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Fire detection and alarm systems —

Part 27: Point-type fire detectors using a scattered-light, transmitted-light or ionization smoke sensor, an electrochemical-cell carbon-monoxide sensor and a heat sensor

Systèmes de détection et d'alarme d'incendie —

Partie 27: Détecteurs d'incendie ponctuels utilisant un détecteur de fumée basé sur le principe de la diffusion de la lumière, de la transmission de la lumière ou de l'ionisation, un détecteur de monoxyde de carbone à cellule électrochimique et un détecteur de chaleur

Reference number
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Foreword

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

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

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

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

ISO 7240-27 was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 3, *Fire detection and alarm systems*.

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

— *Part 1: General and definitions*

— *Part 2: Control and indicating equipment*

— *Part 4: Power supply equipment*

— *Part 5: Point-type heat detectors*

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

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

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

— *Part 9: Test fires for fire detectors* (Technical Specification)

— *Part 10: Point-type flame detectors*

— *Part 11: Manual call points*

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

— *Part 13: Compatibility assessment of system components*

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

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

— *Part 16: Sound system control and indicating equipment*

— *Part 19: Design, installation, commissioning and service of sound systems for emergency purposes*

— *Part 21: Routing equipment*

— *Part 22: Smoke-detection equipment for ducts*

— *Part 27: Point-type fire detectors using a scattered-light, transmitted-light or ionization smoke sensor, an electrochemical-cell carbon-monoxide sensor and a heat sensor*

— *Part 28: Fire protection control equipment*

The following parts are under development:

— Part 17, dealing with short-circuit isolators;

— Part 18, dealing with input/output devices;

— Part 20, dealing with aspirating smoke detectors;

— Part 24, dealing with sound-system loudspeakers;

— Part 25, dealing with components using radio links;

— Part 26, dealing with oil mist detectors.

Introduction

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

The performance of fire detectors is assessed from results obtained in specific tests; this part of ISO 7240 is not intended to place any other restrictions on the design and construction of such 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 minimized 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-detector — heat-detector combination 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 from 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 can 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 can be 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 part of ISO 7240.

Fire detection and alarm systems —

Part 27:
Point-type fire detectors using a scattered-light, transmitted-light or ionization smoke sensor, an electrochemical-cell carbon-monoxide sensor and a heat sensor

1 Scope

This part of ISO 7240 specifies requirements, test methods and performance criteria for multi-sensor point-type fire detectors that incorporate an optical or ionization smoke sensor, an electro-chemical cell for sensing carbon monoxide (CO) 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 part of ISO 7240 can be used only for guidance. Fire detectors using smoke, CO and, optionally, heat sensors which have special characteristics and which have been developed for specific risks are not covered by this part of ISO 7240.

2 Normative references

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

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

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

ISO 7240-5:2003, *Fire detection and alarm systems — Part 5: Point-type heat detectors*

ISO 7240-6, *Fire detection and alarm systems — Part 6: Carbon monoxide fire detectors using electro-chemical cells*

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

ISO 7240-8, *Fire detection and alarm systems — Part 8: Carbon monoxide fire detectors using an electro-chemical cell in combination with a heat sensor*

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 heat, 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 Cab: Damp heat, steady state*

EN 50130-4:1995 (as amended), *Alarm Systems — Part 4: Electromagnetic compatibility — Product family standard: Immunity requirements for components of fire, intruder and social alarm systems*

3 Definitions

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

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, as described in 5.1.5, 5.1.6 or 5.1.7 (as applicable)

EXAMPLES Smoke response threshold value, CO response threshold value.

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

3.2
sensing assembly
those parts of the detector that are required in order to produce an electrical change in response to changes in the concentration of one of the sensed inputs

EXAMPLES Smoke sensing assembly, CO sensing assembly.

4 General requirements

4.1 Compliance

In order to comply with this part of ISO 7240 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.

4.2 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 of up to 500 lx and at an angle of up to

- 5° from the axis of the detector in any direction, and
- 45° from the axis of the detector in at least one direction.

4.3 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.

4.4 Monitoring of detachable detectors

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

4.5 Manufacturer's adjustments

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

4.6 On-site adjustment of response behaviour

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

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

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

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

4.7 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 can 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 can, therefore, be necessary to take other precautions against false alarms due to the entry of small insects.

4.8 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's 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 detector's sensitivity to fires, nor shall it lead to a significant increase in the probability of unwanted alarms.

Since it is not practical to conduct 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 4.8 if this assessment shows that

a) for any rate of increase in CO concentration less than 1 µl/l/min, the detector signals 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.

4.9 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 conduct 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 4.9 if this assessment shows that

a) for any rate of increase in smoke density, R, which is greater than $A/4$ 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 $1,6 \times A/R$ 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.

4.10 Marking

Each detector shall be clearly marked with the following information:

a) number of this part of ISO 7240 (i.e. ISO 7240-27);

b) name or trademark of the manufacturer or supplier;

c) model designation (type or number);

d) wiring terminal designations;

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

For detachable detectors, the detector head shall be marked with a), b), c), 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.

4.11 Data

Either detectors shall 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.

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.

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

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

4.12 Requirements for software controlled detectors

4.12.1 General

The requirements of 4.12.2, 4.12.3 and 4.12.4 shall apply to detectors that rely on software control in order to fulfil the requirements of this part of ISO 7240.

4.12.2 Software documentation

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

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

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

   2) way in which the modules interact,

   3) overall hierarchy of the program,

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

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

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

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

4.12.2.2 The manufacturer shall have available detailed design documentation, which it is necessary to provide only if required by the testing authority. It shall comprise at least the following:

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

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

   1) name of the module,

   2) description of the tasks performed,

   3) 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 a hard copy or in machine-readable form (e.g. ASCII-code), including all global and local variables, constants and labels used, and sufficient comment to recognize the program flow;

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

4.12.3 Software design

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

a) The software shall have a modular structure.

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

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

4.12.4 Storage of programs and data

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

Site-specific data shall be held in memory that can 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:

a) temperature: (15 to 35) °C;

b) relative humidity: (25 to 75) %;

c) 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 that a specimen 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 that a specimen 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 the recognition of a fault signal].

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

5.1.3 Mounting arrangements

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

5.1.5.1 Measure the smoke response threshold value of the specimen using the method described in ISO 7240-7:2003, 5.1.5. The CO level in the smoke tunnel throughout the test shall not exceed 3 µl/l.

5.1.5.2 Record the aerosol density at the moment that the specimen gives an alarm signal, or a signal specified by the manufacturer, as m, expressed in decibels per metre, for detectors using scattered or transmitted light, or as y for detectors using ionization. This shall be taken as the smoke response threshold value.

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

NOTE If the detector is not capable of giving an alarm signal from smoke alone, it is necessary for the manufacturer to provide special means by which the smoke response threshold value can be measured. For example, it can 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 should preferably be chosen such that the nominal smoke response threshold value is in the range 0,05 dB/m to 0,7 dB/m for detectors using scattered or transmitted light, or $y = 0{,}2$ to $y = 2{,}0$ for detectors using ionization.

5.1.6 Measurement of CO response threshold value

5.1.6.1 Install the specimen for which the response threshold value is being 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, unless otherwise specified in the test procedure.

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

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

5.1.6.4 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.

5.1.6.5 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.

5.1.6.6 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.

Detectors for which the manufacturer claims compliance with ISO 7240-6 or ISO 7240-8 shall be subjected to the tests required in the respective part of ISO 7240. In such cases, the response threshold values measured in those tests may be used as the CO response threshold values for the purposes of this part of ISO 7240.

NOTE If the detector is not capable of giving an alarm signal from CO alone, it is necessary for the manufacturer to provide special means by which the CO response threshold value can be measured. For example, it can 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 should preferably be chosen such that the nominal CO response threshold value is in the range of 30 µl/l to 60 µ/l.

5.1.6.7 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

5.1.7.1 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.

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

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

5.1.7.4 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.

5.1.7.5 Raise the air temperature at a rate of rise specified by the manufacturer (within the range of 3 °C/min to 20 °C/min) and measure the heat response value as specified in ISO 7240-5:2003, 5.1.5, until the signal specified by the manufacturer is produced by the heat sensor.

The signal may be an alarm, but may 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 may supply a detector with special outputs. However, it is essential that the output signal be routed through the amplification path.

NOTE If the detector is not capable of giving an alarm signal from temperature change alone, it is 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, can be acceptable.

5.1.7.6 Assess the heat response value as

a) the time taken from the start of the temperature increase to the point at which either 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 amount of time.

NOTE In the case of a), a shorter amount of time represents a higher sensitivity. In the case of b), a larger change represents a higher sensitivity.

5.1.7.7 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 composed 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) data required in 4.11;

c) means to enable a quantitative measurement of

1) the smoke response threshold value of the detector in accordance with 5.1.5,

2) the CO response threshold value of the detector in accordance with 5.1.6,

3) the heat response value of the temperature sensing element(s) of the detector in accordance with 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 24 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 1). After the reproducibility tests, the two specimens with the lowest CO sensitivity (i.e. those with the highest CO response threshold values) shall be numbered 21 and 22, and the two specimens with the lowest smoke sensitivity (i.e. those with the highest smoke response threshold values) shall be numbered 23 and 24. The others shall be numbered 1 to 20 arbitrarily.

5.1.10 Test report

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

Table 1 — Test schedule

Test	Subclause	Specimen number(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	4
saturation	5.13	2
exposure to chemical agents associated with a fire	5.14	3
variation in supply parameters	5.15	5
air movement	5.16	6
dazzling	5.17	6 [b]
dry heat (operational)	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 (endurance)	5.22	10
low humidity, steady state (endurance)	5.23	11
sulfur dioxide SO_2 corrosion (endurance)	5.24	12
shock (operational)	5.25	13
impact (operational)	5.26	14
vibration, sinusoidal (operational)	5.27	15
vibration, sinusoidal (endurance)	5.28	15
electromagnetic compatibility (EMC) immunity tests (operational)	5.29	
a) electrostatic discharge		16 [c]
b) radiated electromagnetic fields (operational)		17 [c]
c) conducted disturbances induced by electromagnetic fields (operational)		18 [c]
d) fast transient bursts		19 [c]
e) slow, high-energy transients		20 [c]
fire sensitivity	5.30	21, 22, 23, 24

[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 may be conducted at the end of the sequence of tests. However, it should be noted that in the event of a failure, it might not be possible to identify which test exposure caused the failure [see EN 50130-4:1995 (as amended), Clause 4].

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 being 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 as 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 as 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 5.2 if

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

— 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 response threshold value of the specimen being 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} and the minimum value as S_{min}.

5.3.3 Requirements

The specimen shall meet the requirements of 5.3 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 being tested eight times as described in 5.1.5. Rotate the specimen 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 as m_{max} or y_{max} and the minimum smoke response threshold value as 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 5.4 if

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

— 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 being tested eight times as specified in 5.1.5. Rotate the specimen 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} and 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 5.5 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 being tested eight times as specified in 5.1.7 at a rate of rise of air temperature of 10 K/min. Rotate the specimen 45° about its vertical axis 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} and 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 5.6 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 being tested, in its most sensitive orientation, using the methods described in ISO 7240-5:2003, 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.

5.7.3 Requirements

The specimen shall meet the requirements of 5.7 if

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

— 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 7240-5:2003, 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 being 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 as $\overline{y}$ or $\overline{m}$.

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

5.8.3 Requirements

The specimen shall meet the requirements of 5.8 if

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

— 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 being tested as specified in 5.1.6.

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

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

5.9.3 Requirements

The specimen shall meet the requirements of 5.9 if the ratio of the response threshold values $S_{max}:\overline{S}$ is not greater than 1,33, and the ratio of the CO response threshold values $\overline{S}:S_{min}$ 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 $\overline{T}$.

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

5.10.3 Requirements

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.

5.11 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 that can be encountered in the service environment.

5.11.2 Test procedure

Install the specimen being 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 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 2, within 10 min. Allow the detectors to stabilize for a period of 1 h at the elevated gas concentration. Where the response threshold value is adjustable, the cross sensitivity shall be tested at the maximum sensitivity setting provided.

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

Table 2 — Gas and vapour concentrations

Test	Chemical agent	Concentration µl/l	Exposure period h	Recovery period h
1	Carbon monoxide	15 ± 1,5	24	1 to 2
2	Nitrogen dioxide	5 ± 0,5	96	1 to 2
3	Sulfur dioxide	5 ± 0,5	96	1 to 2
4	Chlorine	2 ± 0,2	96	1 to 2
5	Ammonia	50 ± 5,0	1	1 to 2
6	Heptane	100 ± 10	1	1 to 2
7	Ethanol	500 ± 50	1	24 to 25
8	Acetone	1 500 ± 150	1	24 to 25

5.11.3 Requirements

The specimen shall meet the requirements of 5.11 if no alarm or fault signals are given during the conditioning.

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 being 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} and the lesser as S_{min}.

5.12.3 Requirements

The specimen shall meet the requirements of 5.12 if:

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

— 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 being 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 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 the rate of increase of gas concentration is 50 µl/l/min to a concentration of 500 µl/l. Maintain the gas concentration for a period of 2 h.

After a recovery period of 4 h at standard atmospheric conditions, reset the detector and 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} and the lesser as S_{min}.

5.13.3 Requirements

The specimen shall meet the requirements of 5.13 if the ratio of the response threshold values S_{max}:S_{min} is not greater than 1,6.

5.14 Exposure to chemical agents associated with a fire

5.14.1 Object of the test

To show that the detector sensitivity does not change significantly following simultaneous exposure to nominated chemical agents that can be present in a fire and carbon monoxide.

5.14.2 Test procedure

5.14.2.1 State of the specimen during conditioning

Install the specimen for which the response threshold value is being measured as described in 5.1.3 in the gas test chamber 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 is less than 1 µl/l.

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 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.

5.14.2.2 Conditioning

a) 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 1 h at the elevated gas concentration.

b) Introduce carbon monoxide into the chamber as described in 5.1.6.

c) Purge the gas test chamber at the completion of each test period and reset the detector.

Table 3 — Gas concentration for exposure to chemical agents associated with a fire

Substance	Concentration µl/l	Exposure period h
Carbon dioxide	5 000	1
Nitrogen dioxide	50	0,5
Sulfur dioxide	50	0,5

5.14.2.3 Measurements during conditioning

Monitor the specimen during each exposure to detect any alarm or fault signals. For each exposure, measure the CO response threshold value as described in 5.1.6.

5.14.2.4 Final measurements

Following each exposure, after a recovery period of between 1 h and 2 h at standard laboratory conditions, measure the CO response threshold value as described in 5.1.6. Designate the greatest of the CO response threshold values measured during each exposure and that measured after each exposure as S_1 and designate the CO response threshold value measured for the same specimen in the reproducibility test as S_0.

5.14.3 Requirements

The specimen shall meet the requirements of 5.14 if for all the gases listed in Table 3

— no fault or alarm signal is given during the conditioning, and

— the ratio of the CO response threshold values S_1:S_0 is not greater than 1.6.

5.15 Variation in supply parameters

5.15.1 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.

5.15.2 Test procedure

Apply the following test procedure.

a) 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 as m_{max} or y_{max} and the minimum as m_{min} or y_{min}.

b) 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} and the minimum value as S_{min}.

c) For detectors incorporating heat sensors, measure the heat response value of the specimen being 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} and 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), it can be necessary to consider signal levels and timing. If required, the manufacturer can be requested to provide suitable supply equipment to allow the supply parameters to be changed as required.

5.15.3 Requirements

The specimen shall meet the requirements of 5.15 if

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

— 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.

5.16 Air movement

5.16.1 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.

5.16.2 Test procedure

Apply the following test procedure:

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

b) 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 as $y_{(1,0)\max}$ and $y_{(1,0)\min}$ or as $m_{(1,0)\max}$ and $m_{(1,0)\min}$, as appropriate.

c) Additionally, for detectors using ionization, subject the specimen being 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 that 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 being tested into an airflow with the appropriate velocity for the required time.

d) Measure the CO response threshold value of the specimen being tested as specified in 5.1.5 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.

e) 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.

5.16.3 Requirements

The specimen shall meet the requirements of 5.16 if

— for detectors using ionization, Equation (1) applies:

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

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, Equation (2) applies:

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

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

— for a CO sensor, Equation (3) applies:

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

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

5.17 Dazzling

5.17.1 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 applies only to detectors using scattered light or transmitted light as it is considered unlikely that detectors using ionization are influenced.

5.17.2 Test procedure

Install the dazzling apparatus, described in ISO 7240-7:2003, Annex D, in the smoke tunnel.

Install the specimen being 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, ten 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}.

5.17.3 Requirements

The specimen shall meet the requirements of 5.17 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, and
- for each orientation, the ratio of the response thresholds m_{max}: m_{min} is not greater than 1.6.

5.18 Dry heat (operational)

5.18.1 Object of the test

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

5.18.2 Test procedure

5.18.2.1 Reference

The test apparatus and the procedure shall be in accordance with IEC 60068-2-2, Test Bb, and with 5.18.2.2 to 5.18.2.5.

5.18.2.2 State of the specimen during conditioning

a) Install the specimen being tested in the smoke tunnel described in ISO 7240-7:2003, 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.

b) Install the specimen being 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.

5.18.2.3 Conditioning

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 $\leqslant$ 1 K/min for the transitions to and from the conditioning temperature.

5.18.2.4 Measurements during conditioning

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

5.18.2.5 Final measurements

a) Measure the response threshold value as described in 5.1.5, but with the temperature at (55 ± 2) °C.

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

b) Measure the CO response threshold value as specified in 5.1.6, but at a temperature of (55 ± 2) °C.

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

5.18.3 Requirements

The specimen shall meet the requirements of 5.18 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, and

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

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

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

5.19.2.1 Reference

The test apparatus and procedure shall be in accordance with IEC 60068-2-1, Test Ab, and with 5.19.2.2 to 5.19.2.5.

5.19.2.2 State of the specimen during conditioning

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

5.19.2.3 Conditioning

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.

5.19.2.4 Measurements during conditioning

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

5.19.2.5 Final measurements

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

a) response threshold value described in 5.1.5;

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

b) 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;

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 5.19 if

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

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

— 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

5.20.2.1 Reference

The test apparatus and procedure shall be in accordance with IEC 60068-2-1, Test Ab, and with 5.20.2.2 to 5.20.2.5.

5.20.2.2 State of the specimen during conditioning

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

5.20.2.3 Conditioning

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.

5.20.2.4 Measurements during conditioning

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

5.20.2.5 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.

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}.

5.20.3 Requirements

The specimen shall meet the requirements of 5.20 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, and

— 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

5.21.2.1 Reference

The test apparatus and procedure shall be in accordance with IEC 60068-2-30, Test Db using the Variant 1 test cycle and with 5.21.2.2 to 5.21.2.5.

5.21.2.2 State of the specimen during conditioning

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

5.21.2.3 Conditioning

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.

5.21.2.4 Measurements during conditioning

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

5.21.2.5 Final measurements

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

a) smoke response threshold value as described in 5.1.5;

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

b) 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 as S_{max} and the lesser as S_{min};

c) 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;

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}.

5.21.3 Requirements

The specimen shall meet the requirements of 5.21 if

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

— the ratio of the response threshold values y_{max}: y_{min} or m_{max}: m_{min} is no greater than 1,6, and

— the ratio of the response threshold values S_{max}:S_{min} is no greater than 1,6, and

— the ratio of the heat response values T_{max}:T_{min} is no greater than 1,3, or no 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 (endurance)

5.22.1 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.)

5.22.2 Test procedure

5.22.2.1 Reference

The test apparatus and the procedure shall be in accordance with IEC 60068-2-78, Test Cab, and with 5.22.2.2 to 5.22.2.4.

5.22.2.2 State of the specimen during conditioning

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

5.22.2.3 Conditioning

Apply the following conditioning:

— temperature: (40 ± 2) °C;

— relative humidity: (93 ± 3) %;

— duration: 21 days.

5.22.2.4 Final measurements

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

a) smoke response threshold value as described in 5.1.5;

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

b) 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 as S_{max} and the lesser as S_{min};

c) 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;

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}.

5.22.3 Requirements

The specimen shall meet the requirements of 5.22 if

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

— the ratio of the response threshold values y_{max}:y_{min} or m_{max}:m_{min} is no greater than 1,6, and

— the ratio of the response threshold values S_{max}:S_{min} is no greater than 1,6, and

— for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} is no greater than 1,3, or no 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.

5.23 Low humidity, steady state (endurance)

5.23.1 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 the resistance to drying out of the electrolyte in the electrochemical cell.)

5.23.2 Test procedure

5.23.2.1 State of the specimen during conditioning

Mount the specimen being tested in accordance with 5.1.3. Do not supply it with power during the conditioning.

5.23.2.2 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.

5.23.2.3 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.

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

5.23.3 Requirements

The specimen shall meet the requirements of 5.23 if

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

— the ratio of the CO response threshold values S_{max}:S_{min} is no greater than 1,6.

5.24 Sulfur dioxide SO_2 corrosion (endurance)

5.24.1 Object of the test

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

5.24.2 Test procedure

5.24.2.1 Reference

The test apparatus and procedure shall be in accordance with IEC 60068-2-42, Test Kc, but carry out the conditioning specified in 5.19.2.3.

5.24.2.2 State of the specimen during conditioning

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

5.24.2.3 Conditioning

Apply the following conditioning:

— temperature: (25 ± 2) °C;

— relative humidity: (93 ± 3) %;

— SO_2 concentration: (25 ± 5) µl/l;

— duration: 21 days.

5.24.2.4 Final measurements

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

a) smoke response threshold value as described in 5.1.5;

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

b) 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 as S_{max} and the lesser as S_{min};

c) 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;

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}.

5.24.3 Requirements

The specimen shall meet the requirements of 5.24 if

- no fault signal, attributable to the endurance conditioning, is given on reconnection of the specimen, and
- the ratio of the response threshold values y_{max}:y_{min} or m_{max}:m_{min} is no greater than 1,6, and
- the ratio of the CO response threshold values S_{max}:S_{min} is no greater than 1,6, and
- for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} is no greater than 1,3, or no 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.

5.25 Shock (operational)

5.25.1 Object of the test

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

5.25.2 Test procedure

5.25.2.1 Reference

The test apparatus and procedure shall be in accordance with IEC 60068-2-27, Test Ea, but carry out the conditioning specified in 5.20.2.3.

5.25.2.2 State of the specimen during conditioning

Mount the specimen being 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.

5.25.2.3 Conditioning

For specimens with a mass $\leqslant$ 4,75 kg, apply the following conditioning:

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

5.25.2.4 Measurements during conditioning

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

5.25.2.5 Final measurements

After the conditioning, measure the following:

a) smoke response threshold value as described in 5.1.5;

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

b) 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 as $S_{max}$and the lesser as S_{min};

a) 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.

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}.

5.25.3 Requirements

The specimen shall meet the requirements of 5.25 if

— no 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 no greater than 1.6,

— the ratio of the CO response threshold values S_{max}:S_{min} is no greater than 1,6, and

— for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} is no greater than 1,3, or no 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 Impact (operational)

5.26.1 Object of the test

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

5.26.2 Test procedure

5.26.2.1 Apparatus

Use the test apparatus described in Annex C.

5.26.2.2 State of the specimen during conditioning

Mount the specimen being 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.

5.26.2.3 Conditioning

Apply the following conditioning:

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

5.26.2.4 Measurements during conditioning

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

5.26.2.5 Final measurements

After the conditioning, measure the following:

a) smoke response threshold value as described in 5.1.5;

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

b) 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 as S_{max} and the lesser as S_{min}.

c) 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.

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}.

5.26.3 Requirements

The specimen shall meet the requirements of 5.26 if

- no alarm or fault signal is given during the conditioning or the additional 2 min, and
- the impact does not detach the detector from its base, or the base from the mounting, and
- the ratio of the response threshold values y_{max}:y_{min} or m_{max}:m_{min} is no greater than 1,6, and
- the ratio of the CO response threshold values S_{max}:S_{min} is no greater than 1,6, and
- for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} is no greater than 1,3, or no 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 Vibration, sinusoidal (operational)

5.27.1 Object of the test

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

5.27.2 Test procedure

5.27.2.1 Reference

The test apparatus and procedure shall be in accordance with IEC 60068-2-6, Test Fc, and with 5.27.2.2 to 5.27.2.5.

5.27.2.2 State of the specimen during conditioning

Mount the specimen being 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, so that one of the three axes is perpendicular to the normal mounting plane of the specimen.

5.27.2.3 Conditioning

Apply the following conditioning:

- frequency range: (10 to 150) Hz;
- acceleration amplitude: 5 m/s^2 (≈ 0,5 g_n);
- number of axes: 3;
- sweep rate: 1 octave/min;
- number of sweep cycles: 1 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. It is necessary to make only one final measurement.

5.27.2.4 Measurements during conditioning

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

5.27.2.5 Final measurements

The final measurements, as specified in 5.28.2.4, 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 as y_{max} or m_{max}, and the lesser 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 as S_{max} and 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 as T_{max} and the lesser as T_{min}.

5.27.3 Requirements

The specimen shall meet the requirements of 5.27 if

- no fault signal, attributable to the endurance conditioning, is given on reconnection of the specimen, and
- the ratio of the response threshold values y_{max}:y_{min} or m_{max}:m_{min} is no greater than 1.6, and

— the ratio of the CO response threshold values S_{max}:S_{min} is no greater than 1,6, and

— for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} is no greater than 1,3, or no 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 (endurance)

5.28.1 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.

5.28.2 Test procedure

5.28.2.1 Reference

The test apparatus and the procedure shall be in accordance with IEC 60068-2-6, Test Fc, and with 5.23.2.2 to 5.23.2.5.

5.28.2.2 State of the specimen during conditioning

Mount the specimen being 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, so that one of the three axes is perpendicular to its normal mounting axis of the specimen.

5.28.2.3 Conditioning

Apply the following conditioning:

— frequency range: (10 to 150) Hz;

— acceleration amplitude: 10 m/s^2 ($\approx$ 1,0 g_n);

— number of axes: 3;

— sweep rate: 1 octave/min;

— number of sweep cycles: 20 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. It is necessary to make only one final measurement.

5.28.2.4 Final measurements

After the conditioning, measure the following:

a) smoke response threshold value as described in 5.1.5;

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

b) 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 as S_{max} and the lesser as S_{min};

c) 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;

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}.

5.28.3 Requirements

The specimen shall meet the requirements of 5.28 if

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

— the ratio of the response threshold values y_{max}: y_{min} or m_{max}:m_{min} is no greater than 1,6, and

— the ratio of the CO response threshold values S_{max}:S_{min} is no greater than 1,6, and

— for detectors incorporating a heat sensor, the ratio of the heat response values T_{max}:T_{min} is no greater than 1,3, or no 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 Electromagnetic compatibility (EMC) immunity tests (operational)

5.29.1 The following EMC immunity tests shall be carried out, in accordance with EN 50130-4:

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.

5.29.2 For these tests, the criteria for compliance in accordance with EN 50130-4 and the following shall apply.

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

1) smoke response threshold value as described in 5.1.5;

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

2) 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 as S_{max} and 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;

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}.

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

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

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

— the lower response threshold value S_{min} shall be no less than 30 μl/l, and

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

— 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 Fire sensitivity

5.30.1 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.

5.30.2 Test procedure

5.30.2.1 Principle

The specimens are mounted in a standard fire test room (see Annex D) 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.

5.30.2.2 Test fires

Subject the specimens to the five test fires: TF2, TF3, TF4, TF5, and TF8. The type, quantity and arrangement of the fuel and the method of ignition are specified in Annexes E to I 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 may be necessary, to adjust the quantity, condition (e.g. moisture content) and arrangement of the fuel to obtain valid test fires.

5.30.2.3 Mounting of specimens

Mount the four specimens (Nos. 21, 22, 23 and 24) on the fire-test room ceiling in the designated area (see Annex D) 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 that dynamically modify their sensitivity in response to varying ambient conditions can require special reset procedures and/or stabilization times. The manufacturer's guidance should be sought in such cases to ensure that the state of the detectors at the start of each test is representative of their normal quiescent state.

5.30.2.4 Initial conditions

IMPORTANT — The stability of the air and temperature affects the smoke flow and gas flow within the room. This is particularly important for 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 such that the following conditions are obtained before the test is started:

— air temperature, T: (23 ± 5) °C;

— air movement: negligible;

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

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

— CO concentration: $S \leqslant 5$ μl/l.

5.30.2.5 Recording of the fire parameters and response values

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.

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

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

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

5.30.3 Requirements

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

6 Test report

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

a) identification of the detector tested;

b) reference to this part of ISO 7240 (i.e. ISO 7240-27:2009);

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

d) conditioning period and conditioning atmosphere;

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

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

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

Annex A
(normative)

Gas test chamber for response threshold value and cross sensitivity measurements

The following 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 J should be carefully considered and taken into account when a gas test chamber is designed and used to make measurements in accordance with this part of ISO 7240.

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 taken 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 being tested and the sensing parts of the measuring equipment. The detector being 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.

Means shall be provided for creating an essentially 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.

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

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.

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.

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
(informative)

Construction of the heat tunnel

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 part of ISO 7240.

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

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 an increasing temperature is generally more difficult in a recirculating tunnel.

The temperature control system shall be able to maintain the temperature within $\pm$ 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, for example

a) 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 $\pm$ 0,1) m/s;

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

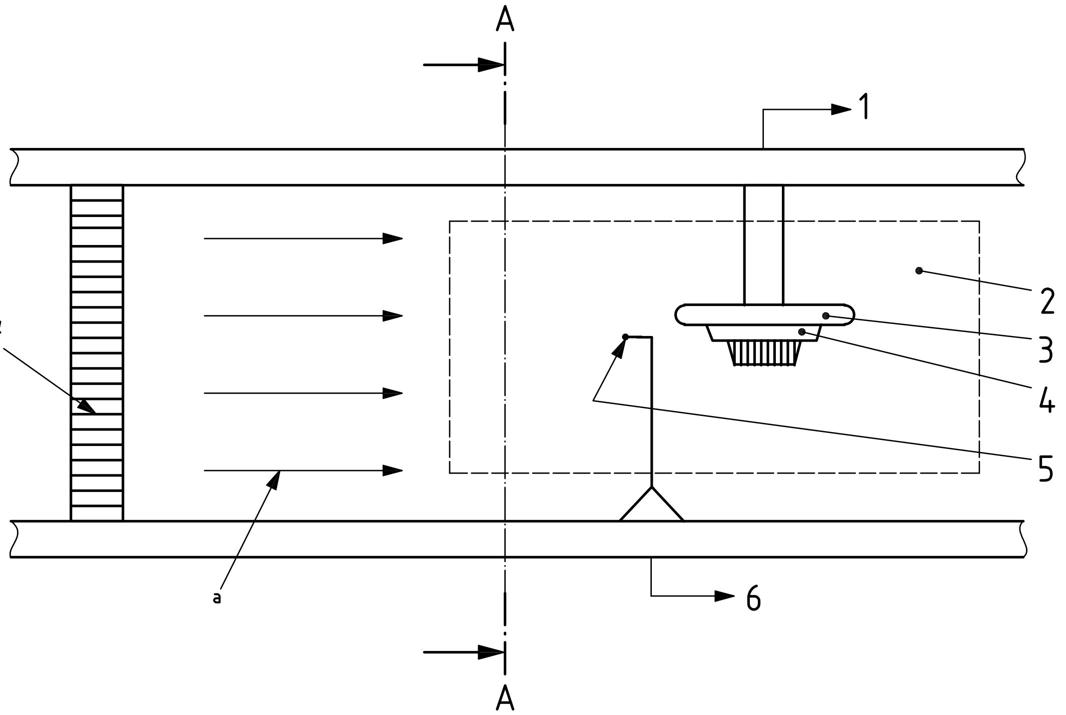
The important point is that the specified temperature profiles are obtained with the required accuracy within the working section.

For a non-recirculating tunnel, the anemometer used for air flow control and monitoring may be placed in a section of the tunnel upstream of the heater, where it is subject to a substantially constant temperature, thereby eliminating any need to temperature-compensate its output. A constant velocity, indicated by an anemometer so positioned, should correlate with a constant mass flow through the working volume. However, to maintain a constant mass flow at normal atmospheric pressure in a recirculating tunnel, it is necessary to increase the air velocity as the air temperature is increased. Careful consideration should, therefore, be given to ensuring that 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 compensates sufficiently quickly at high rates of rise of air temperature.

The air flow created by a fan in the tunnel is turbulent, and it is necessary to pass it 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, a honeycomb or both, in line with, and upstream of, the working section of the tunnel. Care should be taken to ensure that the air flow from the heater is mixed to a uniform temperature before entering the turbulence reducer.

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

Special attention 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 are 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 output to supply and monitoring equipment

2 working volume

3 mounting board

4 detector(s) under test

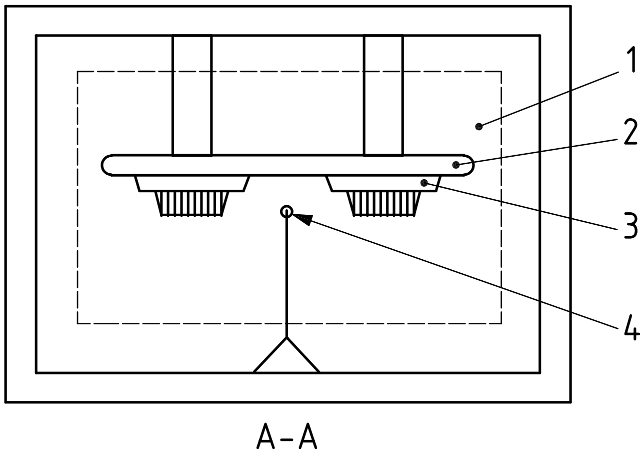
5 temperature sensor

6 output control and measuring equipment

7 turbulence reducer

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 impact test

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

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

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

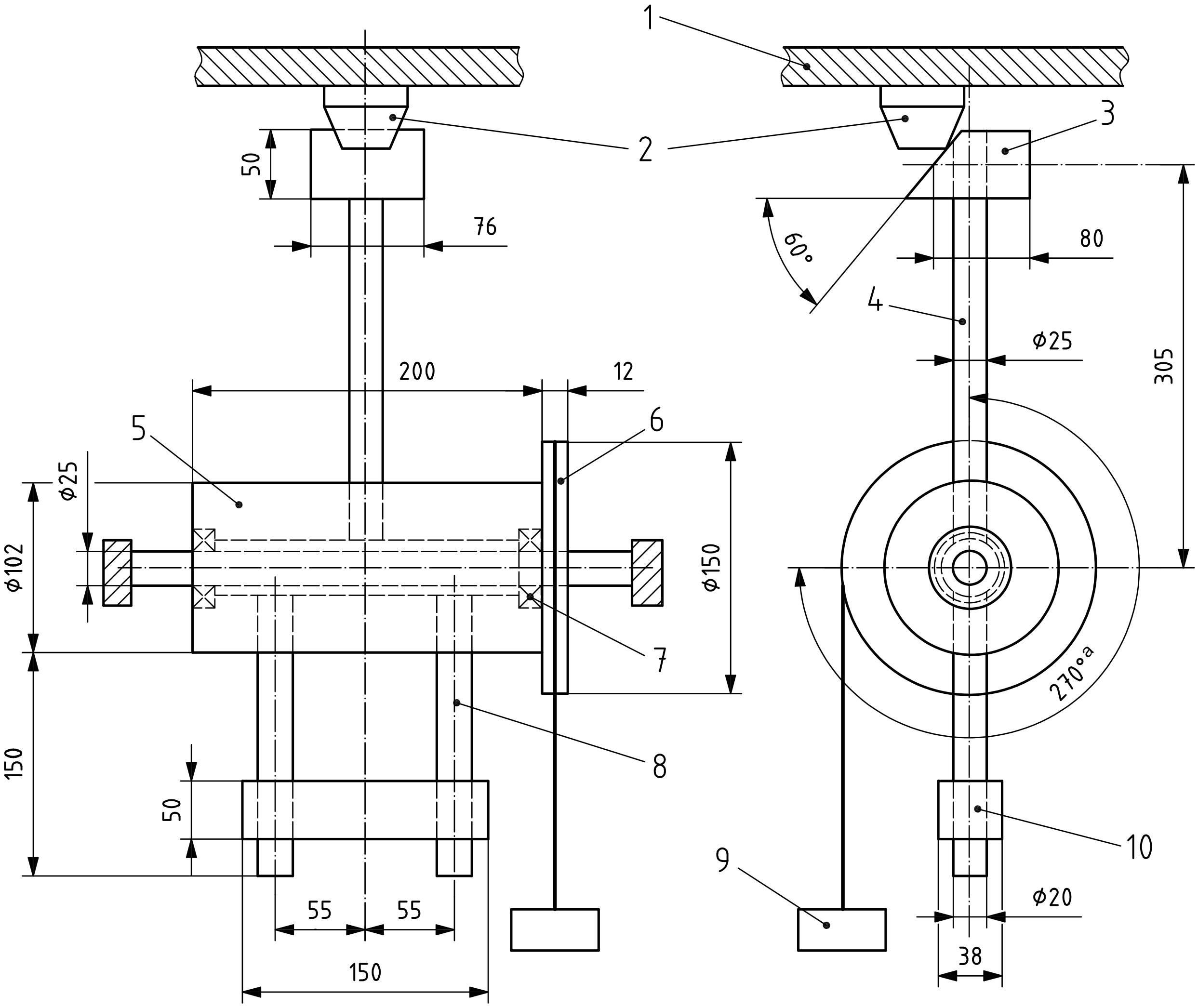
Diametrically opposite the hammer shaft are two steel counter-balance arms, each 20 mm in outside diameter and 185 mm long. These arms are screwed into the boss so that the length of 150 mm protrudes. A steel counter-balance weight is mounted on the arms so that its position can be adjusted to balance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

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

To operate the apparatus, the position of the mounting board with the specimen is first adjusted as shown in Figure C.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 spins the hammer and arm through an angle of $3\pi/2$ rad to strike the specimen. The mass, in kilograms, of the operating weight to produce the required impact energy of 1,9 J equals $0{,}388/(3\pi r)$ kg, where r is the effective radius of the pulley, in metres. This equals approximately 0,55 kg for a pulley radius of 75 mm.

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

Dimensions in millimetres, unless otherwise indicated



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 C.1 — Impact apparatus

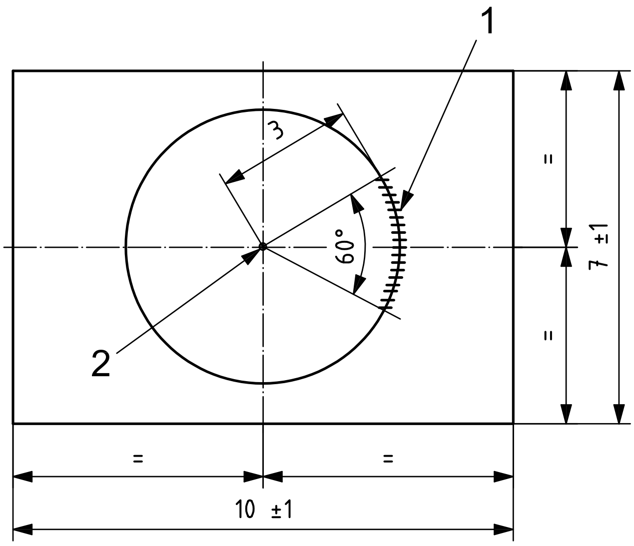
Annex D
(normative)

Fire test room

The specimens being 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 D.1 and D.2. Details of the smoke measuring instruments are given in 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



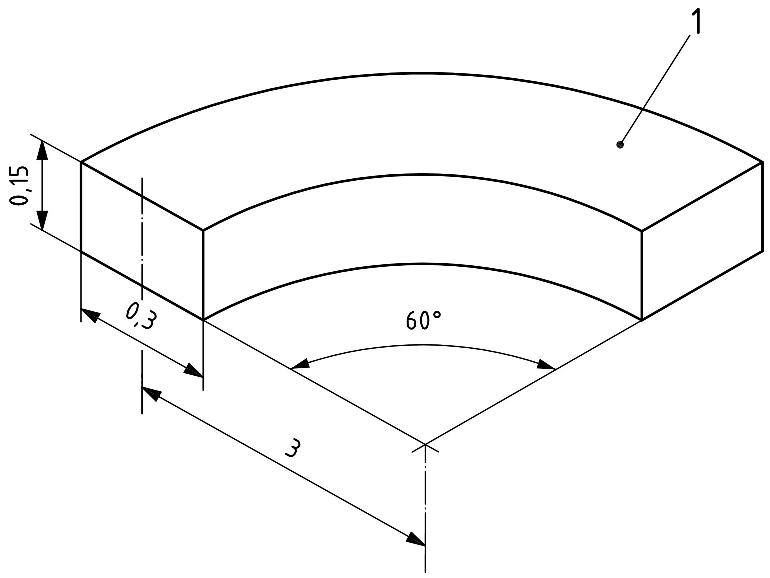
Key

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

2 position of test fire

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

Dimensions in metres, unless otherwise indicated



Key

1 ceiling

Figure D.2 — Mounting position for instruments and specimens

Annex E
(normative)

Smouldering (pyrolysis) wood fire (TF2)

E.1 Fuel

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

E.2 Hotplate

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

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

E.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 E.1.

E.4 Heating rate

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

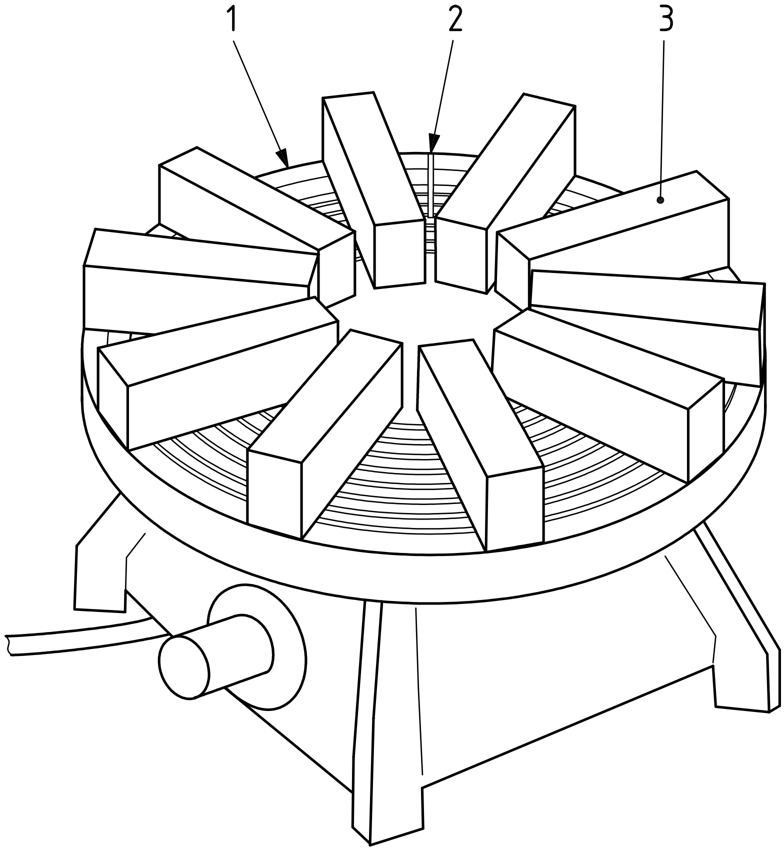
E.5 End-of-test condition

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.

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

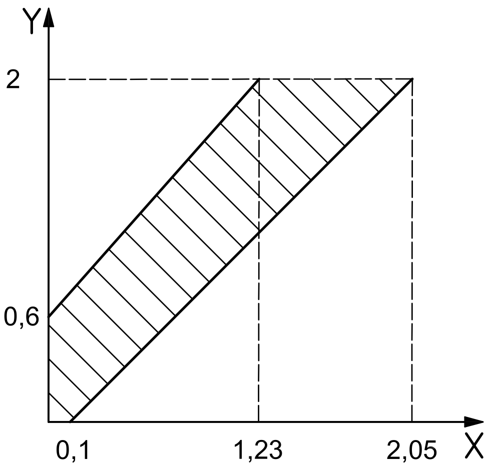
If the end of test condition, $m_E = 2$ dB/m is reached before all the specimens have responded, then the test is considered valid only if $S > 45$ µl/l.



Key

1 grooved hotplate
2 temperature sensor
3 wooden sticks

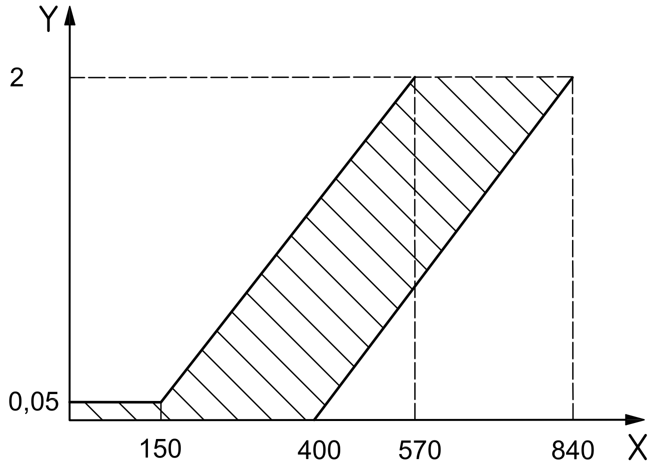
Figure E.1 — Arrangement of sticks on hotplate



Key

X *y*
Y *m*, expressed in decibels per metre

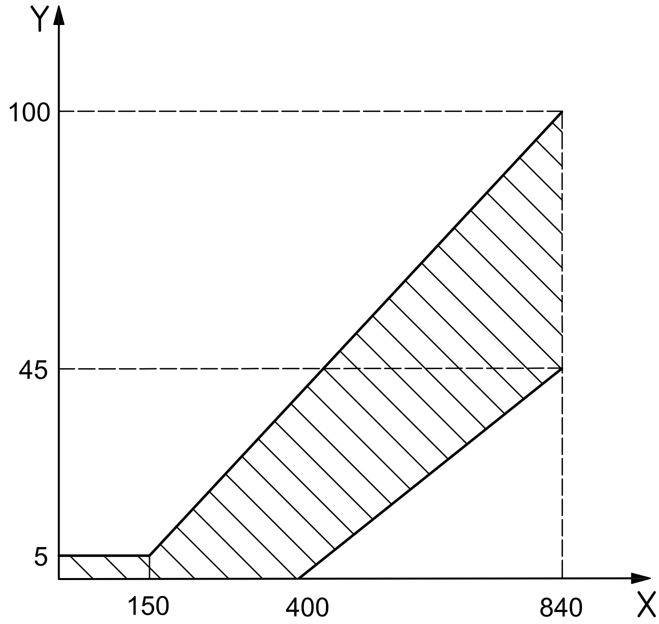
Figure E.2 — Fire TF2 — Limits for *m* versus *y*



Key

X time, *t*, expressed in seconds
Y *m*, expressed in decibels per metre

Figure E.3 — Fire TF2 — Limits for *m* versus time, *t*



Key

X time, t, expressed in seconds

Y S, expressed in microlitres per litre

Figure E.4 — Fire TF2 — Limits for S versus time, t

Annex F
(normative)

Glowing, smouldering cotton fire (TF3)

F.1 Fuel

Approximately 90 pieces of braided cotton wick, each with a length of 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.

F.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 F.1.

Dimensions in metres

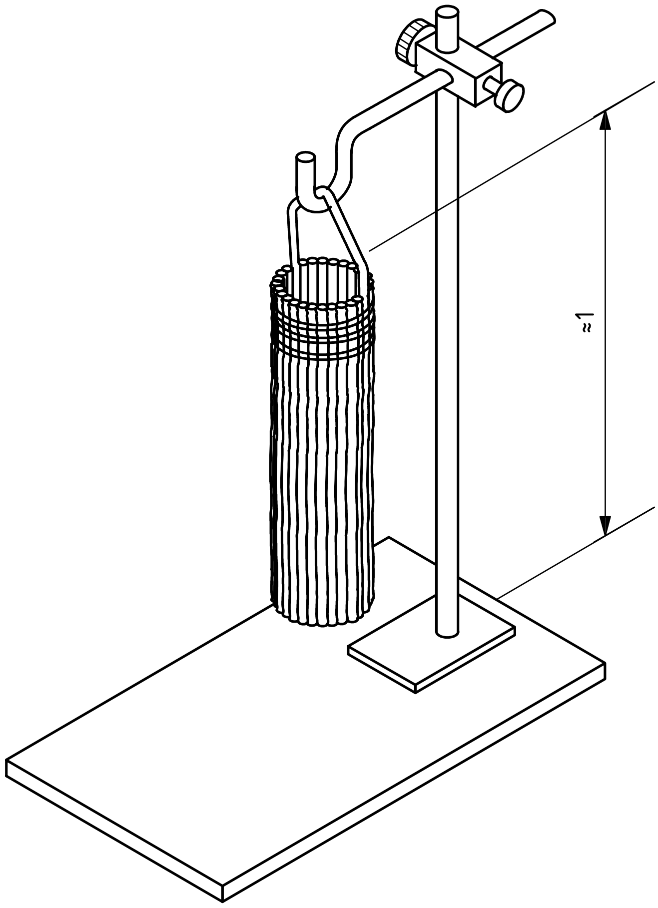


Figure F.1 — Arrangement of cotton wicks

F.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.

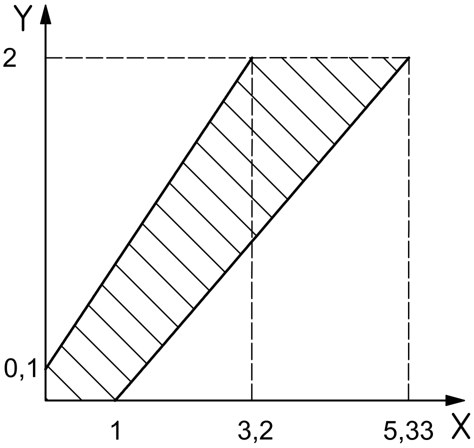
F.4 End-of-test condition

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.

F.5 Test validity criteria

The development of the fire shall be such that the curves of m against y, m against time, t, and S against time, t, fall within the limits shown in Figures F.2, F.3 and F4, respectively. That is, at the end-of-test condition $m_E = 2$ dB/m, $3,2 \leqslant y \leqslant 5,33$ and $280 \text{ s} \leqslant t \leqslant 750$ s.

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

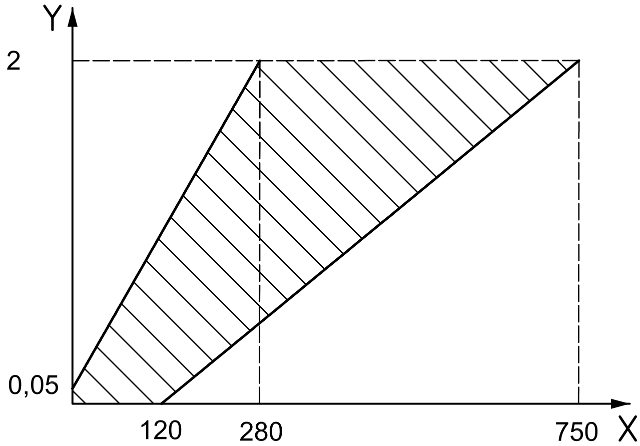


Key

X y

Y m, expressed in decibels per metre

Figure F.2 — Fire TF3 — Limits for m versus y

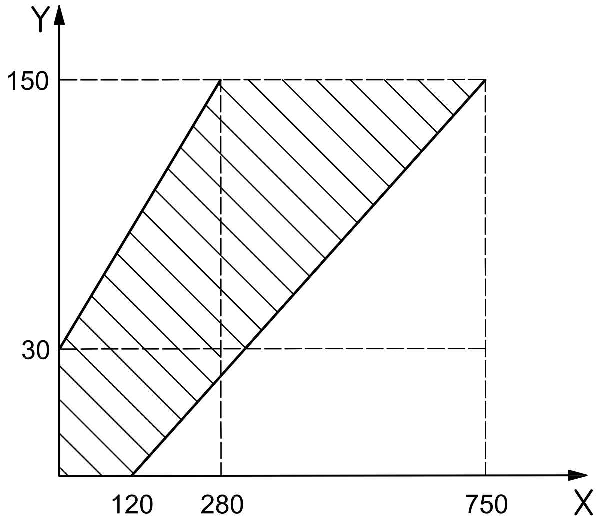


Key

X time, t, expressed in seconds

Y m, expressed in decibels per metre

Figure F.3 — Fire TF3 — Limits for m versus time, t



Key

X time, *t*, expressed in seconds

Y *S*, expressed in microlitres per litre

Figure F.4 — Fire TF3 — Limits for *S* versus time, *t*

Annex G
(normative)

Open plastics (polyurethane) fire (TF4)

G.1 Fuel

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

G.2 Conditioning

The mats shall be maintained in a humidity not exceeding 50 % at least 48 h prior to the test.

G.3 Arrangement

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

G.4 Ignition

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

G.5 Method of ignition

Ignition shall be by match or spark.

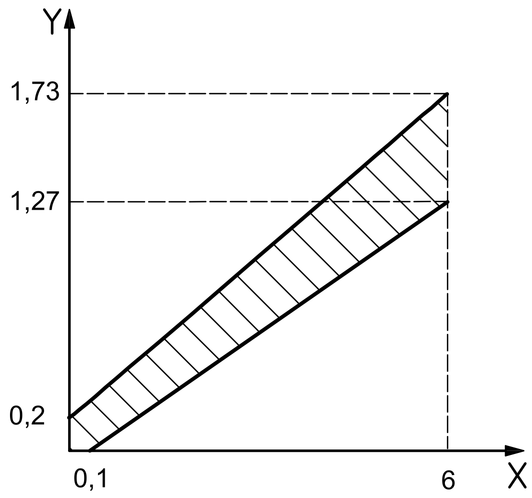
G.6 End-of-test condition

The end-of-test condition shall be when $y_E = 6$, $t > 180$ s, $S > 20$ µl/l or all of the specimens have generated an alarm signal, whichever is the earlier.

G.7 Test validity criteria

The development of the fire shall be such that the curves of m against y, m against time, t, and S against time, t, fall within the limits shown in Figures G.1,G.2 and G.3, respectively. That is, at the end-of-test condition $y_E = 6$ or $S = 20$ µl/l, $1{,}27 < m < 1{,}73$ and $140 \text{ s} < t < 180$ s.

If the end of test condition, $y_E = 6$ is reached before all the specimens have responded, then the test is considered valid only if $S > 20$ µl/l.

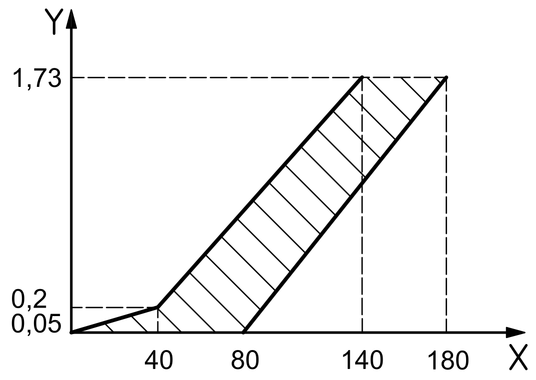


Key

X *y*

Y *m*, expressed in decibels per metre

Figure G.1 — Fire TF4 — Limits for *m* versus *y*

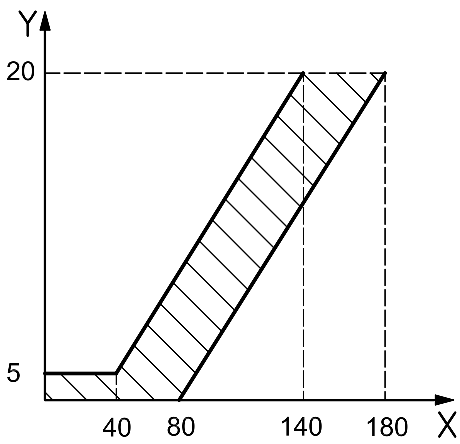


Key

X time, *t*, expressed in seconds

Y *m*, expressed in decibels per metre

Figure G.2 — Fire TF4 — Limits for *m* versus time, *t*



Key

X time, *t*, expressed in seconds

Y *S*, expressed in microlitres per litre

Figure G.3 — Fire TF4 — Limits for *S* versus time, *t*

Annex H
(normative)

Liquid (heptane) fire (TF5)

H.1 Fuel

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

H.2 Arrangement

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

H.3 Ignition

Ignition shall be by flame or spark.

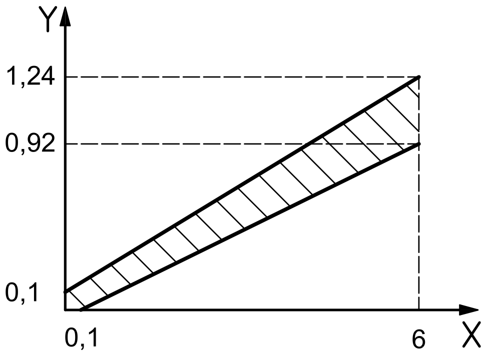
H.4 End-of-test condition

The end-of-test condition shall be when $y_E = 6$, $t > 240$ s, $S > 16$ µl/l, or all of the specimens have generated an alarm signal, whichever is the earlier.

H.5 Test validity criteria

The development of the fire shall be such that the curves of m against y, m against time, t, and S against time, t, fall within the limits shown in Figures H.1, H2 and H.3, respectively. That is, at the end-of-test condition $y_E = 6$ or $S = 16$ µ/l, $0{,}92 < m < 1{,}24$ and $120 \text{ s} < t < 240$ s.

If the end of test condition, $y_E = 6$ is reached before all the specimens have responded, then the test is considered valid only if $S > 16$ µl/l.

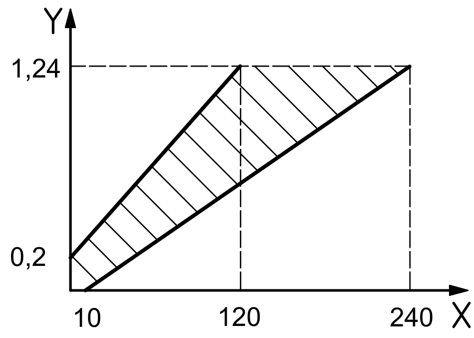


Key

X y

Y m, expressed in decibels per metre

Figure H.1 — Fire TF5 — Limits for m versus y

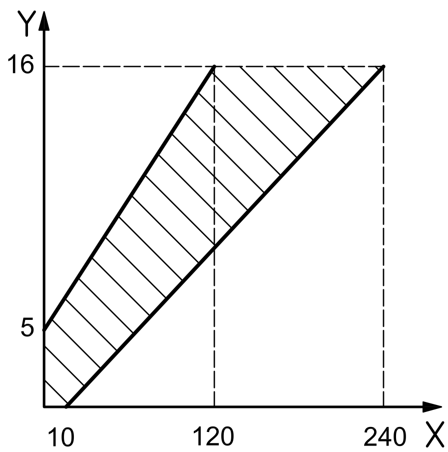


Key

X time, t, expressed in seconds

Y m, expressed in decibels per metre

Figure H.2 — Fire TF5 — Limits for m versus time, t



Key

X time, t, expressed in seconds

Y S, expressed in microlitres per litre

Figure H.3 — Fire TF5 — Limits for S versus time, t

Annex I
(normative)

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

I.1 Fuel

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

I.2 Arrangement

Burn the decalin in a square steel tray with dimensions of approximately 100 mm x 100 mm and 20 mm depth.

I.3 Volume

Use approximately 170 ml of decalin ($C_{10}H_{18}$).

I.4 Ignition

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

I.5 End-of-test condition

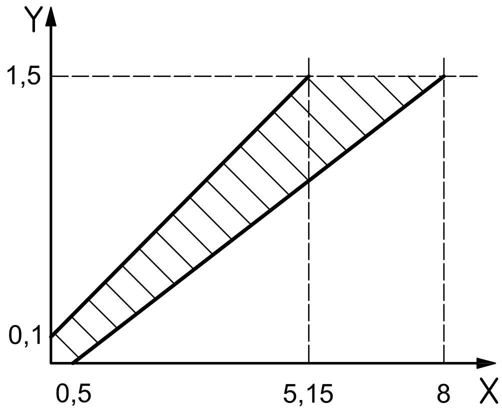
The end of test condition shall be when: $m_E = 1{,}5$ dB/m, $t > 445$ s, $S > 8$ µl/l, or all of the specimens have generated an alarm signal, whichever is the earlier.

I.6 Test validity criteria

The development of the fire shall be such that the curves of m against y, m against time, t, and S against time, t, fall within the hatched areas shown in Figures I.1, I.2 and I.3, respectively. That is, at the end-of-test condition $m_E = 1{,}5$ dB/m, $5{,}15 < y < 8{,}0$, 4 µl/l $< S <$ 8 µl/l and 360 s $< t <$ 445 s.

During the test, the rise in temperature, ΔT, shall not exceed 6 K.

The test condition may be changed to get the specified profile of test fire if it was not produced by the conditions specified. For example, the height of room or the position of fire may be altered to ensure that the smoke reaches the ceiling and the tray may be kept cool (e.g. by using a heavier grade steel or by placing the tray in an outer bath of cooling water) to ensure that ΔT does not rise above 6 K.

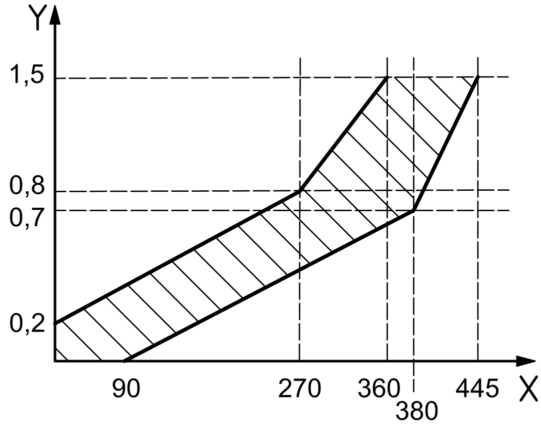


Key

X *y*

Y *m*, expressed in decibels per metre

Figure I.1 — Fire TF8 — Limits for *m* versus *y*

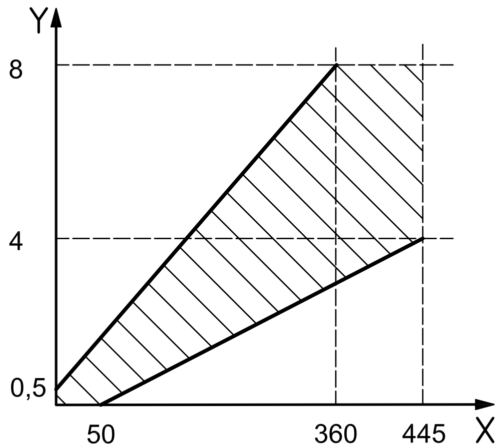


Key

X time, *t*, expressed in seconds

Y *m*, expressed in decibels per metre

Figure I.2 — Fire TF8 — Limits for *m* versus time, *t*



Key

X time, *t*, expressed in seconds

Y *S*, expressed in microlitres per litre

Figure I.3 — Fire TF8 — Limits for *S* versus time, *t*

Annex J
(informative)

Information concerning the construction of the gas test chamber

Fire detectors respond when the signal(s) from one or more fire sensors fulfil certain criteria. The gas concentration at the sensor(s) is related to the gas concentration 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 gas concentration, etc. The relative change of the response threshold value measured in the gas test chamber is the main parameter considered when the stability of fire detectors is evaluated by testing in accordance with this part of ISO 7240.

Many different gas test chamber designs are suitable for the tests specified in this part of ISO 7240, but the following points should be considered when designing and characterising a gas chamber.

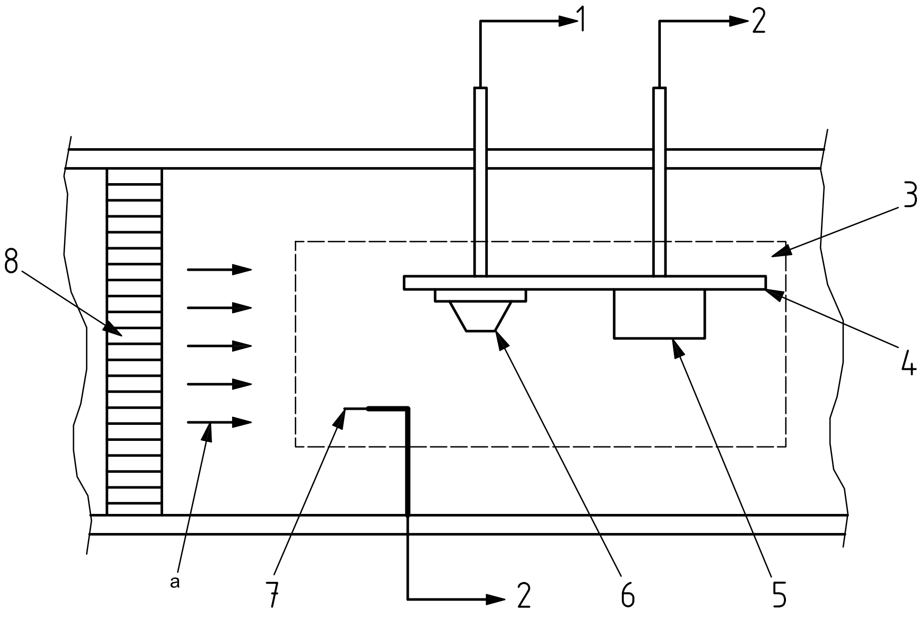
The larger the gas test chamber, the larger the volume of gas required during tests. Environmental control, personal safety and uniform gas distribution are more easily achieved if the volume of the gas test chamber is kept to a minimum. The control of test gases that can escape the chamber is also important. The chamber should be as gas-tight as possible.

The response-threshold value measurements require increasing gas concentration until the detector responds. This can be facilitated in a closed-circuit gas test chamber. A purging system is required to purge the gas test chamber after each gas exposure. Some means of maintaining the pressure inside the chamber close to atmospheric can be required to prevent pressure variations caused by the introduction of CO or other test gas.

The airflow created by a fan in the chamber is turbulent, and it is necessary that it pass through a turbulence reducer to create a nearly laminar and uniform airflow in the working volume (see Figure J.1). This may be facilitated by using a filter, a honeycomb or both, in line with and upstream of the working section of the tunnel. Care should be taken to ensure that the airflow is well mixed to give a uniform temperature and gas concentration before entering the flow turbulence reducer. Efficient mixing may be obtained by feeding the gas to the tunnel upstream of the fan.

Means of heating the air before it enters the working section are required. The chamber should have a system capable of controlling the heating, so as to achieve the specified temperatures and temperature profiles in the working volume. The heating should be achieved by means of low-temperature heaters to avoid the production of extraneous gases or alteration of the test gas.

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



Key

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

a Air flow.

Figure J.1 — Gas test chamber, working section, side view

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