INTERNATIONAL STANDARD

ISO 7240-22

First edition
2007-05-15

Fire detection and alarm systems —

Part 22:
Smoke-detection equipment for ducts

Systèmes de détection et d'alarme d'incendie —

Partie 22: Équipement de détection des fumées dans les conduits

Reference number
ISO 7240-22:2007(E)

Contents

Page

Foreword

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

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

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

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

ISO 7240-22 was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 3, *Fire detection and alarm systems*.

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

— *Part 1: General and definitions*

— *Part 2: Control and indicating equipment*

— *Part 4: Power supply equipment*

— *Part 5: Point-type heat detectors*

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

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

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

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

— *Part 10: Point-type flame detectors*

— *Part 11: Manual call points*

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

— *Part 13: Compatibility assessment of system components*

— *Part 14: Guidelines for drafting codes of practice for design, installation and use of fire detection and fire alarm systems in and around buildings* [Technical report]

— *Part 15: Point type fire detectors using scattered light, transmitted light or ionization sensors in combination with a heat sensor*

- *Part 16: Sound system control and indicating equipment*
- *Part 19: Design, installation, commissioning and service of sound systems for emergency purposes*
- *Part 21: Routing equipment*
- *Part 22: Smoke-detection equipment for ducts*

The following parts are under preparation:

- *Part 26, dealing with oil-mist detectors*
- *Part 27, dealing with carbon fire detectors using optical or ionization smoke sensors, electrochemical cell carbon monoxide sensors and heat sensors*
- *Part 28, dealing with fire protection control equipment*

Introduction

Smoke-detection equipment for ducts (s.d.e.d.) is used as part of a fire detection system to sample the environment within air ducts of a building. Detection of smoke releases a signal to the connected control and indicating equipment and can be used as a signal to an air-handling system to prevent the spread of smoke within the building.

A fire-detection and alarm system is required to function satisfactorily not only in the event of a fire, but also during and after exposure to conditions likely to be met in practice such as corrosion, vibration, direct impact, indirect shock and electromagnetic interference. Some tests specified are intended to assess the performance of the s.d.e.d. under such conditions.

The performance of s.d.e.d. is assessed from results obtained in specific tests. This part of ISO 7240 is not intended to place any other restrictions on the design and construction of such equipment.

Fire detection and alarm systems —

Part 22: Smoke-detection equipment for ducts

1 Scope

This part of ISO 7240 specifies requirements, test methods and performance criteria for smoke-detection equipment for ducts (s.d.e.d.) for use in fire-detection and fire alarm systems installed in buildings; see ISO 7240-1.

The s.d.e.d. samples the air from a duct and detects smoke in the sample.

NOTE 1 A common method of operation is to use differential pressure arising from airflow in the duct.

The s.d.e.d. can use smoke detectors complying with ISO 7240-7 or other detectors complying with tests specified in this part of ISO 7240.

A common application for s.d.e.d. is to detect visible smoke, for which detectors using scattered light or transmitted light can be more suitable. However, requirements for detectors using ionization are also included in this part of ISO 7240 for use in applications where detection of less visible fire aerosols is desired.

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

NOTE 2 Certain types of detectors contain radioactive materials. The national requirements for radiation protection differ from country to country and are not specified in this part of ISO 7240.

2 Normative references

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

ISO 209-1, *Wrought aluminium and aluminium alloys — Chemical composition and forms of products — Part 1: Chemical composition*

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

ISO 7240-7:2003, *Fire detection and fire alarm systems — Part 7: Point-type smoke detectors using scattered light, transmitted light or ionization*

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

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

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

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

IEC 60068-2-27:1987, *Environmental testing — Part 2: Test Ea and guidance: Shock*

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

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

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

3 Terms and definitions

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

3.1
response threshold value
A_{th}
aerosol concentration in the proximity of the specimen at the moment that it generates a signal which indicates the presence of smoke, when tested as specified in 5.1.5

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

3.2
smoke-detection equipment for ducts
s.d.e.d.
apparatus with an integral or associated point-type smoke detector that samples the air moving in a duct and detects smoke in the sample

4 General requirements

4.1 Compliance

In order to comply with this part of ISO 7240, the s.d.e.d. shall meet the requirements in 4.2 to 4.8, which shall be verified by visual inspection or engineering assessment, shall be tested as described in Clause 5 and shall meet the requirements of these tests.

4.2 Visual alarm indication

Each s.d.e.d. shall be provided with a red visual indicator, by which the s.d.e.d. can be identified when the associated detector releases an alarm and which remains illuminated until the alarm condition is reset. Where other conditions of the s.d.e.d. can be visually indicated, they shall be clearly distinguishable from the alarm indication, except when the s.d.e.d. is switched into a service mode. The alarm indicator may be the smoke detector indicator provided the indicator is visible when the detector is in-situ as part of the s.d.e.d.

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

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

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

4.3 Connection of ancillary devices

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

4.4 Monitoring of detachable detectors

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

4.5 Manufacturer's adjustments

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

4.6 On-site adjustment of response behaviour

If there is provision for on-site adjustment of the response behaviour of the s.d.e.d., then

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

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

These adjustments may be carried out at the s.d.e.d., the detector or the control and indicating equipment.

4.7 Marking

Each s.d.e.d. shall be clearly marked with the following information:

a) number of this part of ISO 7240 (i.e. ISO 7240-22);

b) name or trademark of the manufacturer or supplier;

c) model designation (type or number);

d) wiring-terminal designations;

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

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

The marking shall be visible during installation of the s.d.e.d. and shall be accessible during maintenance.

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

4.8 Data

Either the s.d.e.d. shall be supplied with sufficient technical, installation and maintenance data to enable correct installation and operation or, if all of this data is not supplied with each s.d.e.d. unit, reference to the appropriate data sheet shall be given on, or with, each s.d.e.d. unit. These data shall include

— the range of operating differential pressures between the inlet and outlet sampling tubes and the recommended method for measuring the pressures,

— the range of operating duct air velocities,

— the range of applicable duct sizes for specific sampling tube lengths, and

— the models of point smoke detectors for which the s.d.e.d. meets the requirements of this part of ISO 7240.

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

4.9 Requirements for software-controlled smoke-detection equipment for ducts

4.9.1 General

The requirements of 5.8.2 and 5.8.3 shall be met for s.d.e.d. that rely on software control in order to fulfil the requirements of this part of ISO 7240.

4.9.2 Software documentation

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

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

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

   2) the way in which the modules interact,

   3) the overall hierarchy of the program,

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

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

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

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

4.9.2.2 The manufacturer shall have available detailed design documentation, which needs to be provided only if required by the testing authority. It shall be comprised of at least the following:

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

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

   1) the name of the module,

   2) a description of the tasks performed, and

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

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

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

4.9.3 Software design

In order to ensure the reliability of the s.d.e.d., the following requirements for software design shall apply.

a) The software shall have a modular structure.

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

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

4.9.4 The storage of programs and data

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

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

5 Tests

5.1 General

5.1.1 Atmospheric conditions for tests

Unless otherwise stated in a test procedure, the testing shall be carried out 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.

5.1.2 Operating conditions for tests

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

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

5.1.3 Mounting arrangements

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

5.1.4 Tolerances

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

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

5.1.5 Response threshold value

Install the specimen for which the response threshold value, A_{th}, is being measured in the smoke tunnel described in Annex A, in its normal operating position, by its normal means of attachment.

NOTE This measurement can be taken only where the sampling apparatus of the s.d.e.d. can fit inside the smoke tunnel. Where the sampling apparatus is too large, it will be necessary to agree other arrangements with the manufacturer.

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

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

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

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

— for s.d.e.d. incorporating detectors using scattered or transmitted light, in decibels per metre per minute: $0{,}015 \leqslant \frac{\Delta m}{\Delta t} \leqslant 0{,}1$;

— for s.d.e.d. incorporating detectors 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 s.d.e.d., so that a response can be obtained in a reasonable time.

The rate of increase in aerosol density shall be similar for all measurements on a particular s.d.e.d. type.

Conduct tests on the s.d.e.d. specimen at each of the following air velocities:

a) the minimum specified by the manufacturer,

b) the maximum specified by the manufacturer, and

c) the mean of the minimum and maximum.

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

Designate the greater of the response threshold value as y_{max} or m_{max} for each air velocity; the lesser as y_{min} or m_{min} for each air velocity.

5.1.6 Provision for tests

The following shall be provided for testing compliance with this part of ISO 7240:

a) 13 s.d.e.d. specimens;

b) data required in 4.7.

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 twelve specimens found in the reproducibility test (5.3) should also represent the production mean, and that the limits specified in the response threshold value test should also be applicable to the manufacturer's production.

5.1.7 Test schedule

The specimens shall be tested according to the test schedule given in Table 1. After the reproducibility test, number the two least sensitive specimens (i.e. those with the highest response thresholds) 12 and 13, and the others 1 to 11 arbitrarily.

Table 1 — Test schedule

Test	Subclause	Specimen number(s)
Repeatability	5.2	One chosen arbitrarily
Reproducibility	5.3	All specimens
Variation of supply parameters [a]	5.4	1
Dazzling [b]	5.5	2
Dry heat (operational)	5.6	3
Cold (operational)	5.7	4
Damp heat, steady state (operational)	5.8	5
Damp heat, steady state (endurance)	5.9	6
Sulfur dioxide, SO_2, corrosion (endurance)	5.10	7
Shock (operational)	5.11	8
Impact (operational)	5.12	9
Vibration, sinusoidal (operational)	5.13	10
Vibration, sinusoidal (endurance)	5.14	10
Air leakage [c]	5.15	7, 10
Electromagnetic compatibility (EMC), Immunity tests (operational)	5.16	11
Fire sensitivity	5.17	12, 13

[a] This test duplicates a test undertaken as part of the assessment of point type smoke detectors for conformance to ISO 7240-7. Where the s.d.e.d. includes a smoke detector conforming to ISO 7240-7 and does not include any additional active electronic components, this test may be omitted.

[b] This test only applies to detectors using scattered or transmitted light principle of operation. Where the s.d.e.d. includes a smoke detector conforming to ISO 7240-7 or the sensing element is mounted within an opaque enclosure, this test may be omitted.

[c] Air leakage test is undertaken after the corrosion test and the vibration tests.

5.1.8 Test report

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

5.2 Repeatability

5.2.1 Object of test

To show that the s.d.e.d. has stable behaviour with respect to its sensitivity even after a number of alarm conditions.

5.2.2 Test procedure

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

Designate the maximum response threshold value as y_{max} or m_{max} for each air velocity, the minimum value as y_{min} or m_{min} for each air velocity.

5.2.3 Requirements

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

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.

5.3 Reproducibility

5.3.1 Object of test

To show that the sensitivity of the s.d.e.d. does not vary unduly from specimen to specimen and to establish response threshold value data for comparison with the response threshold values measured after the environmental tests.

5.3.2 Test procedure

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

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

Designate the maximum response threshold value as y_{max} or m_{max} for each air velocity, the minimum value as y_{min} or m_{min} for each air velocity.

5.3.3 Requirements

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

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.

5.4 Variation in supply parameters

5.4.1 Object of test

To show that, within the specified range(s) of the supply parameters (e.g. voltage), the sensitivity of the s.d.e.d. is not unduly dependent on these parameters.

5.4.2 Test procedure

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

Designate the greater of the response threshold value as y_{max} or m_{max}; the lesser as y_{min} or m_{min}.

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

5.4.3 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 be not less than 0,2, or m_{min} shall be not less than 0,05 dB/m.

5.5 Dazzling

5.5.1 Object of test

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

5.5.2 Test procedure

Mount the specimen as specified in 5.1.3 and connect it to supply and monitoring equipment as specified in 5.1.2. Install the dazzling apparatus (see Annex D) over the portion of the specimen mounted outside the duct, such that the smoke-sensing element and housing are fully enclosed by the apparatus. Perform the following procedure.

a) At the mean air velocity specified in 5.1.5, measure the response threshold value as specified in 5.1.5.

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

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

d) Then switch the five lamps OFF.

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

5.5.3 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.

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

5.6 Dry heat (operational)

5.6.1 Object of test

To demonstrate the ability of the s.d.e.d. to function correctly at high ambient temperatures that may occur for short periods in the service environment.

5.6.2 Test procedure

5.6.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-2, Test Bb, and in 5.6.2.2 to 5.6.2.4.

5.6.2.2 State of specimen during conditioning

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

5.6.2.3 Conditioning

Apply the following conditioning:

- tunnel air velocity: maximum is specified by the manufacturer;
- temperature: starting at an initial air temperature of (23 ± 5) °C, increase the air temperature in the smoke tunnel to (55 ± 2) °C;
- duration: maintain this temperature for 2 h.

NOTE Test Bb specifies rates of change of temperature of < 1 °C/min for the transitions to and from the conditioning temperature.

5.6.2.4 Measurements during conditioning

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

5.6.2.5 Final measurements

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

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

5.6.3 Requirements

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

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

5.7 Cold (operational)

5.7.1 Object of test

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

5.7.2 Test procedure

5.7.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-1, Test Ab, and in 5.7.2.2 to 5.7.2.5.

5.7.2.2 State of specimen during conditioning

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

5.7.2.3 Conditioning

Apply the following conditioning:

— tunnel air velocity: maximum is specified by the manufacturer;

— temperature: starting at an initial temperature of (23 ± 5) °C, decrease the air temperature in the smoke tunnel to (–10 ± 3) °C;

— duration: 16 h.

NOTE Test Ab specifies rates of change of temperature of $<$ 1 °C/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

After a recovery period of at least 1 h at the standard atmospheric conditions, measure the response threshold value at the mean air velocity specified in 5.1.5.

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

5.7.3 Requirements

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

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

5.8 Damp heat, steady state (operational)

5.8.1 Object of test

To demonstrate the ability of the s.d.e.d. to function correctly at high relative humidity (without condensation), which can occur for short periods in the anticipated service environment.

5.8.2 Test procedure

5.8.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-78, Test Cab, and in 5.8.2.2 to 5.8.2.5.

5.8.2.2 State of the specimen during conditioning

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

5.8.2.3 Conditioning

Apply the following conditioning:

— tunnel air velocity: maximum specified by the manufacturer;

— temperature: (40 ± 2) °C in the smoke tunnel;

— relative humidity: (93 ± 3) % in the smoke tunnel;

— duration: 4 d.

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

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

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

5.8.3 Requirements

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

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

5.9 Damp heat, steady state (endurance)

5.9.1 Object of test

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

5.9.2 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 5.9.2.4.

5.9.2.2 State of the specimen during conditioning

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

NOTE As power is not supplied to the specimen during conditioning, it is not necessary to mount the specimen in the smoke tunnel and it can be mounted on a plate simulating the smoke tunnel wall.

5.9.2.3 Conditioning

Apply the following conditioning to the whole of the s.d.e.d., including any portion that might not normally be mounted inside a duct:

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

5.9.2.4 Final measurements

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

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

5.9.3 Requirements

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

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

5.10 Sulfur dioxide, SO_2, corrosion (endurance)

5.10.1 Object of test

To demonstrate the ability of the s.d.e.d 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: Test Kc, but carry out the conditioning as specified in 5.10.2.3.

5.10.2.2 State of the specimen during conditioning

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

NOTE As power is not supplied to the specimen during conditioning, it is not necessary to mount the specimen in the smoke tunnel and it can be mounted on a plate simulating the smoke tunnel wall.

5.10.2.3 Conditioning

Apply the following conditioning to the whole of the s.d.e.d., including any portion that may not normally be mounted inside a duct:

— temperature: (25 ± 2) °C;

— relative humidity: (93 ± 3) %;

— SO_2 concentration: (25 ± 5) µl/l;

— duration: 21 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 at least 1 h at the standard atmospheric conditions. After this, mount the specimen as specified in 5.1.3 and measure the response threshold value at the mean air velocity as specified in 5.1.5.

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

5.10.3 Requirements

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

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

5.11 Shock (operational)

5.11.1 Object of test

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

5.11.2 Test procedure

5.11.2.1 Reference

Use the test apparatus and perform the procedure generally as specified in IEC 60068-2-27, Test Ea, but carry out the conditioning as specified in 5.11.2.3.

5.11.2.2 State of specimen during conditioning

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

5.11.2.3 Conditioning

For specimens with a mass $M < 4{,}75$ kg, apply the following conditioning:

- shock pulse type: half sine;
- pulse duration: 6 ms;
- peak acceleration: $10 \times (100 - 20M)$ m/s^2 (where M is the mass of the specimen in kilograms);
- number of directions: 6;
- pulses per direction: 3.

Do not test specimens with a mass $M > 4{,}75$ kg.

5.11.2.4 Measurements during conditioning

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

5.11.2.5 Final measurements

After the conditioning, mount the specimen as specified in 5.1.3 and measure the response threshold value at the mean air velocity as specified in 5.1.5.

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

5.11.3 Requirements

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

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

5.12 Impact (operational)

5.12.1 Object of test

To demonstrate the immunity of the s.d.e.d. to mechanical impacts upon its exposed surface that it can sustain in the normal shipping, installation and service environments, and which it can reasonably be expected to withstand.

5.12.2 Test procedure

5.12.2.1 Apparatus

The test apparatus (Annex E) shall consist of a swinging hammer incorporating a rectangular-section aluminium alloy head (aluminium alloy Al Cu_4SiMg complying with ISO 209-1, solution- and precipitation-treated condition) with the plane-impact face chamfered to an angle of 60° to the horizontal when in the striking position (i.e. when the hammer shaft is vertical). The hammer head shall be (50 ± 2,5) mm high, (76 ± 3,8) mm wide and (80 ± 4) mm long at mid-height.

5.12.2.2 State of specimen during conditioning

Mount the specimen rigidly to the apparatus by its normal mounting means and position it so that the portion of the s.d.e.d. that is not mounted within the duct (e.g. the detector housing) is struck by the upper half of the impact face when the hammer is in the vertical position (i.e. when the hammerhead is moving horizontally). Choose the azimuthal direction and the position of impact relative to the specimen as that most likely to impair the normal functioning of the specimen. Connect the specimen to its supply and monitoring equipment as specified in 5.1.2.

5.12.2.3 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.

5.12.2.4 Measurements during conditioning

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

5.12.2.5 Final measurements

After the conditioning, mount the specimen as specified in 5.1.3 and measure the response threshold value at the mean air velocity as specified in 5.1.5.

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

5.12.3 Requirements

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

The impact shall not detach the s.d.e.d. from the mounting.

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

5.13 Vibration, sinusoidal (operational)

5.13.1 Object of test

To demonstrate the immunity of the s.d.e.d. to vibration at levels considered appropriate to the normal service environment.

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 5.13.2.5.

5.13.2.2 State of specimen during conditioning

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

5.13.2.3 Conditioning

Apply the following conditioning:

- frequency range: (10 to 150) Hz;
- acceleration amplitude: 5 m/s^2 (≈ 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. It is necessary to make only one final measurement.

5.13.2.4 Measurements during conditioning

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

5.13.2.5 Final measurements

After the conditioning, visually inspect the specimen for mechanical damage both internally and externally. Then mount the specimen as specified in 5.1.3 and measure the response threshold value at the mean air velocity as specified in 5.1.5.

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

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

5.13.3 Requirements

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

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

5.14 Vibration, sinusoidal (endurance)

5.14.1 Object of test

To demonstrate the ability of the s.d.e.d. to withstand the long-term effects of vibration at levels appropriate to the shipping, installation and service environment.

5.14.2 Test procedure

5.14.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-6, Test Fc, and 5.14.2.2 to 5.14.2.4.

5.14.2.2 State of specimen during conditioning

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

5.14.2.3 Conditioning

Apply the following conditioning:

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

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

5.14.2.4 Final measurements

After the conditioning, mount the specimen as specified in 5.1.3 and measure the response threshold value at the mean air velocity as specified in 5.1.5.

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

5.14.3 Requirements

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

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

5.15 Air leakage

5.15.1 Object

To demonstrate the ability of the s.d.e.d. to remain sealed and thereby ensure minimum leakage to or from the sampled environment.

In the case where the s.d.e.d. is installed completely within the volume of the duct, it is not necessary to satisfy this test. However, installation instructions should include a clear method of installation such that the duct remains sealed. The instructions should also specify that other components of the s.d.e.d. are physically separated (independent from duct pressure) and only electrically connected.

5.15.2 Test procedure

5.15.2.1 State of specimen during conditioning

Mount each specimen as specified in 5.1.3 in a test apparatus that can be evacuated and pressurised (see Annex F). Do not supply it with power during conditioning.

5.15.2.2 Conditioning

Apply the following conditioning to each specimen.

- vacuum: Evacuate the s.d.e.d. to a differential pressure of −1,13 kPa.
- duration: 10 min.
- pressurise: Pressurize the s.d.e.d. to +3,0 kPa.
- duration: 10 min.

5.15.2.3 Final measurements

Measure the differential pressure for the evacuate test and the pressure test.

5.15.3 Requirements

The air leakage for the s.d.e.d. shall be not more than that amount in Table 2.

Table 2 — Maximum Leakage

Differential pressure after 10 min	
−1,13 kPa initial vacuum	+3,0 kPa initial pressure
⩽ −0,75 kPa	⩾ 2,0 kPa

5.16 Electromagnetic compatibility (EMC) immunity tests (operational)

5.16.1 The following EMC immunity tests shall be carried out as specified in EN 50130-4:

a) electrostatic discharge;

b) radiated electromagnetic fields;

c) conducted disturbances induced by electromagnetic fields;

d) fast transient bursts;

e) slow high-energy voltage surges.

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

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

- Measure the response threshold value at the mean air velocity as specified in 5.1.5.
- Designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as y_{max} or m_{max} and the lesser as y_{min} or m_{min}.

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

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.

5.17 Fire sensitivity

5.17.1 Object of test

To show that the s.d.e.d. has adequate sensitivity to visible smoke types required for general applications in fire detection systems for buildings.

5.17.2 Test procedure

5.17.2.1 Principle of test

The specimens are mounted in a duct leading from a standard fire-test room (see Annex A) and exposed to two test fires designed to produce smoke representative of the type that can impair visibility in a building, at two duct air velocities.

5.17.2.2 Test fires

Subject the specimens to the two test fires, TF2 and TF4. The type, quantity and arrangement of the fuel and the method of ignition for each test fire are specified in Annexes G and H, respectively, along with the end-of-test condition and the test validity criteria.

It is permissible, and can be necessary, to adjust the quantity, condition (e.g. moisture content) and arrangement of the fuel to obtain valid test fires.

5.17.2.3 Mounting of specimens

Mount the specimen as specified in 5.1.3 in the smoke tunnel (see Annex A).

Where the tube length specified by the manufacturer exceeds or is less than the width of the test tunnel, the sampling tube length should be adjusted to equal the width of the test tunnel. The adjusted tube length should provide the same number and size of equally spaced holes, as per the manufacturer's longest or shortest tube, whichever is appropriate.

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

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

5.17.2.4 Initial conditions

IMPORTANT — The stability of the air and temperature affects the smoke flow within the room. This is particularly important for the test fires that produce low thermal lift for the smoke (e.g. TF2). 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 and duct with clean air until it is free from smoke, so that the conditions given below can be obtained.

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

— air temperature, T: (23 ± 5) °C;

— airflow in the duct: adjusted to the minimum air velocity as specified by the manufacturer in 5.1.5;

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

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

5.17.2.5 Recording of the fire parameters and response values

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

Table 3 — Fire parameters

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

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

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

5.17.2.6 Repeat test

Repeat each test fire test, but at the maximum air velocity as specified by the manufacturer in 5.1.5.

5.17.3 Requirements

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

6 Test report

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

a) name and address of the testing organization;

b) name of manufacturer or agent;

c) identification of the s.d.e.d. tested;

d) reference to this part of ISO 7240;

e) a list of the information to meet the requirements of 5.1.7;

f) date of tests;

g) conditioning period and the conditioning atmosphere;

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

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

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

k) air velocities where the s.d.e.d. passed the tests in this part of ISO 7240;

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

m) any limitations of use;

n) statement indicating whether or not the s.d.e.d. complied with this part of ISO 7240.

Annex A
(normative)

Smoke tunnel and fire test room arrangement for response measurements

This annex specifies those properties of the smoke tunnel that are of primary importance for making repeatable and reproducible measurements of response threshold values of s.d.e.d. and the response of the s.d.e.d. to the test fires.

The smoke tunnel shall have a horizontal working section containing a working volume. The working volume is defined as the 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 sampling portion of s.d.e.d. being tested and the sensing parts of the measuring equipment. The s.d.e.d. being tested shall be mounted in its normal operating position with the air flow in the working volume.

The smoke tunnel shall be located close to the fire-test room so as to minimize changes that can occur in the smoke characteristics of the fire (see Annex I). The test fire room shall be as specified in ISO 7240-7:2003, Annex F. An arrangement shall be made to transfer unfiltered smoke from the fire test room to the duct. Air from the duct shall be drawn and replaced back into the test fire room in such a way so as to minimize the disturbance to the air in the test fire room. The duct smoke tunnel shall operate so as to draw air from the test fire room at the start and during the test fire.

It shall be possible to control the temperature at the required values, to increase the temperature in the working volume of the smoke tunnel at a rate not exceeding 1 K/min to 55 °C and decrease the temperature in the working volume of the smoke tunnel at a rate not exceeding 1 K/min to −10 °C.

It shall be possible to control the relative humidity at the required values to increase the relative humidity in the smoke tunnel to 93 %.

Both aerosol density measurements, m in dB/m 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 sensing apparatus.

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

Means shall be provided for creating a constant airflow, variable from (1 ± 0,2) m/s to (20 ± 4,0) m/s, throughout the working volume.

Only one s.d.e.d. specimen shall be mounted in the tunnel, unless it has been demonstrated that measurements made simultaneously on more than one specimen are in close agreement with measurements made by testing specimens 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 s.d.e.d. using scattered light or transmitted light is characterized by the absorbance index (extinction module) of the test aerosol, measured in the proximity of the alarm, at the moment that it generates an alarm signal.

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

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

where

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

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

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

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

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

The effective radiated power of the light beam shall be:

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

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

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

C.2.2 Operating method and basic construction

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

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 detector using ionization.

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

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

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

where

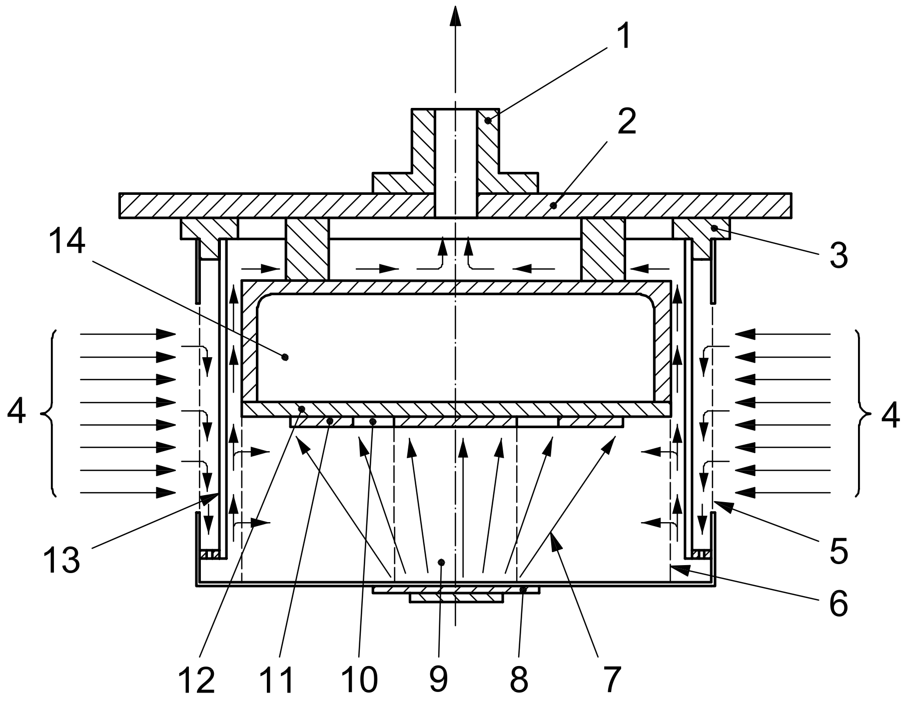
I_0 is the chamber current in air without test aerosol or smoke;

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

η is the chamber constant;

Z is the particle concentration in particles per cubic metre;

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



Key

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

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 $(1,9 \pm 0,095) \times 10^{11}\ \Omega$, 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) %;

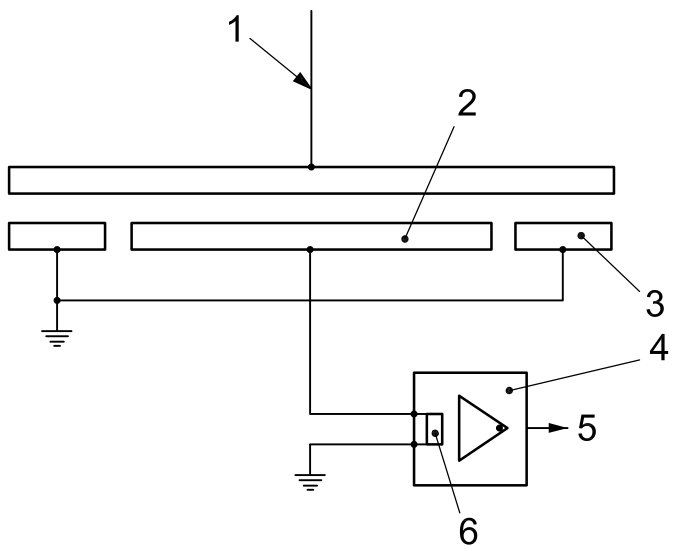
with the potential of the guard ring within ± 0,1 V of the voltage of the measuring electrode.

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 $< 10^9\ \Omega$.

d) Suction system:

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



Key

1 supply voltage

2 measuring electrode

3 guard ring

4 current measuring amplifier

5 output voltage proportional to chamber current

6 input impedance, $Z_{in} > 10^9\ \Omega$

Figure C.2 — Measuring ionization chamber — Operating circuit

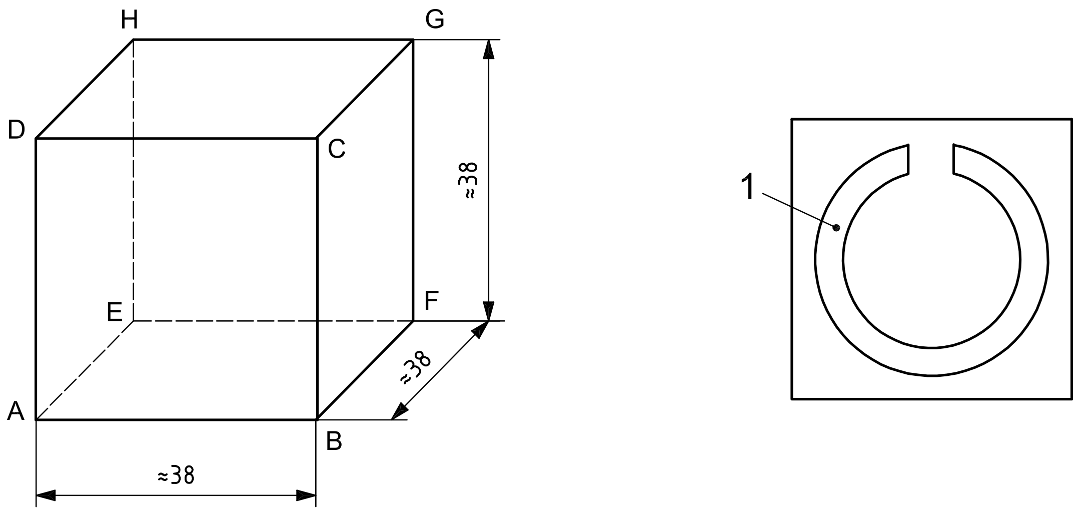
Annex D
(normative)

Apparatus for dazzling test

The dazzling apparatus [see Figure D.1 a)] shall be constructed so that it can be mounted over the s.d.e.d. sensing element. The apparatus is cube-shaped, with five of the cube faces (ABFE, AEHD, BFGC, EFGH and CDHG) closed and lined on the inside with high-gloss aluminium foil. The remaining cube face (ABCD) is open to allow the apparatus to be installed over the sensing element enclosure.

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 five closed surfaces of the cube. To obtain a stable light output, the tubes should be aged for 100 h and discarded at 2 000 h.

Dimensions in millimetres



a) b)

Key

1 fluorescent lamp

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

Annex E
(normative)

Apparatus for impact test

The apparatus for the impact test (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 with overall dimensions of 76 mm (width) × 50 mm (depth) × 94 mm (length) and is manufactured from aluminium alloy (Al Cu_4SiMg as specified in ISO 209-1), 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 depends on the bearings used.

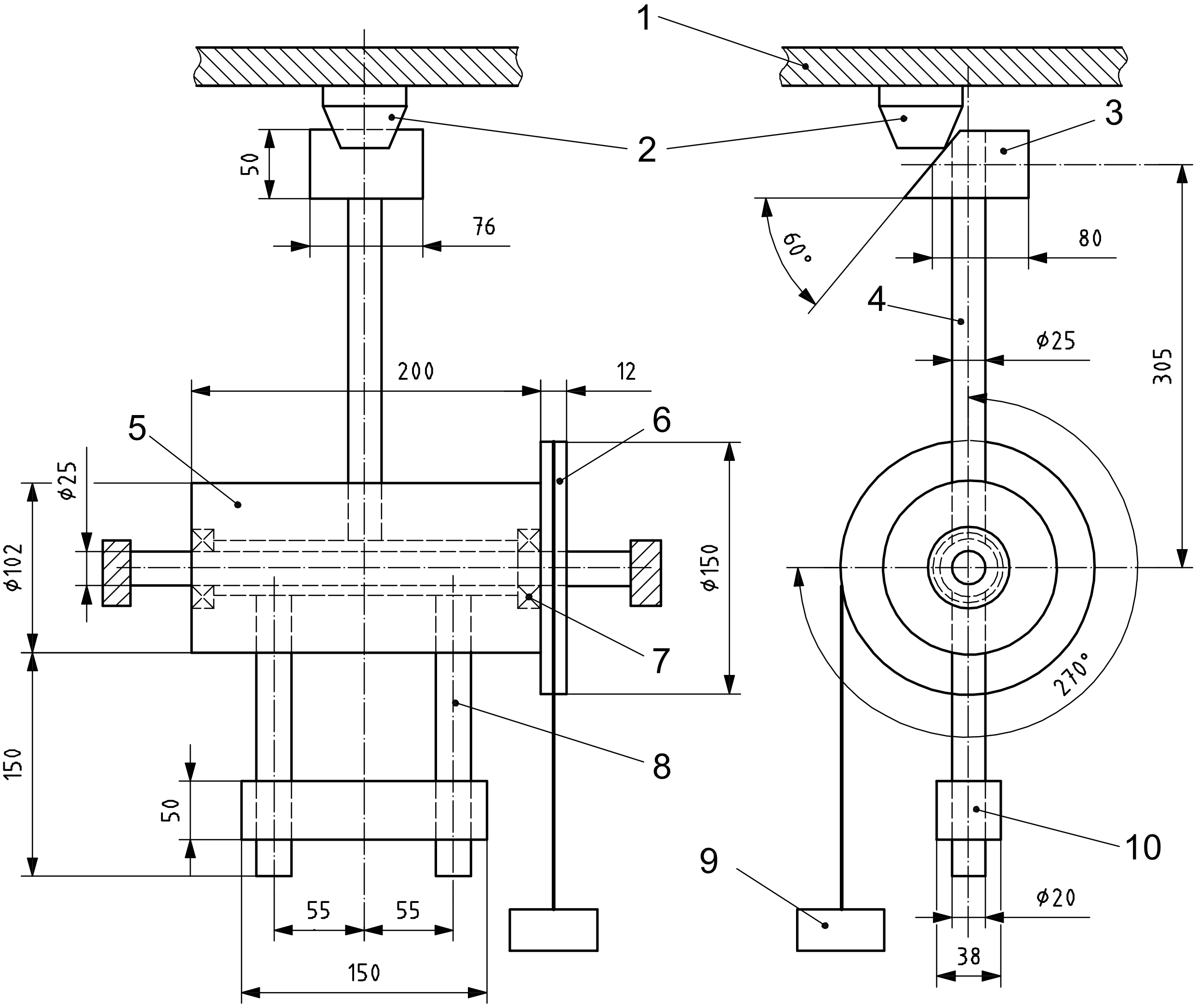
Diametrically opposite the hammer shaft are two steel counter-balance arms, each 20 mm in outside diameter and 185 mm long. These arms are screwed into the boss so that the length of 150 mm protrudes. A steel counter-balance weight is mounted on the arms so that its position can be adjusted to balance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

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

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

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

Dimensions in millimetres



Key

1 mounting board
2 exposed portion of s.d.e.d.
3 striker
4 striker shaft
5 boss
6 pulley
7 ball bearings
8 counter balance arms
9 operating weight
10 counter balance weight

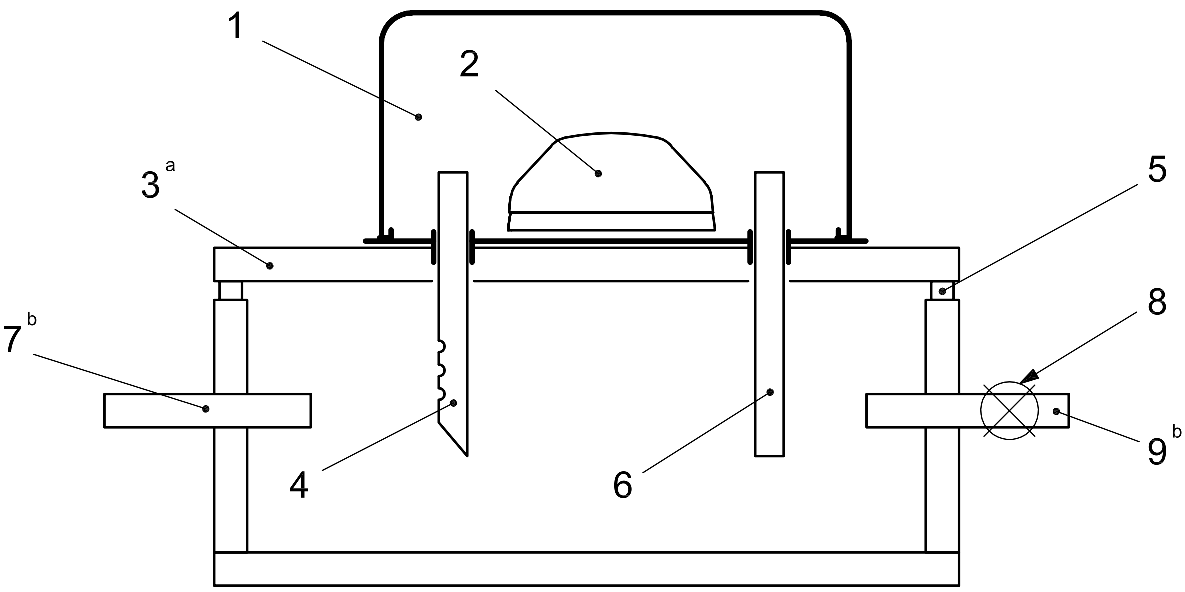
NOTE The dimensions, apart from those relating to the hammer head, are shown for guidance.

Figure E.1 — Impact apparatus

Annex F
(informative)

Air-leakage test apparatus

Figure F.1 shows an example of the apparatus and mounting method of s.d.e.d. to measure the air leakage of the s.d.e.d. when mounted on the side of a duct.



Key

1 smoke-detection equipment for ducts
2 smoke detector
3 flange plate
4 inlet sampling pipe
5 box seal
6 outlet sampling pipe
7 to pressure gauge
8 inlet valve
9 to pump

[a] The flange plate should be constructed from corrosion resistant material such as stainless steel.

[b] Outlets to the pump and the pressure gauge should be sealed at the entry point to the test apparatus.

Figure F.1 — Section view of air leakage test apparatus

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.

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

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.

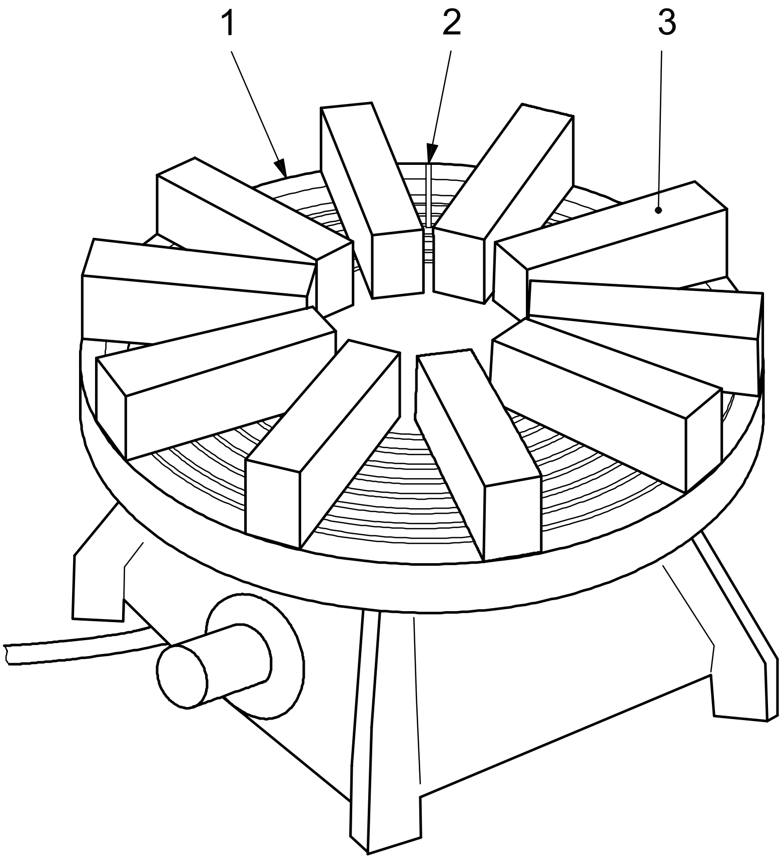
G.5 End-of-test condition

The end-of-test condition, m_E, shall be when m = 0,5 dB/m in the duct-tunnel working section (see Figure I.2) or the specimen has generated an alarm signal, whichever is the earlier. No flaming shall occur before the end-of-test condition has been reached.

G.6 Test validity criteria

The specimen shall generate an alarm signal before m = 0,5 dB/m in the duct-tunnel working section (see Figure I.2).

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, $y \leqslant 0{,}5$ and $225 \leqslant t \leqslant 540$ at the end-of-test condition m_E = 0,5 dB/m.



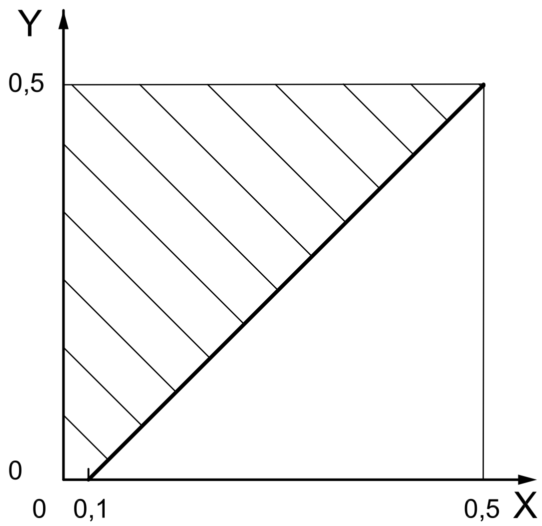
Key

1 grooved hotplate

2 temperature sensor

3 wooden sticks

Figure G.1 — Arrangement of sticks on hotplate

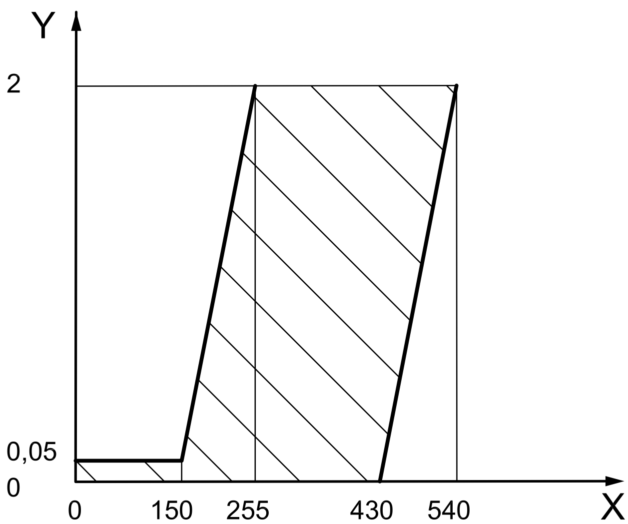


Key

X y-value

Y m-value, expressed in dB/m

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



Key

X time, expressed in seconds

Y m-value, expressed in dB/m

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

Annex H
(normative)

Flaming plastics (polyurethane) fire (TF4)

H.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.

H.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.

H.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.

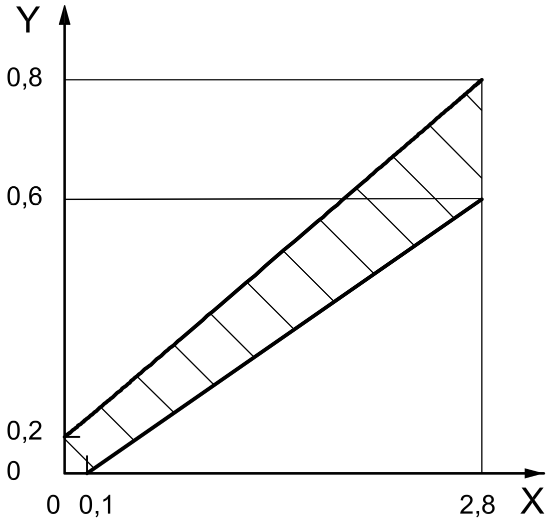
H.4 End-of-test condition

The end-of-test condition, m_E, shall be when m = 0,7 dB/m or all of the specimens have generated an alarm signal, whichever is the earlier.

H.5 Test validity criteria

The specimen shall generate an alarm signal before m = 0,7 dB/m in the duct-tunnel working section (see Figure I.2).

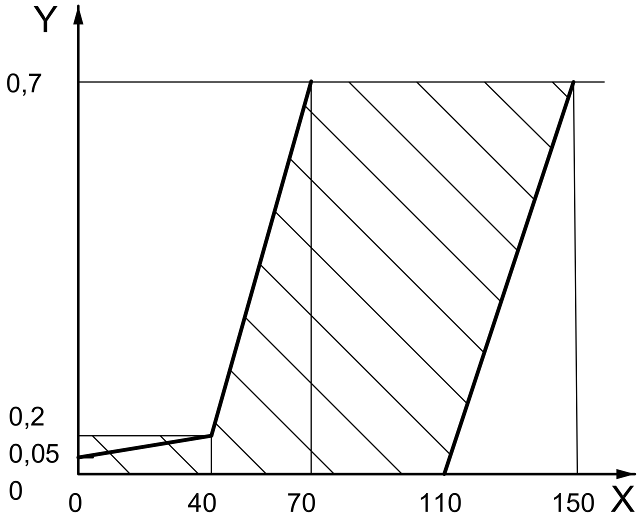
The development of the fire shall be such that the curves of m against y, and m against time, t, fall within the hatched areas shown in Figures H.1 and H.2, respectively. That is, at the end-of-test condition y_E = 2,8, $0,6 \leqslant m \leqslant 0,8$ and $70 \leqslant t \leqslant 150$.



Key

X *y*-value
Y *m*-value, expressed in dB/m

Figure H.1 — Limits of *m* against *y*, Fire TF4



Key

X time, expressed in seconds
Y *m*-value, expressed in dB/m

Figure H.2 — Limits of *m* against time, *t*, Fire TF4

Annex I
(informative)

Information concerning the construction of the smoke tunnel

Smoke-detection equipment for ducts described in this part of ISO 7240 respond when the signal(s) from one or more smoke sensors fulfil certain criteria. The smoke concentration at the sensor(s) is related to the smoke concentration surrounding the sampling tube(s) but the relationship is usually complex and dependent on several factors, such as orientation, mounting, air velocity, turbulence, rate of rise of smoke density, etc. The relative change of the response threshold value measured in the smoke tunnel is the main parameter considered when the stability of duct smoke detectors is evaluated by testing in accordance with this part of ISO 7240.

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

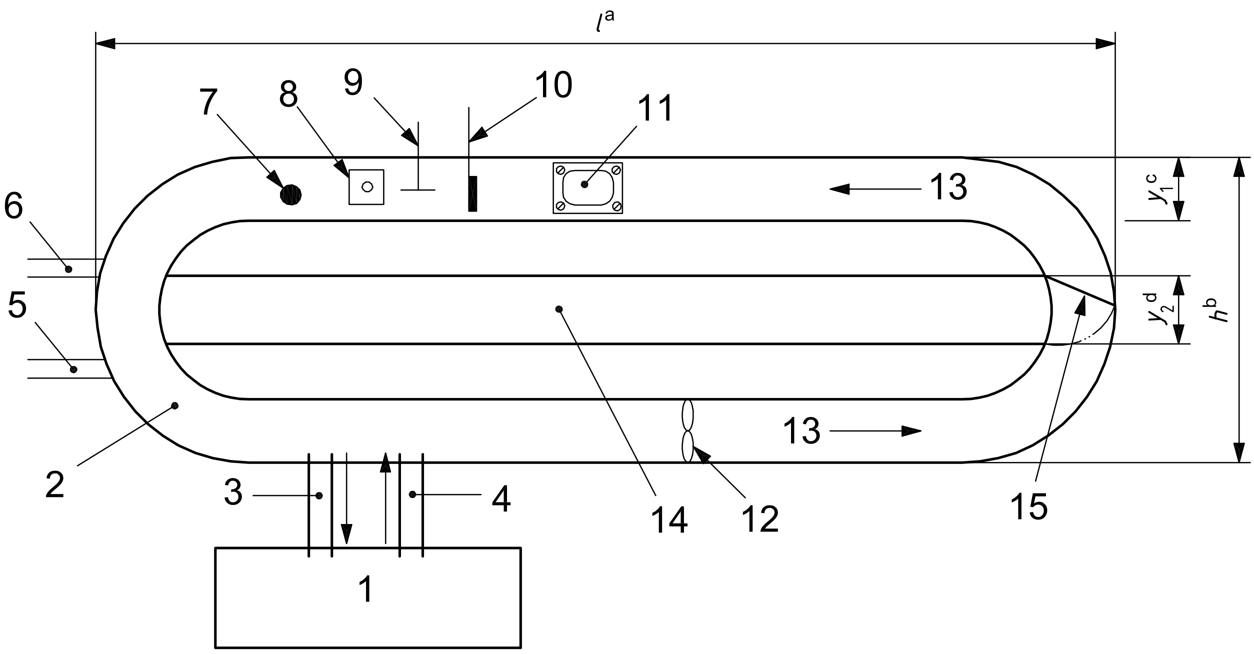
The response threshold value measurements require increasing aerosol density until the s.d.e.d. responds. This can be facilitated in a closed circuit smoke tunnel.

As the smoke tunnel is also used in for the test fires, a facility for drawing from and re-circulating smoke to the test fire room is also required. The design of the facility is critical to enable sufficient volume of smoke to enter the smoke tunnel and to achieve the required smoke concentration within the sensing volume before the test fire fuel burns out. It can be necessary to adjust the amount of fuel burnt accordingly. An example of a re-circulating smoke tunnel used in conjunction with a test fire room specified in ISO 7240-7 is shown in Figures I.1 and I.2.

Means for heating and cooling the air before it enters the working section are required. The tunnel should have a system capable of controlling the heating and cooling to achieve the specified temperatures and temperature profiles in the working volume. The 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 entrance openings in the chamber housing. However, the effect of the suction is negligible if the MIC is placed 10 cm to 15 cm downstream of the s.d.e.d.

It is recommended that the volume flow rate at which the smoke is extracted from the fire test room is kept as constant as possible for all tests, irrespective of the air velocity required. This may be achieved by feeding air from the fire test room into the test tunnel at a constant rate and using a regulating mechanism, such as a by-pass duct, which maintains the air velocity in the working section at the desired rate.

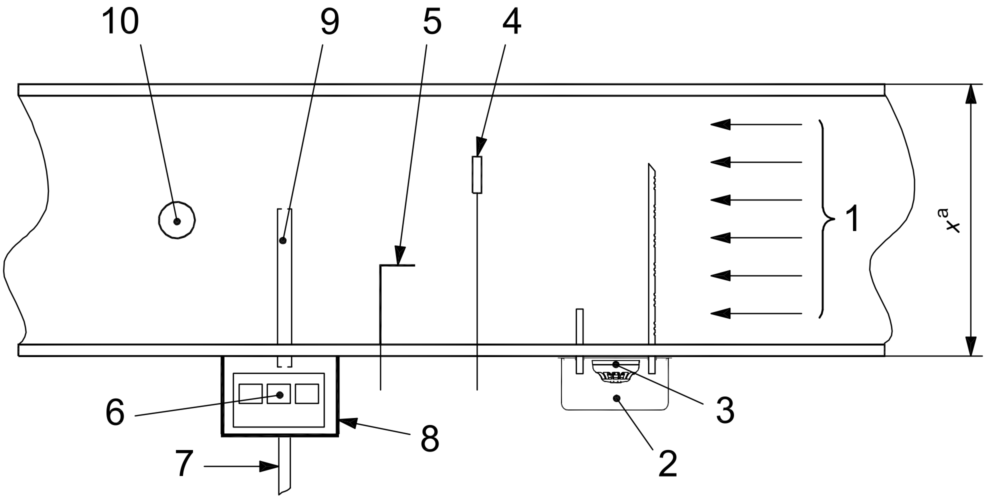


Key

1 test fire room
2 smoke tunnel
3 return air duct to test fire room
4 extract duct from test fire room
5 clean air intake
6 air exhaust
7 obscuration meter
8 MIC and sampling tube
9 temperature sensor
10 air velocity sensor
11 s.d.e.d. under test
12 fan
13 airflow
14 by-pass duct
15 by-pass duct airflow regulator

a l = 10 m.
b h = 2 m.
c y_1 = 0,3 m.
d y_2 = 0,3 m.

Figure I.1 — Example of smoke tunnel and test fire room arrangement, side view



Key

1 airflow

2 s.d.e.d. under test

3 supply and monitoring equipment

4 flow sensor

5 temperature sensor

6 MIC enclosed within sealed box

7 MIC suction

8 MIC control and measuring equipment

9 MIC sampling tube

10 obscuration meter

[a] X = 0,5 m.

Figure I.2 — Duct-tunnel working section, top view

Annex J
(informative)

Information concerning the construction of the measuring ionization chamber

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

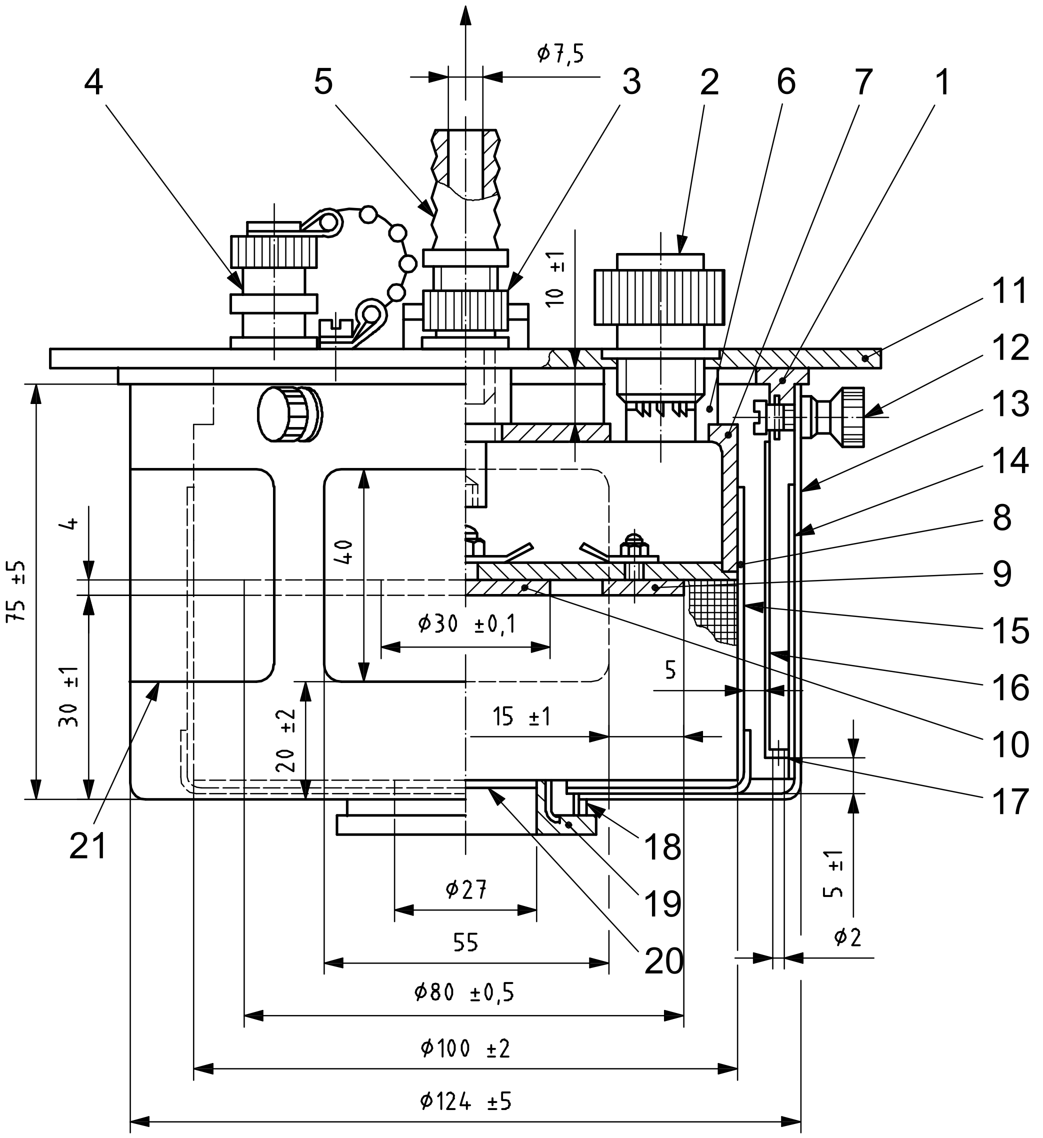
NOTE The measuring ionization chamber is fully described by M. Avlund[1)].

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

Reference No.	Item	Number provided	Dimensions, special features	Material
1	Insulating ring	1		Polyamide
2	Multipole socket	1	10-pole	
3	Measuring electrode terminal	1	To chamber supply	
4	Measuring electrode terminal	1	To amplifier or current measuring device	
5	Suction nozzle	1		
6	Guide socket	4		Polyamide
7	Housing	1		Aluminium
8	Insulating plate	1		Polycarbonate
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		

1) *Investigation of ionization chamber for reference measurements of smoke density*, published by DELTA Electronics, Venlighedsvej 4, DK-2970 Hørsholm, Denmark.

Dimensions in millimetres



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

NOTE 2 Dimensions without a tolerance marked are recommended dimensions.

Figure J.1 — Mechanical construction of measuring ionization chamber

ICS 13.220.20

Price based on 41 pages