INTERNATIONAL STANDARD

ISO 12239

Second edition
2010-12-15

Smoke alarms using scattered light, transmitted light or ionization

Détecteurs de fumée à lumière dispersée, lumière transmise ou ionisation

Reference number
ISO 12239:2010(E)

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Foreword

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

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

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

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

ISO 12239 was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 3, *Fire detection and alarm systems*.

This second edition cancels and replaces the first edition (ISO 12239:2003), which has been technically revised.

Introduction

This International Standard for smoke alarms is drafted on the basis of functions that are to be provided on all smoke alarms covered by this standard, and optional functions with requirements which may be provided. It is intended that the options shall be used for specific applications, as recommended in application guidelines.

Each optional function is included as a separate entity, with its own set of associated requirements, in order to permit smoke alarms covered by this standard with different combinations of functions to conform to this International Standard.

Two optional sound output levels are specified in this International Standard. The options allow national regulators to specify minimum sound output levels (70 dBA or 85 dBA) as required under national regulations.

Two optional sound output patterns are specified in this International Standard. The options allow national regulators to choose a sound pattern complying with ISO 8201 or ISO 7731 depending on the desired response by building occupants to an alarm condition.

An optional extended temperature-range test is included for smoke alarms installed in areas subject to a greater temperature range, such as leisure accommodation vehicles.

Other functions may also be provided, even if not specified in this International Standard, if they do not jeopardize any function required by this document.

Smoke alarms using scattered light, transmitted light or ionization

IMPORTANT — Certain types of smoke alarms contain radioactive materials. The national requirements for radiation protection differ from country to country and they are not specified in this International Standard. Such smoke alarms should, however, comply with the applicable national standards, which should be consistent with the recommendations of the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD).

1 Scope

This International Standard specifies requirements, test methods, performance criteria, and manufacturer's instructions for smoke alarms that operate using scattered light, transmitted light, or ionization, and are intended for household or similar residential applications.

For the testing of other types of smoke alarms, or smoke alarms working on different principles, this International Standard should be used only for guidance. Smoke alarms with special characteristics and developed for specific risks are not covered by this International Standard.

This International Standard allows, although it does not require, the inclusion within the smoke alarm of facilities for the following:

- visual alarm condition indication;
- visual fault condition indication;
- extended temperature-range operation;
- interconnection with other similar smoke alarms or accessories;
- alarm-silencing facility.

Where such facilities are included, this International Standard specifies applicable requirements.

This International Standard does not cover devices intended for incorporation in systems using separate control and indicating equipment. Such systems are specified in all parts of ISO 7240.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 209, *Aluminium and aluminium alloys — Chemical composition*

ISO 2919, *Radiation protection — Sealed radioactive sources — General requirements and classification*

ISO 7240-3, *Fire detection and alarm systems — Part 3: Audible alarm devices*

ISO 7731, *Ergonomics — Danger signals for public and work areas — Auditory danger signals*

ISO 8201, *Acoustics — Audible emergency evacuation signal*

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

IEC 60065:2005, *Audio, video and similar electronic apparatus — Safety requirements*

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

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

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

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

IEC 60068-2-42, *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*

IEC 60950-1:2005, *Information technology equipment — Safety — Part 1: General requirements*

IEC 61672-1:2002, *Electroacoustics — Sound level meters — Part 1: Specifications*

OECD, Recommendations for ionization chamber smoke detectors in implementation of radiation protection standards. Nuclear Energy Agency, Organisation for Economic Co-operation and Development, Paris, France. 1977

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

— m (3.9)
— y (3.18)

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

3.2
alarm condition
audible signal specified by the manufacturer as indicating the existence of a fire

3.3
alarm-silence facility
means of temporarily disabling or desensitizing a smoke alarm

3.4
battery-low condition
combination of battery voltage and series resistance which results in a fault warning

3.5
fault condition
condition in which the smoke alarm is affected by an adverse condition of a component

3.6
fault warning
audible signal specified by the manufacturer as indicating the existence of an actual or incipient fault that may prevent an alarm condition

3.7
interconnectable smoke alarm
smoke alarm which may be interconnected with other smoke alarms to provide a common alarm condition

3.8
least sensitive orientation
point of rotation, relative to air flow, about the vertical axis where a detector produces the maximum response threshold value

3.9
m
absorbance index
measured light attenuation characterizing the concentration of particulates in smoke or an aerosol

NOTE The equation for m is given in Annex C.

3.10
most sensitive orientation
point of rotation, relative to air flow, about the vertical axis where a detector produces the minimum response threshold value

3.11
normal condition
condition in which the smoke alarm is supplied with power but is not giving either an alarm condition or a fault condition, although able to give such signals if the occasion arises

3.12
primary power source
source of power intended to supply the smoke alarm

3.13
response threshold
A_{th}
smoke concentration at which the smoke alarm changes to its alarm condition

3.14
secondary power source
source of power intended to supply the smoke alarm in the event that the primary power source is unavailable

3.15
smoke alarm
device containing within one housing all the components, except possibly the power source, necessary for detecting smoke and generating an alarm condition

3.16
type A smoke alarm
type A
smoke alarm that does not contain radioactive materials

3.17
type B smoke alarm
type B
smoke alarm containing radioactive materials

3.18
y
dimensionless variable, reflecting the change in the current flowing in an ionization chamber as a known function of the concentration of particulates in the smoke or aerosol

NOTE The equation for y is given in Annex C.

4 General requirements

4.1 Compliance

In order to comply with this International Standard, the smoke alarm shall meet the requirements of this clause, shall be tested as specified in Clause 5 and shall meet the requirements of the tests.

4.2 Alarm condition

4.2.1 Aural indicator

4.2.1.1 Signal pattern

4.2.1.1.1 Where the smoke alarm is used to alert occupants to *evacuate* the area, the alarm condition shall be the emergency evacuation signal defined in ISO 8201.

4.2.1.1.2 Where the smoke alarm is used to alert occupants to *investigate* the area for the cause of the alarm condition, the alarm condition shall be the auditory danger signal defined in ISO 7731.

4.2.1.2 Signal level — Optional function

The alarm condition aural indicator shall commence sounding at a level not greater than 45 dBA, rising gradually to the maximum level of not more than 105 dBA over a period of between 3 s to 10 s (see 5.18 and 5.19).

4.2.1.3 Signal frequency characteristics — Optional function

The audible alarm signal shall have a fundamental frequency of 520 Hz with odd harmonics to approximate a square wave.

4.2.2 Visual indicator

4.2.2.1 Interconnectable smoke alarms

Interconnectable smoke alarms shall be provided with an integral red visual indicator, by which the individual smoke alarm, when in alarm condition, may be identified. Visual indicators shall not operate on interconnected smoke alarms that have not detected smoke.This visual indicator may also perform other additional functions, but the alarm indication needs to be distinct from any additional function.

4.2.2.2 Non-interconnectable smoke alarms — Optional function

Smoke alarms that do not include an interconnection function shall be provided with an integral red visual alarm condition indicator. The indicator shall flash or be continuously illuminated when the alarm condition is present. The indicator may be combined with the fault condition visual indicator. The failure of any visual alarm condition indicator shall not prevent the alarm condition.

4.3 Mains-on visual indicator

A smoke alarm intended for connection to the a.c. mains shall be provided with a mains-on visual indicator. The indicator shall be continuously illuminated when the mains power is present. The indicator shall be green.

4.4 Fault condition visual indicator — Optional function

The smoke alarm shall be provided with an integral amber or yellow visual fault condition indicator. The indicator shall flash or be continuously illuminated when the fault condition is present. The indicator may be combined with the alarm condition visual indicator. The failure of any visual fault condition indicator shall not prevent the alarm condition.

4.5 Smoke alarm signals

The following conditions shall apply to smoke alarms which employ features in addition to the requirements of this International Standard.

— The alarm condition shall take precedence over any other signal, even when such other signal is initiated first.

— The alarm signal shall be distinctive from the signals of non-alarm condition functions. Use of a common sounder is permitted if distinctive signals are obtained.

— If an aural fault condition is provided, it shall be distinctive from alarm condition signals but may be common to all functions employed.

— Any fault condition associated with features, in addition to the requirements of this International Standard, shall not interfere with the operation and supervision of the smoke alarm.

4.6 Test facility

A test facility shall be provided to simulate the ability of the sensing assembly to detect the presence of smoke. The test facility shall be accessible from outside the smoke alarm when installed as specified in the installation instructions.

4.7 Means of calibration

The manufacturer's means of calibration shall not be readily adjustable after manufacture.

4.8 User-replaceable components

Except for batteries or fuses, a smoke alarm shall have no user-replaceable or serviceable components.

4.9 Primary power source

4.9.1 General

The primary power source of the smoke alarm may be internal or external to the smoke alarm housing.

4.9.2 Internal

Where the primary power source is internal to the smoke alarm, the source shall meet the following requirements:

a) be capable of supplying the quiescent load of the smoke alarm together with the additional load resulting from weekly operation of the test facility of 10 s for at least 1 year before the battery-low condition is given;

b) provide a distinctive battery-low condition before the battery is incapable of operating for alarm condition purposes (see 5.17);

c) at the point when a battery-low condition commences, have sufficient capacity for the smoke alarm to produce an alarm condition, as specified in 5.18 or 5.19 as appropriate, for at least 4 min or, in the absence of smoke, a battery-low condition for at least 30 d;

d) be replaceable by the user, unless the power-source operating life in the smoke alarm is 10 years or greater.

In the absence of suitable test procedures to verify battery capacity, data concerning the smoke-alarm loads and the battery characteristics shall be provided by the manufacturer to indicate that the above requirement can be met.

4.9.3 External

Where the primary power source is external to the smoke alarm, an internal or external secondary power source shall be provided (see 4.10).

4.10 Secondary power source

4.10.1 General

4.10.1.1 For smoke alarms intended for connection to an external primary power source, a secondary power source shall be provided and the following requirements shall apply.

a) Primary-cell secondary power source: the secondary power source shall be capable of meeting the requirements of 4.9.2.

b) Rechargeable-cell secondary power source: the secondary power source shall be capable of supplying the quiescent load of the smoke alarm for a minimum period of 72 h, followed by an alarm condition as specified in 5.18 or 5.19 as appropriate, for at least 4 min in the event of fire or, in the absence of smoke, a fault warning for at least 24 h.

4.10.1.2 In the absence of suitable test procedures to verify the secondary power source, data concerning the smoke alarm loads and the secondary facility characteristics shall be provided by the manufacturer to indicate that the above requirements can be met.

4.10.2 Monitoring of secondary power source

The secondary power source shall be monitored for fault conditions. These conditions shall include battery-low condition and open- and short-circuit failure of the secondary power source.

4.11 Battery connections

4.11.1 Except where a polarized connector is used, lead or terminal connections to batteries shall be identified with the correct polarity (e.g. plus or minus). The polarity may be indicated on the unit adjacent to the battery terminals or leads.

4.11.2 Any leads connecting the terminal connectors of batteries in smoke alarms to the smoke-alarm circuit board shall be provided with strain-relieving devices adjacent to both battery terminal connectors and the smoke alarm circuit board so that when the leads are subjected to a pull of 20 N without jerks for 1 min in any direction allowed by the design, the pull is not transmitted to the joints between the leads and the battery terminal connectors or between the leads and the smoke alarm circuit board.

4.12 User-replaceable battery

4.12.1 General

Removal and replacement of user-replaceable batteries shall not require the use of tools.

4.12.2 Indication

The removal of any user-replaceable battery shall result in a visual, mechanical or aural warning that the battery has been removed. The visual warning shall not depend upon a power source.

Conformity may be achieved by, but is not restricted to, one of the following examples:

— a warning flag that will be exposed with the battery removed and the cover closed;

— a hinged cover or battery compartment that cannot be closed when the battery is removed;

— a unit that cannot be replaced upon its mounting base/bracket with the battery removed.

4.13 Electrical safety

The apparatus shall be designed and constructed so as to present no danger, either in normal use or under fault conditions, as determined by 5.26.

4.14 Connection of external ancillary devices

The smoke alarm may provide for connections to external ancillary devices (e.g. remote indicators, control relays, transmitters). Open- or short-circuit failure of these connections shall not prevent the correct operation of the smoke alarm.

4.15 Terminals for external conductors

4.15.1 The smoke alarm or base, as appropriate, if intended to have external connections, shall provide for the connection of conductors by means of screws, nuts or equally effective devices.

4.15.2 For mains-powered smoke alarms which utilize a "flying lead"-type connector, the connector shall be regarded as a conductor. "Flying lead"-type connectors shall be subjected to a pull test, such that when the connector is subjected to a pull of 20 N without jerks for 1 min in any direction allowed by the design, the connector does not become detached.

4.15.3 If terminals are provided, they shall allow the connection of conductors having nominal cross-sectional areas of between 0,4 mm^2 and 1,5 mm^2. Terminals shall be designed so that they clamp the conductor between metal surfaces without rotation of those surfaces but with sufficient contact pressure and without damage to the conductor. Disconnection of the conductors, or access to the conductors for disconnection, shall not be possible without the use of a tool.

4.16 Protection against the ingress of foreign bodies

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

NOTE This requirement is intended to restrict the access of insects into the sensitive parts of the smoke alarm. 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 the access holes may introduce the danger of clogging by dust, etc. It may, therefore, be necessary to take other measures.

4.17 Interconnectable smoke alarms — Optional function

If a means of connecting a number of smoke alarms to give a common alarm condition is provided, the following shall apply.

a) The audible alarm condition shall be emitted by all of the interconnecting smoke alarms when smoke is detected by any of the interconnected smoke alarms.

b) If the smoke alarms are provided with an alarm-silence facility, initiation of the alarm-silence period of one of the smoke alarms shall not prevent the audible alarm condition being emitted by that smoke alarm when smoke is detected by any of the other smoke alarms.

c) The interconnection of the maximum number of smoke alarms allowed by the manufacturer shall not have a significant effect on the sensitivity of the smoke alarms nor on their ability to meet the battery capacity (see 5.17) or sound output requirements (see 5.18 or 5.19 as applicable).

d) For battery-operated smoke alarms, open- or short-circuits of the interconnecting leads either shall not prevent the smoke alarms from functioning individually or shall result in an alarm condition or fault condition.

This requirement does not apply to mains- or mains/battery-supplied smoke alarms for which the supply and interconnect wiring should be installed in accordance with the appropriate national regulations.

4.18 Alarm-silence facility — Optional function

If means of temporarily disabling or desensitizing a smoke alarm are provided, the following shall apply.

a) The initiation of the alarm-silence period shall require the operation of a manual control. This control may be the same as a manual control provided for the test facility (see 4.6). This control may be integral or separate to the smoke alarm.

b) Operation of the alarm-silence control shall disable or desensitize the smoke alarm for at least 5 min. The sensitivity of the smoke alarm shall be restored within 15 min of operation of the alarm-silence control. If the alarm-silence period is adjustable, it shall not be possible to set it to less than 5 min or to more than 15 min.

c) Continuous operation of the alarm-silence control shall not lead to the smoke alarm being disabled or desensitized for more than 15 min without an alarm condition, a fault warning occurring.

NOTE This requirement is intended to prevent the permanent loss of sensitivity due to accidental or deliberate jamming of the control.

4.19 Radioactive material in type B smoke alarms

4.19.1 Direct contact with radioactive sources shall not be possible without the use of tools.

4.19.2 Radioactive sources shall be sealed in compliance with the relevant requirements of ISO 2919, with a minimum classification of C32222.

4.19.3 The normal activity of the radio-nuclide shall be not more than 37 kBq. Radium-226 shall not be used.

4.20 Smoke alarms with voice — Optional function

4.20.1 Smoke alarms using voice messages shall be capable of producing an audible warning signal and a voice message or messages.

4.20.2 All messages related to fire safety shall be declared by the manufacturer and shall be considered by the testing authority. The message determined to be worst case shall be subject to a conformance assessment.

When selecting the worst case message, message length, loudness and repetition timing should be considered.

4.20.3 For messages that require immediate action, the warning signal and message sequence broadcast by the device shall be within the following limits:

a) warning signal, lasting for 2 s to 10 s; followed by

b) silence, lasting for 0,25 s to 2 s; followed by

c) voice message; followed by

d) silence, lasting for 0,25 s to 5 s.

The time for each cycle shall not exceed 30 s.

The periods of silence may need to be longer than indicated in certain circumstances, for example in spaces with long reverberation times, but shall not be such that the time between the start of each cycle exceeds 30 s.

NOTE For other messages, it is permitted to extend either the silence period after the voice message or the period within which the message is repeated, or both.

4.21 Marking

4.21.1 Smoke-alarm

4.21.1.1 Each smoke alarm shall be legibly and indelibly marked with the following:

a) the number and date of this International Standard (i.e. ISO 12239:2010);

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

c) the model designation (type or number);

d) the type of smoke alarm (type A or type B) and an explanation of the meaning of the type designation;

e) the nominal sound level output as measured in 5.18 or 5.19 as appropriate;

f) the aural alarm condition signal (ISO 8201 or ISO 7731);

g) the date of manufacture or the batch number;

h) the manufacturer's recommended date for replacement, subject to normal, regular maintenance (provision may be made for a place to note the date of change of the smoke alarm);

i) for smoke alarms incorporating user-replaceable batteries, the type and number of batteries recommended by the manufacturer and the following instruction to the user, which shall be visible during the operation of changing the batteries:

"Test the smoke alarm for correct operation using the test facility whenever the battery is replaced"

j) for smoke alarms incorporating non-replaceable batteries, the following warning which shall be visible during normal use:

“WARNING — Battery not replaceable — See instruction manual”

k) for type B, smoke alarms shall be permanently marked with the trefoil symbol, name of radionuclide and activity. Additional marking requirements may be required by national regulations, and include any additional advice regarding restrictions of trade or disposal of the smoke alarm;

l) markings required in IEC 60065:2005, Clause 5, which may be on any external part of the apparatus, but it is not necessary for the specified markings to be visible after installation;

m) for class I apparatus in accordance with IEC 60065, the following information shall be visible near the mains input terminals:

“WARNING — THIS APPARATUS MUST BE GROUNDED”; and

if live parts are made accessible when a cover is removed or opened, a warning to that effect, which is visible before the cover is removed or opened;

n) a notice on the outer surface of the enclosure: DO NOT PAINT. The letters shall be not less than 3 mm high and plainly visible after the smoke alarm is installed in its intended manner.

4.21.1.2 Conformity shall be checked by visual inspection. The indelibility of the marking shall be checked by establishing that it cannot be removed when rubbed lightly with a piece of cloth soaked first with petroleum spirit then with water.

4.21.2 Packaging

The point-of-sale packaging shall be marked with the following:

a) the model designation (type or number);

b) the type of smoke alarm (type A or type B) and an explanation of the meaning of the type designation;

c) the nominal sound level output as measured in 5.18 or 5.19 as appropriate;

d) the aural alarm condition signal (ISO 8201 or ISO 7731);

e) for smoke alarms using 520 Hz alarm condition signal frequency, the nominal frequency;

f) for type B smoke alarms, permanently marked with the trefoil symbol, name of radionuclide and activity. The markings shall be visible from the outside of the packaging. Additional markings may be required by national regulations, and include any additional advice regarding restrictions of trade or disposal of the smoke alarm.

4.22 Data

4.22.1 Information supplied on or with smoke alarms shall include instructions on siting, installation and maintenance.

4.22.2 The information provided with smoke alarms incorporating user-replaceable batteries shall include specific guidance on changing the batteries. This guidance shall include any advice which is necessary to ensure that the battery is properly connected. It shall also include a recommendation that the operation of the smoke alarm be tested with the test facility whenever the batteries are replaced.

4.22.3 It is recommended that the information should also state that if the smoke alarm fails to operate correctly, the advice of the manufacturer should be sought.

4.22.4 For smoke alarms incorporating non-replaceable batteries, information shall be given on the action to be taken if a battery-low condition is indicated.

4.22.5 Information for interconnectable smoke alarms shall state the maximum number that may be interconnected. Details of suitable cables shall also be given.

4.22.6 Information for smoke alarms intended for connection to mains supplies shall include a warning that draws attention to the hazards associated with mains voltages and recommends that the smoke alarm, together with any associated supply and interconnect wiring, be installed in accordance with appropriate national electrical installation regulations.

4.22.7 If it is claimed that the smoke alarm is also suitable for use in extended temperature range, this shall be stated in the information supplied on or with the smoke alarm.

4.23 Additional requirements for software controlled smoke alarms

4.23.1 General

For smoke alarms which rely on software control in order to fulfil the requirements of this International Standard, the requirements of 4.23.2, 4.23.3 and 4.23.4 shall be met.

4.23.2 Software documentation

4.23.2.1 The manufacturer shall submit 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 International Standard 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 smoke alarm,

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

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

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

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

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

b) description of each part of the program, containing at least:

   1) the name of the part,

   2) a description of the tasks performed,

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

c) full source code listings, as hard copy or in machine-readable form (e.g. ASCII-code), including all global and local variables, constants and labels used, and sufficient comment for 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 design documentation can be reviewed at the manufacturer's premises.

4.23.3 Software design

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

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

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

4.23.4 Storage of programs and data

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

4.23.4.2 Site-specific data shall be held in memory which retains data for at least two weeks without external power to the device, 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 Optional functions

If an option is taken, all the corresponding requirements shall be met.

Other functions may also be provided, even if not specified in this International Standard. However, such options shall not contradict any requirements of this document and shall not, in case of a fault, jeopardize any function required by this document.

NOTE 1 Each optional function is included as a separate entity, with its own set of associated requirements, in order to permit smoke alarms covered by this International Standard with different combinations of functions to conform to this International Standard.

Two optional sound output levels are specified in this International Standard. The options allow national regulators to specify minimum sound output levels (70 dBA or 85 dBA) as required under national regulations. In the absence of regulations, the louder of the two options should be installed.

NOTE 2 An optional extended temperature range test is included for smoke alarms installed in areas subject to a greater temperature range, such as leisure accommodation vehicles.

5.1.2 Atmospheric conditions for tests

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

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

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

5.1.3 Operating conditions for tests

If a test method requires a specimen to be operational, then connect the specimen to a suitable power source with characteristics as required by the manufacturer's data. Unless otherwise specified in the test method, the power source parameters applied to the specimen shall be set within the manufacturer's specified range(s) and shall remain substantially constant throughout the tests. The value chosen for each parameter shall normally be the nominal value, or the mean of the specified range.

The details of the power source used shall be given in the test report (see Clause 6).

5.1.4 Mounting arrangements

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

5.1.5 Tolerances

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

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

5.1.6 Measurement of response threshold value

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

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

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

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

Connect the specimen to its power source as specified in 5.1.3, and allow it to stabilize for at least 15 min.

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

— for smoke alarms using scattered or transmitted light, in decibels per metre per minute: $0,015 \leqslant \frac{\Delta m}{\Delta t} \leqslant 0,1$;

— for smoke alarms using ionization, per minute: $0,05 \leqslant \frac{\Delta y}{\Delta t} \leqslant 0,3$.

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

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

All aerosol density measurements shall be made in the proximity of the specimen.

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

5.1.7 Provision for tests

Provide the following for testing compliance with this International Standard:

a) 20 specimens and in addition the number of specimens necessary for the interconnection test and the electrical safety test as specified in 5.21 and 5.26 respectively;

b) the data specified in 4.21 and 4.22;

c) design documentation (e.g. drawings, parts lists, block diagrams and descriptions of the principles of operation of the test facility).

The specimens submitted shall be deemed representative of the manufacturer's normal production with regard to their construction and calibration. This implies that the mean response threshold value of the 20 specimens found in the initial sensitivity test (5.3) should also represent the production mean, and that the limits specified in the initial sensitivity test should also be applicable to the manufacturer's production.

5.1.8 Test schedule

Number the smoke alarms as specified in 5.3.2. Carry out the tests, as specified in Table 1, on each smoke alarm in the order in which they are listed.

5.1.9 Test report

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

Table 1 — Test schedule

Test	Subclause	Specimen no(s).
Directional dependence	5.2	One chosen arbitrarily
Initial sensitivity	5.3	All specimens
Repeatability	5.4	One chosen arbitrarily
Air movement	5.5	1
Dazzling[a]	5.6	2
Dry heat (operational)	5.7	3
Cold (operational)	5.8	4
Damp heat (operational)	5.9	5
Sulfur dioxide (SO_2) corrosion	5.10	6, 7
Impact	5.11	8
Vibration (operational)	5.12	9
Vibration (endurance)	5.13	9
Extended temperature	5.14	3, 4
Electromagnetic compatibility (EMC) immunity tests (operational)	5.15	
Electrostatic discharge		10
Radiated electromagnetic fields		11
Conducted disturbance induced by electromagnetic fields		12
Fast transient bursts		13
Slow high energy transients		14
Fire sensitivity	5.16	1, 2, 19, 20
Battery-low condition	5.17	1, 15
Sound output[b]	5.18 or 5.19	1, 15
Sounder durability	5.20	3, 4, 5, 6, 7
Interconnectable smoke alarms	5.21	21[c]
Alarm-silence facility	5.22	19
Variation in supply voltage	5.23	20
Polarity reversal	5.24	20
Secondary power source[d]	5.25	1, 15
Electrical safety	5.26	Additional specimens (as required)
Sequence timing for smoke alarms with voice	5.27	2, 3

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

[b] Sound output shall be tested as specified in either 5.18 or 5.19 as nominated by the manufacturer.

[c] Number of specimens depends on manufacturer's specification.

[d] This test only applies to smoke alarms with a secondary power source.

5.2 Directional dependence

5.2.1 Object of test

The object of the test is to show that the sensitivity of the specimen is not unduly dependent on the direction of air flow around the smoke alarm.

5.2.2 Test procedure

Measure the response threshold value of the specimen to be tested eight times as specified in 5.1.6 with the specimen being rotated 45° about its vertical axis between each measurement, so that the measurements are taken for eight different orientations relative to the direction of air flow.

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

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

5.2.3 Requirements

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

The lower response threshold value y_{min} shall not be less than 0,2, or m_{min} shall not be less than 0,05 dB/m.

5.3 Initial sensitivity

5.3.1 Object of test

The object of the test is to establish the sensitivity of each specimen prior to testing. This will be used as a baseline for some of the other tests.

5.3.2 Test procedure

Measure the response threshold value of the specimen as specified in 5.1.6. Number the smoke alarms in order of sensitivity, No. 1 having the lowest response threshold and No. 20 the highest response threshold.

Designate the maximum response threshold value as y_{max} or m_{max} and the minimum value as y_{min} or m_{min}. Calculate the mean of these response threshold values and designate it as $\bar{y}$ or $\bar{m}$.

5.3.3 Requirement

The following relationships shall apply: $y_{max}: \bar{y}$ or $m_{max}: \bar{m} \leqslant 1{,}33$ and $\bar{y}: y_{min}$ or $\bar{m}: m_{min} \leqslant 1{,}5$.

5.4 Repeatability

5.4.1 Object of test

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

5.4.2 Test procedure

Measure the response threshold value of the specimen to be tested six times as specified in 5.1.6.

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

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

5.4.3 Requirements

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

The lower response threshold value y_{min} shall be not less than 0,2, or m_{min} shall be not less than 0,05 dB/m.

5.5 Air movement

5.5.1 Object of test

The object of the test is to show that the sensitivity of the specimen 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.

5.5.2 Test procedure

Measure the response threshold value of the specimen to be tested as specified in 5.1.6 in the most and least sensitive orientations, as determined in 5.3. Designate these appropriately as $y_{(0,2)max}$ and $y_{(0,2)min}$ or $m_{(0,2)max}$ and $m_{(0,2)min}$.

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

For ionization-chamber smoke alarms, 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 5 min.

5.5.3 Requirements

One of the following relationships shall apply:

— for smoke alarms using ionization:

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

— for smoke alarms using scattered or transmitted light:

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

The smoke alarm shall not emit either a fault condition or an alarm condition during the test with aerosol-free air.

5.6 Dazzling

5.6.1 Object of test

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

5.6.2 Test procedure

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

Perform the following procedure.

a) Measure the response threshold value as specified in 5.1.6.

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

c) Switch the four lamps ON again and after at least 1 min, measure the response threshold value as specified in 5.1.6, with the lamps ON.

d) Then switch the four lamps OFF.

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

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

5.6.3 Requirements

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

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

5.7 Dry heat (operational)

5.7.1 Object of test

The object of the test is to demonstrate the ability of the specimen to function correctly at high ambient temperatures, which may occur for short periods in the service environment.

5.7.2 Test procedure

5.7.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-2, Test Bb, and in 5.7.2.2 to 5.7.2.5.

5.7.2.2 State of specimen during conditioning

Mount the specimen to be tested as specified in 5.1.4 in the smoke tunnel (see Annex A), in its least sensitive orientation, and connect it to its supply and monitoring equipment as specified in 5.1.3.

5.7.2.3 Conditioning

Condition the specimen as follows:

temperature:	Starting at an initial air temperature of (23 ± 5) °C, increase the air temperature to (40 ± 2) °C.
duration:	Maintain this temperature for 2 h.

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

5.7.2.4 Measurements during conditioning

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

5.7.2.5 Final measurements

Measure the response threshold value as specified in 5.1.6, but at a temperature of (40 ± 2) °C.

Of the two response threshold values measured for the specimen in this test and in the initial sensitivity test, designate the greater as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.7.3 Requirements

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

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

5.8 Cold (operational)

5.8.1 Object of test

The object of the test is to demonstrate the ability of the specimen to function correctly at low ambient temperatures, which may occur for short periods in the service environment.

5.8.2 Test procedure

5.8.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-1, Test Ab, and in 5.8.2.2 to 5.8.2.5.

5.8.2.2 State of specimen during conditioning

Mount the specimen to be tested as specified in 5.1.4 in the smoke tunnel described in Annex A, in the least sensitive orientation, with an initial air temperature of (23 ± 5) °C, and connect it to its power source as specified in 5.1.3.

5.8.2.3 Conditioning

Condition the test specimen as follows:

temperature:	Starting at an initial air temperature of (23 ± 5) °C, decrease the air temperature in the tunnel to (0 ± 2) °C, at a rate not exceeding 1 K/min, and maintain this temperature for 2 h.
duration:	Maintain this temperature for 2 h.

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

5.8.2.4 Measurements during conditioning

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

5.8.2.5 Final measurements

Measure the response threshold value as specified in 5.1.6, but at a temperature of (0 ± 2) °C.

Of the two response threshold values measured for the specimen in this test and in the initial sensitivity test, designate the greater as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.8.3 Requirement

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

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

5.9 Damp heat (operational)

5.9.1 Object of test

The object of the test is to demonstrate the ability of the specimen to function correctly after exposure to high relative humidity (without condensation) and temperature, which may occur for short periods in the service environment.

5.9.2 Test procedure

5.9.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-78, Test Cab, and in 5.9.2.2 to 5.9.2.5.

5.9.2.2 State of the specimen during conditioning

Mount the specimen to be tested as specified in 5.1.4 in the smoke tunnel described in Annex B, in its least sensitive orientation, with an initial air temperature of (23 ± 5) °C, and connect it to its power source as specified in 5.1.3.

5.9.2.3 Conditioning

Condition the test specimen as follows.

— expose the specimen to be tested to an initial air temperature of (40 ± 2) °C, and a relative humidity of less than 45 %.

— after 2 h, increase the relative humidity to (93 ± 3) % over a period of 1 h. Maintain this temperature and humidity for a period of 4 d.

— allow the specimen to recover for a period of 1 h to 2 h at standard laboratory conditions.

5.9.2.4 Measurements during conditioning

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

5.9.2.5 Final measurements

Measure the response threshold value as specified in 5.1.6.

Of the two response threshold values measured for the specimen in this test and in the initial sensitivity test, designate the greater as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.9.3 Requirements

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

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

5.10 Sulfur dioxide (SO_2) corrosion

5.10.1 Object of test

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

5.10.2 Test procedure

5.10.2.1 Reference

Use the test apparatus and perform the procedure generally as specified in IEC 60068-2-42, but carry out the conditioning as specified in 5.10.2.2 to 5.10.2.4.

5.10.2.2 State of the specimen during conditioning

Mount the specimen as specified in 5.1.4. Do not supply it with power during the conditioning, but equip it with untinned copper wires, of the appropriate diameter, connected to a sufficient number of terminals to allow the final measurement to be made without making further connections to the specimen.

5.10.2.3 Conditioning

Condition the test specimen as follows:

- temperature: (25 ± 2) °C;
- relative humidity: (93 ± 3) %;
- SO_2 concentration: (25 ± 5) µl/l;
- duration: 4 d.

5.10.2.4 Final measurements

Immediately after the conditioning, subject the specimen to a drying period of 16 h at (40 ± 2) °C, ⩽ 50 % RH, followed by a recovery period of 1 h to 2 h at standard laboratory conditions. After this recovery period, measure the response threshold value as specified in 5.1.6.

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

5.10.3 Requirements

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

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

5.11 Impact (operational)

5.11.1 Object of test

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

5.11.2 Test procedure

5.11.2.1 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 described in Annex E.

5.11.2.2 State of the specimen during conditioning

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

Connect the specimen to its power source as specified in 5.1.3.

5.11.2.3 Conditioning

Use the following test parameters during the conditioning:

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

5.11.2.4 Measurements during conditioning

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

5.11.2.5 Final measurements

After the conditioning, measure the response threshold value as specified in 5.1.6.

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

5.11.3 Requirements

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

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

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

5.12 Vibration, sinusoidal (operational)

5.12.1 Object of test

The object of the test is to demonstrate the immunity of the specimen to vibration at levels considered appropriate to the normal shipping, installation, and service environment.

5.12.2 Test procedure

5.12.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-6, Test Fc, and in 5.12.2.2 to 5.12.2.5.

5.12.2.2 State of the specimen during conditioning

Mount the specimen on a rigid fixture as specified in 5.1.4 and connect it to its power source as specified in 5.1.3.

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

5.12.2.3 Conditioning

Condition the test specimen as follows:

- frequency range: (10 to 150) Hz;
- acceleration amplitude: 5 m/s^2 ($\approx$ 0,5 g_n);
- number of axes: 3;
- sweep rate: 1 octave/min;
- number of sweep cycles: 1/axis.

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

5.12.2.4 Measurements during conditioning

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

5.12.2.5 Final measurements

After conditioning, visually inspect the specimen both internally and externally for mechanical damage. Then measure the response threshold as specified in 5.1.6.

The final measurements are normally made after the vibration endurance test and only need to be made here if the operational test is conducted in isolation.

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

5.12.3 Requirements

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

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

5.13 Vibration, sinusoidal (endurance)

5.13.1 Object of test

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

5.13.2 Test procedure

5.13.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-6, Test Fc, and in 5.13.2.2 to 5.13.2.4.

5.13.2.2 State of the specimen during conditioning

Mount the specimen on a rigid fixture as specified in 5.1.4, but do not supply it with power during conditioning.

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

5.13.2.3 Conditioning

Condition the test specimen as follows:

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

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

5.13.2.4 Final measurements

After conditioning, measure the response threshold value as specified in 5.1.6.

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

5.13.3 Requirements

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

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

5.14 Extended temperature (operational) — Optional function

5.14.1 Object of test

The object of the test is to demonstrate the ability of the specimen to function correctly in an extended temperature range.

5.14.2 Test procedure

Mount the specimen to be tested in the smoke tunnel described in Annex B, in its least sensitive orientation, with an initial air temperature of (23 ± 5) °C, and connect it to its power source as specified in 5.1.3.

Apply the following temperature cycle ten times.

a) Raise the temperature to (65 ± 2) °C in (2 ± 0,5) h.

b) Hold the temperature at (65 ± 2) °C until 8,5 h after the beginning of the cycle.

c) Reduce the temperature to (–10 ± 2) °C in (4 ± 1) h.

d) Hold the temperature at (–10 ± 2) °C until 19,5 h after the beginning of the cycle.

e) Increase the temperature to (23 ± 5) °C in (2 ± 0,5) h.

f) Hold the temperature at (23 ± 5) °C until 24 h after the beginning of the cycle.

After each cycle of temperature conditioning has been completed, measure the response threshold value as specified in 5.1.6, but at a temperature of (0 ± 2) °C.

Of the ten response threshold values measured for the specimen in this test and the initial sensitivity test, designate the greater as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.14.3 Requirement

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

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

5.15 Electromagnetic compatibility (EMC) immunity tests (operational)

5.15.1 Carry out the following EMC immunity tests as specified in EN 50130-4:

a) mains-supply voltage dips and short interruptions;

b) electrostatic discharge;

c) radiated electromagnetic fields;

d) conducted disturbances induced by electromagnetic fields;

e) fast transient bursts;

f) slow high-energy voltage surges.

5.15.2 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.

— Measure the response threshold value as specified in 5.1.6.

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

b) The required operating condition shall be as specified in 5.1.3.

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

5.16 Fire sensitivity

5.16.1 Object of test

The object of the test is to demonstrate the ability of the specimen to respond to a broad spectrum of smoke types as required for general application in residences.

5.16.2 Test procedure

5.16.2.1 Principle of test

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

5.16.2.2 Test fires

Subject the two most sensitive specimens and the two least sensitive specimens determined in 5.3 to the four test fires TF2 to TF5[1)]. The type, quantity and arrangement of the fuel and the method of combustion are described for each test fire in Annexes G to J, along with the end-of-test condition and the required profile curve limits.

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 condition, 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 may be necessary, to adjust the quantity and arrangement of the fuel to obtain valid test fires.

5.16.2.3 Mounting of the specimens

Mount the specimens 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.

For smoke alarms intended for wall-mounting only, mount the four specimens (Nos. 17 to 20) within 0,5 m of the middle of the long walls as shown in Annex G with specimen Nos. 18 and 19 closest to the ceiling, and specimen Nos. 17 and 20 furthest removed from ceiling, consistent with the manufacturer's instructions.

For smoke alarms intended for either ceiling or wall mounting, mount specimen Nos. 17 and 18 on the ceiling within the designated area and mount specimen Nos. 19 and 20 on the walls as described above.

1) Test fire 1 (TF1) is not considered applicable to this International Standard.

Connect each specimen to its power source as specified in 5.1.3, and allow it to stabilize in its quiescent condition before the start of each test fire.

5.16.2.4 Initial conditions

IMPORTANT — The stability of the air and temperature affects the smoke flow within the room. This is particularly important for the test fires 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.

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

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

— temperature, T: (23 ± 5) °C;

— air movement: negligible;

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

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

5.16.2.5 Recording of the fire parameters and response values

During each test fire, record the fire parameters in Table 2 as a function of time from the start of the test. Record each parameter continuously or at least once per second.

Table 2 — Fire parameters

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

The alarm condition given by the specimen shall be taken as the indication that a smoke alarm has responded to the test fire.

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

5.16.3 Requirements

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

5.17 Battery-low condition

5.17.1 Object of test

The object of the test is to demonstrate that a specimen will give a battery-low condition before an increase in the internal resistance or decrease in the terminal voltage of the battery prevents correct operation.

NOTE Where this test method is not appropriate to apply, an alternative method can be agreed between the manufacturer and the test house.

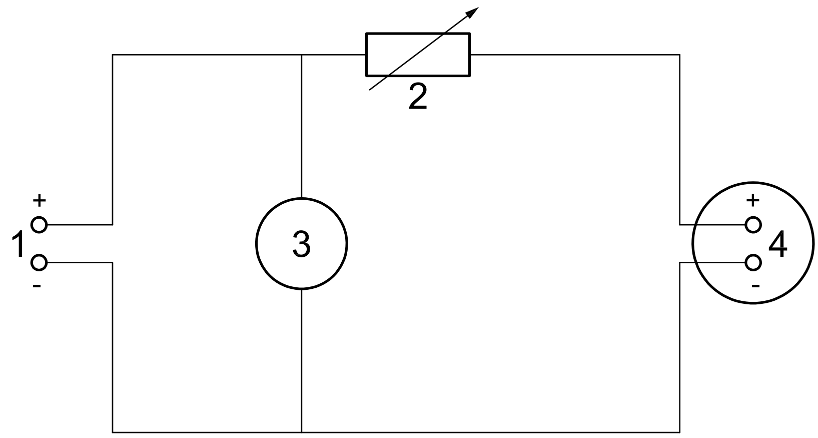
5.17.2 Test procedure

Connect the smoke alarm as shown in Figure 1.

With the series resistor R set to 0 and the supply voltage V set to the rated battery voltage, V_R, measure the response threshold of the smoke alarm as specified in 5.1.6.

With the series resistor R set to 0, decrease the supply voltage V in stages of 0,01 × V_R at intervals of at least 1 min, until the battery-low condition is indicated. Record the supply voltage at which the battery-low condition is given as V_E and measure the response threshold of the smoke alarm as specified in 5.1.6.

With the supply voltage V set at V_R, increase the resistance of the series resistor R from 0 in increments of 0,1 Ω at intervals of at least 1 min until the battery-low condition is given. Record the resistance at which the battery-low condition is given as R_E and measure the response threshold of the smoke alarm as specified in 5.1.6.



Key

1 regulated d.c. power supply

2 series resistor

3 supply voltage

4 smoke alarm with battery removed

Figure 1 — Battery-low condition test configuration

5.17.3 Requirements

The ratio of the response thresholds measured at V_E and R_E to the response threshold measured with the series resistor set to 0 and the supply voltage set to V_R shall be not less than 0,625 and not greater than 1,6.

5.18 85 dBA Sound output — Optional function

5.18.1 Object of test

The object of the test is to demonstrate that the specimen shall be capable of providing an output of at least 85 dBA and no more than 105 dBA at 3 m while connected to a source of rated voltage and frequency and mounted on a wooden board as specified in ISO 7240-3 with the front of the smoke alarm at 90° to the horizontal and facing the microphone.

A sound-level meter conforming to IEC 61672-1:2002 Class 2 or better shall be used.

5.18.2 Method of test

Test at least two samples. Additionally, test units intended for multiple-station interconnection in that configuration, with the maximum line resistance and the sound output measured on the smoke alarm subject to an abnormal smoke condition. For a battery-operated (or equivalent) unit, deplete the battery to a point just above or at the battery-low condition.

Make the measurement in a free-field condition to minimize the effects of reflected sound energy. The ambient noise level shall be at least 10 dB below the measured level produced by the smoke alarm.

Free-field conditions may be simulated by mounting the unit on a wooden board (see ISO 7240-3), locating the microphone directly in front of and 3 m away from the unit, and conducting the test outdoors on a clear day with a wind velocity of not more than 8 km/h and an ambient temperature of 15 °C to 25 °C.

Alternatively, an anechoic chamber of not less than 28 m^3, with no dimension less than 2 m and with an absorption factor of 0,99 or greater from 100 Hz to 10 kHz for all surfaces, may be used for this measurement.

For smoke alarms using 520 Hz nominal output frequency, measure the fundamental frequency and the 3rd and 5th harmonics.

5.18.3 Requirements

The sound output shall commence at a level not greater than 45 dBA, rising gradually to at least 85 dBA and no more than 105 dBA over a period of between 3 s and 10 s.

For battery-operated smoke alarms, the sound output shall be at least 85 dBA and no more than 105 dBA after 1 min of alarm operation and at least 82 dBA after 4 min of alarm operation.

For mains-powered smoke alarms, the sound output shall be at least 85 dBA and no more than 105 dBA after 4 min of alarm operation.

For smoke alarms using 520 Hz nominal output frequency,

— the 3rd harmonic shall be (−9,6 ± 2) dB, and

— the 5th harmonic shall be (−14 ± 2) dB

relative sound pressure level to the measured fundamental frequency.

5.19 70 dBA Sound output — Optional function

5.19.1 Object of test

The object of the test is to demonstrate that the specimen shall be capable of providing an output of at least 70 dBA and no more than 105 dBA at 3 m while connected to a source of rated voltage and frequency and mounted on a wooden board as specified in ISO 7240-3 with the front of the smoke alarm at 90° to the horizontal and facing the microphone.

A sound-level meter conforming to IEC 61672-1 Class 2 or better shall be used.

NOTE Research indicates that a minimum of 75 dBA is required to wake sleeping persons; however, this option has been included to permit smoke alarms to comply with this International Standard where local regulations permit a lower sound output.

5.19.2 Method of test

Test at least two samples. Additionally, test units intended for multiple-station interconnection in that configuration, with the maximum line resistance and the sound output measured on the smoke alarm subject to an abnormal smoke condition. For a battery-operated (or equivalent) unit, deplete the battery to a point just above or at the battery-low condition.

Make the measurement in a free-field condition to minimize the effects of reflected sound energy. The ambient noise level shall be at least 10 dB below the measured level produced by the smoke alarm.

Free-field conditions may be simulated by mounting the unit on a wooden board (see ISO 7240-3), locating the microphone directly in front of and 3 m away from the unit, and conducting the test outdoors on a clear day with a wind velocity of not more than 8 km/h and an ambient temperature of 15 °C to 25 °C.

Alternatively, an anechoic chamber of not less than 28 m^3, with no dimension less than 2 m and with an absorption factor of 0,99 or greater from 100 Hz to 10 kHz for all surfaces, may be used for this measurement.

For smoke alarms using 520 Hz nominal output frequency, measure the fundamental frequency and the 3rd and 5th harmonics.

5.19.3 Requirements

The sound output shall commence at a level not greater than 45 dBA, rising gradually to at least 70 dBA and no more than 105 dBA over a period of between 3 s to 10 s.

For battery-operated smoke alarms, the sound output shall be at least 70 dBA and no more than 105 dBA after 1 min of alarm operation and at least 67 dBA after 4 min of alarm operation.

For mains-powered smoke alarms, the sound output shall be at least 70 dBA and no more than 105 dBA after 4 min of alarm operation.

For smoke alarms using 520 Hz nominal output frequency,

— the 3rd harmonic shall be (–9,6 ± 2) dB, and

— the 5th harmonic shall be (–14 ± 2) dB

relative sound pressure level to the measured fundamental frequency.

5.20 Sounder durability

5.20.1 Object of test

The object of the test is to demonstrate the ability of the specimen sounder to operate as intended after an endurance test.

5.20.2 Test procedure

Connect the specimen to its power source as specified in 5.1.3. Where the primary power source is internal, a filtered supply adjusted to the specified voltage should be used.

Operate the specimen for 8 h of alternating 5 min periods of energization and de-energization in the standby and the alarm conditions.

After conditioning, measure the sound output of the smoke alarm as specified in 5.18 or 5.19 as nominated by the manufacturer.

5.20.3 Requirements

The specimen shall meet the sound output requirements as specified in 5.18 or 5.19 as nominated by the manufacturer.

5.21 Interconnectable smoke alarms

5.21.1 Object of test

The object of the test is to demonstrate the ability of interconnectable specimen to operate as intended and to ensure that the interconnect facility does not impair the operation of any single smoke alarm.

5.21.2 Test procedure

Connect the smoke alarm under test with the maximum number of smoke alarms allowed in the manufacturer's instructions (see 4.22.5).

If more than five smoke alarms may be interconnected, it is permissible to interconnect a minimum of five smoke alarms and simulate the remainder by an equivalent electrical load.

Trigger one smoke alarm into the alarm condition and check all of the interconnected smoke alarms for an audible alarm condition.

If the smoke alarms have an alarm-silence facility, operate the alarm-silence control on one smoke alarm and, during the alarm-silence period, trigger another smoke alarm into the alarm condition. Check the interconnected smoke alarms for an audible-alarm condition, including the smoke alarm in the alarm-silence condition.

With the smoke alarms interconnected, measure the response threshold of the smoke alarm under test as specified in 5.1.8. Where the primary power source is internal, repeat the response threshold test with the interconnecting leads short-circuited.

With smoke alarms interconnected, repeat the sound-output test described in 5.18 or 5.19, as applicable, on one of the smoke alarms. During this test, ensure that the other interconnected smoke alarms are sufficiently screened or distanced so that their audible-alarm conditions do not influence the measurement. Where the primary power source is internal, repeat the sound output test with the interconnecting leads short-circuited.

Where the primary power source is internal, reassess the capacity requirements, including the load introduced by interconnecting the maximum permitted number of smoke alarms (see 4.9).

5.21.3 Requirements

Requirements for interconnectable smoke alarms are the following.

— All of the interconnected smoke alarms shall give an audible-alarm condition within 1 min of an alarm condition.

— The ratio(s) of the response threshold(s) measured in this test to the response threshold measured in the initial sensitivity test shall be between 0,625 and 1,6.

— The sound output shall meet the requirements of 5.18 or 5.19 as applicable.

— The internal primary power source requirements specified in 4.9 can still be met.

5.22 Alarm-silence facility

5.22.1 Object of test

The object of the test is to demonstrate the ability of specimen with an alarm-silence facility to operate as intended and to ensure that the alarm-silence facility does not permanently impair the operation of the smoke alarm.

5.22.2 Test requirement

Generate smoke as specified in 5.1.6 in the smoke tunnel specified in Annex A, with an air velocity of (0,2 ± 0,04) m/s and an air temperature of (23 ± 5) °C, but increase the smoke density to three times the response threshold (m or y) recorded for smoke alarm No. 6, when tested as specified in 5.3.2. Using smoke alarm No. 6, with a supply voltage corresponding to V_R, operate the alarm-silence control, immediately insert the smoke alarm into the smoke-filled smoke tunnel and maintain the smoke density between three and four times m or y for at least 15 min. Repeat the test but with a supply voltage of V_E, as determined in 5.17.2.

With the supply voltage corresponding to V_R, put smoke alarm No. 6 into the alarm-silence condition by the operation of the alarm-silence control. Measure the response threshold as specified in 5.1.6 but with the smoke generation commencing $(15^{+0,25}_{0})$ min after the operation of the alarm-silence control. Repeat the test but with a supply voltage of V_E, as specified in 5.17.2. Repeat the test but, after operating the alarm-silence control, hold the control ON continuously for the remainder of the test.

5.22.3 Requirements

The smoke alarm shall not emit an alarm condition during the first 5 min after the alarm-silence control is operated.

The ratio of the response thresholds measured to the response threshold recorded for smoke alarm No. 6 when tested as specified in 5.3.2 shall be not less than 0,625 and not greater than 1,6.

While the silence control is held ON continuously:

a) within 15 min of the initial activation of the alarm-silence control, the smoke alarm shall emit a fault warning for as long as the control is held ON;

b) the ratio of the response threshold measured during the test to the response threshold recorded for the same smoke alarm when tested as specified in 5.3.2 shall be not less than 0,625 and not greater than 1,6.

5.23 Variation in supply voltage

5.23.1 Object of test

The object of the test is to demonstrate that, within the specified range(s) of the supply voltage, the sensitivity of the specimen is not unduly dependent on these parameters.

5.23.2 Test procedure

Measure the response threshold value of the specimen to be tested as specified in 5.1.6, under the extremes of the specified supply conditions (e.g. maximum and minimum voltage).

Test smoke alarms intended to operate from mains supplies with supply voltages of 0,85 times the lower limit and 1,1 times the upper limit of the nominal supply voltage range specified in the manufacturer's requirements. If the smoke alarm is provided with a rechargeable battery, allow sufficient time for the battery voltage to stabilize before measuring the response threshold.

Where the primary power source is internal, carry out the tests with a supply voltage corresponding to V_R, and also at the battery-low condition voltage (V_E) as specified in 5.17.2.

Where a secondary power source is used, also test the smoke alarm with the primary supply disconnected. Where the secondary power source is other than mains, the manufacturer shall specify a maximum and minimum voltage. Conduct the tests at the maximum and the minimum voltage.

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

5.23.3 Requirements

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

The lower response threshold value y_{min} shall not be less than 0,2 or m_{min} shall not be less than 0,05 dB/m.

5.24 Polarity reversal

5.24.1 Object of test

The object of the test is to demonstrate the ability of the specimen to function properly after being misconnected with respect to polarity.

5.24.2 Test procedure

For battery-operated smoke alarms (including secondary power source batteries or equivalent) intended to be connected to a polarized terminal arrangement, reverse the polarity for 10 s to 15 s, if it is possible to establish the reversed connection with the intended battery type without causing mechanical damage to the smoke alarm.

Unless a fault condition or alarm condition occurs, maintain this condition for 2 h.

For mains-operated smoke alarms, reverse the polarity of the supply lines. Unless a fault condition or alarm condition occurs, maintain this condition for 2 h.

For interconnectable smoke alarms, connect the interconnect leads with the polarity reversed. Unless a fault condition or alarm condition occurs, maintain this condition for 2 h.

Following the reverse-polarity conditioning, connect the specimen to its power source as specified in 5.1.3 and measure its response threshold value as in 5.1.6.

Where the primary power source is internal or a secondary power source is included, determine the voltage (V_E) at which the battery-low condition occurs as specified in 5.17.2.

Of the two response threshold values for the specimen in this test and the initial sensitivity test, designate the greater as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

5.24.3 Requirements

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

Where the primary power source is internal or a secondary power source is included and the voltage V_E is applied, a battery-low condition shall occur after the polarity reversal test. The battery-low condition voltage (V_E) determined after the polarity reversal test shall be within 5 % of the battery-low condition voltage determined prior to the test.

5.25 Secondary power source

5.25.1 Object of test

The object of the test is to demonstrate that the specimen will enter a fault condition when the secondary power source is depleted, open-circuited and short-circuited.

5.25.2 Test procedure

Connect the specimen to the primary power source and secondary power source, then follow the test procedure specified in 5.17.

Restore the specimen to the normal condition, then disconnect the primary power source and repeat the test procedure specified in 5.17.

Restore the specimen to the normal condition, then disconnect the secondary power source.

Restore the specimen to the normal condition, then disconnect the secondary power source and immediately apply a short-circuit between the secondary power source terminals.

5.25.3 Requirements

The specimen shall enter the fault condition following each test step.

5.26 Electrical safety

5.26.1 Object of test

The object of the test is to demonstrate that the specimen provides adequate personal protection against hazardous currents passing through the human body (electric shock), excessive temperature and the start and spread of fire.

5.26.2 Test procedure

5.26.2.1 Heating under normal operating conditions

Assess the apparatus in accordance with the requirements of IEC 60065:2005, Clause 7.

5.26.2.2 Shock hazard under normal operating conditions

Assess the apparatus in accordance with the requirements of IEC 60065:2005, Clauses 8 and 9, when mounted in any orientation on a vertical surface and when mounted on the underside of a horizontal surface.

The requirement of IEC 60065:2005, 9.1.6, shall apply to the pins of an appliance inlet on the apparatus following withdrawal of the connector attached to the mains supply wires.

5.26.2.3 Insulation requirements

For an apparatus intended to be operated from a supply greater than 34 V (peak or d.c.), assess the apparatus in accordance with the requirements of IEC 60065:2005, Clause 10, disregarding the test specified in 10.1.

5.26.2.4 Fault conditions

Assess the apparatus in accordance with the requirements of IEC 60065:2005, Clause 11.

5.26.2.5 Mechanical strength

Assess the apparatus in accordance with the requirements of IEC 60065:2005, Clause 12, disregarding 12.1.1, 12.1.3 and 12.1.4.

5.26.2.6 Clearances and creepage distances

Assess the apparatus in accordance with the requirements of IEC 60065:2005, Clause 13.

5.26.2.7 Components

Assess the following components for conformance with the relevant requirements of IEC 60065:2005, Clause 14:

- resistors, capacitors, inductors and transformers (whose short-circuiting or disconnection would cause an infringement of the requirements for operation under fault conditions, with respect to overheating, fire or shock hazard);
- protective devices, switches, safety interlocks, voltage-setting devices and the housing arrangements for batteries; and
- power, voltage and current ratings, as appropriate, of all components for suitability for the application for which they are used.

Conformity shall be checked by circuit measurement, analysis of the circuit design, measurements on the components in question and by inspection, as appropriate.

5.26.2.8 Protection against the start and spread of fire

Assess the apparatus in accordance with the requirements of IEC 60065, Clause 20.

5.26.2.9 Wiring connections

Assess the apparatus in accordance with the requirements of IEC 60950-1:2005, 3.2 and 3.3.

5.26.3 Requirements

The specimen shall satisfy the requirements of the tests.

5.27 Sequence timing for smoke alarms with voice

5.27.1 Object of the test

The object of the test is to verify that the signal sequence and timing of the voice message and the warning signal are within the requirements.

5.27.2 Test procedure

Connect the specimen to a suitable power supply and set it to the minimum voltage declared by the manufacturer.

Activate the following sound sequence.

- Measure the time differences between the signals at the start of the aural sequence and at the end of the aural sequence.

— Repeat the measurements six times at 5 min intervals.

— Repeat the procedure with the power supply set to the maximum voltage declared by the manufacturer.

5.27.3 Measurements during conditioning

For each sound sequence, measure the sequence and duration of the warning signal, silence periods and voice message.

5.27.4 Requirements

The measurements of 5.27.3 shall be within the limits specified in 4.20.3.

6 Test report

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

a) identification of the smoke alarm tested;

b) reference to this International Standard (ISO 12239:2010);

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

d) conditioning period and the conditioning atmosphere;

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

f) details of the power source;

g) details of any deviation from this International Standard or from the International Standards to which reference is made; and

h) details of any operations regarded as optional.

Annex A
(normative)

Smoke tunnel for response-threshold value measurement

This annex specifies those properties of the smoke tunnel which are of primary importance for making repeatable and reproducible measurements of response threshold values of smoke detectors. However, since it is not practical to specify and measure all parameters which may influence the measurements, the background information in Annex K should be carefully considered and taken into account when a smoke tunnel is designed and used to make measurements in accordance with this International Standard.

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 detector 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 detector mounting arrangement shall not unduly obstruct the air flow between the board and the tunnel ceiling.

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

Both aerosol density measurements, m, expressed 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.

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

Only one 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.

Annex B
(normative)

Test aerosol for response threshold value measurements

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

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

— particle mass distribution;

— optical constants of the particles;

— particle shape;

— particle structure.

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

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

Annex C
(normative)

Smoke-measuring instruments

C.1 Obscuration meter

The response threshold of 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.

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

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

where

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

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

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

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

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

The effective radiated power of the light beam shall be:

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

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

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

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

C.2 Measuring ionization chamber (MIC)

C.2.1 General

The response threshold of 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 detector, at the moment that it generates an alarm condition.

C.2.2 Operating method and basic construction

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

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

The principle of operation of the measuring ionization chamber is shown in Figure C.1. The measuring chamber contains a measuring volume and a suitable means by which the sampled air is sucked in and passes the measuring volume in such a way that the aerosol/smoke particles diffuse into this volume. This diffusion is such that the flow of ions within the measuring volume is not disturbed by air movements.

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

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

$$Z \times \bar{d} = \eta \times y \qquad \text{and} \qquad y = \left(\frac{I_\text{o}}{I}\right) - \left(\frac{I}{I_\text{o}}\right)$$

where

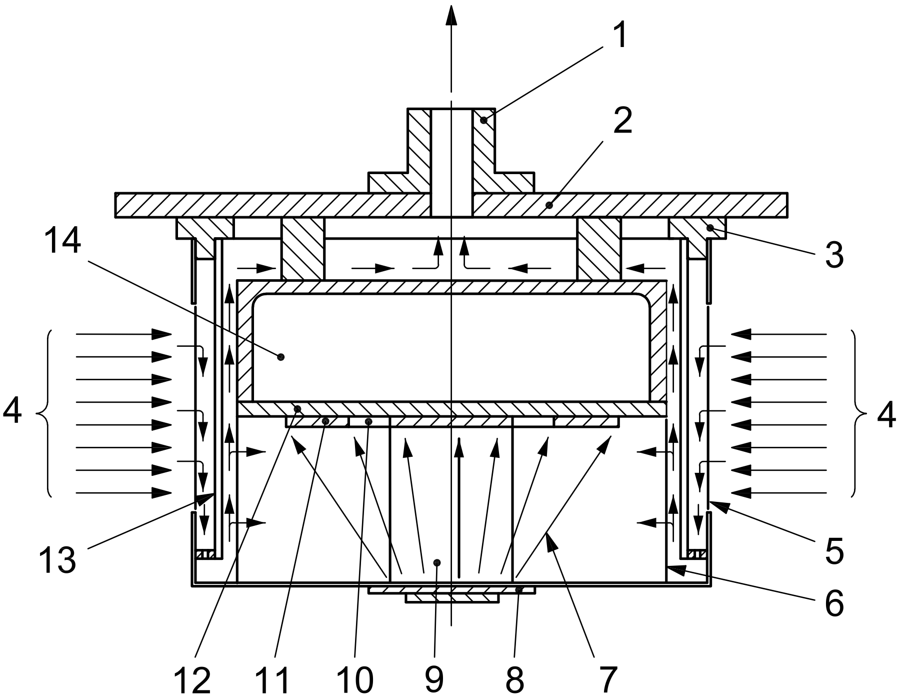
I_o is the chamber current in air without test aerosol or smoke;

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 C.1 — Measuring ionization chamber — Method of operation

C.2.3 Technical data

a) Radiation source

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

b) Ionization chamber

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

pressure: (101,3 ± 1) kPa;

temperature: (25 ± 2) °C;

relative humidity: (55 ± 20) %;

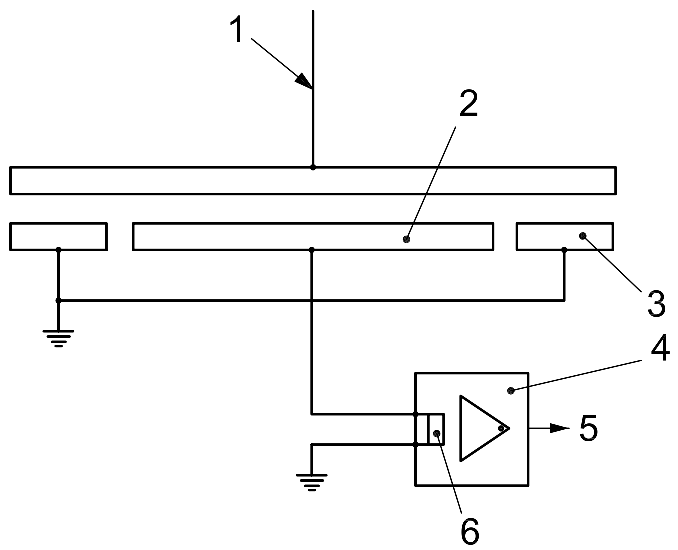
with the potential of the guard ring within ± 0,1 V of the voltage of the measuring electrode.

c) Current measuring amplifier

The chamber is operated in the circuit shown in Figure C.2, with the supply voltage such that the chamber current between the measuring electrodes is 100 pA in aerosol- or smoke-free air. The input impedance of the current measuring device shall be $< 10^9$ Ω.

d) Suction system

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



Key

1 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 C.2 — Measuring ionization chamber — Operating circuit

Annex D
(normative)

Apparatus for dazzling test

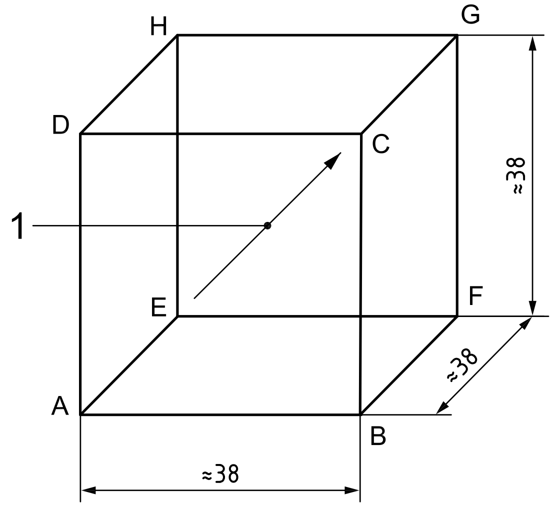
The dazzling apparatus [see Figure D.1 a)] shall be constructed so that it can be inserted in the working section of the smoke tunnel. The apparatus is cube-shaped, with four of the cube faces (ABFE, AEHD, BFGC and EFGH) closed and lined on the inside with high-gloss aluminium foil. The other two opposing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

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

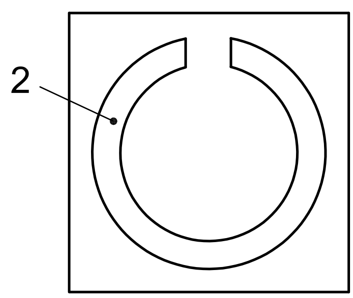
The smoke detector to be tested shall be installed in the centre of the upper cube face [see Figure D.1 a)] so that light can play on it from all directions.

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

Dimensions in centimetres



a)



b)

Key

1 stream of aerosol

2 fluorescent lamp

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

Annex E
(normative)

Apparatus for impact test

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

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

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

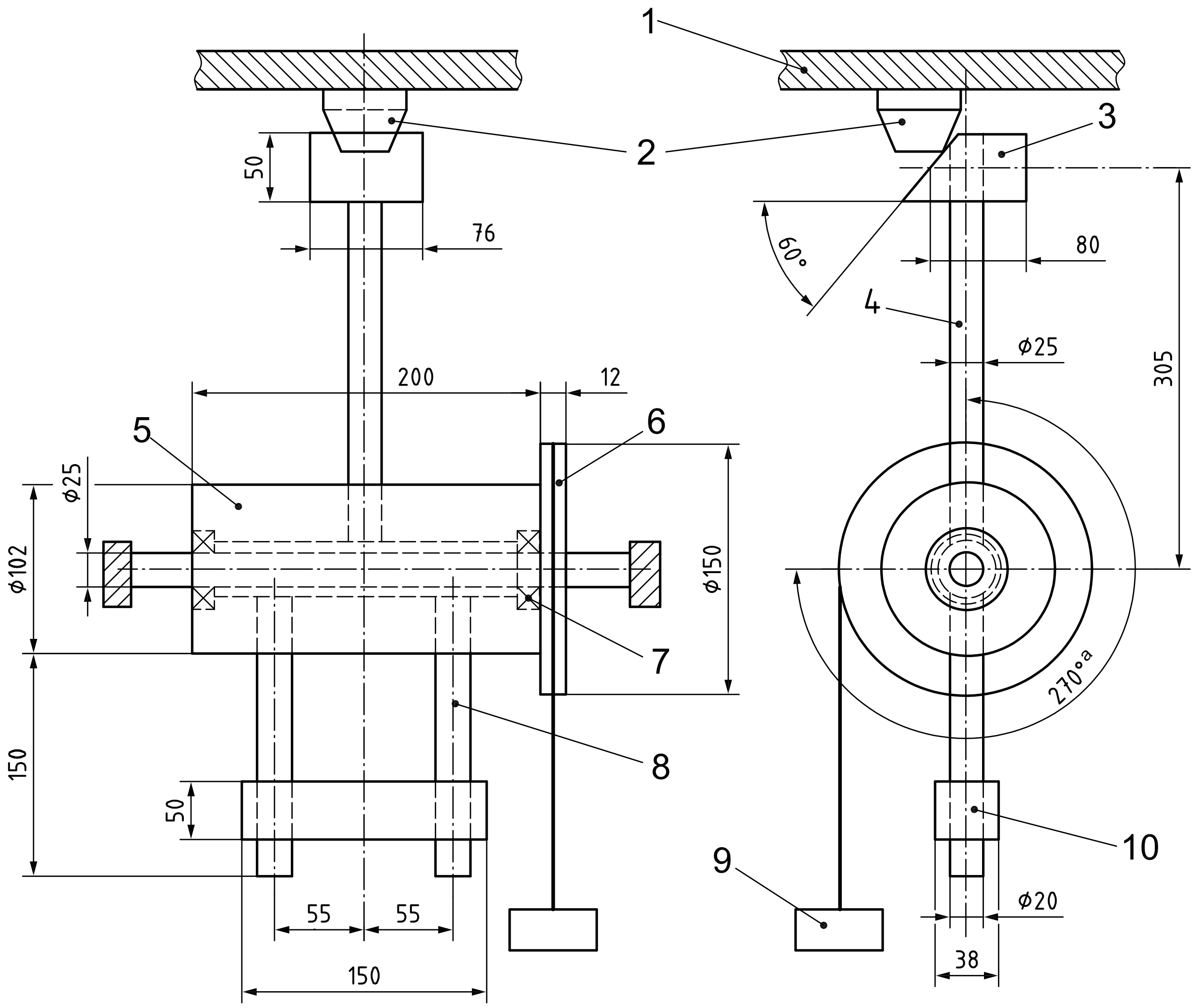
Diametrically opposite the hammer shaft are two steel counter-balance arms, each 20 mm in outside diameter and 185 mm long. These arms are screwed into the boss so that the length of 150 mm protrudes. A steel counter-balance weight is mounted on the arms so that its position can be adjusted to balance 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.

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.

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.

As this International Standard 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.

Dimensions in millimetres



Key

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

[a] Angle of movement.

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

Figure E.1 — Impact apparatus

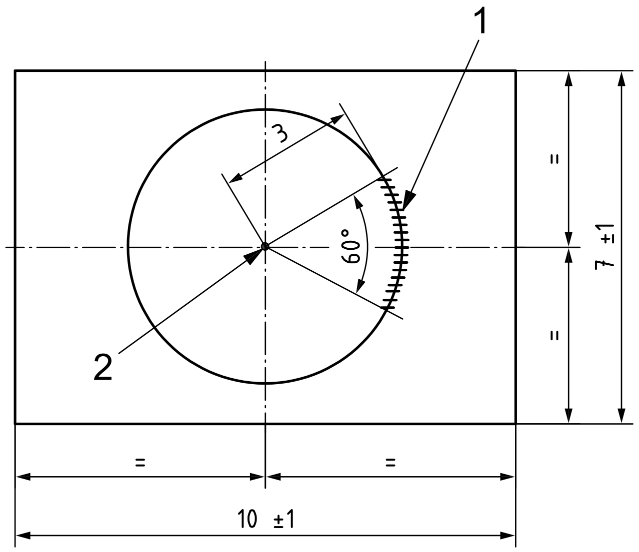
Annex F
(normative)

Fire test room

The 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.

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

Dimensions in metres



Key

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

2 position of test fire

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

The dimensions of the test room shall be within the following limits:

Length: (10 ± 1) m;

Width: (7 ± 1) m;

Height: (4 ± 0,2) m.

The ceiling and walls shall be flat with no obstructions between the fire source and the detectors and instrumentation. The fire source shall be centred as much as possible with respect to the four walls to minimize reflection of smoke.

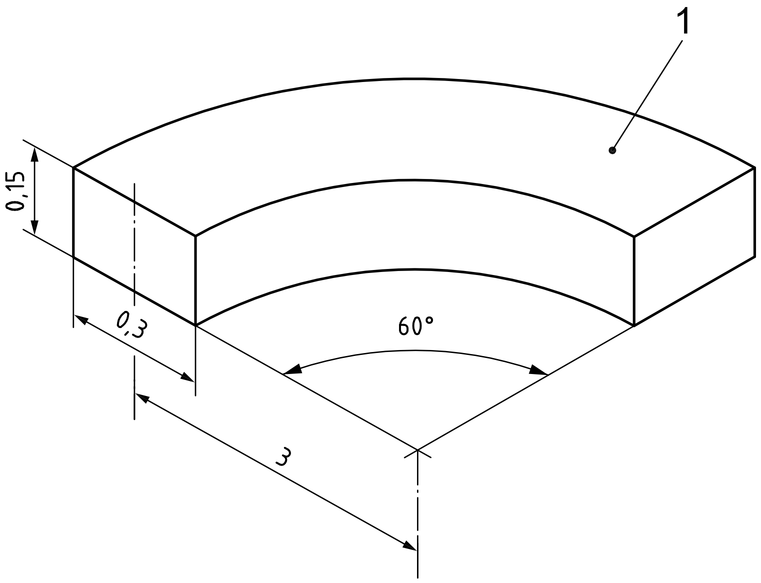
The fire test room shall be equipped with the following measuring instruments:

— measuring ionization chamber (MIC);

— obscuration meter;

— temperature probe.

Dimensions in metres



Key

1 ceiling

Figure F.2 — Mounting position for instruments and specimens

Annex G
(normative)

Smouldering pyrolysis wood fire (TF2)

G.1 Fuel

Approximately 10 dried beechwood sticks (moisture content ≈ 5 %), each stick having dimensions of 75 mm × 25 mm × 20 mm, are usually found sufficient.

G.2 Hotplate

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

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

G.3 Arrangement

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

G.4 Heating rate

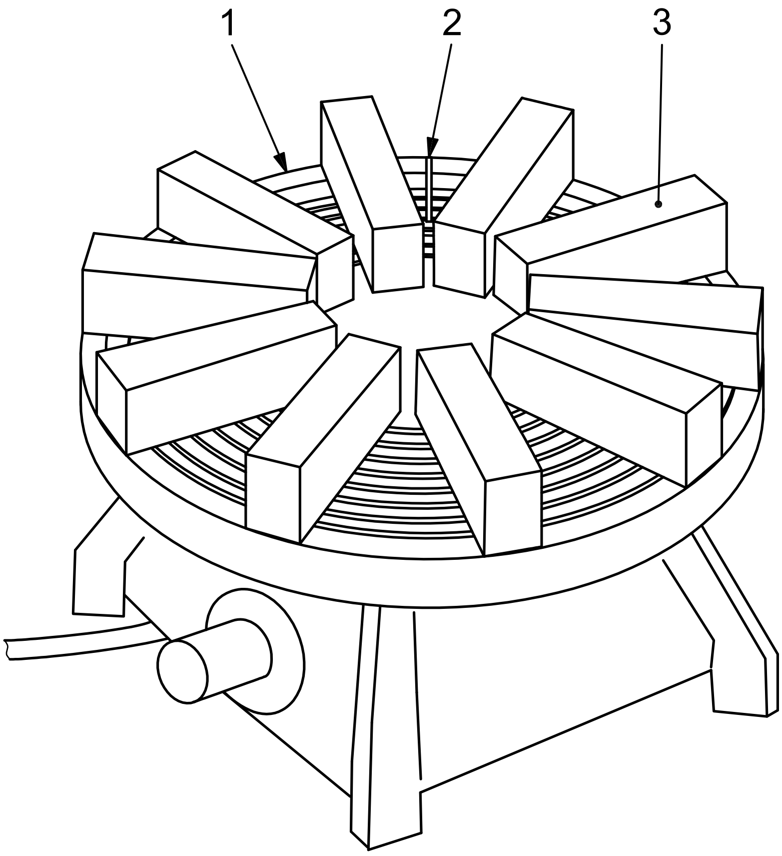
The hotplate shall be powered such that its temperature rises from ambient to 600 °C in approximately 11 min.

G.5 End-of-test condition

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

G.6 Test validity criteria

No flaming shall occur before the end-of-test condition has been reached. The development of the fire shall be such that the curves of m against y, and m against time, t, fall within the hatched areas shown in Figures G.2 and G.3, respectively. That is, $1{,}23 \leqslant y \leqslant 2{,}05$ and $570 \leqslant t \leqslant 840$ at the end-of-test condition $m_E = 2$ dB/m.



Key

1 grooved hotplate
2 temperature sensor
3 wooden sticks

Figure G.1 — Arrangement of sticks on hotplate

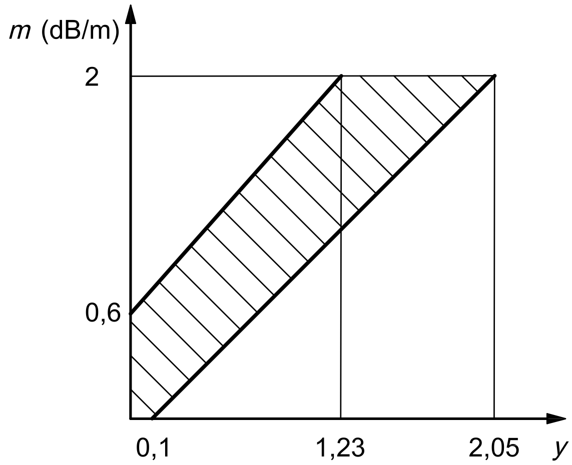


Figure G.2 — Limits for m against y, Fire TF2

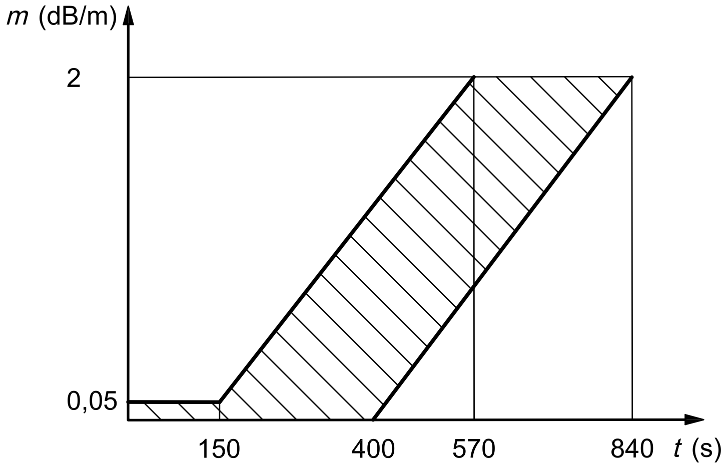


Figure G.3 — Limits for m against time, t, Fire TF2

Annex H
(normative)

Glowing smouldering cotton fire (TF3)

H.1 Fuel

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

H.2 Arrangement

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

Dimensions in metres

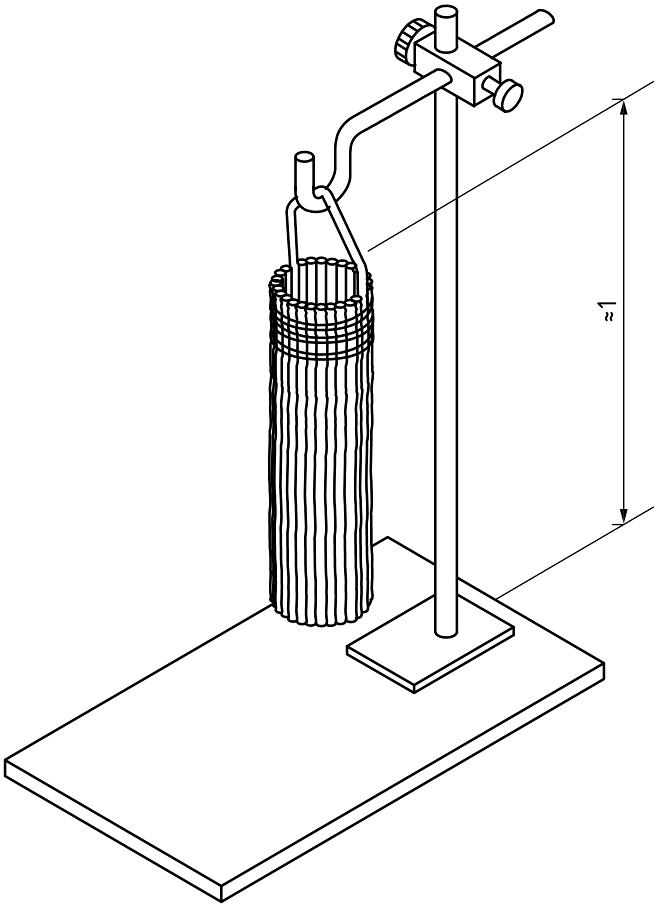


Figure H.1 — Arrangement of cotton wicks

H.3 Ignition

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

H.4 End-of-test condition

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

H.5 Test validity criteria

The development of the fire shall be such that the curves of m against y, and m against time, t, fall within the hatched areas shown in Figures H.2 and H.3, respectively. That is, at the end-of-test condition $m_E = 2$ dB/m, $3{,}2 \leqslant y \leqslant 5{,}33$ and $280 \leqslant t \leqslant 750$.

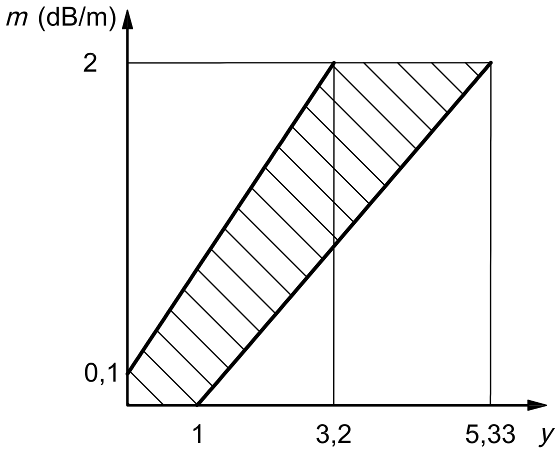


Figure H.2 — Limits for m against y, Fire TF3

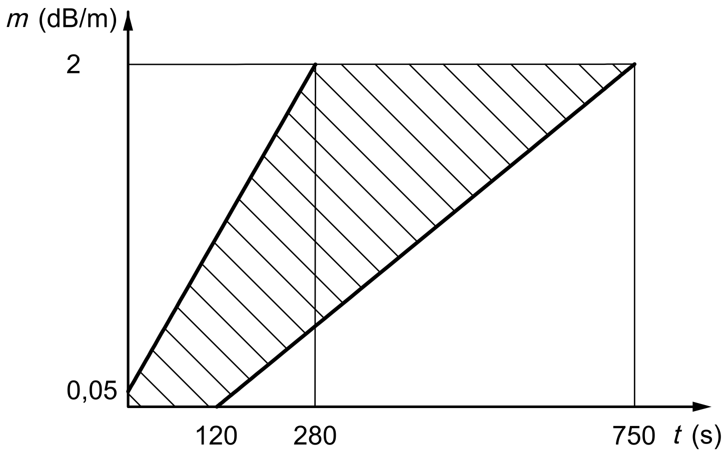


Figure H.3 — Limits for m against time, t, Fire TF3

Annex I
(normative)

Flaming plastics (polyurethane) fire (TF4)

I.1 Fuel

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

I.2 Arrangement

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

I.3 Ignition

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

I.4 End-of-test condition

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

I.5 Test validity criteria

The development of the fire shall be such that the curves of m against y, and m against time, t, fall within the hatched areas shown in Figures I.1 and I.2, respectively. That is, at the end-of-test condition $y_E = 6$, $1{,}27 \leqslant m \leqslant 1{,}73$ and $140 \leqslant t \leqslant 180$.

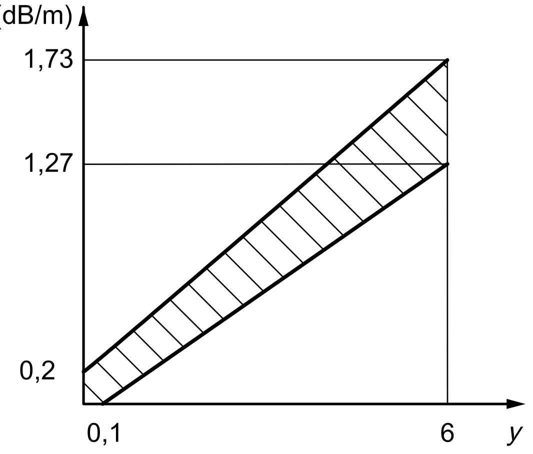


Figure I.1 — Limits for m against y, Fire TF4

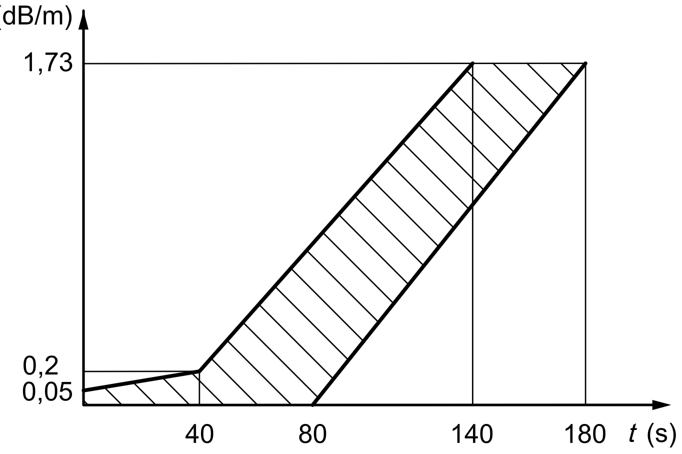


Figure I.2 — Limits for m against time, t, Fire TF4

Annex J
(normative)

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

J.1 Fuel

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

J.2 Arrangement

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

J.3 Ignition

Ignition shall be by flame or spark, etc.

J.4 End-of-test condition

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

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

J.5 Test validity criteria

The development of the fire shall be such that the curves of m against y, and m against time, t, fall within the hatched areas shown in Figures J.1 and J.2, respectively. That is, at the end-of-test condition $y_E = 6$, $0{,}92 \leqslant m \leqslant 1{,}24$ (except for the special case above, for which $m \leqslant 1{,}1$) and $120 \leqslant t \leqslant 240$.

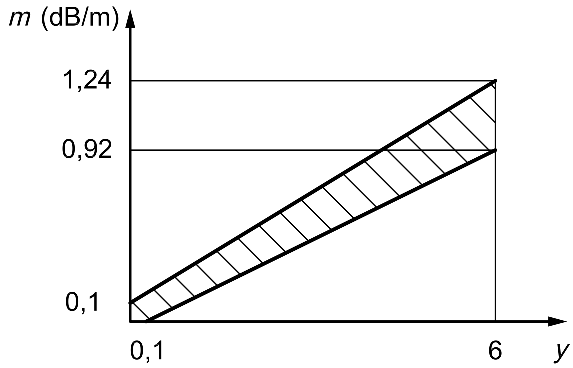


Figure J.1 — Limits for m against y, Fire TF5

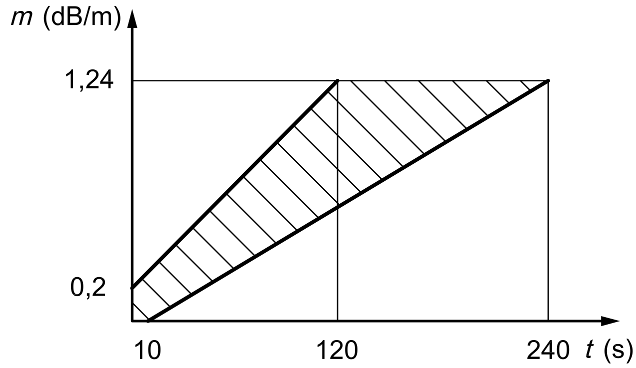


Figure J.2 — Limits for m against time, t, Fire TF5

Annex K
(informative)

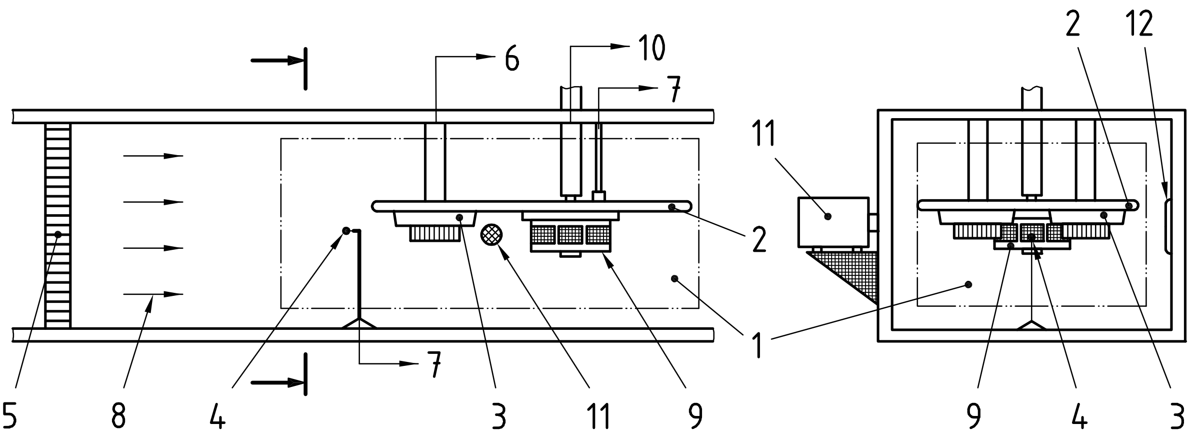
Information concerning the construction of the smoke tunnel

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

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

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

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



Key

1 working volume
2 mounting board
3 detector(s) under test
4 temperature sensor
5 low 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 K.1 — Smoke tunnel — Working section side view and cross-section

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

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

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

Annex L
(informative)

Information concerning the construction of the measuring ionization chamber

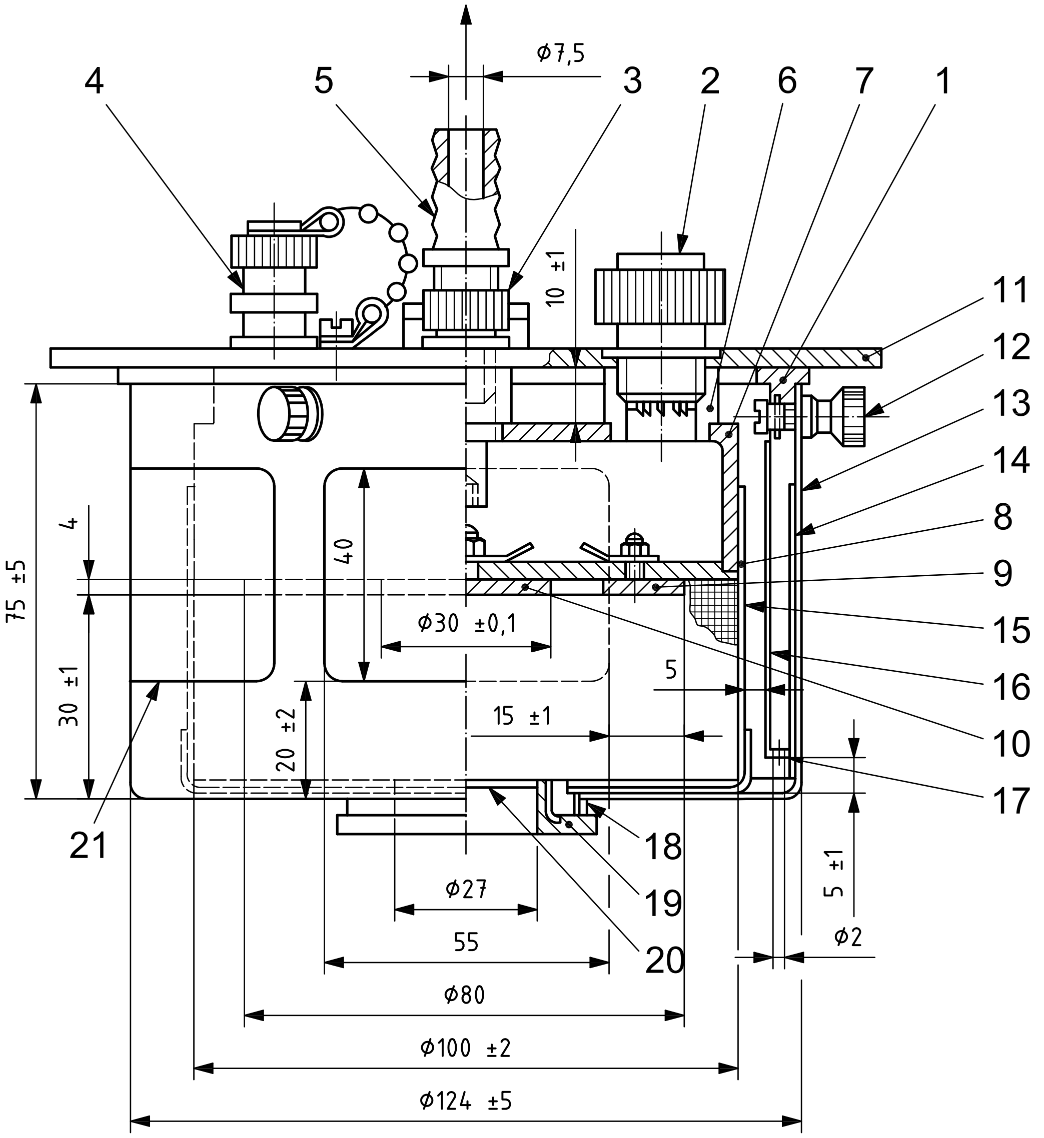
The mechanical construction of the measuring ionization chamber (MIC) is shown in Figure L.1. The functionally important dimensions are marked with their tolerances. Further details of the various parts of the device are given in Table L.1.

NOTE The MIC 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.

Table L.1 — List of parts of the MIC

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

Dimensions in millimetres



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

NOTE 2 Dimensions without a tolerance marked are recommended dimensions.

Figure L.1 — Mechanical construction of measuring ionization chamber

ICS 13.220.20

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