectors using scattered or transmitted light with 0,05 dB/m < *m* < 0,3 dB/m declared smoke-response value band

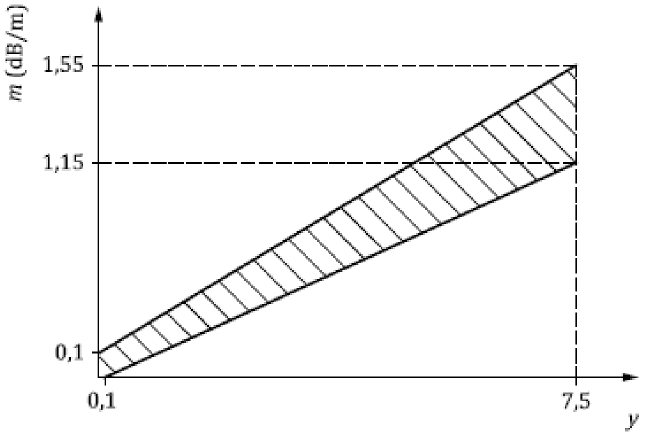


Figure K.2 — Limits for *m* against *y*, Fire TF5 — Detectors using scattered or transmitted light with 0,2 dB/m < *m* < 0,6 dB/m declared smoke-response value band

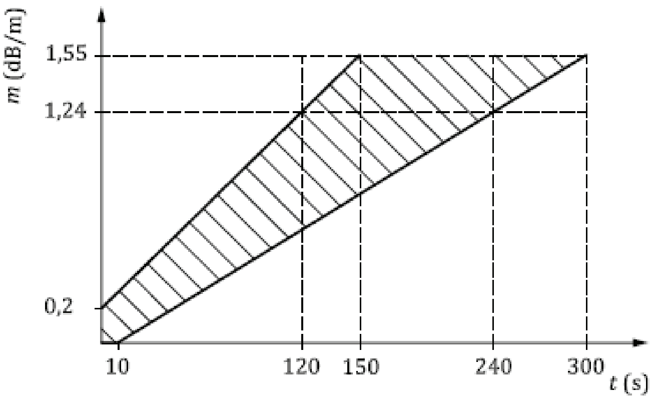


Figure K.3 — Limits for *m* against time, *t*, Fire TF5

K.5 End-of-test conditions

K.5.1 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 smoke-response value band of 0,05 dB/m < *m* < 0,3 dB/m;
- y_E = 7,5 for detectors using scattered or transmitted light, with a declared smoke-response value band of 0,2 dB/m < *m* < 0,6 dB/m; or all of the specimens have generated an alarm signal, if the alarm signal is generated before y_E is reached.

K.5.2 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* ≤ 1,1 dB/m has been reached.

Annex L
(normative)

Low-temperature black-smoke liquid (decalin) fire (TF8)

L.1 Fuel

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

L.2 Arrangement

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

L.3 Volume

Use approximately 170 ml of decalin.

L.4 Ignition

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

L.5 Test validity criteria

L.5.1 The development of the fire shall be such that the curves of m against y, and m against time, t, fall within the limits shown in Figures L.1 and K.2 respectively. That is, $4,5 \leq y \leq 9$, and $550 \text{ s} \leq t \leq 1\,000 \text{ s}$, at the end-of-test condition $m_E = 1,7$ dB/m.

L.5.2 The temperature rise ΔT during the test shall be less than 10 K.

L.5.3 If the end-of-test condition $m_E = 1,7$ dB/m is reached before all the specimens using ionization have responded, then the test is only considered valid if a y-value of 6 has been reached.

L.5.4 The test condition can be changed to get the specified profile of test fire if it was not produced. For example, the height of room or the position of fire can be altered to ensure the smoke reaches the ceiling and the tray can be kept cool (e.g. by using heavier grade steel or by placing the tray in an outer bath of cooling water) to ensure ΔT does not rise more than 10 K.

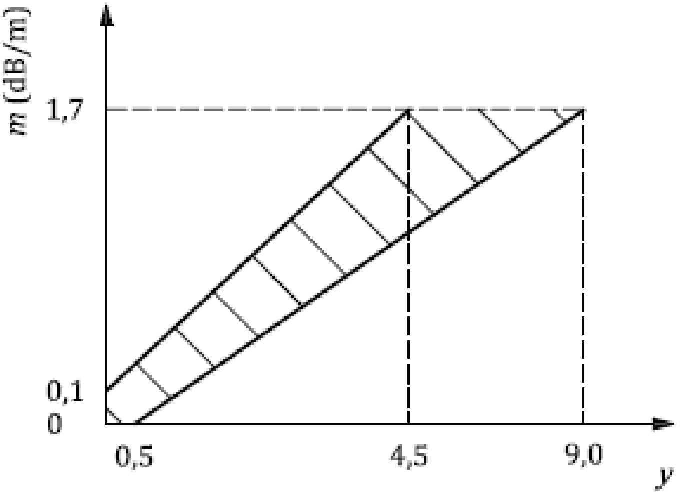


Figure L.1 — Limits for *m* against *y*, Fire TF8

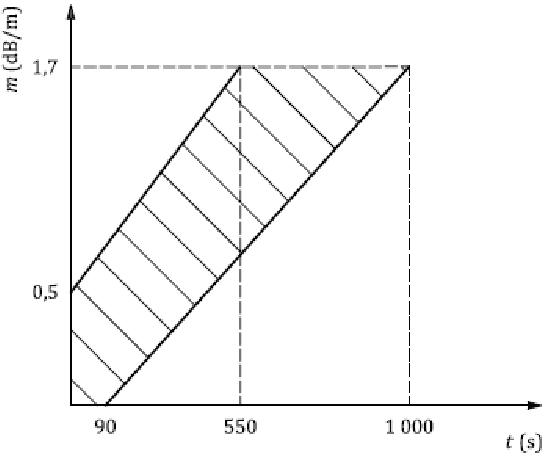


Figure L.2 — Limits for *m* against time, *t*, Fire TF8

L.6 End-of-test conditions

The end-of-test condition m_E shall be when m = 1,7 dB/m, or when all of the specimens have generated an alarm signal, whichever is the earlier.

Annex M
(informative)

Construction of the measuring ionization chamber

M.1 General

The mechanical construction of the measuring ionization chamber 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 measuring ionization chamber is fully described in *Investigation of ionization chamber for reference measurements of smoke density*, by M. Avlund, published by DELTA Electronics, Venlighedsvej 4 DK-2970 Hørsholm, Denmark.

M.2 Technical data

The measuring ionization chamber contains the following components.

a) **Radiation source**

— Isotope: americium^{241}Am

— Activity: (130 ± 6,5) kBq

— Average energy: (4,5 ± 0,225) MeV

— Mechanical construction: Americium oxide embedded in gold between two layers of gold, covered with a hard gold alloy. The source is in the form of a circular disc with a diameter of 27 mm, which is mounted in a holder such that no cut edges are accessible.

b) **Ionization chamber**

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

— pressure: (101,3 ± 1) kPa;

— temperature: (25 ± 2) °C;

— relative humidity: (55 ± 20) %;

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

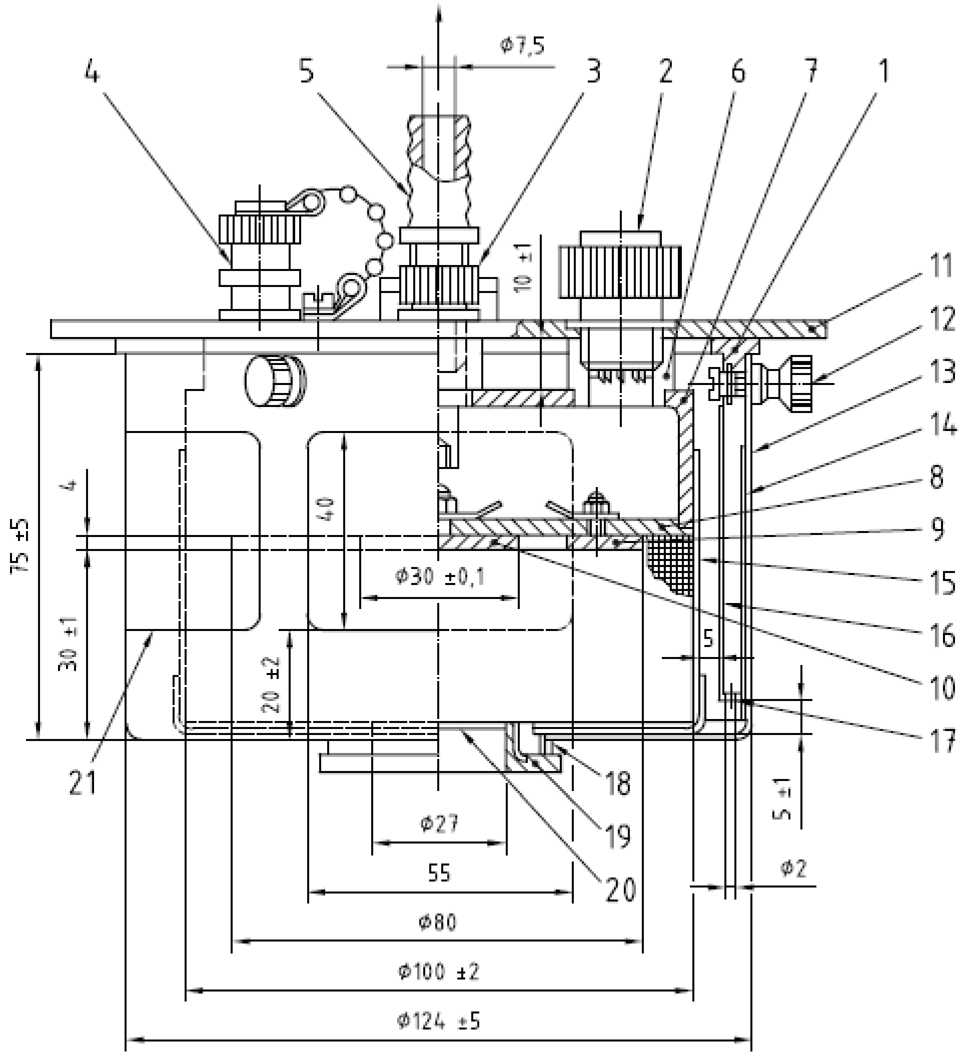
c) **Current-measuring amplifier**

The chamber is operated in the circuit shown in Figure M.2, with a 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 Ω.

d) **Suction system**

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

Dimensions in millimetres



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

NOTE 2 Dimensions without a tolerance marked are recommended dimensions.

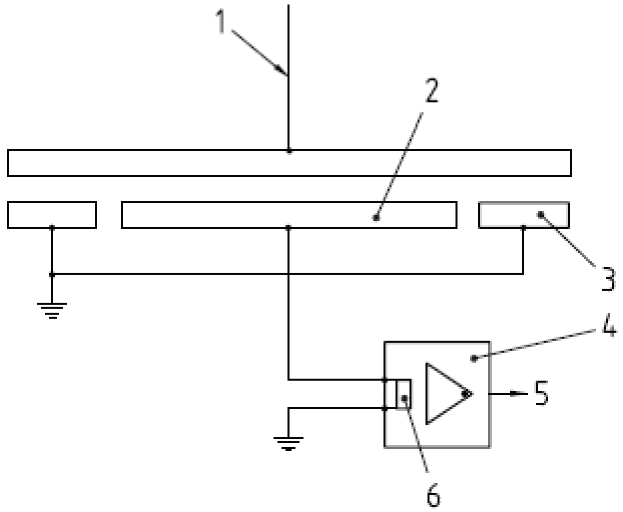
Figure M.1 — Mechanical construction of the measuring ionization chamber

Table M.1 — List of parts of the measuring ionization chamber

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

Table M.1 *(continued)*

Reference No.	Item	Number provided	Dimensions, special features	Material
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 M.2
21	Openings on the periphery	6	—	—



Key

1 supply voltage

2 measuring electrode

3 guard ring

4 current measuring amplifier

5 output voltage proportional to chamber current

6 input impedance, $Z_{in} < 10^9$ Ω

Figure M.2 — Measuring ionization chamber — Operating circuit

Annex N
(informative)

Construction of the heat tunnel

N.1 Heat detectors respond when the signal(s) from one or more sensors fulfil certain criteria. The temperature of the sensor(s) is related to the air temperature surrounding the detector but the relation is usually complex and dependent on several factors, such as orientation, mounting, air velocity, turbulence, rate of rise of air temperature. Response times and response temperature and their stability are the main parameters considered when the fire detection performance of heat detectors is evaluated by testing in accordance with this part of ISO 7240.

N.2 Many different heat tunnel designs are suitable for the tests specified in this standard but the following points should be considered when designing and characterizing a heat tunnel (see Figure N.1).

a) There are two basic types of heat tunnel: recirculating and non-recirculating. All else being equal, a non-recirculating tunnel requires a higher-powered heater than a recirculating tunnel, particularly for the higher rates of rise of air temperature. More care is generally needed to ensure that the high-power heater and control system of a non-recirculating tunnel are sufficiently responsive to the changes in heat demand necessary to attain the required temperature-versus-time conditions in the working section. On the other hand, maintaining a constant mass flow with increasing temperature is generally more difficult in a recirculating tunnel.

b) The temperature control system shall be able to maintain the temperature within ± 2 K of the “ideal ramp” for all of the specified rates of rise of air temperature. Such performance can be achieved in different ways such as the following:

   1) by proportional heating control, where more heating elements are used when generating higher rates of rise. Improved temperature control can be achieved by powering some of the heating elements continuously, while controlling others. With this control system, the distance between the tunnel heater and the detector under test should not be so large that the intrinsic delay in the temperature control feedback loop becomes excessive at an air flow of (0,8 ± 0,1) m/s.

   2) by rate-controlled feed-forward heating control, assisted by proportional/integral (PI) feedback. This control system will permit greater distance between the tunnel heater and the detector under test.

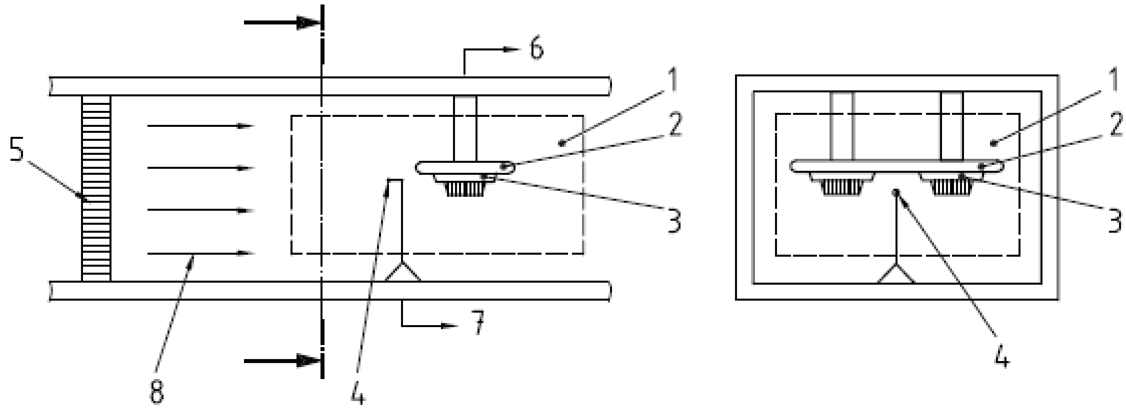
c) The important point is that the specified temperature profiles are obtained with the required accuracy within the working section.

d) For a non-recirculating tunnel, the anemometer used for air flow control and monitoring can be placed in a section of the tunnel upstream of the heater, where it will be subject to a substantially constant temperature, thereby eliminating any need to temperature compensate its output. A constant velocity, indicated by an anemometer so positioned, should correlate with a constant mass flow through the working volume. However, to maintain a constant mass flow at normal atmospheric pressure in a recirculating tunnel, it is necessary to increase the air velocity as the air temperature is increased. Careful consideration should therefore be given to ensuring that an appropriate correction is applied to the temperature coefficient of the anemometer monitoring the air flow. It should not be assumed that an automatically temperature-compensated anemometer will compensate sufficiently quickly at high rates of rise of air temperature.

e) The air flow created by a fan in the tunnel will be turbulent, and needs to pass through a turbulence-reducer to create a nearly laminar and uniform air flow in the working volume (see Figure N.1). This can be facilitated by using a filter, honeycomb or both, in line with, and upstream of the working section of the tunnel. Care should be taken to ensure that the air flow from the heater is mixed to a uniform temperature, before entering the turbulence-reducer.

f) It is not possible to design a tunnel where uniform temperature and flow conditions prevail in all parts of the working section. Deviations will exist, especially close to the walls of the tunnel, where a boundary layer of slower and cooler air will normally be observed. The thickness of this boundary layer and the temperature gradient across it can be reduced by constructing or lining the walls of the tunnel with a low-thermal-conductivity material.

g) Special attention should be given to the temperature-measuring system in the tunnel. The required overall time constant of not greater than 2 s in air means that the temperature sensor should have a very small thermal mass. In practice, only the fastest thermocouples and similar small sensors will be adequate for the measuring system. The effect of heat loss from the sensor via its leads can normally be minimized by exposing several centimetres of the lead to the air flow.



Key

1 working volume
2 mounting board
3 detector(s) under test
4 temperature sensor
5 turbulence reducer
6 to supply and monitoring equipment
7 to control and measuring equipment
8 air flow

Figure N.1 — Working section and cross-section of mounting arrangement for simultaneously testing two detectors

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