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Fire detection and alarm systems —
Part 15: Multisensor fire detectors

Systèmes de détection et d'alarme d'incendie —

Partie 15: Détecteurs d'incendie multicapteurs

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Foreword

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

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

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

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

ISO 7240-15 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*

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

— *Part 11: Manual call points*

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

Compatibility assessment of system components will be the subject of the future Part 13.

Introduction

This part of ISO 7240 for multisensor fire detectors describes requirements for different types of multisensor fire detectors.

This part of ISO 7240 is drafted on the basis of functions which are required to be provided on all multisensor fire detectors covered by this standard, and optional functions with requirements which may be provided. It is intended that the options will 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 multisensor fire detectors covered by this standard with different combinations of functions to conform to this standard.

Other functions associated with fire detection and fire alarm may also be provided, even if not specified in this part of ISO 7240, if they do not jeopardize any function required by this document.

Fire detection and alarm systems —

Part 15:
Multisensor fire detectors

1 Scope

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

The performance of single components within a multisensor fire detector covered by this standard may not be sufficient for conformity to other standards for the single sensor.

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

2 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 alarm systems — Part 1: General and definitions*

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

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

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

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

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

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

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

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

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

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

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7240-1, ISO 7240-5, ISO 7240-7 and the following apply.

3.1.1
detector response
defined change of the status of a fire detector after actuation of an alarm signal

3.1.2
multisensor fire detector
detector incorporating sensors within one mechanical housing which responds to more than one physical phenomenon of fire, e.g. smoke and heat, smoke and gas or heat and gas

NOTE The mechanism for actuating alarm signals or for operating automatic fire protection equipment may be located with the detector or in another part of the system, for example at the control and indicating equipment.

3.1.3
non-volatile memory
memory elements which do not require the presence of an energy source for the retention of their contents

3.1.4
sensor response
defined change of the output signal of a sensing element

NOTE The output signal may be a response to combustion or may result from environmental influences such as temperature, wind, air pressure, electromagnetic irradiation, etc.

3.1.5
site-specific detector data
alterable data required for the detector to operate in a defined detector configuration

3.1.6
smoke-response value
A_{sr}
aerosol density in the proximity of a test specimen at the moment that it generates a reference signal in a smoke tunnel

3.1.7
temperature-response value
temperature in the proximity of a test specimen at the moment that it generates a reference signal

3.1.8
volatile memory
memory elements which require the presence of an energy source for the retention of their contents

3.2 Abbreviations

3.2.1
c.i.e.
control and indicating equipment

3.2.2
MSFD
multisensor fire detector

4 Functions

4.1 General

The MSFD shall be capable of detecting the mandatory test fires as specified in 6.18.3.1.

The MSFD shall be capable of processing signals from all incorporated sensing elements intended to respond to a fire parameter. At least a common signal shall be produced (either in the MSFD itself or in the c.i.e.) which can be interpreted as a fire alarm signal.

Means shall be provided for the transmission of the fire signal to the c.i.e.

Where the mechanism for actuating alarm signals is located in the c.i.e., means shall be provided for the transmission of all signals which are necessary for the actuation process.

4.2 Optional functions

4.2.1 Requirements for optional functions

Each optional function is included as a separate entity, with its own set of associated requirements, in order to permit multisensor fire detectors covered by this part of ISO 7240 with different combinations of functions to conform to this document.

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

The fault of an option shall not jeopardize any function required by this part of ISO 7240.

4.2.2 Types of optional functions

The MSFD may include one or more of the following optional functions:

a) be capable of detecting one or more of the optional fires specified in 6.18.3.1;

b) be provided with means for monitoring the integrity of one or more sensing elements;

c) be provided with means (remote or internal) for changing its response behaviour;

NOTE A change in the response behaviour could be caused by changing a detection algorithm of the MSFD;

d) be capable of visually indicating conditions other than a fire alarm (e.g. fault or stand-by);

e) be provided with a means of calibration;

f) be designed in such a way that the detector head can be detached from its base;

g) provide for connections to ancillary devices, e.g. remote indicators, control relays, etc;

h) provide for special sensitivity settings in order to limit its sensitivity (see 6.19).

5 General requirements

5.1 Design considerations

MSFDs should be designed for installation under the same conditions as other fire detectors specified in the other parts of ISO 7240. MSFDs shall be designed so that they are reliable and sufficiently durable for their intended period of use. In particular, MSFDs shall withstand the environmental conditions which may occur in buildings.

MSFDs shall be so designed that the signal(s) from the smoke sensor(s), combined with the signal(s) from the heat sensor(s), produce a fire signal.

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

5.2 Applicability

In order to conform with this standard, the detector shall meet the requirements of Clauses 4 and 5, shall be tested as described in Clause 6 and shall meet the requirements of the tests.

5.3 Individual alarm indication

Each detector shall be provided with an integral red visual indicator, by which the individual detector which released an alarm can be identified, until the alarm condition is reset. Where other conditions of the detector may be visually indicated, they shall be clearly distinguishable from the alarm condition, except when the detector is switched into a service mode.

For detachable detectors, the indicator may be integral with the base or the detector head.

The visual indicator shall be visible from a distance of 6 m at an angle of up to 5° from the axis of the detector in any direction, in ambient light intensity up to 500 lx.

5.4 Indication of other conditions

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

5.5 Calibration

Where means of calibration are provided, they shall not be readily adjustable after manufacture.

5.6 Sensitivity adjustment

Where means for field adjustment of the sensitivity of the detector are provided, then

a) unless the requirements of 5.7 are met, the range of adjustment shall be limited such that the detector meets the requirements of this standard at the highest and lowest sensitivities possible;

b) the means of adjustment shall not be readily accessible when the detector is installed and ready for operation.

For the purpose of this clause, adjustment of sensitivity includes any adjustment which leads to a change in the response to fire.

5.7 Sensitivity attenuation and signal disablement

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

5.8 Monitoring of detachable detectors

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

5.9 Drift compensation

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

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

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

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

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

5.10 Marking

Each detector shall be clearly marked with the following information:

a) a reference to this part of ISO 7240 (e.g. ISO 7240-15:2003);

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

c) the model designation (type or number);

d) the terminal designations;

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

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

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

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

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

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

5.11 Technical documentation

Detectors shall be supplied with sufficient technical, installation and maintenance documentation to ensure their correct handling, installation and operation. If all of these data are not supplied with each detector, reference to the appropriate data sheet shall be given on, or with, each detector.

For assessment of the detector performance, the documentation shall include a description of the different detector functions and of the options taken.

5.12 Manufacturer's declaration

The manufacturer shall declare the following:

— attestation of conformity with this part of ISO 7240;

— attestation that the detector is so designed that under the tested environmental conditions, each material and each electronic component operates within the limits of its specifications.

5.13 Electrical requirements

5.13.1 Connection of ancillary devices

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

5.13.2 Fault signal

Where means are provided to monitor the sensing elements and a fault is detected, either a common signal or separate signals for each sensing element shall be produced and made available to the c.i.e.

5.14 Protection against ingress of foreign bodies

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

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

5.15 Requirements for software-controlled multisensor fire detectors

5.15.1 General requirements

In the case of multisensor detectors which contain elements that are controlled by software in order to fulfil the requirements of this part of ISO 7240, the detectors shall conform to the requirements of 5.15.2, and shall conform to the requirements of 5.15.3 where relevant to the technology used.

5.15.2 Software documentation

5.15.2.1 General documentation

The manufacturer shall prepare documentation which gives an overview of the software design, which shall be submitted to the testing authority together with the multisensor fire detectors. This documentation shall comprise at least a functional description of the main program flow, including the following:

— a brief description of the major modules which are included in the software and the function(s) each performs;

— the ways in which the modules interact;

— a sample of the documentation for one of the modules described above;

— a date or version reference.

The description shall use graphic representations of the system design and the data flows, or an equivalent clear method of software documentation.

5.15.2.2 Detailed documentation

The manufacturer shall prepare detailed design documentation and shall make it available for inspection in a manner which respects the manufacturer's rights of confidentiality.

NOTE This does not necessarily entail submitting such documentation to the testing authority.

This documentation shall comprise at least the following:

a) description of each module of the program, containing

   — the name of the module,

   — the date or version reference,

   — a description of the tasks performed,

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

b) full specification of the implementation phase, e.g.

   — source code prior to compiling or assembling,

   — CASE tool listings,

   — listing of graphic development tools for fuzzy logic.

5.15.3 Program monitoring — Optional function

Means may be provided for monitoring the execution of the program. If the monitoring function detects that the program has halted or latched, a signal shall be made available to the c.i.e. within a time limit specified by the manufacturer.

5.16 Storage of programs and data

The program shall be held in non-volatile memory. Each device containing program memory shall be identifiable such that its contents can be uniquely cross-referenced to the software documentation.

For site-specific detector data stored in volatile memory, the data shall be automatically renewed or protected against power loss.

5.17 Monitoring of memory contents — Optional function

Means may be provided for detecting the loss of site-specific data. If such a loss occurs, a signal shall be made available to the c.i.e. within a time limit specified by the manufacturer.

6 Tests

6.1 General

6.1.1 Test classification

6.1.1.1 General

The purpose of the environmental tests is to demonstrate that a detector can operate correctly in its service environment and that it will continue to do so for a reasonable time. The tests are intended to demonstrate failures due to realistic service environments, however, some significant failure mechanisms are brought about by changes which occur slowly under these realistic service conditions. In order to make tests within a practical and economic time-scale, it is sometimes necessary to accelerate these changes by intensifying the conditions (e.g. by increasing the level of an environmental parameter or by increasing the frequency of its application). The tests are divided into two classes: operational and endurance.

6.1.1.2 Operational tests

The test specimen is subjected to test conditions which correspond to the service environment. The object of these tests is to demonstrate the ability of the equipment to withstand and operate correctly in the normal service environment and/or to demonstrate the immunity of the equipment to certain aspects of that environment.

The specimen is, therefore, operational, its condition is monitored and it may be functionally tested during the tests.

6.1.1.3 Endurance tests

The test specimen may be subjected to conditions more severe than the normal service environment in order to accelerate the effects of the normal service environment. The object of these tests is to demonstrate the ability of the equipment to withstand the long-term effects of the service environment. Since the tests are intended to study the residual rather than the immediate effects, the specimens are normally not supplied with power or monitored during the conditioning period. However, if by reason of the design of the specimen, it is necessary for a power supply to be connected, any signal generated during the test shall be ignored.

6.1.2 Assessment of the performance of the sensors

6.1.2.1 General

In order to assess the influence of the environmental tests quantitatively, a suitable detector parameter shall be measured before and after the tests. For each test, the observable changes of the parameter which define clear pass/fail criteria are specified.

The same parameter shall also be used to assess the repeatability (6.2) and the reproducibility (6.4) of the specimen.

Since an MSFD consists of more than one sensor responding to more than one phenomenon associated with combustion, the performance of all incorporated sensors shall be assessed.

6.1.2.2 Performance of the smoke sensor(s)

For the assessment of the performance of a smoke sensor, a smoke tunnel as specified in A.1, the application of a test aerosol as specified in A.3, and aerosol-measuring equipment as specified in A.4 shall be used.

Since the MSFD has to respond to smoke even though the other sensors may not produce a signal, the alarm threshold value for the aerosol can be measured and shall be taken as the assessment parameter.

6.1.2.3 Performance of the heat sensor(s)

For the assessment of the performance of the heat sensor, a heat tunnel as specified in Annex C shall be used.

Since the MSFD need not respond to temperature with an alarm signal, it is the responsibility of the manufacturer to specify a method by which a signal can be derived from the MSFD which can be used as a parameter for the assessment of the performance of the heat sensor.

6.1.2.4 Orientation

The orientation for which the maximum smoke response value or the maximum temperature response value is measured is referred to as the least sensitive orientation for smoke and temperature, respectively. The orientation for which the minimum smoke response value or the minimum temperature response value is measured is referred to as the most sensitive orientation for smoke and temperature, respectively.

6.1.3 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 specified in IEC 60068-1 as follows:

— temperature: (15 to 35) °C;

— relative humidity: (25 to 75) %;

— air pressure: (86 to 106) kPa.

If variations in these parameters have a significant effect on a measurement, then such variations should be kept to a minimum during a series of measurements carried out as part of one test on one specimen.

6.1.4 Operating conditions for tests

If a test method requires a specimen to be operational, connect the specimen to suitable supply and indicating equipment in accordance with the manufacturer's instructions. Unless otherwise specified in the test method, set the supply parameters applied to the specimen within the manufacturer's specified range(s) and keep them substantially constant throughout the tests. The value chosen for each parameter shall normally be the nominal value, or the mean of the specified range.

The details of the supply and indicating equipment used are noted in the test report (Clause 7).

6.1.5 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, choose the method considered to be most unfavourable for each test.

6.1.6 Tolerances

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

6.1.7 Measurement of the smoke response value

Mount the specimen for which the smoke response value is to be measured in a smoke tunnel, as specified in A.1, 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 (6.3), 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 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 K and not faster than 0,2 K/min for all the measurements on a particular detector type.

Connect the specimen to its supply and indicating equipment as described in 6.1.4, and allow it to stabilize for at least 15 min.

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

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

— for 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 detector, to get a response in a reasonable time.

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

Make all aerosol density measurements in the proximity of the specimen.

The smoke response value shall be recorded as m, in decibels per metre, or as y, a dimensionless parameter (see A.4).

6.1.8 Measurement of the temperature response value

Install the specimen for which the temperature response value is to be measured in a heat tunnel, as specified in Annex C, in its normal operating position, by its normal means of attachment. The orientation of the specimen, relative to the direction of air flow, shall be the least sensitive one as determined in the directional dependence test (6.3), unless otherwise specified in the test procedure.

Connect the specimen to its supply and indicating equipment as specified in 6.1.4, and allow it to stabilize for at least 15 min.

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

Raise the air temperature until the heat sensor produces a signal (this might be a fire signal), as specified by the manufacturer. The rate of rise of the air temperature and the associated tolerances shall correspond to one of the values, except for 0,2 K/min, 1 K/min and 30 K/min, as specified in ISO 7240-5. Record the temperature at which this signal is produced as reference data.

The choice of the rate within the range of 3 K/min to 20 K/min shall be specified by the manufacturer.

For this purpose, the manufacturer may supply an MSFD with special outputs. However, it is essential that the output signal be routed through the amplification path.

6.1.9 Provision for tests

The data specified in 5.10 and 5.11 plus the following numbers of detectors shall be provided for testing in accordance with this part of ISO 7240:

— for detachable detectors: 20 detector heads and bases;

— for non-detachable detectors: 20 specimens.

The specimens submitted shall be deemed representative of the manufacturer's normal production with regard to their construction and calibration.

This implies that the mean smoke response value of the 19 specimens as measured in the reproducibility test (6.4) should also represent the production mean, and that the deviation limits specified for the reproducibility test should also be applicable to the manufacturer's production.

6.1.10 Test schedule

Test the specimens as specified in Table 1. After the reproducibility test (6.4), number the four specimens with the least sensitive smoke response (i.e. those with the highest smoke response value) 17 to 20. Number the others 1 to 16 arbitrarily.

When it is required to determine both the smoke and the temperature response value after an environmental test, determine the smoke response value first.

Table 1 — Test schedule

Test	Subclause	Specimen No(s). to be tested
Repeatability	6.2[a]	one chosen arbitrarily
Directional dependence	6.3[a]	one chosen arbitrarily
Reproducibility	6.4[a]	all specimens
Variation of supply parameters	6.5	1
Air movement	6.6	2
Dazzling[b]	6.7	3
Dry heat (operational)	6.8	4
Cold (operational)	6.9	5
Damp heat, steady state (operational)	6.10	6
Damp heat, steady state (endurance)	6.11[a]	7
Sulfur dioxide (SO_2) corrosion (endurance)	6.12[a]	8
Shock (operational)	6.13[a]	9
Impact (operational)	6.14[a]	10
Vibration, sinusoidal (operational)	6.15	11
Vibration, sinusoidal (endurance)	6.16[a]	11
Electrostatic discharge (operational)	6.17	12 [c]
Radiated electromagnetic fields (operational)	6.17	13[c]
Conducted disturbances induced by electromagnetic fields (operational)	6.17	14[c]
Fast transient bursts (operational)	6.17	15[c]
Slow high energy voltage surge (operational)	6.17	16[c]
Fire sensitivity	6.18	17, 18, 19, 20
Special requirements on detector sensitivity (optional)	6.19	17, 18, 19, 20

[a] The smoke and temperature response shall be measured.

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

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

6.1.11 Test report

The test results shall be reported in accordance with Clause 7.

6.2 Repeatability

6.2.1 Object of test

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

6.2.2 Test procedure

Measure the smoke response value and the temperature response value of the specimen six times as specified in 6.1.7. and 6.1.8.

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

Designate the maximum of the measured temperature response values as T_{max} and the minimum value as T_{min}.

6.2.3 Requirements

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

The ratio of $(T_{max} – 25) : (T_{min} – 25)$ shall be not greater than 1,3.

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

6.3 Directional dependence

6.3.1 Object of test

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

6.3.2 Test procedure

Measure the smoke response value and the temperature response value of the specimen eight times as specified in 6.1.7 and 6.1.8, the specimen being rotated 45° about its vertical axis between each measurement, so that the measurements are taken at eight different orientations relative to the direction of air flow.

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

Designate the maximum of the measured temperature response values as T_{max} and the minimum value as T_{min}.

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

6.3.3 Requirements

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

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

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

6.4 Reproducibility

6.4.1 Object of test

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

6.4.2 Test procedure

Measure the smoke response value and the temperature response value of each of the test specimens as specified in 6.1.7 and 6.1.8.

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

Calculate the mean value of the temperature response values and designate it as $\overline{T}$.

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

Designate the maximum of the measured temperature response values as T_{max} and the minimum value as T_{min}.

6.4.3 Requirements

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

The ratio of $(T_{max} - 25) : (\overline{T} - 25)$ shall be not greater than 1,33 and the ratio of $(\overline{T} - 25) : (T_{min} - 25)$ shall be not greater than 1,5.

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

6.5 Variation in supply parameters (voltage)

6.5.1 Object of test

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

6.5.2 Test procedure

Measure the smoke response value of the specimen to be tested as specified in 6.1.7, under the extremes of the specified supply conditions, e.g. maximum and minimum voltage.

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

6.5.3 Requirements

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

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

6.6 Air movement

6.6.1 Object of test

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

6.6.2 Test procedure

Measure the smoke response value of the specimen to be tested as described in 6.1.7 in the most and the least sensitive orientation. Designate these appropriately as $y_{(0,2)\text{max}}$ and $y_{(0,2)\text{min}}$ or $m_{(0,2)\text{max}}$ and $m_{(0,2)\text{min}}$.

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

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

Record any signal that is emitted.

6.6.3 Requirements

One of the following relationships shall apply:

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

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

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

6.7 Dazzling

6.7.1 Object of test

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

6.7.2 Test procedure

Mount the apparatus for the dazzling test (see Annex E) in the smoke tunnel as specified in A.1. Install the specimen in the apparatus in the least sensitive orientation and connect it to its supply and monitoring equipment. Measure the smoke response value as specified in 6.1.7 and then perform the following procedure.

a) Switch the first lamp ON for 10 s and then OFF for 10 s. Repeat this ten times.

b) Repeat this sequence for each of the other three lamps in turn.

c) Connect the four lamps as two pairs of opposite lamps.

d) Switch the first pair ON for 10 s and then OFF for 10 s. Repeat this ten times.

e) Repeat this sequence for the other pair of lamps.

f) Switch the four lamps ON together and, after at least 1 min, measure the smoke response value as specified in 6.1.7 with the lamps ON.

g) Then switch the four lamps OFF.

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

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

6.7.3 Requirements

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

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

6.8 Dry heat (operational)

6.8.1 Object of test

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

6.8.2 Test procedure

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

Increase the air temperature in the tunnel to (50 ± 2) °C, at rate not exceeding 1 K/min, and maintain this temperature for 2 h.

Measure the smoke response value in accordance with 6.1.7, but at a temperature of (50 ± 2) °C.

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

6.8.3 Requirements

No alarm or fault signals shall be produced during conditioning.

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

6.9 Cold (operational)

6.9.1 Object of test

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

6.9.2 Test procedure

6.9.2.1 Reference

Use the test apparatus and perform the procedure s as specified in IEC 60068-2-1, Test Ab, but carry out the conditioning procedure as specified in 6.9.2.3.

6.9.2.2 State of the specimen during conditioning

Mount the specimen as specified in 6.1.5 and connect it to its supply and indicating equipment as specified in 6.1.4.

6.9.2.3 Conditioning

Condition the specimen(s) using the following parameters:

— temperature: (−10 ± 3) °C;

— duration: 16 h.

6.9.2.4 Measurements during conditioning

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

6.9.2.5 Final measurements

After the recovery period, measure the smoke response value as specified in 6.1.7.

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

6.9.3 Requirements

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

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

6.10 Damp heat, steady state (operational)

6.10.1 Object of test

To demonstrate the ability of the detector to function correctly at high relative humidity (without condensation).

6.10.2 Test procedure

6.10.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-78, Test Cab, but carry out the conditioning procedure specified in 6.10.2.3.

6.10.2.2 State of the specimen during conditioning

Mount the specimen as specified in 6.1.5 and connect it to its supply and indicating equipment as specified in 6.1.4.

6.10.2.3 Conditioning

Condition the specimen(s) using the following parameters:

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

6.10.2.4 Measurements during conditioning

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

6.10.2.5 Final measurements

After a minimum recovery period of 1 h, measure the smoke response value as specified in 6.1.7.

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

6.10.3 Requirements

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

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

6.11 Damp heat, steady state (endurance)

6.11.1 Object of test

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

6.11.2 Test procedure

6.11.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-78, Test Cab, but carry out the conditioning procedure specified in 6.11.2.3.

6.11.2.2 State of the specimen during conditioning

Mount the specimen as specified in 6.1.5, but do not supply it with power during the conditioning.

6.11.2.3 Conditioning

Condition the specimen(s) using the following parameters:

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

6.11.2.4 Final measurements

After the recovery period, measure the smoke response value and the temperature response value as specified in 6.1.7 and 6.1.8.

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

Designate the greater of the temperature response values measured in this test and for the same specimen in the reproducibility test as T_{max} and the lesser as T_{min}.

6.11.3 Requirements

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

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

6.12 Sulfur dioxide (SO_2) corrosion (endurance)

6.12.1 Object of test

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

6.12.2 Test procedure

6.12.2.1 Reference

Use the test apparatus and perform the procedure generally as specified in IEC 60068-2-42, Test Kc, but carry out the conditioning specified in 6.12.2.3.

6.12.2.2 State of the specimen during conditioning

Mount the specimen as specified in 6.1.5. Do not supply it with power during the conditioning, but equip it with untinned copper wires of the appropriate diameter, connected to sufficient terminals to allow the final measurements to be made without making further connections to the specimen.

6.12.2.3 Conditioning

Condition the specimen(s) using the following parameters:

— temperature (25 ± 2) °C;

— relative humidity (93 ± 3) %;

— SO_2 concentration (25 ± 5) µl/l;

— duration 21 d.

6.12.2.4 Final measurements

Immediately after the conditioning, subject the specimen to a drying period of 16 h at 40 °C, ⩽ 50 % RH, followed by a recovery period of 1 h to 2 h at standard laboratory conditions. After this recovery period, measure the smoke response value and the temperature response value as specified in 6.1.7 and 6.1.8.

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

Designate the greater of the temperature response value measured in this test and for the same specimen in the reproducibility test as T_{max} and the lesser as T_{min}.

6.12.3 Requirements

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

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

6.13 Shock (operational)

6.13.1 Object of test

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

6.13.2 Test procedure

6.13.2.1 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 6.13.2.3.

6.13.2.2 State of the specimen during conditioning

Mount the specimen on a rigid fixture as specified in 6.1.5, and connect it to its supply and indicating equipment as specified in 6.1.4.

6.13.2.3 Conditioning

For specimens with a mass $\leqslant$ 4,75 kg, condition the specimen(s) using the following parameters:

— 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 > 4,75 kg.

6.13.2.4 Measurements during conditioning

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

6.13.2.5 Final measurements

After the conditioning, measure the smoke response value and the temperature response value as specified in 6.1.7 and 6.1.8.

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

Designate the greater of the temperature response value measured in this test and for the same specimen in the reproducibility test as T_{max} and the lesser as T_{min}.

6.13.3 Requirements

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

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

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

6.14 Impact (operational)

6.14.1 Object of test

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

6.14.2 Test procedure

6.14.2.1 Apparatus

The test apparatus (Annex F) shall consist of a swinging hammer incorporating a rectangular-section aluminium alloy head (aluminium alloy Al Cu4SiMg 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). A suitable apparatus is specified in Annex F.

6.14.2.2 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 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 indicating equipment as specified in 6.1.4.

6.14.2.3 Conditioning

Condition the specimen(s) using the following parameters:

— impact energy (1,9 ± 0,1) J;

— hammer velocity (1,5 ± 0,125) m/s;

— number of impacts 1.

6.14.2.4 Measurements during conditioning

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

6.14.2.5 Final measurements

After the conditioning, measure the smoke response value and the temperature response value as specified in 6.1.7 and 6.1.8.

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

Designate the greater of the temperature response value measured in this test and for the same specimen in the reproducibility test as T_{max} and the lesser as T_{min}.

6.14.3 Requirements

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

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

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

6.15 Vibration, sinusoidal (operational)

6.15.1 Object of test

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

6.15.2 Test procedure

6.15.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-6, Test Fc, but carry out the conditioning procedure specified in 6.15.2.3.

6.15.2.2 State of the specimen during conditioning

Mount the specimen on a rigid fixture as specified in 6.1.5 and connect it to its supply and indicating equipment as specified in 6.1.4.

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

6.15.2.3 Conditioning

Condition the specimen(s) using the following parameters:

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

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.

6.15.2.4 Measurements during conditioning

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

6.15.2.5 Final measurements

After the conditioning, measure the smoke response value as specified in 6.1.7.

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

6.15.3 Requirements

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

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

6.16 Vibration, sinusoidal (endurance)

6.16.1 Object of test

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

6.16.2 Test procedure

6.16.2.1 Reference

Use the test apparatus and perform the procedure as specified in IEC 60068-2-6, Test Fc, but carry out the conditioning procedure specified in 6.16.2.3.

6.16.2.2 State of the specimen during conditioning

Mount the specimen on a rigid fixture as specified in 6.1.5, but do not supply it with power during conditioning.

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

6.16.2.3 Conditioning

Condition the specimen(s) using the following parameters:

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

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.

6.16.2.4 Final measurements

After the conditioning, measure the smoke response value and the temperature response value as specified in 6.1.7 and 6.1.8.

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

Designate the greater of the temperature response values measured in this test and for the same specimen in the reproducibility test as T_{max} and the lesser as T_{min}.

6.16.3 Requirements

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

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

6.17 Electromagnetic compatibility (EMC)

6.17.1 Carry out the following EMC immunity tests as described in EN 50130-4:

a) electrostatic discharge;

b) radiated electromagnetic fields;

c) conducted disturbances induced by electromagnetic fields;

d) fast transient bursts;

e) slow high-energy voltage surges.

6.17.2 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 smoke response value as described in 6.1.7

— Designate the greater of the smoke response value measured in this test and 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 described in 6.1.4.

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

6.18 Fire sensitivity

6.18.1 Object of test

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

6.18.2 Principle

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

6.18.3 Test procedure

6.18.3.1 Test fires

Subject the specimens to the five mandatory test fires TF2, TF3, TF4, TF5 and TF8. Test fires TF1 and TF6 are optional. The type, quantity and arrangement of the fuel and the method of combustion are specified in Annexes H to N for each test fire, 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 signal, or the end-of-test condition is reached, whichever is the earlier. If these conditions are not met, then the test is invalid and shall be repeated. It is permissible, and may be necessary, to adjust the quantity and arrangement of the fuel in order to obtain valid test fires.

6.18.3.2 Mounting of the specimens

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

Connect each specimen to its supply and indicating equipment, as described in 6.1.4, and allow it to stabilize in its quiescent condition before the start of each test fire.

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

6.18.3.3 Initial conditions

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

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

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:

- air temperature, T — (23 ± 5) °C;
- air movement — negligible;
- smoke density (ionization) — $y \leqslant 0,05$;
- smoke density (optical) — $m \leqslant 0,02$ dB/m.

6.18.3.4 Recording of the fire parameters and response values

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

Table 2 — Fire parameters

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

The alarm signal produced by the supply and indicating 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 detector after the end-of-test condition has been reached shall be ignored.

6.18.4 Requirements

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

6.19 Special requirements on detector sensitivity — Optional function

6.19.1 Object of test

The detector may have a sensitivity setting which limits the sensitivity to smoke in order to mitigate against false alarms.

6.19.2 Procedure

Check conformity to this clause during the fire sensitivity test.

6.19.3 Requirements

For this sensitivity setting, all four specimens shall generate an alarm in each test fire before the specified end-of-test condition is reached and $m > 0{,}5$ dB/m and $y > 1{,}5$.

If the detector has more than one sensitivity setting, at least one setting shall fulfil the requirements of this clause.

7 Test report

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

a) identification of the alarm tested;

b) reference to this part of ISO 7240 (ISO 7240-15:2004);

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

d) conditioning period and the conditioning atmosphere;

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

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

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

Annex A
(normative)

Smoke tunnel

A.1 Response threshold value measurements

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

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 E to be inserted. The alarm to be tested shall be mounted in its normal operating position on the underside of a flat board aligned with the air flow in the working volume. The board shall be of such dimensions that the edge or edges of the board are at least 20 mm from any part of the detector. The alarm-mounting arrangement shall not unduly obstruct the air flow between the board and the tunnel ceiling.

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

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

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

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

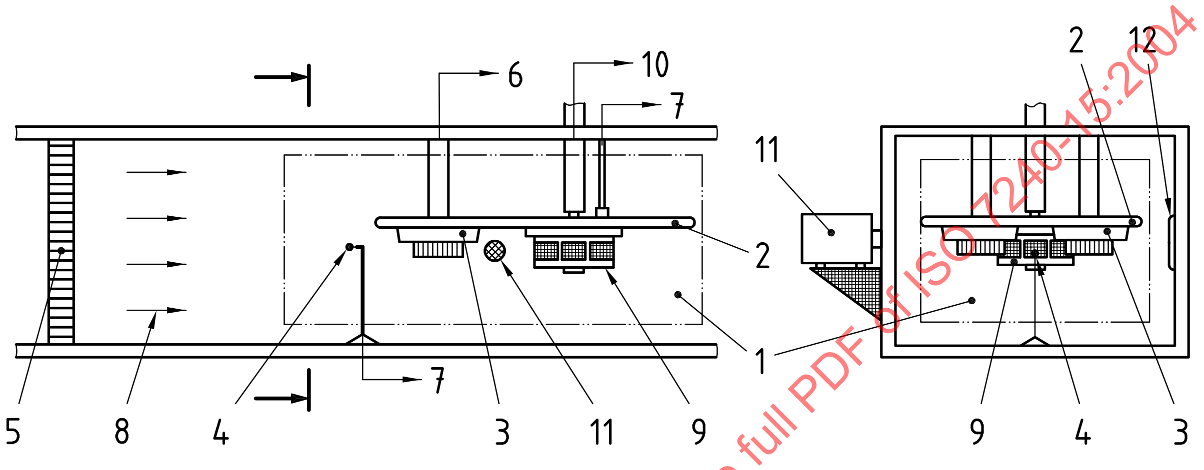
A.2 Construction of the smoke tunnel

Smoke alarms 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 smoke response value measured in the smoke tunnel is the main parameter considered when the stability of smoke alarms 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 smoke response value measurements require increasing aerosol density until the alarm responds. This may be facilitated in a closed-circuit smoke tunnel. A purging system is required to purge the smoke tunnel after each aerosol exposure.

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



Key

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

Figure A.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 measuring ionization chamber (MIC) creates a mean air velocity of approximately 0,04 m/s in the plane of the inlet openings in the chamber housing. However, the effect of the suction will be negligible if the MIC is placed 10 cm to 15 cm downstream of the detector position.

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 smoke response value measurements.

A.3 Test aerosol for response 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.

A.4 Aerosol-measuring instruments

A.4.1 Obscuration method

A.4.1.1 Obscuration meter

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

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

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

where

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

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

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

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.

A.4.2 Measuring ionization chamber (MIC)

A.4.2.1 General

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

A.4.2.2 Operating method and basic construction

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

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 A.2. The measuring chamber contains a measuring volume and a suitable means by which the sampled air is sucked in and passes the measuring volume in such a way that the aerosol/smoke particles diffuse into this volume. This diffusion is such that the flow of ions within the measuring volume is not disturbed by air movements.

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 alarms using ionization.

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

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

where

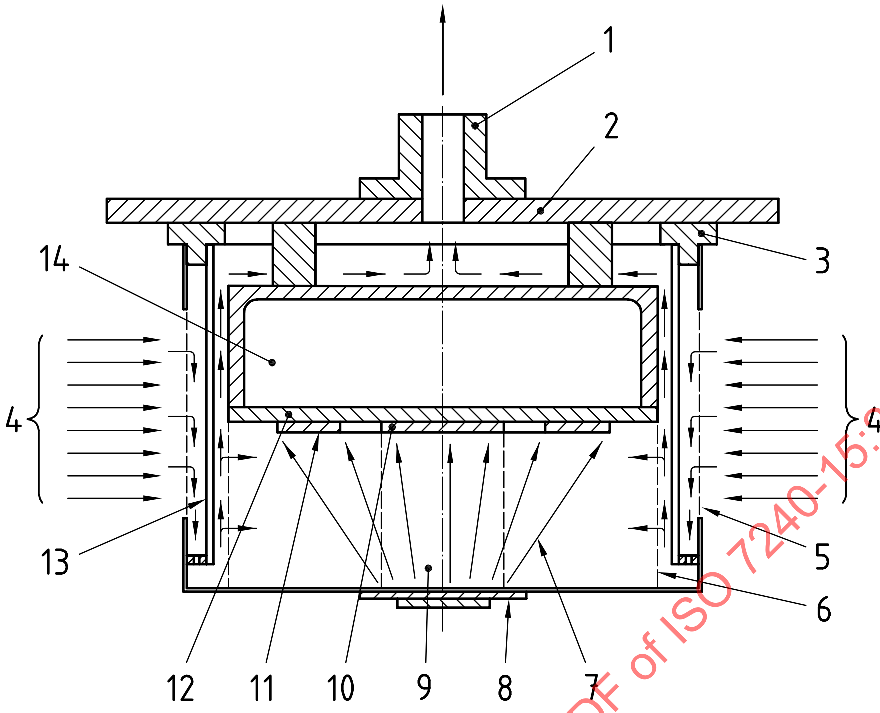
I_0 is the chamber current in air without test aerosol or smoke;

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

η is the chamber constant;

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

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



Key

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

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

Annex B
(informative)

Construction of the measuring ionization chamber

B.1 General

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

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

B.2 Technical data

The measuring ionization chamber contains the following components.

a) Radiation source

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

b) Ionization chamber

The chamber impedance (i.e. the reciprocal of the slope of the current versus voltage characteristic of the chamber in its linear region where the chamber current $\leqslant$ 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.

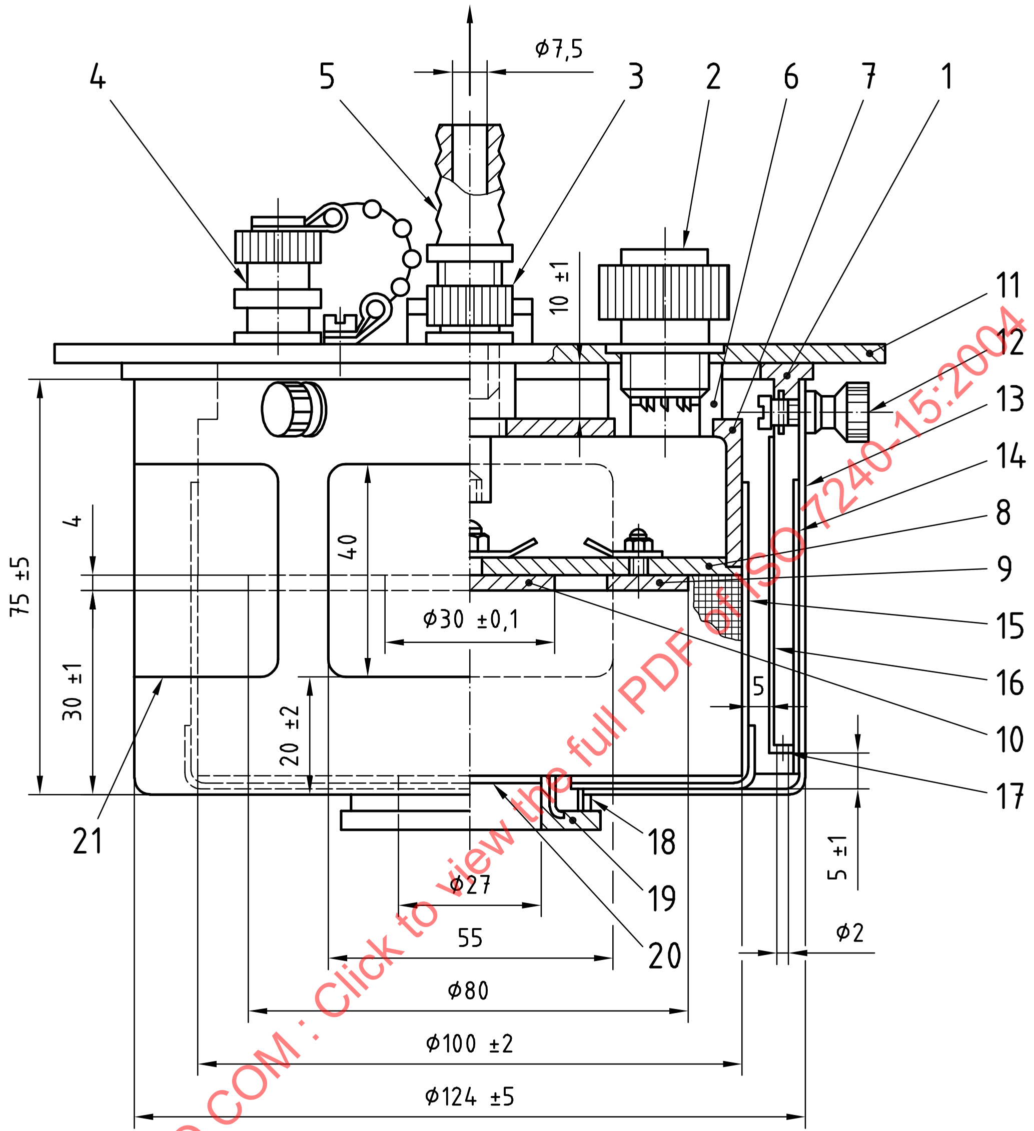
c) Current-measuring amplifier

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

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.

Dimensions in millimetres



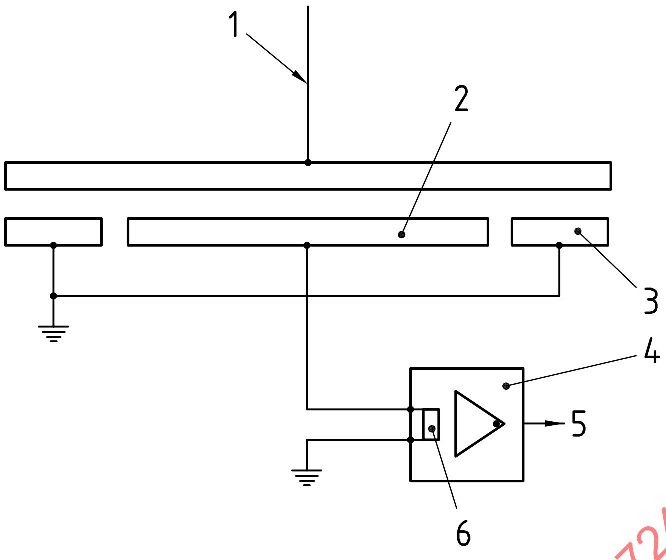
NOTE 1 See Table B.1 for the list of parts.

NOTE 2 Dimensions without a tolerance marked are recommended dimensions.

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

Table B.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 B.2
21	Openings on the periphery	6	—	—



Key

1 supply voltage
2 measuring electrode
3 guard ring
4 current measuring amplifier
5 output voltage proportional to chamber current
6 input impedance, $Z_{in} < 10^9 \Omega$

Figure B.2 — Measuring ionization chamber — Operating circuit

Annex C
(normative)

Heat tunnel for temperature-response value measurements

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

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

a) The heat tunnel shall have a horizontal working section containing a working volume. The working volume is a defined part of the working section, where the air temperature and air flow conditions are within ± 2 K and ± 0,1 m/s, respectively, of the nominal test conditions. Conformance with this requirement shall be regularly verified under both static and rate-of-rise conditions, by measurements at an adequate number of points distributed within and on the imaginary boundaries of the working volume. The working volume shall be large enough to fully enclose the detector(s) to be tested, the required amount of mounting board and the temperature measuring sensor.

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

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

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

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

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

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

Annex D
(informative)

Construction of the heat tunnel

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

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

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

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

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

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

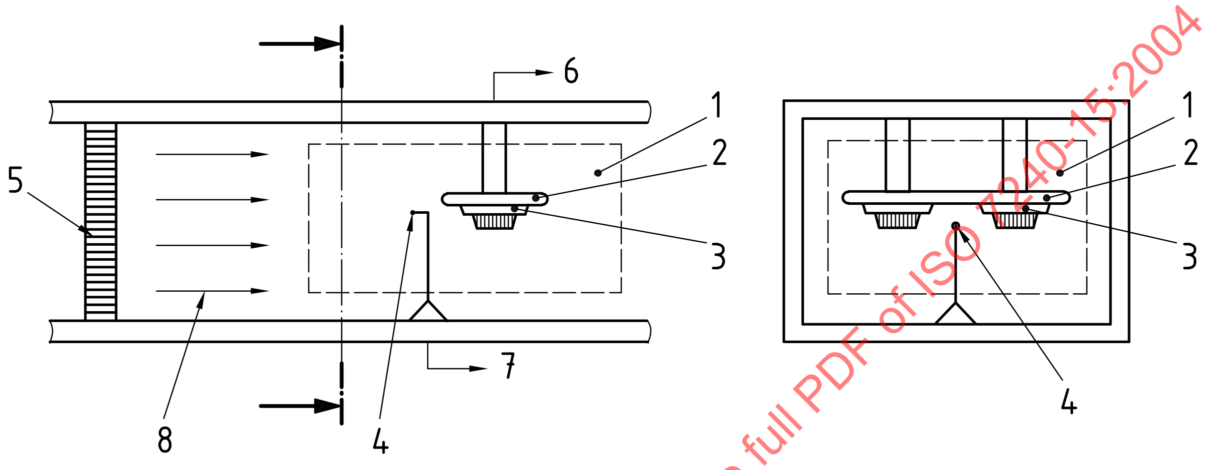
The important point is that the specified temperature profiles are obtained with the required accuracy within the working section.

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

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

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

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



Key

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

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

Annex E
(normative)

Apparatus for the dazzling test

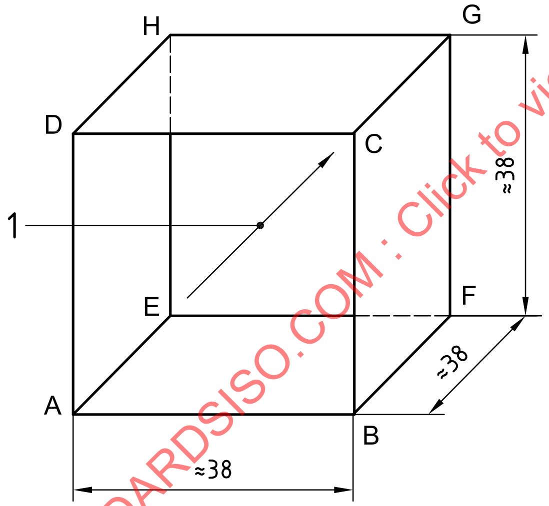
The dazzling apparatus [see Figure E.1 a)] shall be constructed so that it can be inserted in the working section of the smoke tunnel. The apparatus is cube-shaped, with four of the cube faces (ABFE, AEHD, BFGH and EFGH) closed and lined on the inside with high-gloss aluminium foil. The other two opposing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

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

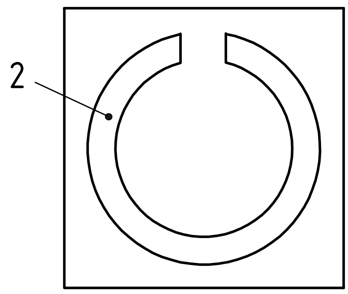
The smoke detector to be tested shall be installed in the centre of the upper cube face [see Figure E.1 a)] so that light can play on it from all directions.

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) **Dazzling apparatus**



b) **Lamp**

Key

1 stream of aerosol

2 fluorescent lamp

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

Annex F
(normative)

Apparatus for the impact test

The apparatus (see Figure F.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 Cu4SiMg 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 will depend on the bearings used.

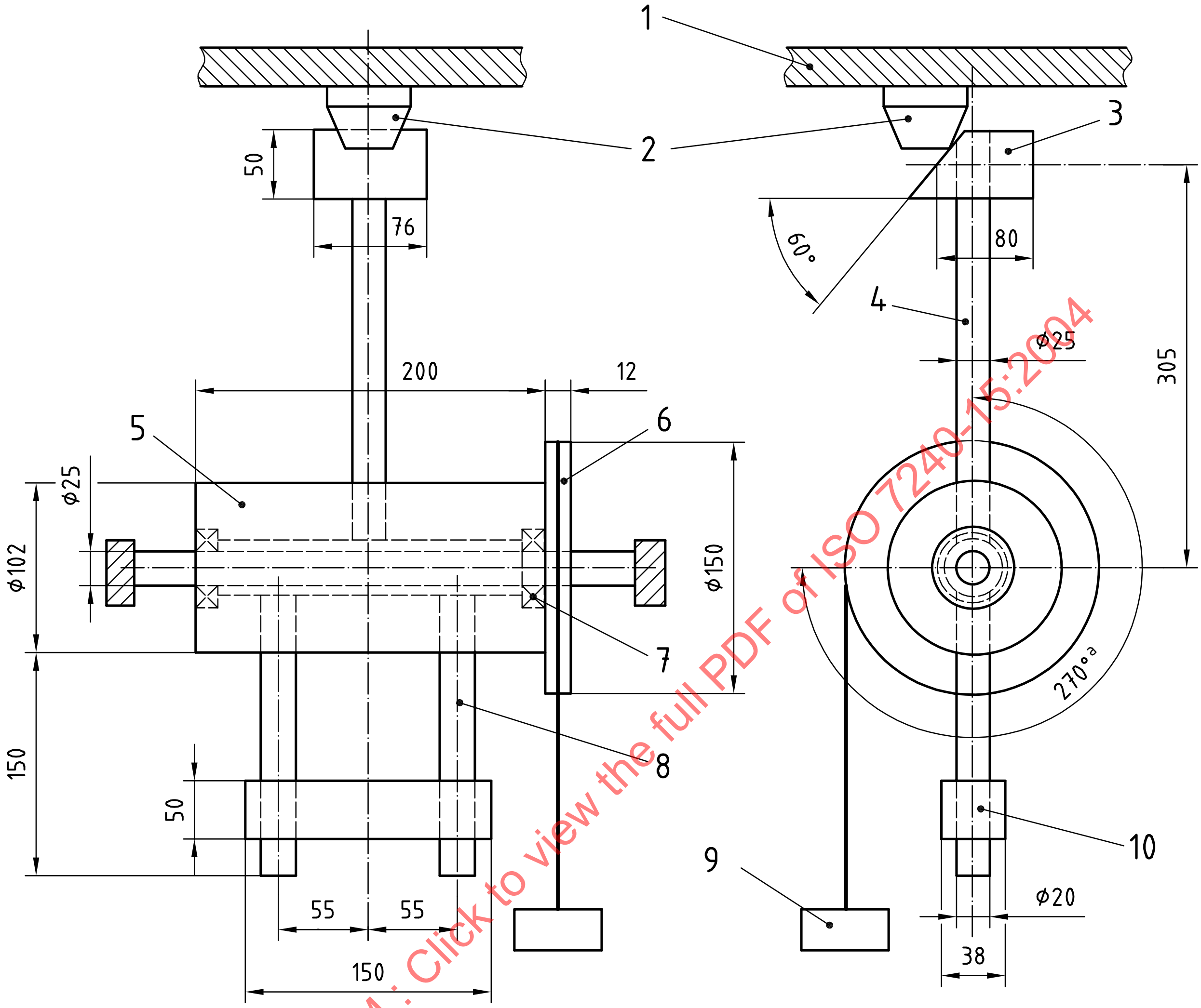
Diametrically opposite the hammer shaft are two steel counter-balance arms, each 20 mm in outside diameter and 185 mm long. These arms are screwed into the boss so that the length of 150 mm protrudes. A steel counter-balance weight is mounted on the arms so that its position can be adjusted to balance the mass of the striker and arms, as in Figure F.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 F.1.

To operate the apparatus, the position of the mounting board with the specimen is first adjusted as shown in Figure F.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 part of ISO 7240 requires a hammer velocity at impact of (1,5 ± 0,13) m/s, the mass of the hammer head will need to be reduced by drilling the back face sufficiently to obtain this velocity. It is estimated that a head of mass of about 0,79 kg will be required to obtain the specified velocity, but this will have to be determined by trial and error.

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 F.1 — Impact apparatus

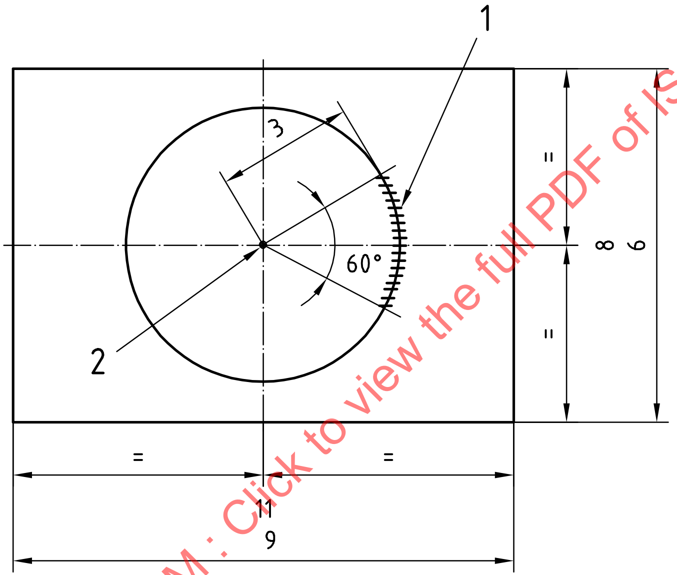
Annex G
(normative)

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 G.1 and G.2.

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

Dimensions in metres



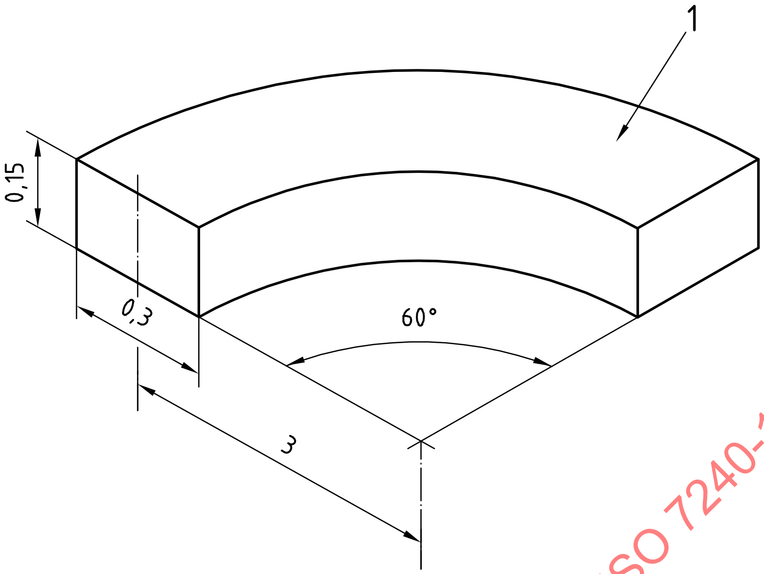
Key

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

2 position of test fire

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

Dimensions in metres



Key

1 ceiling

Figure G.2 — Mounting positions for instruments and specimens

Annex H
(normative)

Open cellulosic (wood) fire (TF1)

H.1 Fuel

Approximately 70 dried beechwood sticks, dried in heating oven to a moisture content less than 3 %.

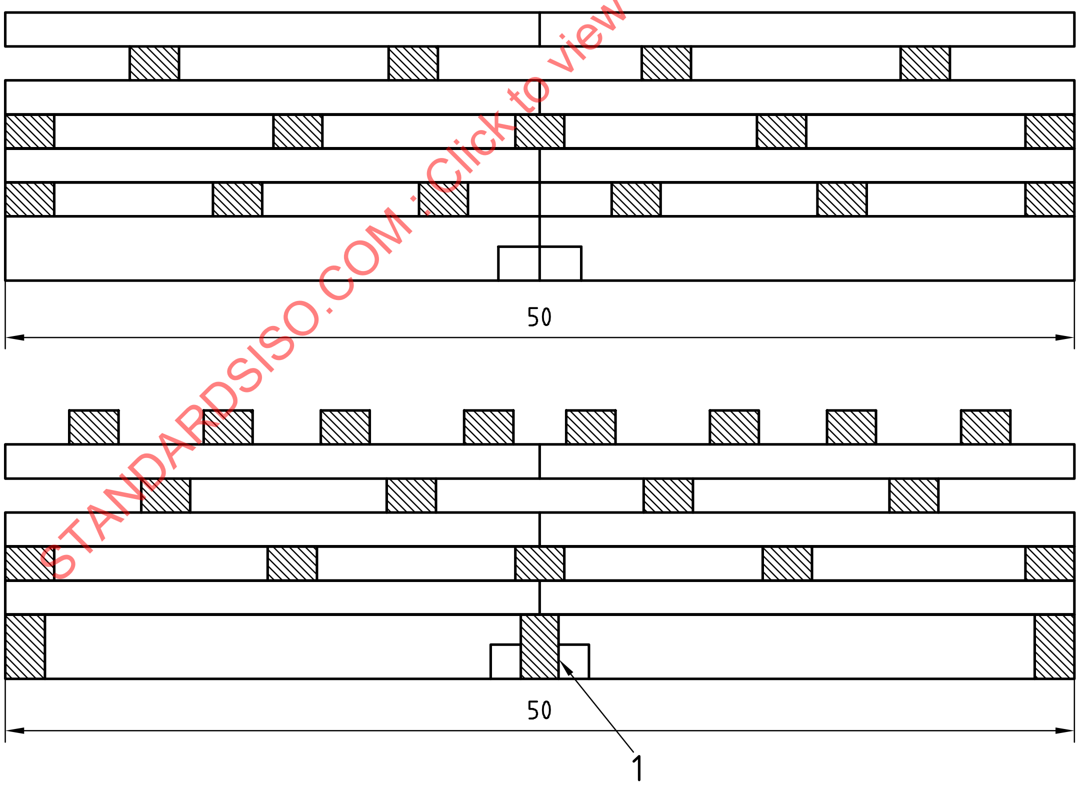
H.2 Arrangement

The sticks shall be arranged in at least 7 layers superimposed on a base surface measuring approximately 50 cm × 50 cm by 8 cm high (see Figure H.1).

H.3 Ignition starter

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

Dimensions in centimetres



Key

1 container for methylated spirits

Figure H.1 — Wood arrangement for test fire TF1

H.4 Preparation

Sticks transported from oven in a closed plastic bag (if necessary) just prior to laying out test arrangement.

H.5 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 is the earlier.

H.6 Test validity criteria

The development of the fire shall be such that the curves of m against y, and m against time, t, fall within the hatched areas shown in Figures H.2 and H.3. That is, $0,5 \leqslant y \leqslant 6,0$ and $270 \leqslant t \leqslant 370$ at the end-of-test condition $y_E = 6$.

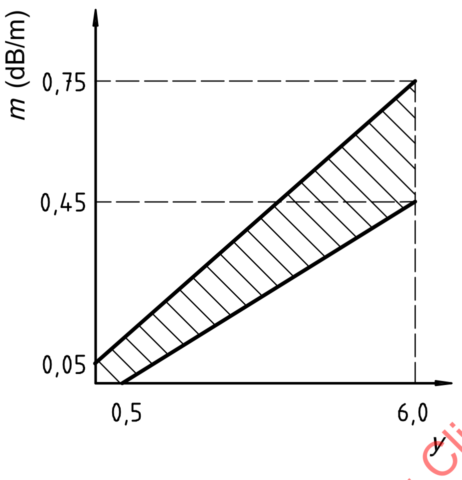


Figure H.2 — Limits for m against y, Fire TF1

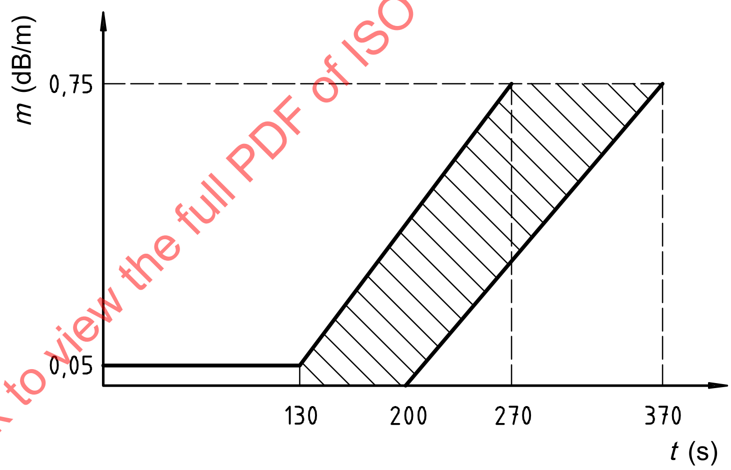


Figure H.3 — Limits for m against time, t, Fire TF1

Annex I
(normative)

Smouldering (pyrolysis) wood fire (TF2)

I.1 Fuel

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

I.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.

I.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 I.1.

I.4 Heating rate

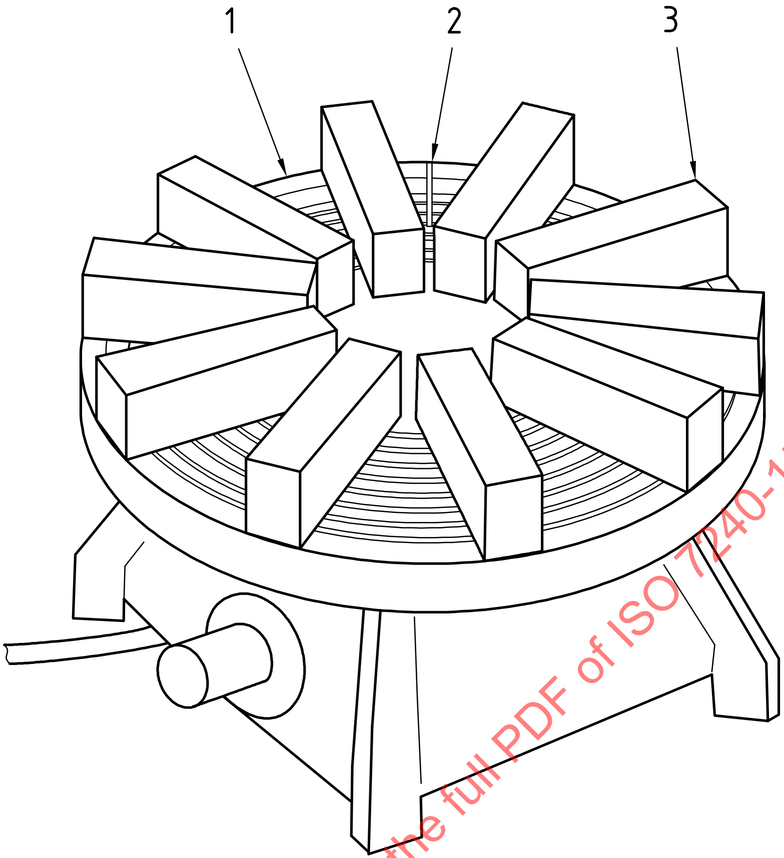
The hotplate shall be powered such that its temperature rises from ambient to 600 °C in approximately 11 min.

I.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 is the earlier.

I.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 I.2 and I.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 I.1 — Arrangement of sticks on the hotplate

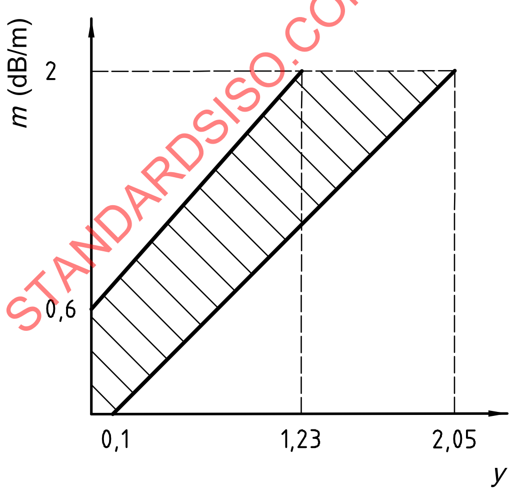


Figure I.2 — Limits for *m* against *y*, Fire TF2

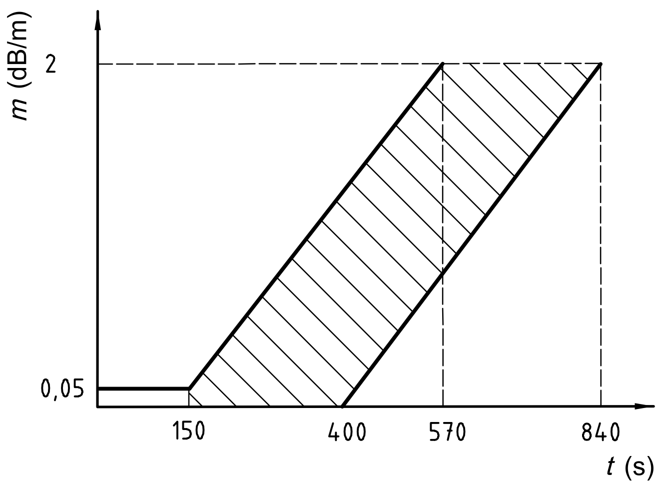


Figure I.3 — Limits for *m* against time, *t*, Fire TF2

Annex J
(normative)

Glowing smouldering cotton fire (TF3)

J.1 Fuel

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

J.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 J.1.

Dimensions in metres

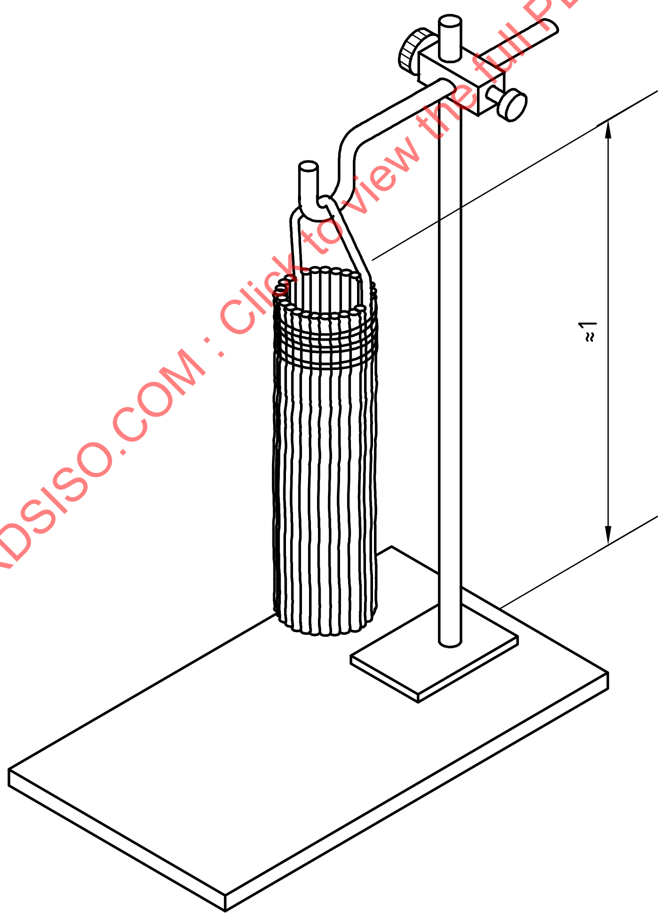


Figure J.1 — Arrangement of the cotton wicks