INTERNATIONAL STANDARD

ISO 7240-27

Second edition
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Fire detection and alarm systems —

Part 27:
Point type fire detectors using a smoke sensor in combination with a carbon monoxide sensor and, optionally, one or more heat sensors

Systèmes de détection et d'alarme d'incendie —

Partie 27: Détecteurs ponctuels d'incendie utilisant un capteur de fumée en combinaison avec un capteur de monoxyde de carbone (CO) et, optionnellement, un ou plusieurs capteurs de chaleur

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Foreword

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

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

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

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

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 7240-27:2009), which has been technically revised.

The main changes compared to the previous edition are as follows:

— other carbon monoxide sensing technologies are now permitted by introducing additional environmental tests;

— a damp heat, steady-state (operational) test like that used in the European standard EN 54-31 has been incorporated;

— for tests in the gas chamber, the allowable background of carbon monoxide has been increased from 1 µl/l to 1,5 µl/l;

— in the test for exposure to chemical agents at environmental concentrations, the concentration of heptane and ethanol have been increased to 500 µl/l and 1000 µl/l, respectively and the exposure times to NO_2 and SO_2 have been reduced to 1 h and 24 h, respectively;

— the test for exposure to chemical agents associated with a fire has been deleted as being too complex and not relevant due to CO sensors having already responded when high concentrations of NO_2, SO_2 and CO have been reached;

— a Bibliography has been added which list standards and documents not used as normative references.

A list of all parts in the ISO 7247-series can be found on the ISO website.

Introduction

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

The performance of fire detectors is assessed from results obtained in specific tests; this document is not intended to place any other restrictions on the design and construction of such detectors.

Smoke detectors using ionization or optical sensors, and complying with ISO 7240-7, are well established for the protection of life and property. Even so, they can respond to stimuli other than smoke and, in some circumstances, can be prone to false alarms. False alarm rates are usually minimised by careful application, giving some limitations in use, and occasionally with a reduction in protection provided.

It is generally accepted that fire detectors using carbon monoxide (CO) sensors alone, while suitable for the detection of smouldering fires involving carbonaceous fuels, can be relatively insensitive to free-burning fires supported by a plentiful supply of oxygen. This limitation can be largely overcome by the inclusion of a heat sensor whose output is combined in some way with that of the CO sensor. Performance requirements for CO fire detectors and for CO and heat detectors can be found in ISO 7240-6 and ISO 7240-8 respectively.

Although the CO and heat detector is capable of responding to free-burning fires, it can still be relatively insensitive to low-temperature fires that produce large amounts of visible smoke but low concentrations of CO and little heat. This limitation prevents the CO and heat detector being a true replacement for a smoke detector in life safety applications.

Many false alarm sources that affect smoke detectors do not produce CO. It is possible therefore that by adding a CO sensor to a smoke detector, and combining its output in some way with that of the smoke sensor, the incidence of false alarms be reduced. This reduction can be achieved while simultaneously providing the ability to respond to a broader range of fire types than is possible with either a smoke or CO detector alone.

It is possible to improve the performance even further by adding a heat sensor to assist in the response to clean-burning high energy fires. This improvement is seen as secondary to the overall performance and for this reason the heat sensor is treated as optional for compliance with this document.

Fire detection and alarm systems —

Part 27:
Point type fire detectors using a smoke sensor in combination with a carbon monoxide sensor and, optionally, one or more heat sensors

1 Scope

This document specifies requirements, test methods and performance criteria for multi-sensor point fire detectors that incorporate a smoke sensor, a carbon monoxide (CO) sensor and, optionally, one or more heat sensors, for use in fire detection and alarm systems installed in buildings (see ISO 7240-1).

For the testing of other types of fire detectors using smoke, CO and, optionally, heat sensors working on different principles, this document can be used only for guidance. This document is not applicable to fire detectors using smoke, CO and, optionally heat sensors, which have special characteristics and which have been developed for specific risks.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

ISO 7240-7:2011, *Fire detection and alarm systems — Part 7: Point-type smoke detectors using scattered light, transmitted light or ionization*

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

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

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

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

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

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

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 2-78: Body Cab: Damp Heat, Steady State*

IEC 62599-2, *Alarm systems — Part 2: Electromagnetic compatibility — Immunity requirements for components of fire and security alarm systems*

3 Terms, definitions and symbols

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
response threshold value
magnitude of the reference parameter at which the detector enters an alarm state when subjected to changes in the smoke or carbon monoxide concentration or temperature

Note 1 to entry: See 5.1.5, 5.1.6 or 5.1.7 (as applicable).

EXAMPLE Smoke response threshold value, CO response threshold value.

Note 2 to entry: The response threshold value can depend on signal processing in the detector and in the control and indicating equipment.

4 General requirements

4.1 Compliance

In order to comply with this document, the detector shall meet the requirements of:

Clause 4, which shall be verified by visual inspection or engineering assessment, shall be tested as described in Clause 5 and shall meet the requirements of the tests.

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

4.2 Response threshold value of detectors using scattered or transmitted light

Detectors using scattered or transmitted light shall conform to one of the two response threshold value bands specified in Table 1 and the corresponding end-of-test conditions for the test fires specified in 5.31.

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

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

4.3 Individual alarm indication

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

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

— 5° from the axis of the detector in any direction;

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

4.4 Connection of ancillary devices

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

4.5 Monitoring of detachable detectors

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

4.6 Manufacturer's adjustments

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

4.7 On-site adjustment of response behaviour

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

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

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

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

4.8 Protection against the ingress of foreign bodies

The detector shall be so designed that a sphere of diameter (1,3 ± 0,05) mm cannot pass into the smoke sensing chamber of the detector, where such an ingress could affect its sensitivity.

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

4.9 Rate-sensitive CO response behaviour

The response threshold value of the detector can depend on the rate of change of CO concentration in the vicinity of the detector. Such behaviour may be incorporated in the detector design to improve the discrimination between ambient CO concentrations and those generated by a fire. If such rate-sensitive behaviour is included, then it shall not lead to a significant reduction in the sensitivity of the detector to fires, nor shall it lead to a significant increase in the probability of unwanted alarms.

Since it is not practical to make tests with all possible rates of increase in CO concentration, an assessment of the rate sensitivity of the detector 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 clause if this assessment shows that

a) for any rate of increase in CO concentration less than 1 µl/l per minute, the detector will signal an alarm condition before the CO concentration reaches 60 µl/l, and

b) the detector does not produce an alarm condition when subjected to a step change in CO concentration of 10 µl/l, superimposed on a background concentration of between 0 µl/l and 5 µl/l.

4.10 Smoke response to slowly developing fires

The provision of "drift compensation" of the smoke sensor (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 detector's sensitivity to smoke from slowly developing fires.

Since it is not practical to make tests with very slow increases in smoke density, an assessment of the detector's response 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 clause if this assessment shows that:

a) for any rate of increase in smoke density R, which is greater than $\frac{A}{4}$ per hour (where A is the detector's initial uncompensated response threshold value), the time for the detector to give an alarm does not exceed $1{,}6 \times \frac{A}{R}$ by more than 100 s, and

b) the range of compensation is limited such that, throughout this range, the compensation does not cause the response threshold value of the detector to exceed its initial value by a factor greater than 1,6.

4.11 Requirements for software controlled detectors

4.11.1 General

The requirements of 4.11.2 and 4.11.3 shall apply to detectors that rely on software control in order to fulfil the requirements of this document.

4.11.2 Software design

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

— The software shall have a modular structure.

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

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

4.11.3 Storage of programs and data

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

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

5 Tests

5.1 General

5.1.1 Atmospheric conditions for tests

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

— temperature: (15 to 35) °C;

— relative humidity: (25 to 75) %;

— air pressure: (86 to 106) kPa.

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

5.1.2 Operating conditions for tests

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

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

5.1.3 Mounting arrangements

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

5.1.4 Tolerances

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

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

5.1.5 Measurement of smoke response threshold value

Measure the smoke response threshold value of the specimen using the method described in ISO 7240-7:2011, 5.1.5. The CO level in the smoke tunnel throughout the test shall not exceed 1,5 µl/l.

Record the aerosol density at the moment that the specimen gives an alarm signal, or a signal specified by the manufacturer, as *m* (dB/m) for detectors using scattered or transmitted light, or as *y* for detectors using ionization. This shall be taken as the smoke response threshold value.

NOTE 1 Detectors for which the manufacturer claims compliance with ISO 7240-7 are subjected to the tests required in that document. In such cases, the response threshold values measured in those tests can be used as the smoke response threshold values for the purposes of this document.

NOTE 2 If the detector is not capable of giving an alarm signal from smoke alone, it will be necessary for the manufacturer to provide special means by which the smoke response threshold value can be measured. For example, it could be acceptable to provide a supplementary output that varies with the aerosol density, or specially modified software to indicate when the aerosol density has caused an internal threshold to be reached. In such cases the special means are preferably chosen such that the nominal smoke response threshold value is in the range 0,05 to 0,7 (dB/m) for detectors using scattered or transmitted light, or 0,2 to 2,0 (*y*) for detectors using ionization.

5.1.6 Measurement of CO response threshold value

Install the specimen for which the response threshold value is to be measured in a gas test chamber, as specified in Annex A and as described in 5.1.3. The orientation of the specimen, relative to the direction of gas flow, shall be the least sensitive orientation as determined in the directional dependence test, unless otherwise specified in the test procedure.

Before commencing each measurement, the gas test chamber shall be purged to ensure that the carbon monoxide concentration is less than 1,5 µl/l.

The air velocity in the proximity of the specimen shall be (0,2 ± 0,04) m s^{-1} during the measurement, unless otherwise specified in the test procedure.

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

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

Increase carbon monoxide gas concentration at a rate of between 1 µl/l/min and 6 µl/l/min until either the specimen has entered an alarm state or the concentration has reached 100 µl/l. Record the time and carbon monoxide concentration at the moment the specimen gives an alarm. This shall be taken as the response threshold value, *S*.

NOTE 1 Detectors for which the manufacturer claims compliance with ISO 7240-6 or ISO 7240-8 are subjected to the tests required in those documents. In such cases, the response threshold values measured in those tests can be used as the CO response threshold values for the purposes of this document.

NOTE 2 If the detector is not capable of giving an alarm signal from CO alone, it will be necessary for the manufacturer to provide special means by which the CO response threshold value can be measured. For example, it could be acceptable to provide a supplementary output that varies with the CO concentration, or specially modified software to indicate when the CO concentration has caused an internal threshold to be reached. In such cases the special means are preferably chosen such that the nominal CO response threshold value is in the range 30 µl/l to 60 µ/l.

For detectors whose response is rate sensitive, the manufacturer may specify a rate of increase within this range to ensure that the measured response threshold value is representative of the static response threshold value of the detector. The rate of increase in CO concentration shall be similar for all measurements on a particular detector type.

5.1.7 Measurement of heat sensor response value

Where detectors comply with ISO 7240-5, the response times measured in those tests may be used as the heat response values for the purposes of this part of ISO 7240.

Install the specimen for which the temperature response value is to be measured in a heat tunnel, as specified in Annex B and mounted as described in 5.1.3. The orientation of the specimen, relative to the direction of airflow, shall be the least sensitive one, as determined in the directional dependence test (5.5), unless otherwise specified in the test procedure.

Connect the specimen to its supply and monitoring equipment as specified in 5.1.2, and allow it to stabilize for at least 15 min.

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

Raise the air temperature at a rate of rise specified in the test and measure the heat response value as specified in ISO 7240-5:2012, 5.1.5, until the signal specified by the manufacturer is produced by the heat sensor.

NOTE 1 The signal can be an alarm, but can also be a signal that is combined with the CO and/or smoke sensor(s) signal before an alarm is generated. For this purpose the manufacturer can supply a detector with special outputs as long as the output signal is routed through the amplification path.

NOTE 2 If the detector is not capable of giving an alarm signal from temperature change alone, it will be necessary for the manufacturer to provide special means by which the response of the heat sensor(s) can be measured. For example, a supplementary output that varies with temperature, or specially modified software to indicate when an internal temperature threshold has been reached, could be acceptable.

Assess the heat response value as:

a) the time taken from the start of the temperature increase to the point at which the heat signal reaches a level specified by the manufacturer, or the detector gives an alarm signal, or

b) the change in signal level produced in a certain time.

NOTE 3 In the case of a), a shorter time will represent a higher sensitivity. In the case of b) a larger change will represent a higher sensitivity.

Record the measured heat response value as *T*.

5.1.8 Provision for tests

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

a) for detachable detectors: 24 detector heads and bases; for non-detachable detectors: 24 specimens;

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

b) the data required in Clause 8;

c) means to enable a quantitative measurement of:

   1) the smoke response threshold value of the detector according to 5.1.5;

   2) the CO response threshold value of the detector according to 5.1.6;

   3) the heat response value of the temperature sensing element(s) of the detector according to 5.1.7.

The specimens submitted shall be deemed representative of the manufacturer's normal production with regard to their construction and calibration. This implies that the mean response threshold value of the 20 five specimens found in the reproducibility test (5.8, 5.9 and 5.10), should also represent the production mean, and that the limits specified in the reproducibility test should also be applicable to the manufacturer's production.

5.1.9 Test schedule

The specimens shall be tested according to the following test schedule (see Table 2). After the reproducibility tests, the two specimens having the lowest CO sensitivity (i.e. those with the highest CO response threshold values) shall be numbered 22 and 23, and the two specimens having the lowest smoke sensitivity (i.e. those with the highest smoke response threshold values) shall be numbered 24 and 25. The others shall be numbered 1 to 21 arbitrarily.

5.1.10 Test report

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

5.2 Repeatability of smoke response

5.2.1 Object of the test

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

5.2.2 Test procedure

Measure the smoke response threshold value of the specimen to be tested six times as described in 5.1.5. The orientation of the specimen relative to the direction of airflow is arbitrary, but it shall be the same for all six measurements.

The maximum smoke response threshold value shall be designated m_{max}, for detectors using scattered or transmitted light, or as y_{max} for detectors using ionization. The minimum smoke response threshold value shall be designated m_{min}, for detectors using scattered or transmitted light, or as y_{min} for detectors using ionization.

5.2.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— the ratio of the smoke response threshold values y_{max}:y_{min} or m_{max}:m_{min} is not greater than 1,6;

— the minimum response threshold value y_{min} is not less than 0,2, or m_{min} is not less than 0,05 dB/m.

5.3 Repeatability of CO response

5.3.1 Object of the test

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

5.3.2 Test procedure

Measure the CO response threshold value of the specimen to be tested six times as specified in 5.1.6. The orientation of the specimen, relative to the direction of airflow is arbitrary, but it shall be the same for all six measurements.

Designate the maximum response threshold value as S_{max}; the minimum value as S_{min}.

Table 2 — Test schedule

Test	Clause	Specimen No(s).
Repeatability of smoke response	5.2	one chosen arbitrarily
Repeatability of CO response	5.3	one chosen arbitrarily
Directional dependence of smoke response	5.4	one chosen arbitrarily
Directional dependence of CO response	5.5	one chosen arbitrarily
Directional dependence of heat response	5.6	one chosen arbitrarily[a]
Lower limit of heat response	5.7	1[a]
Reproducibility of smoke response	5.8	all specimens
Reproducibility of CO response	5.9	all specimens
Reproducibility of heat response	5.10	all specimens [a]
Exposure to chemical agents at environmental concentrations	5.11	1
Long-term stability of CO response	5.12	2
Saturation	5.13	3
Variation in supply parameters	5.14	4
Air movement	5.15	5
Dazzling	5.16	6[b]
Dry heat (operational)	5.17	7
Dry heat (endurance)	5.18	7
Cold (operational), smoke	5.19	8
Cold (operational), CO	5.20	8
Damp heat, cyclic (operational)	5.21	9
Damp heat, steady-state (operational)	5.22	10
Damp heat, steady-state (endurance)	5.23	11
Low humidity, steady-state (endurance)	5.24	12
Sulfur dioxide SO_2 corrosion (endurance)	5.25	13
Shock (operational)	5.26	14
Impact (operational)	5.27	15
Vibration, sinusoidal (operational)	5.28	16
Vibration, sinusoidal (endurance)	5.29	16
Electromagnetic compatibility (EMC) immunity tests (operational a) electrostatic discharge b) radiated electromagnetic fields (operational) c) conducted disturbances induced by electromagnetic fields (operational) d) fast transient bursts e) slow high energy transients	5.30	17[c] 18[c] 19[c] 20[c] 21[c]
Fire sensitivity	5.31	22, 23, 24, 25

[a] Test applied only to detectors incorporating heat sensor(s).

[b] Test applied only to detectors using scattered or transmitted light.

[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 may 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 can be impossible to identify which test exposure caused the failure (see IEC 62599-2).

5.3.3 Requirements

The specimen shall meet the requirements of Clause 5 if the ratio of the response threshold values S_{max}: S_{min} is not greater than 1,6.

5.4 Directional dependence of smoke response

5.4.1 Object of the test

To confirm that the smoke sensitivity of the detector is not unduly dependent on the direction of airflow around the detector.

5.4.2 Test procedure

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

Designate the maximum smoke response threshold value m_{max}, or y_{max} and the minimum smoke response threshold value shall be designated m_{min}, or y_{min}.

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

5.4.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— the ratio of the smoke response threshold values y_{max}:y_{min} or m_{max}:m_{min} is not greater than 1,6;

— the minimum response threshold value y_{min} is not less than 0,2, or m_{min} is not less than 0,05 dB/m.

5.5 Directional dependence of CO response

5.5.1 Object of the test

To confirm that the CO sensitivity of the detector is not unduly dependent on the direction of airflow around the detector.

5.5.2 Test procedure

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

Designate the maximum response threshold value as S_{max}; the minimum value as S_{min}.

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

5.5.3 Requirements

The specimen shall meet the requirements of Clause 5 if the ratio of the response threshold values S_{max}: S_{min} is not greater than 1,6.

5.6 Directional dependence of heat response (optional function)

5.6.1 Object of the test

To confirm that the heat sensitivity of the detector is not unduly dependent on the direction of airflow around the detector.

5.6.2 Test procedure

Measure the heat response value of the specimen to be tested eight times as specified in 5.1.7 at a rate of rise of air temperature of 10 K/min, the specimen being rotated about a vertical axis by 45 ° between each measurement, so that the measurements are taken for eight different orientations relative to the direction of airflow. Stabilize the specimen at 25 °C before each measurement.

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

Designate the maximum heat response value as T_{max}; the minimum value as T_{min}.

Record the maximum heat response value and the minimum heat response value orientations. The orientation for which the maximum response time, or the minimum change in signal level was measured is referred to as the *least sensitive* heat orientation. The orientation for which the minimum response time, or the maximum change in signal level was measured is referred to as the *most sensitive* heat orientation.

5.6.3 Requirements

The specimen shall meet the requirements of Clause 5 if the ratio of the heat response values T_{max}:T_{min} is not greater than 1,3, or is not greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.7 Lower limit of heat response (optional function)

5.7.1 Object of the test

To confirm that detectors are not more sensitive to heat alone, without the presence of smoke and/or CO, than is permitted in ISO 7240-5.

5.7.2 Test procedure

Measure the heat response value of the specimen to be tested, in its most sensitive orientation, using the methods described in ISO 7240-5:2012, 5.3 and 5.4, but with the test being terminated when an air temperature of 55 °C has been reached. For the purposes of these tests, the test parameters for Class A1 detectors shall be used.

NOTE It is important to limit the temperature of the detector to 55 °C to prevent possible damage to the electro-chemical cell, if applicable.

5.7.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— in the test for static response temperature, the specimen does not give an alarm signal at a temperature less than 54 °C;

— the specimen does not give an alarm signal at any rate of rise of air temperature in a time less than the lower response time limits specified in ISO 7240-5:2012, Table 4 for a Class A1 detector.

5.8 Reproducibility of smoke response

5.8.1 Object of the test

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

5.8.2 Test procedure

The smoke response threshold value of each of the specimens to be tested shall be measured as described in 5.1.5.

The mean of these smoke response threshold values shall be calculated and shall be designated $\bar{y}$ or $\bar{m}$.

The maximum smoke response threshold value shall be designated m_{max}, or y_{max} and the minimum smoke response threshold value shall be designated m_{min}, or y_{min}.

5.8.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— the ratio of the response threshold values y_{max}: $\bar{y}$ or m_{max}: $\bar{m}$ is not greater than 1,33, and the ratio of the response threshold values $\bar{y}$:y_{max} or $\bar{m}$:m_{min} is not greater than 1,5;

— the minimum response threshold value y_{min} is not less than 0,2 or $m$min is not less than 0,05 dB/m.

5.9 Reproducibility of CO response

5.9.1 Object of the test

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

5.9.2 Test procedure

Measure the CO response threshold value of each of the specimens to be tested as specified in 5.1.6.

Calculate the mean of these response threshold values, which shall be designated $\bar{S}$.

Designate the maximum response threshold value as S_{max}; the minimum value as S_{min}.

5.9.3 Requirements

The specimen shall meet the requirements of Clause 5 if the ratio of the response threshold values S_{max}: $\bar{S}$ is not greater than 1,33, and the ratio of the CO response threshold values $\bar{S}$:S_{min} is not greater than 1,5.

5.10 Reproducibility of heat response (optional function)

5.10.1 Object of the test

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

5.10.2 Test procedure

Measure the heat response value of each of the test specimens as specified in 5.1.7 at a rate of rise of air temperature of 20 K/min and record the heat response value.

Calculate the mean of these response values, which shall be designated $\bar{T}$.

Designate the maximum heat response value as T_{max}; the minimum value as T_{min}.

5.10.3 Requirements

The specimen shall meet the requirements of Clause 5 if the ratio of the heat response values T_{max}:T_{min} is not greater than 1,3, or is not greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.11 Exposure to chemical agents at environmental concentrations

5.11.1 Object of the test

To demonstrate the ability of the detector to withstand the effects of exposure to atmospheric pollutants or chemicals, which can be encountered in the service environment.

5.11.2 Test procedure

Install the specimen to be tested in a gas test chamber, as specified in Annex A, in its normal operating position, by its normal means of attachment. Orient the specimen, relative to the direction of gas flow, to the most sensitive orientation, as determined in the directional dependence test.

Before commencing each measurement, purge the gas test chamber to ensure that the carbon monoxide concentration and test gas concentration are less than 1,5 µl/l prior to each test.

The air velocity in the proximity of the specimen shall be (0,2 ± 0,04) m/s during the measurement. The air temperature in the tunnel shall be (23 ± 2) °C and shall not vary by more than 5 K for all the measurements on the specimen.

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

Introduce a single gas into the gas test chamber such that the gas concentration reaches the required concentration as specified in Table 3 within 10 min. Allow the detectors to stabilize for a period of 15 min at the elevated gas concentration. Where the response threshold value is adjustable, the cross sensitivity shall be tested at the maximum sensitivity setting provided.

Measure the CO response threshold value and designate the maximum response threshold value as S_{max}; the minimum value as S_{min}.

Purge the gas test chamber at the completion of each test period.

5.11.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

a) no alarm or fault signals are given during the conditioning;

b) the ratio of the response threshold values S_{max}:S_{min} is not greater than 1,6.

Table 3 — Gas and vapour concentrations

Test	Chemical agent	Concentration (µl/l)	Exposure period (h)	Recovery period (h)
1	Carbon monoxide	15 ± 10 %	24	1–2
2	Nitrogen dioxide	5 ± 10 %	24	1–2
3	Sulfur dioxide	5 ± 10 %	24	1–2
4	Chlorine	2 ± 10 %	1	1–2
5	Ammonia	50 ± 10 %	1	1–2
6	Heptane	500 ± 10 %	1	1–2
7	Ethanol	1 000 ± 10 %	1	24–25
8	Acetone	1 500 ± 10 %	1	24–25

5.12 Long-term stability of CO response

5.12.1 Object of the test

To show that the detector suffers no significant changes to its response behaviour after a long period of operation.

5.12.2 Test procedure

Connect the specimen to be tested to its supply and monitoring equipment as specified in 5.1.2 and operate in standard atmospheric conditions for a period of 84 days.

At the end of the test period, measure the response threshold value as specified in 5.1.6.

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

5.12.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm signal or fault signal, attributable to the stability test, is given during the test;

— the ratio of the response threshold values S_{max}:S_{min} is not greater than 1,6.

5.13 Saturation

5.13.1 Object of the test

To show that the detector suffers no significant changes to its response behaviour after exposure to high levels of carbon monoxide.

5.13.2 Test procedure

Install the specimen for which the saturation sensitivity is to be measured, as described in 5.1.3, in a gas test chamber as specified in Annex A. The orientation of the specimen, relative to the direction of gas flow, shall be the least sensitive orientation, as determined in the directional dependence test.

Before commencing each measurement, purge the gas test chamber to ensure that the carbon monoxide concentration and test gas concentration is less than 1,5 µl/l prior to each test.

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

The air temperature in the tunnel shall be (23 ± 5) °C and shall not vary by more than 5 K for all the measurements on the specimen.

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

Introduce carbon monoxide gas into the chamber such that, after 10 min, a stable gas concentration of 500 µl/l is achieved. Maintain the gas concentration for a period of 1 h.

After a recovery period of 1 h at the standard atmospheric conditions, reset the detector and measure the CO response threshold value as specified in 5.1.6.

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

5.13.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

- For detectors which generate an alarm during the conditioning period:
  - the detector shall give and stay in an alarm condition during the conditioning period and generate an alarm signal within two minutes of being reset; and
  - after the recovery time, either:
    - the ratio of the response values S_{max}:S_{min} is not greater than 1,6, or
    - it signals an alarm or a fault;
- for detectors which generate a fault during the conditioning period:
  - the detector shall generate no alarm signal, but a fault signal within two minutes after being reset; and
  - after the recovery time, either:
    - the ratio of the response values S_{max}:S_{min} is not greater than 1,6, or
    - it signals a fault;
- for detectors which do not generate an alarm or a fault during the conditioning period:
  - the detector shall generate no alarm signal after being reset; and
  - after the recovery time, either:
    - the ratio of the response values S_{max}:S_{min} is not greater than 1,6, or
    - it signals a fault.

5.14 Variation in supply parameters

5.14.1 Object of the test

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

5.14.2 Test procedure

Apply the following test procedure:

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

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

— Measure the CO response threshold value of the specimen as specified in 5.1.6 at the upper and lower limits of the supply parameter (e.g. voltage) range(s) specified by the manufacturer.

Designate the maximum response threshold value as S_{max}; the minimum value as S_{min}.

— For detectors incorporating heat sensors, measure the heat response value of the specimen to be tested as specified in 5.1.7 at a rate of rise of air temperature of 20 K/min at the upper and lower limits of the supply parameter (e.g. voltage) range(s) specified by the manufacturer.

Designate the maximum heat response value as T_{max}; the minimum value as T_{min}.

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

5.14.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— the ratio of the smoke response value m_{max}:m_{min} or y_{max}:y_{min} is not greater than 1,6;

— the ratio of the response threshold values S_{max}:S_{min} is not greater than 1,6;

— the ratio of the heat response values T_{max}:T_{min} is not greater than 1,3, or is not greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.15 Air movement

5.15.1 Object of the test

To show that the smoke sensitivity and the CO sensitivity of the detector is not unduly affected by the rate of the airflow.

5.15.2 Test procedure

Measure the smoke response threshold value of the specimen to be tested as described in 5.1.5, in the most and least sensitive orientations, and designate the response threshold values in these tests $y_{(0,2)max}$ and $y_{(0,2)min}$ or $m_{(0,2)max}$ and $m_{(0,2)min}$, as appropriate.

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

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

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

Measure the CO response threshold value of the specimen to be tested as specified in 5.1.6 in the most and least sensitive orientations as determined in 5.3. Designate these as $S_{(0.2)\min}$ and $S_{(0.2)\max}$ respectively.

Repeat these measurements, but with an air velocity in the proximity of the detector of (1 ± 0,2) m/s. Designate the response threshold values in the most and least sensitive orientations in these tests as $S_{(1,0)\min}$ and $S_{(1,0)\max}$ respectively.

5.15.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— for detectors using ionization Formula (1) applies:

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

and the detector gives neither a fault signal nor an alarm signal during the test with aerosol-free air,

— for detectors using scattered or transmitted light Formula (2) applies:

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

— for CO sensor Formula (3) applies:

$$0,625 \le \frac{S_{(0,2)\max} + S_{(0,2)\min}}{S_{(1,0)\max} + S_{(1,0)\min}} \le 1,6 \quad (3)$$

and, the detector gives neither a fault signal nor an alarm signal during the test with gas-free air.

5.16 Dazzling

5.16.1 Object of the 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 applied to detectors using scattered light or transmitted light as detectors using ionization are considered unlikely to be influenced.

5.16.2 Test procedure

Install the dazzling apparatus, described in Annex C in the smoke tunnel.

Install the specimen to be tested in the dazzling apparatus in the least sensitive orientation and connected to its supply and monitoring equipment as specified in 5.1.2.

Apply the following procedure:

— Measure the response threshold value of the specimen as described in 5.1.5.

— Switch ON the four lamps simultaneously for 10 s and then OFF for 10 s, 10 times.

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

— Switch OFF the four lamps.

Repeat the above procedure but with the detector rotated 90°, in one direction from the least sensitive orientation.

NOTE Either direction can be chosen.

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

5.16.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— during the periods when the lamps are being switched ON and OFF, and when the lamps are ON before the response threshold value is measured, the specimen gives neither an alarm nor a fault signal;

— for each orientation, the ratio of the response thresholds m_{max}:m_{min} is not greater than 1,6.

5.17 Dry heat (operational)

5.17.1 Object of the test

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

5.17.2 Test procedure

Use the test apparatus and perform the procedure as specified in IEC 60068-2-2, Test Bb, and in this clause.

Install the specimen to be tested in the smoke tunnel described in Annex B, in its least sensitive orientation, with an initial air temperature of (23 ± 5) °C, and connect it to its supply and monitoring equipment as specified in 5.1.2.

Install the specimen to be tested in the CO gas test chamber described in Annex A, in its least sensitive orientation, with an initial air temperature of (23 ± 5) °C, and connect it to its supply and monitoring equipment as specified in 5.1.2.

Apply the following conditioning:

— temperature: (55 ± 2) °C [starting at an initial air temperature of (23 ± 5) °C];

— duration: 2 h.

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

5.17.2.1 Measurements during conditioning

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

5.17.2.2 Final measurements

Measure the response threshold value as described in 5.1.5 but with the temperature at (55 ± 2) °C and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test y_{max} or m_{max}, and the lesser y_{min} or m_{min}.

Measure the CO response threshold value as specified in 5.1.6, but at a temperature of (55 ± 2) °C and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as S_{max}; the lesser as S_{min}.

5.17.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm or fault signals are given during the period that the temperature is increasing to the conditioning temperature or during the conditioning period until the response threshold value is measured;

— the ratio of the response threshold values y_{max}:y_{min} or m_{max}:m_{min} is not greater than 1,6;

— the ratio of the response threshold values S_{max}:S_{min} is not greater than 1,6.

5.18 Dry heat (endurance)

5.18.1 Object of the test

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

5.18.2 Test procedure

Use the test apparatus and perform the procedure as specified in IEC 60068-2-2, Test Bb, and in this clause. Tests for non-heat dissipating specimens (i.e. Tests Ba or Bb) will be applicable. Test Ba (with sudden changes in temperature) may be used, to improve test economy, if it is known that the sudden change in temperature will not be detrimental to the specimen.

Mount the specimen as described in 5.1.2 but do not supply power during the conditioning.

Apply the following conditioning:

— temperature: (50 ± 2) °C;

— duration: 21 days.

5.18.2.1 Final measurements

After a recovery period, of between 1 h and 2 h in standard laboratory conditions, measure:

— the CO response threshold value as described in 5.1.6 and designate the greater of the CO response value measured in this test and that measured for the same specimen in the reproducibility test, S_{max} and the lesser S_{min};

— measure the heat response value of the specimen as specified in 5.1.7 at a rate of rise of air temperature of 20 K/min at the upper and lower limits of the supply parameter (e.g. voltage) range(s) specified by the manufacturer. and designate the maximum heat response value as T_{max} and; the minimum value as T_{min}.

5.18.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no fault signals attributable to the endurance condition are given on reconnection of the specimen;

— the ratio of the CO response value S_{max}:S_{min} is not greater than 1,6;

— the ratio of the heat response value T_{max}:T_{min} is not greater than 1,3.

5.19 Cold (operational), smoke

5.19.1 Object of the test

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

5.19.2 Test procedure

Use the test apparatus and procedure as described in IEC 60068-2-1, Test Ab, and in this clause.

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

Apply the following conditioning:

— temperature: (−10 ± 3) °C;

— duration: 16 h.

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

5.19.2.1 Measurements during conditioning

The specimen shall be monitored during the conditioning period to detect any alarm or fault signals.

5.19.2.2 Final measurements

After a recovery period of between 1 h and 2 h at the standard atmospheric conditions, measure:

— the response threshold value as described in 5.1.5 and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test y_{max} or m_{max} and the lesser shall be designated y_{min} or m_{min};

— for detectors incorporating a heat sensor, the heat response value as described in 5.1.7 at a rate of rise of air temperature of 20 K/min and designate the greater of the heat response values measured in this test and that measured for the same specimen in the reproducibility test as T_{max}, and the lesser as T_{min}.

5.19.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm or fault signal is given during the transition to the conditioning temperature or during the period at the conditioning temperature;

— the ratio of the response threshold values y_{max}:y_{min} or m_{max}:m_{min} is not greater than 1,6;

— the ratio of the heat response values T_{max}:T_{min} is not greater than 1,3, or is not greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.20 Cold (operational), CO

5.20.1 Object of the test

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

5.20.2 Test procedure

Use the test apparatus and procedure as specified in IEC 60068-2-1, Test Ab, and in this clause.

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

Apply the following conditioning:

— temperature: (−10 ± 3) °C;

— duration: 16 h.

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

5.20.2.1 Measurements during conditioning

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

5.20.2.2 Final measurements

Measure the CO response threshold value as specified in 5.1.6, except that the air temperature in the tunnel shall be (−10 ± 3) °C and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test as S_{max}; the lesser as S_{min}.

5.20.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm or fault signals is given during the transition to the conditioning temperature or during the period at the conditioning temperature until the response threshold value is measured;

— the ratio of the response threshold values S_{max}:S_{min} is not greater than 1,6.

5.21 Damp heat, cyclic (operational)

5.21.1 Object of the test

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

5.21.2 Test procedure

Use the test apparatus and procedure shall be as described in IEC 60068-2-30, Test Db using the Variant 1 test cycle, and in this clause.

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

Apply the following conditioning (IEC 60068-2-30 Severity 1):

— lower temperature: (25 ± 3) °C;

— upper temperature: (40 ± 2) °C;

— relative humidity:

  — at lower temperature: ≥95 %;

— at upper temperature: (93 ± 3) %;

— number of cycles: 2.

5.21.2.1 Measurements during conditioning

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

5.21.2.2 Final measurements

After a recovery period of between 1 h and 2 h at the standard atmospheric conditions, measure:

— the smoke response threshold value as described in 5.1.5 and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test y_{max} or m_{max}, and the lesser shall be designated y_{min} or m_{min};

— the CO response threshold value as described in 5.1.6 and designate the greater of the CO response threshold value measured in this test and that measured for the same specimen in the reproducibility test, S_{max}; the lesser as S_{min};

— for detectors incorporating a heat sensor, the heat response value as described in 5.1.7 at a rate of rise of air temperature of 20 K/min and designate the greater of the heat response values measured in this test and that measured for the same specimen in the reproducibility test, T_{max}; the lesser as T_{min}.

5.21.2.3 Requirements

The specimen shall meet the requirements of Clause 5:

— if no alarm or fault signal is given during the conditioning until the response threshold value is measured;

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

— the ratio of the response threshold values S_{max}:S_{min} shall not be greater than 1,6;

— if applicable, the ratio of the heat response values T_{max}:T_{min} shall not be greater than 1,3, or shall not be greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.22 Damp heat, steady-state (operational)

5.22.1 Object of the test

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

5.22.2 Test procedure

Use the test apparatus and procedure as described in IEC 60068-2-78, Test Cab, and in 5.21.2.

Mount the specimen as described in 5.1.3 and shall be connected to supply and monitoring equipment as described in 5.1.2.

Apply the following conditioning:

— temperature: (40 ± 2) °C;

— relative Humidity: (93 ± 3) %;

— duration: 4 days.

A saturated solution of potassium sulfate may be used to maintain the required relative humidity inside a sealed enclosure.

NOTE 1 The relative humidity range is intrinsic to the salt solution used. There is no need to measure humidity level during the test.

NOTE 2 In order to minimize the risk of condensation it is recommended that the test specimen conditioned at 40 °C prior to be introduced in the gas test chamber.

5.22.2.1 Measurements during conditioning

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

During the last hour of the conditioning period, measure the CO response threshold value as described in 5.1.6. Designate the greater of the CO response value measured in this test and that measured for the same specimen in the reproducibility test shall be designated S_{max} and the lesser shall be designated S_{min}.

5.22.2.2 Final measurements

After a recovery period of between 1 h and 2 h at the standard atmospheric conditions, measure the heat response value as described in 5.1.7 at a rate of rise of air temperature of 20 K/min. Designate the greater of the heat response values measured in this test and that measured for the same specimen in the reproducibility test shall be designated as T_{max} and the lesser as T_{min}.

5.22.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

a) no alarm or fault signal shall be given during the transition to the conditioning temperature or during the period at the conditioning temperature until the CO response value is reached;

b) the ratio of the heat response values T_{max}:T_{min} shall be not greater than 1,3;

c) the ratio of the CO response values S_{max}:S_{min} shall be not greater than 1,6.

5.23 Damp heat, steady-state (endurance)

5.23.1 Object of the test

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

5.23.2 Test procedure

Use the test apparatus and perform the procedure as specified in IEC 60068-2-78, Test Cab, and in this clause.

Mount the specimen to be tested as specified in 5.1.3.

Do not be supply it with power during the conditioning.

Apply the following conditioning:

— temperature: (40 ± 2) °C;

— relative humidity: (93 ± 3) %;

— duration: 21 days.

5.23.2.1 Final measurements

After a recovery period of between 1 h and 2 h at the standard atmospheric conditions, measure:

— the smoke response threshold value as described in 5.1.5 and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test y_{max} or m_{max}, and the lesser shall be designated y_{min} or m_{min};

— the CO response threshold value as described in 5.1.6 and designate the greater of the CO response threshold value measured in this test and that measured for the same specimen in the reproducibility test, S_{max}; the lesser as S_{min};

— for detectors incorporating a heat sensor, the heat response value as described in 5.1.7 at a rate of rise of air temperature of 20 K/min and designate the greater of the heat response values measured in this test and that measured for the same specimen in the reproducibility test, T_{max}; the lesser as T_{min}.

5.23.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm or fault signal, attributable to the endurance conditioning, is given on reconnection of the specimen;

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

— the ratio of the response threshold values S_{max}:S_{min} shall not be greater than 1,6;

— for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} shall not be greater than 1,3, or shall not be greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.24 Low humidity, steady-state (endurance)

5.24.1 Object of the test

To demonstrate the ability of the CO sensor to withstand long periods of low humidity in the service environment; i.e. to evaluate its resistance to the drying out of electrolyte in the electrochemical cell, if used.

5.24.2 Test procedure

Mount the specimen to be tested as described in 5.1.3. Do not supply it with power during the conditioning.

Apply the following conditioning:

— temperature: (25 ± 3) °C;

— relative humidity: (11 ± 1) %;

— duration: 21 days.

NOTE The relative humidity specified for this test can be maintained using a saturated solution of lithium chloride inside a sealed enclosure.

5.24.2.1 Final measurements

After a recovery period of between 1 h and 2 h in standard laboratory conditions, measure the CO response threshold value as described in 5.1.6.

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

5.24.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm or fault signal, attributable to the endurance conditioning, is given on reconnection of the specimen;

— the ratio of the CO response threshold values S_{max}:S_{min} shall not be greater than 1,6.

5.25 Sulfur dioxide SO_2 corrosion (endurance)

5.25.1 Object of the test

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

5.25.2 Test procedure

Use the test apparatus and procedure generally specified in IEC 60068-2-42, Test Kc, but carry out the conditioning specified in 5.24.2.

Mount the specimen to be tested as specified in 5.1.3.

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

Apply the following conditioning:

— temperature: (25 ± 2) °C;

— relative humidity: (93 ± 3) %;

— SO_2 concentration: (25 ± 5) µl/l;

— duration: 21 days.

5.25.2.1 Final measurements

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

— the smoke response threshold value as described in 5.1.5 and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test y_{max} or m_{max}, and the lesser shall be designated y_{min} or m_{min};

— the CO response threshold value as described in 5.1.6 and designate the greater of the CO response threshold value measured in this test and that measured for the same specimen in the reproducibility test, S_{max}; the lesser as S_{min};

— for detectors incorporating a heat sensor, the heat response value as described in 5.1.7 at a rate of rise of air temperature of 20 K/min and designate the greater of the heat response values measured in this test and that measured for the same specimen in the reproducibility test, T_{max}; the lesser as T_{min}.

5.25.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm or fault signal, attributable to the endurance conditioning, is given on reconnection of the specimen;

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

— the ratio of the CO response threshold values S_{max}:S_{min} shall not be greater than 1,6;

— for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} shall not be greater than 1,3, or shall not be greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.26 Shock (operational)

5.26.1 Object of the test

To demonstrate the immunity of the detector to mechanical shocks, which are likely to occur, albeit infrequently, in the anticipated service environment. This test is not performed on specimens with a mass >4,75 kg.

5.26.2 Test procedure

Use the test apparatus and procedure shall be as described in IEC 60068-2-27, Test Ea, but carry out the conditioning specified in 5.20.2.

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

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

— shock pulse type: half sine;

— pulse duration: 6 ms;

— peak acceleration: 10 (100 − 20M) ms^{-2} (where M is the specimen's mass in kg);

— number of directions: 6;

— pulses per direction: 3.

5.26.2.1 Measurements during conditioning

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

5.26.2.2 Final measurements

After the conditioning measure the following:

— the smoke response threshold value as described in 5.1.5 and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test y_{max} or m_{max}, and the lesser y_{min} or m_{min};

— the CO response threshold value as described in 5.1.6 and designate the greater of the CO response threshold value measured in this test and that measured for the same specimen in the reproducibility test, S_{max}; the lesser as S_{min};

— for detectors incorporating a heat sensor, the heat response value as described in 5.1.7 at a rate of rise of air temperature of 20 K/min and designate the greater of the heat response values measured in this test and that measured for the same specimen in the reproducibility test, T_{max}; the lesser as T_{min}.

5.26.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm or fault signal, attributable to the endurance conditioning, is given on reconnection of the specimen;

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

— the ratio of the CO response threshold values S_{max}:S_{min} shall not be greater than 1,6;

— for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} shall not be greater than 1,3, or shall not be greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.27 Impact (operational)

5.27.1 Object of the test

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

Use the test apparatus described in Annex D.

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

Use the following test parameters during the conditioning:

— impact energy: (1,9 ± 0,1) J;

— hammer velocity: (1,5 ± 0,13) m/s;

— number of impacts: one.

5.27.1.1 Measurements during conditioning

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

5.27.1.2 Final measurements

After the conditioning measure:

— the smoke response threshold value as described in 5.1.5 and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test y_{max} or m_{max}, and the lesser shall be designated y_{min} or m_{min};

— the CO response threshold value as described in 5.1.6 and designate the greater of the CO response threshold value measured in this test and that measured for the same specimen in the reproducibility test, S_{max}; the lesser as S_{min};

— for detectors incorporating a heat sensor, the heat response value as described in 5.1.7 at a rate of rise of air temperature of 20 K/min and designate the greater of the heat response values measured in this test and that measured for the same specimen in the reproducibility test, T_{max}; the lesser as T_{min}.

5.27.2 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm or fault signals is given during the conditioning or the additional 2 min;

— the impact does not detach the detector from its base, or the base from the mounting;

— the ratio of the response threshold values y_{max}:y_{min} or m_{max}:m_{min} is not greater than 1,6;

— the ratio of the CO response threshold values S_{max}:S_{min} is not greater than 1,6;

— for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} is not greater than 1,3, or is not greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.28 Vibration, sinusoidal (operational)

5.28.1 Object of the test

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

5.28.2 Test procedure

Use the test apparatus and procedure as described in IEC 60068-2-6, Test Fc, and in this clause.

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

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

Apply the following conditioning:

— frequency range: (10 to 150) Hz;

— acceleration amplitude: 5 ms^{-2} (approximately 0,5 g_n);

— number of axes: 3;

— sweep rate: 1 octave/min;

— number of sweep cycles: 1 per axis.

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

5.28.2.1 Measurements during conditioning

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

5.28.2.2 Final measurements

The final measurements, as specified in 5.29.2.1 are normally made after the vibration endurance test and only need be made here if the operational test is conducted in isolation.

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

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

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

5.28.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm or fault signal, attributable to the endurance conditioning, is given on reconnection of the specimen;

— the ratio of the response threshold values y_{max}:y_{min} or m_{max}:m_{min} is not greater than 1,6;

— the ratio of the CO response threshold values S_{max}:S_{min} is not greater than 1,6;

— for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} shall not be greater than 1,3, or is not greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.29 Vibration, sinusoidal (endurance)

5.29.1 Object of the test

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

5.29.2 Test procedure

Use the test apparatus and perform the procedure as specified in IEC 60068-2-6, Test Fc, and in this clause.

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

Apply the following conditioning:

— frequency range: (10 to 150) Hz;

— acceleration amplitude: 10 ms-2 (approximately 1,0 g_n);

— number of axes: 3;

— sweep rate: 1 octave/min;

— number of sweep cycles: 20 per axis.

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

5.29.2.1 Final measurements

After the conditioning measure the following:

— the smoke response threshold value as described in 5.1.5 and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test y_{max} or m_{max}, and the lesser shall be designated y_{min} or m_{min};

— the CO response threshold value as described in 5.1.6 and designate the greater of the CO response threshold value measured in this test and that measured for the same specimen in the reproducibility test, S_{max}; the lesser as S_{min};

— for detectors incorporating a heat sensor, the heat response value as described in 5.1.7 at a rate of rise of air temperature of 20 K/min and designate the greater of the heat response values measured in this test and that measured for the same specimen in the reproducibility test, T_{max}; the lesser as T_{min}.

5.29.3 Requirements

The specimen shall meet the requirements of Clause 5 if:

— no alarm or fault signal, attributable to the endurance conditioning, is given on reconnection of the specimen;

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

— the ratio of the CO response threshold values S_{max}:S_{min} shall not be greater than 1,6;

— for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} shall not be greater than 1,3, or shall not be greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.30 Electromagnetic compatibility (EMC) immunity tests (operational)

5.30.1 Object of the test

To demonstrate the immunity against electromagnetic disturbances.

5.30.1.1 Carry out the following EMC immunity tests as described in IEC 62599-2.

a) electrostatic discharge;

b) radiated electromagnetic fields;

c) conducted disturbances induced by electromagnetic fields;

d) fast transient bursts;

e) slow high energy voltage surges.

5.30.1.2 For these tests apply the criteria for compliance specified in IEC 62599-2 and the following:

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

   1) the smoke response threshold value as described in 5.1.5 and designate the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test y_{max} or m_{max}, and the lesser shall be designated y_{min} or m_{min};

   2) the CO response threshold value as described in 5.1.6 and designate the greater of the CO response threshold value measured in this test and that measured for the same specimen in the reproducibility test, S_{max}; the lesser as S_{min};

3) for detectors incorporating a heat sensor, the heat response value as described in 5.1.7 at a rate of rise of air temperature of 20 K/min and designate the greater of the heat response values measured in this test and that measured for the same specimen in the reproducibility test, T_{max}; the lesser as T_{min}.

5.30.2 Requirements

The specimen shall meet the requirements of Clause 5 if:

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

b) the ratio of the CO response threshold values S_{max}:S_{min} shall not be greater than 1,6;

c) the ratio of the heat response values T_{max}:T_{min} shall not be greater than 1,3, or shall not be greater than the value for which the manufacturer can demonstrate that the resulting change in the CO response threshold value is not more than a factor of 1,6.

5.31 Fire sensitivity

5.31.1 Object of the test

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

5.31.2 Test procedure

Mount the specimens in a standard fire test room (see Annex E) and exposed to a series of test fires designed to produce smoke, heat and CO representative of a wide spectrum of smoke and smoke flow conditions.

Subject the specimens to the five test fires: TF2, TF3, TF4, TF5, and TF8 (if a heat sensor is included). The type, quantity and arrangement of the fuel and the method of ignition are specified in Annexes F to J for each test fire, along with the end-of-test condition and the required profile curve limits.

In order for a test fire to be valid, the development of the fire shall be such that the profile curves of *m* against *y*, *m* against time *t* and *S* against time *t* (for TF2, TF3, TF4, TF5 and TF8) 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 it can be necessary, to adjust the quantity, condition (e.g. moisture content) and arrangement of the fuel to obtain valid test fires.

Mount the four specimens (Nos. 21, 22, 23 and 24) on the fire test room ceiling in the designated area (see Annex E) in accordance with the manufacturer's instructions, such that they are in the least sensitive orientation relative to an assumed airflow from the centre of the room to the specimen.

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

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

5.31.2.1 Initial conditions

WARNING — The stability of the air and temperature affects the smoke flow and gas flow within the room. This is particularly important for the test fires that produce low thermal lift for the smoke (e.g. TF2 and TF3). Therefore, the difference between the temperature near the floor and the ceiling should be <2 °C, and local heat sources that can cause convection currents (e.g. lights

and heaters) should be avoided. If it is necessary for people to be in the room at the beginning of a test fire, they should leave as soon as possible, taking care to produce the minimum disturbance to the air.

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

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

Air temperature, T : (23 ± 5) °C;

Air movement: negligible;

Smoke density (ionization): $y \leq 0,05$;

Smoke density (optical): $m \leq 0,02$ dB/m;

CO concentration: $S \leq 1,5$ µl/l.

5.31.2.2 Measurement during conditioning

During each test fire, record the fire parameters in Table 4 as a function of time from the start of the test. Record each parameter continuously or at least once per second.

Table 4 — Fire parameters

Parameter	Symbol	Units
Temperature change	ΔT	°C
Smoke density (ionization)	y	(dimensionless)
Smoke density (optical)	m	dB/m
Carbon monoxide concentration	S	µl/l

The alarm signal given by the supply and monitoring equipment is 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, m_a and S_a, the fire parameters at the moment of response. A response of the smoke alarm after the end-of-test condition is ignored.

5.31.3 Requirements

The specimen shall meet the requirements of Clause 5 if all four specimens generate an alarm signal, in each test fire, before the specified end-of-test condition is reached.

6 Test report

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

— identification of the detector tested;

— reference to this document (i.e. ISO 7240-27:2018);

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

— conditioning period and conditioning atmosphere;

— temperature and relative humidity in the test room throughout the test;

— details of the supply and monitoring equipment and alarm criteria;

— details of any deviation from this document or from the International Standards to which reference is made, and details of any operations regarded as optional.

7 Marking

Each detector shall be clearly marked with the following information:

— number of this document (i.e. ISO 7240-27);

— name or trademark of the manufacturer or supplier;

— model designation (type or number);

— wiring terminal designations;

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

— maximum temperature, if the CO sensor has an installed temp limit;

— maximum temperature, if a heat sensor is limited to that of class A1.

For detachable detectors, the detector head shall be marked with a), b), c), e) and e), and the base shall be marked with, at least c), i.e. its own model designation, and d).

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

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

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

8 Data

8.1 Hardware documentation

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

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

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

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

8.2 Software documentation

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

— a functional description of the main program flow (e.g. as a flow diagram or schema) including the following:

  — a brief description of the modules and the functions that they perform;

  — the way in which the modules interact;

  — the overall hierarchy of the program;

  — the way in which the software interacts with the hardware of the detector;

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

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

— a designation, by which the software and its version can be uniquely identified.

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

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

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

  1) the name of the module;

  2) a description of the tasks performed;

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

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

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

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

Annex A
(normative)

Gas test chamber for CO response threshold value and cross sensitivity measurements

A.1 This annex specifies those properties of the gas test chamber that are of primary importance for making repeatable and reproducible measurements of response threshold values of fire detectors. However, since it is not practical to specify and measure all parameters that can influence the measurements, the background information in Annex K should be carefully considered and taken into account when a gas test chamber is designed and used to make measurements in accordance with this document.

A.2 The gas test chamber 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 airflow 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 detector to be tested shall be mounted in its normal operating position on the underside of a flat board aligned with the airflow in the working volume. The board shall be of such dimensions that the edge(s) of the board are at least 20 mm from any part of the detector. The detector mounting arrangement shall not unduly obstruct the airflow between the board and the tunnel ceiling.

A.3 Means shall be provided for creating nearly laminar airflow at the required velocities [i.e. (0,2 ± 0,04) m/s or (1,0 ± 0,2) m/s] through the working volume. It shall be possible to maintain the temperature at the required values and to increase the temperature at a rate not exceeding 1 K/min from −10 °C to 55 °C.

A.4 Means shall be provided for the introduction of the test gas such that a homogeneous gas concentration is in the working volume.

A.5 The response threshold of CO fire detectors is characterized by the concentration of CO in air measured in the proximity of the detector, at the moment that it generates an alarm signal. Gas concentration measurements, *S*, shall be made in the working volume in the proximity of the detector.

A.6 The sensors shall have a measuring accuracy of at least 1 µl/l or 5 %, whichever is greater. The response time of the instrument shall be such that it does not cause a measurement error at the highest rate of increase used for tunnel measurements greater than 5 µl/l.

A.7 Only one detector shall be mounted in the chamber, unless it has been demonstrated that measurements made simultaneously on more than one detector are in close agreement with measurements made by testing detectors individually. In the event of a dispute, the value obtained by individual testing shall be accepted.

Annex B
(normative)

Construction of the heat tunnel

B.1 Heat detectors respond when the signal(s) from one or more sensors fulfil(s) 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, etc. 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 document.

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

B.2 There are two basic types of heat tunnels; recirculating and non-recirculating. All else being equal, a non-recirculating tunnel requires a higher-power heater than a recirculating tunnel, particularly for the higher rates of rise of air temperature. More care is generally needed to ensure that the high-power heater and control system of a non-recirculating tunnel are sufficiently responsive to the changes in heat demand necessary to attain the required temperature-versus-time conditions in the working section. On the other hand, maintaining a constant mass flow with increasing temperature is generally more difficult in a recirculating tunnel.

B.3 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 e.g.:

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

— 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.

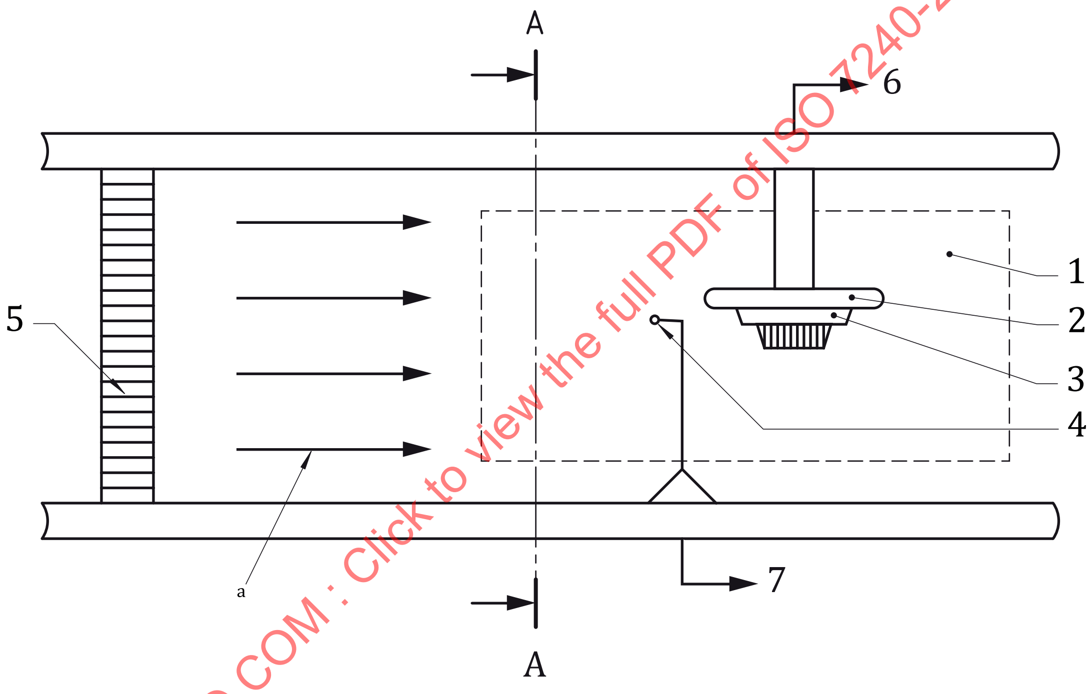
The important point is that the specified temperature profiles are obtained with the required accuracy within the working section.

B.4 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 re-circulating tunnel, it is necessary to increase the air velocity as the air temperature is increased. Careful consideration should therefore be given to ensuring that there is an appropriate correction for 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.

B.5 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 Figures B.1 and B.2). This may 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.

B.6 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.

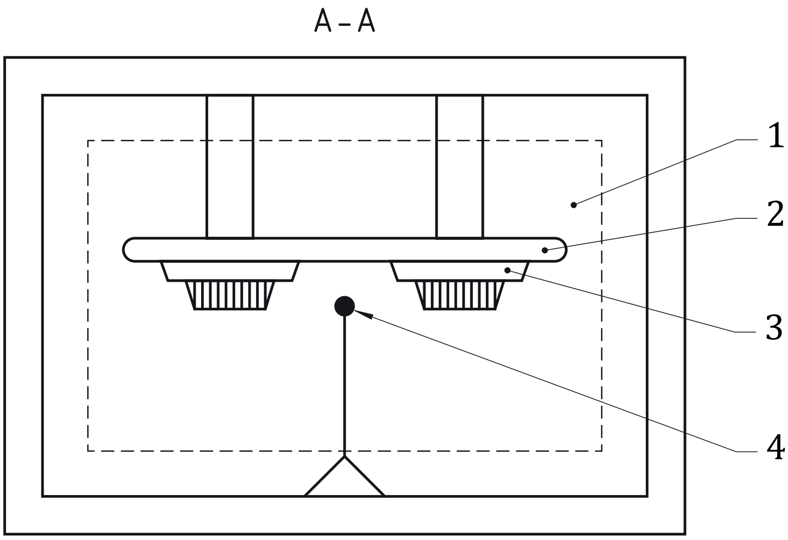
B.7 Special attention shall be given to the temperature measuring system in the tunnel. The required overall time constant of not greater than 2 s in air means that the temperature sensor should have a very small thermal mass. In practice, only the fastest thermocouples and similar small sensors will 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	5	turbulence reducer
2	mounting board	6	output to supply and monitoring equipment
3	detector(s) under test	7	output control and measuring equipment
4	temperature sensor	a	Air flow.

Figure B.1 — Example of working section of heat tunnel



Key

1 working volume

2 mounting board

3 detector(s) under test

4 temperature sensor

Figure B.2 — Example of mounting arrangement for simultaneously testing two detectors

Annex C
(normative)

Apparatus for dazzling test

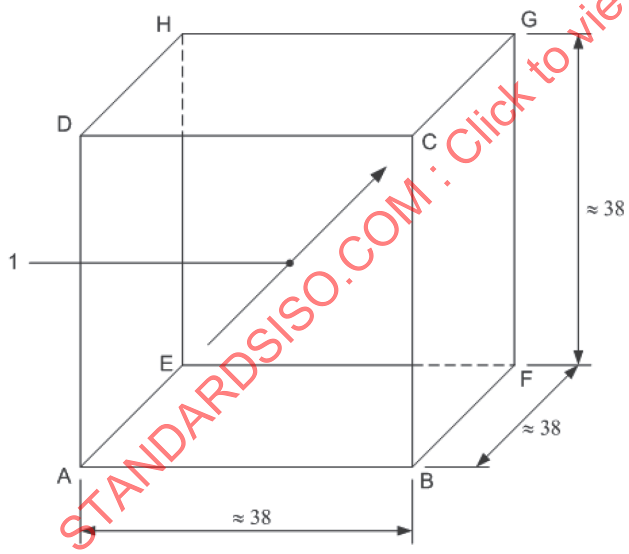
C.1 The dazzling apparatus [see Figure C.1 a)] shall be constructed so that it can be inserted in the working section of the smoke tunnel. The apparatus is cube-shaped, with four of the cube faces (ABFE, AEHD, BFGC and DCGH) closed and lined on the inside with high-gloss aluminium foil. The other two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

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

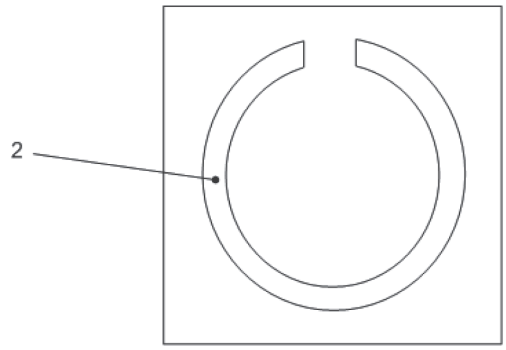
C.3 The specimen to be tested shall be installed in the centre of the upper cube face [see Figure C.1 a)] so that light can play on it from all directions.

C.4 The electrical connections to the fluorescent lamps shall be such that there can be no interference with the detection system through electrical signals.

Dimensions in centimetres



a)



b)

Key

1 stream of aerosol

2 fluorescent lamp

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

Annex D
(normative)

Apparatus for impact test

D.1 The apparatus (see Figure D.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.

D.2 The striker with overall dimensions of 76 mm (width) × 50 mm (depth) × 94 mm (length) and is manufactured from aluminium alloy (Al Cu4SiMg as specified in ISO 209), which has been solution- and precipitation-treated. It has a plane-impact face chamfered at (60 ± 1) to the long axis of the head. The tubular steel shaft has an outside diameter of (25 ± 0,1) mm with a wall thickness of (1,6 ± 0,1) mm.

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

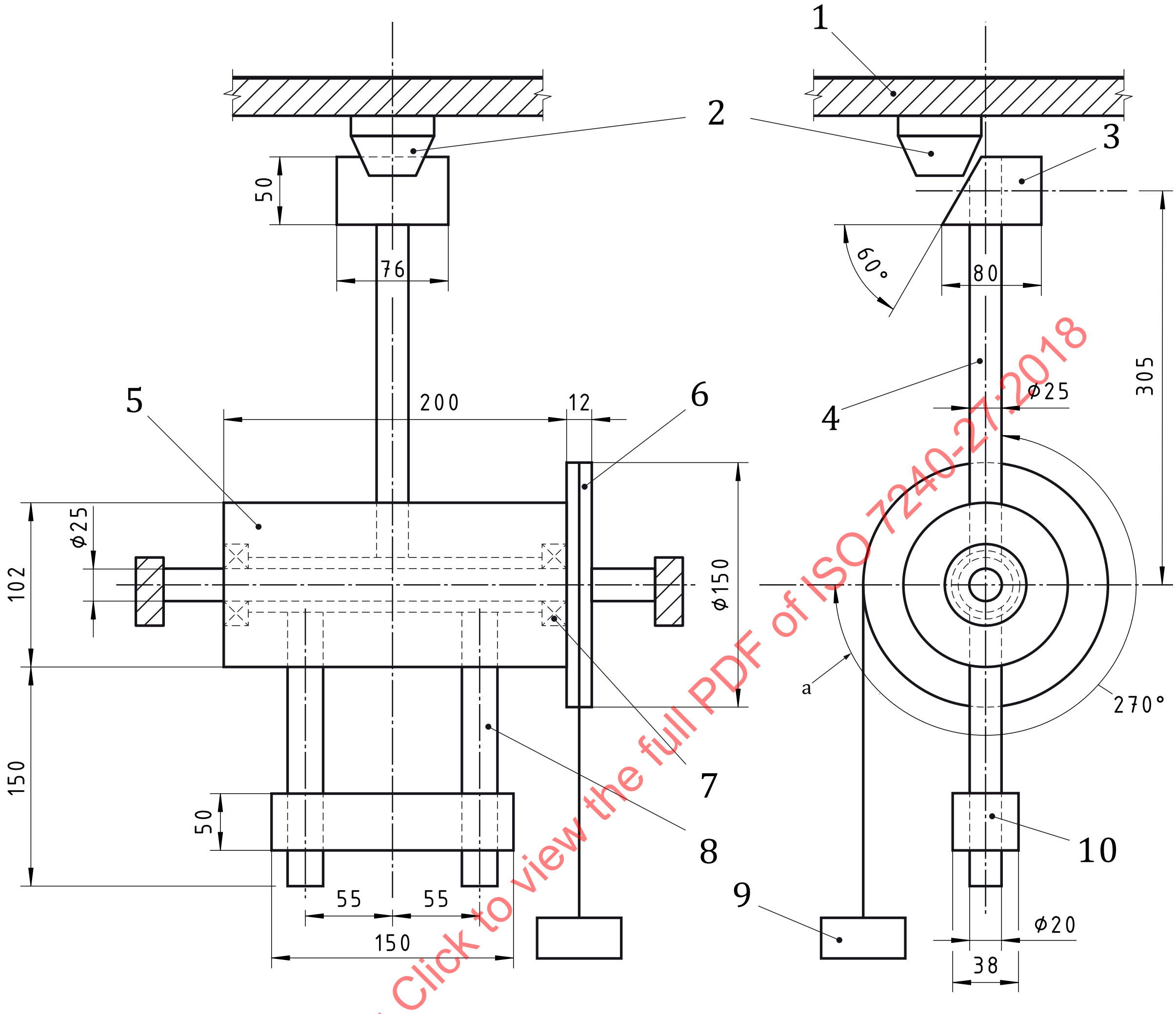
D.4 Diametrically opposite the hammer shaft are two steel counter-balance arms, each 20 mm in outside diameter and 185 mm long. These arms are screwed into the boss so that the length of 150 mm protrudes. A steel counter-balance weight is mounted on the arms so that its position can be adjusted to balance the mass of the striker and arms, as in Figure D.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.

D.5 The rigid frame also supports the mounting board on which the specimen is mounted by its normal fixings. The mounting board is adjustable vertically so that the upper half of the impact face of the hammer will strike the specimen when the hammer is moving horizontally, as shown in Figure D.1.

D.6 To operate the apparatus, the position of the mounting board with the specimen is first adjusted as shown in Figure D.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.

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

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 D.1 — Impact apparatus

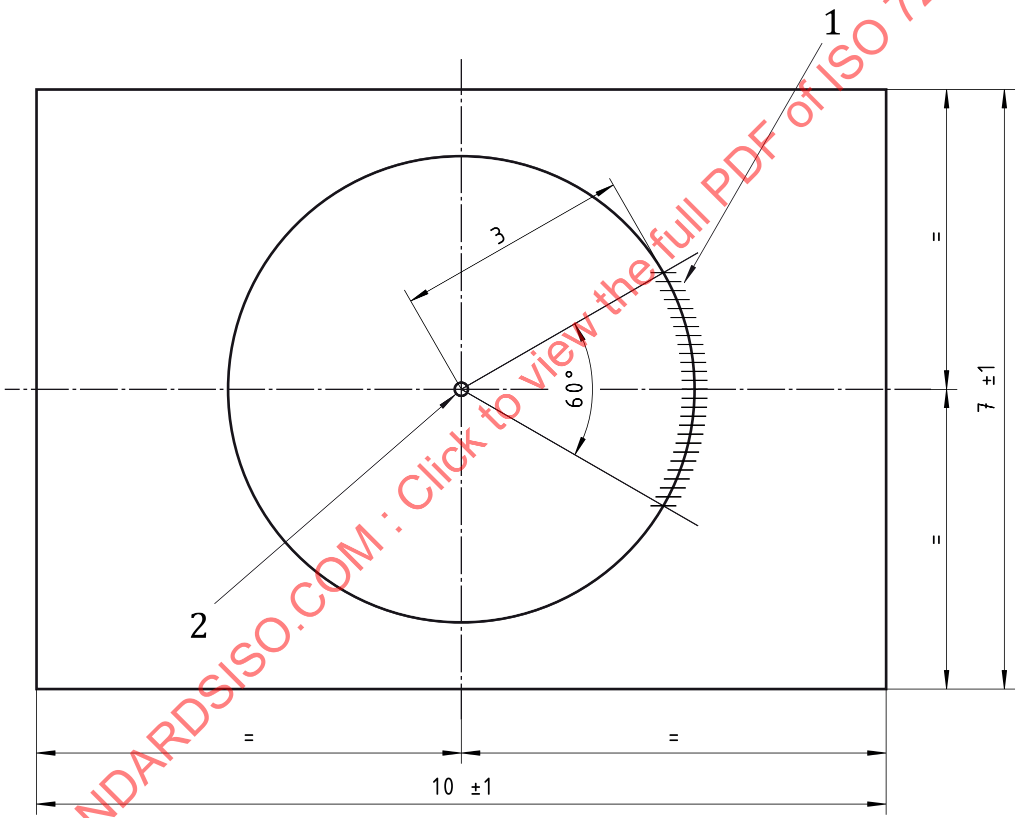
Annex E
(normative)

Fire test room

The specimens to be tested, the measuring ionization chamber (MIC), the temperature probe, the CO monitor and the measuring part of the obscuration meter shall all be located within the volume shown in Figures E.1 and E.2. Details of the smoke measuring instruments are contained within ISO 7240-7.

The specimens, the MIC, the CO monitor 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



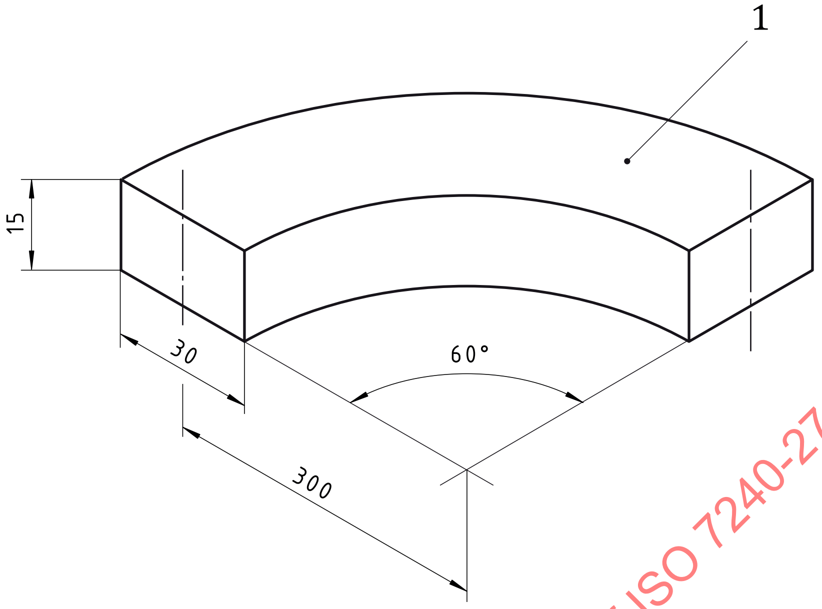
Key

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

2 position of test fire

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

Dimensions in centimetres



Key

1 ceiling

Figure E.2 — Mounting position for instruments and specimens

Annex F
(normative)

Smouldering (pyrolysis) wood fire (TF2)

F.1 Fuel

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

F.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.

F.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.

F.4 Heating rate

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

F.5 End-of-test condition

The end-of-test condition shall be when:

— m_E = 2 dB/m;

— t > 840 s;

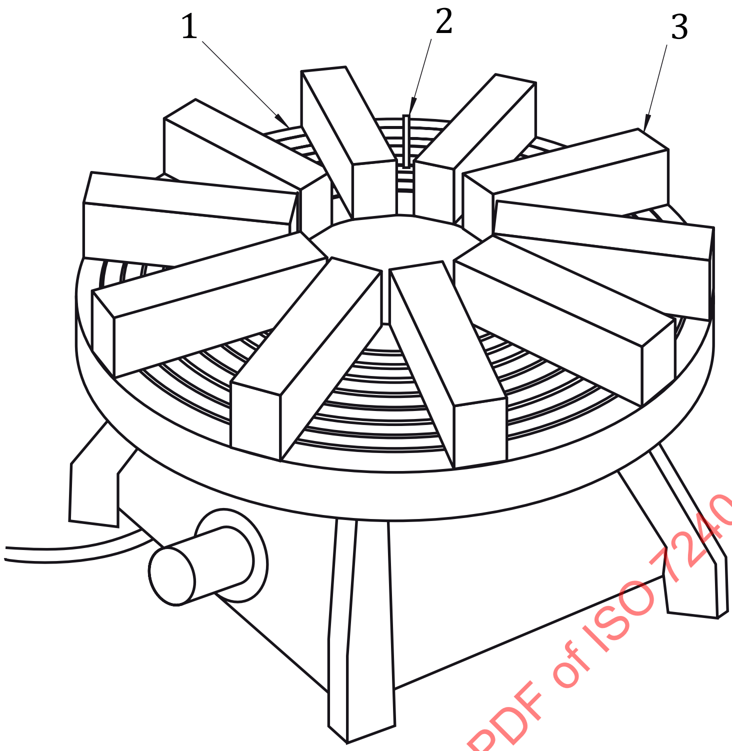
— S > 100 µl/l; or

— all of the specimens have generated an alarm signal, whichever is the earlier.

F.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, and S against time, t, fall within the limits shown in Figures F.2, F.3 and F.4, respectively. That is, $1,23 \leq y \leq 2,05$ and $570 \leq t \leq 840$ at the end-of-test condition m_E = 2 dB/m.

If the end of test condition, m_E = 2 dB/m is reached before all the specimen have responded, then the test is only considered valid if S > 45 µl/l.



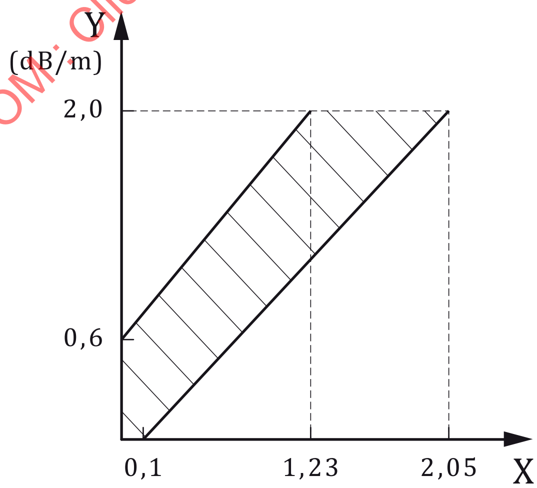
Key

1 grooved hotplate

2 temperature sensor

3 wooden sticks

Figure F.1 — Arrangement of sticks on hotplate

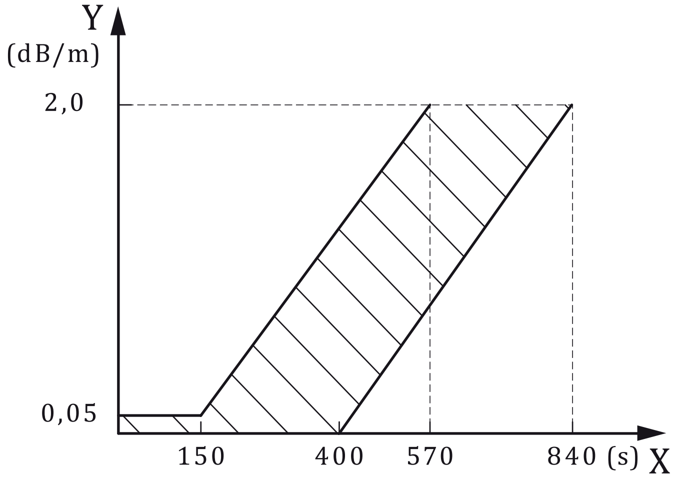


Key

Y *m*-value

X *y*-value

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

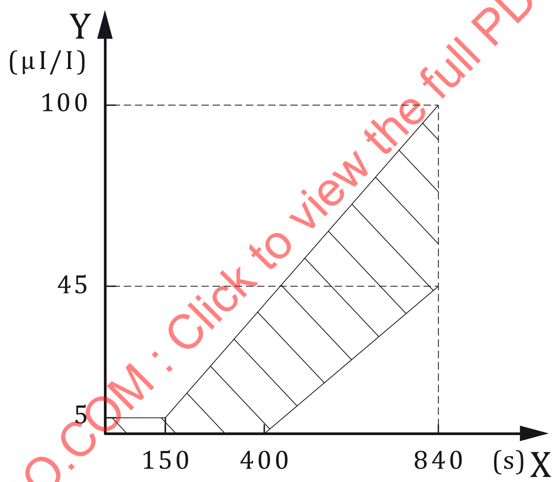


Key

Y *m*-value

X time, *t*

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



Key

Y *S*-value

X time, *t*

Figure F.4 — Limits for *S* against time *t*, Fire TF2

Annex G
(normative)

Glowing smouldering cotton fire (TF3)

G.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.

G.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 G.1.

Dimensions in millimetres

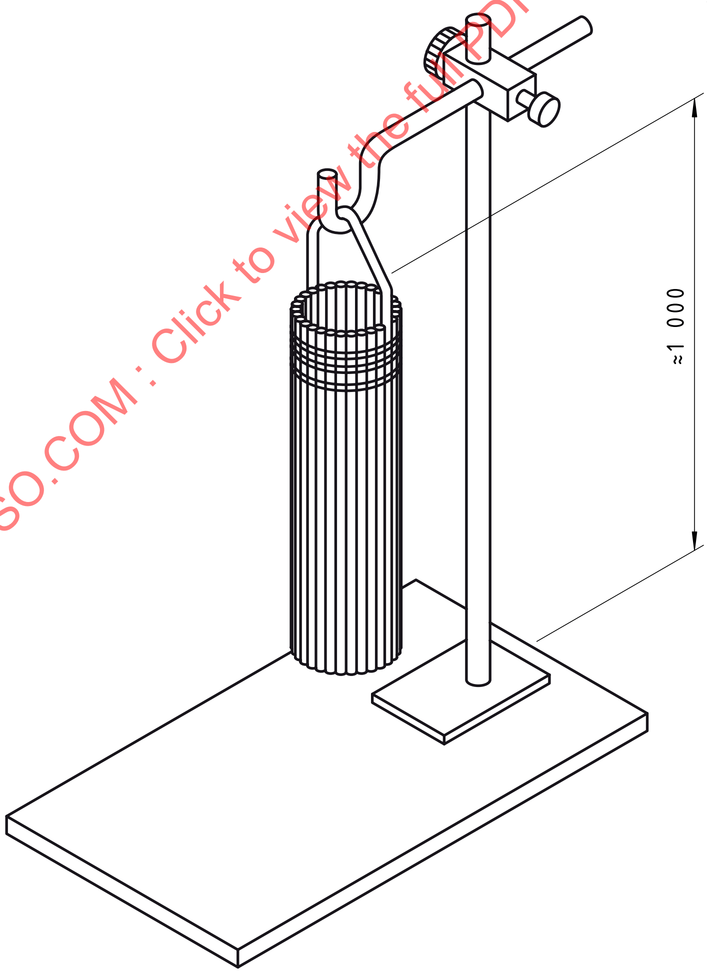


Figure G.1 — Arrangement of cotton wicks

G.3 Ignition

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

G.4 End-of-test condition

The end-of-test condition shall be when:

— $m_E = 2$ dB/m;

— $t > 750$ s;

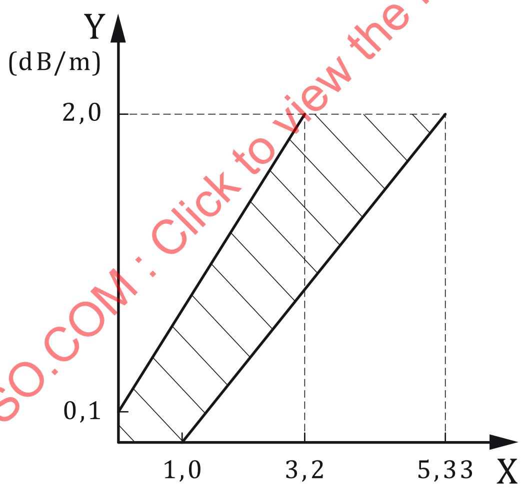
— $S > 150$ µl/l; or

— all of the specimens have generated an alarm signal, whichever is the earlier.

G.5 Test validity criteria

The development of the fire shall be such that the curves of *m* against *y*, and *m* against time, *t*, fall within limits shown in Figures G.2, G.3 and G4, respectively. That is, at the end-of-test condition $m_E = 2$ dB/m, $3,2 \leq y \leq 5,33$ and $280 \leq t \leq 750$.

If the end of test condition, $y_E = 6$ is reached before all the specimens have responded, then the test is only considered valid if $S > 150$ µl/l.



Key

Y *m*-value

X *y*-value

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