LPCB®

Loss Prevention Standard

LPS 1265: Issue 1.1

Requirements and testing procedures for the LPCB approval and listing of carbon monoxide fire detectors using electrochemical cells

The purpose of this standard is to ensure that carbon monoxide (CO) fire detectors using electrochemical cells have adequate sensitivity and reliability for use in fire detection and fire alarm systems for commercial and industrial premises. Carbon monoxide may not be produced in detectable quantities where pyrolysis of material rather than self-sustained combustion occurs (e.g. overheating cables) or in the early stages of rapidly burning flaming fires (e.g. liquid fuel fires). It is important that carbon monoxide fire detectors are only used where a risk assessment indicates that they are appropriate for detecting the types of fires that may occur. CO fire detectors should not be considered as a direct replacement for smoke detectors. CO detectors detect carbon monoxide gas rather than the smoke particulates detected by optical and ionisation smoke detectors.

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PARTICIPATING ORGANISATIONS

This standard was prepared by Expert Group A and approved by the LPC Fire and Security Board of BRE Global Ltd. The following organisations participated in the preparation of this standard:-

Association of British Insurers
Association of Chief Police Officers
Association for Specialist Fire Protection
British Fire Protection Systems Association
British Security Industry Association
Chief & Assistant Chief Fire Officers' Association
Confederation of British Industry
Door & Shutter Manufacturers' Association
Electrical Contractors' Association
Health & Safety Executive
Office of the Deputy Prime Minister
Risk Engineering Data Exchange Group
Royal Institution of Chartered Surveyors

REVISION OF LOSS PREVENTION STANDARDS

Loss Prevention Standards will be revised by issue of revised editions or amendments. Details will be posted on our website at www.redbooklive.com

Technical or other changes which affect the requirements for the approval or certification of the product or service will result in a new issue. Minor or administrative changes (e.g. corrections of spelling and typographical errors, changes to address and copyright details, the addition of notes for clarification etc.) may be made as amendments. (See amendments table on page 50)

The issue number will be given in decimal format with the integer part giving the issue number and the fractional part giving the number of amendments (e.g. Issue 3.2 indicates that the document is at Issue 3 with 2 amendments).

USERS OF LOSS PREVENTION STANDARDS SHOULD ENSURE THAT THEY POSSESS THE LATEST ISSUE AND ALL AMENDMENTS.

FOREWORD

This standard identifies the evaluation and testing practices for the LPCB approval and listing of products. LPCB Listing of life safety and security products for inclusion in the "Red Book" is based on the following

i. Satisfactory product performance during testing and audit testing
ii. Satisfactory product construction
iii. Satisfactory manufacturing processes
iv. Satisfactory product service experience.

NB:- Compliance with this LPS standard does not in itself confer immunity from legal obligations.

Further information concerning the requirements and procedures for obtaining LPCB certification of fire detectors is given in the LPCB Scheme Document SD 021.

NOTES

Compliance with this LPS does not of itself confer immunity from legal obligations. Users of LPSs should ensure that they possess the latest issue and all amendments.

LPCB welcomes comments of a technical or editorial nature and these should be addressed to "the Technical Director" at enquiries@breglobal.co.uk.

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Listed products and services appear in the LPCB "List of Approved Products and Services" which may be viewed on our website: www.redbooklive.com or by downloading the LPCB Red Book App from the App Store (for iPhone and iPad), from Google Play (for Android devices) or from the Windows Store (for Windows 8 Phones and Tablets from 2014).

1 INTRODUCTION

Carbon monoxide (CO) is a known product of the combustion of carbon-based materials. It is an invisible and odourless gas which, unlike smoke, cannot be detected by humans. When present in the atmosphere in sufficient quantity, CO can seriously impair the ability of people to react in a fire situation and can eventually lead to their death. In certain conditions, in which the fire is starved of oxygen and develops slowly, a dangerous concentration of CO may be present in the atmosphere before other fire detectors are able to operate. This can make CO fire detectors suitable for certain applications for the protection of life.

Although there are many techniques for sensing and detecting the presence of CO, not all of the available sensor types are suitable for use in fire detectors. One sensor, the electrochemical cell, has proven suitable for fire detection applications, and is being used in commercially available products. The electrochemical cell does however have known weaknesses. These include sensitivity to substances other than CO that may be present in the atmosphere. In addition, cell performance may be degraded by long-term exposure to very low or very high humidity.

This standard has been drafted to allow the evaluation of detectors using electrochemical cells and includes tests specifically intended to demonstrate that the electrochemical cell used has adequate performance for fire detection applications. Other types of CO sensor may be suitable for use in fire detectors. However, the tests in this standard may not be sufficient to demonstrate the robustness of any other type of sensor.

The test schedule included in this standard also recognises certain strengths and weaknesses in the application of CO fire detectors. For example, it is noted in BS 5839-1:2002 that CO detectors are best suited for the detection of smouldering fires and can be relatively insensitive to free burning fires supported by a plentiful supply of oxygen. In recognition of this, the test schedule includes only the smouldering fires, TF2 and TF3, from EN 54-7: 2000. These are supplemented by one other fire representing deep-seated combustion.

A particular strength of electrochemical cells is that they do not respond to a short-term exposure to steam or condensation, and can therefore be used in some applications in which smoke detectors would be unsuitable. To verify this strength, a cyclic damp heat operational test is included in the standard.

Because this standard has been drafted specifically for CO fire detectors using electrochemical cells, great care must be used in interpreting the results of these tests if applied to detectors using other sensing technologies.

2 SCOPE

This standard specifies requirements and testing procedures for the LPCB certification and listing of point carbon monoxide (CO) detectors that incorporate electrochemical cells, for use in fire detection and fire alarm systems for buildings (see EN 54-1:1996).
For other types of CO fire detector, CO fire detectors working on other principles or multi-sensor fire detectors incorporating at least one CO sensing element, this standard should only be used for guidance. CO fire detectors with special characteristics and developed for specific risks are not covered by this standard.

3 DEFINITIONS

For the purposes of this standard, the following definition and those given in EN 54-1:1996 apply:

3.1 Response threshold value

The CO concentration in the proximity of the specimen at the moment that it generates an alarm signal, when tested as described in 5.1.5.

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

4 REQUIREMENTS

4.1 Compliance

In order to comply with this standard, the detector shall meet the requirements of this clause, 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, they 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 directly below the detector, in an ambient light intensity up to 500 lux.

4.3 Connection of ancillary devices

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

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 each setting at which the manufacturer claims compliance with this standard, the detector shall comply with the requirements of this standard, and access to the adjustment means shall only be possible by the use of a code or special tool or by removing the detector from its base or mounting;
b) any setting(s) at which the manufacturer does not claim compliance with this standard, shall only be accessible 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 the standard.

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

4.7 Rate-sensitive response behaviour

The response threshold value of the detector may depend on the rate of change of CO concentration in the vicinity of the detector. Such behaviour may be incorporated in the detector design to improve the discrimination between ambient CO levels 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 to a significant increase in the probability of false alarm.

Since it is not practical to make tests with all possible rates of increase in CO concentration, an assessment of the detector's rate sensitivity shall be made by analysis of the circuit/software, and/or physical tests and simulations.

The detector shall be deemed to meet the requirements of this clause if this assessment shows that:

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

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

4.8 Marking

Each detector shall be clearly marked with the following information:

a) the name or trademark of the manufacturer or supplier;
b) the model designation (type or number);
c) the wiring terminal designations;
d) 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), and d), and the base shall be marked with, at least b) (i.e. its own model designation) and c).

Where any marking on the device uses symbols or abbreviations not in common use then these shall 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.

4.9 Data

Detectors shall either be supplied with sufficient technical, installation and maintenance data to enable their correct installation and operation1) or, if all of this data is not supplied with each detector, reference to the appropriate data sheet shall be given on, or with each detector.

NOTE: Additional information may be required by organisations certifying that detectors produced by a manufacturer conform to the requirements of this standard.

4.10 Additional requirements for software controlled detectors

4.10.1 General

For detectors which rely on software control in order to fulfil the requirements of this standard, the requirements of 4.10.2, 4.10.3 and 4.10.4 shall be met.

4.10.2 Software documentation

4.10.2.1 Design overview

1) To enable correct operation of the detectors, this 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.

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

a) a functional description of the main program flow (e.g. as a flow diagram or structogram) including:
   1) a brief description of the modules and the functions that they perform;
   2) the way in which the modules interact;
   3) the overall hierarchy of the program;
   4) the way in which the software interacts with the hardware of the detector;
   5) the way in which the modules are called, including any interrupt processing.
b) a description of which areas of memory are used for the various purposes (e.g. the program, site specific data and running data);
c) a designation, by which the software and its version can be uniquely identified.

4.10.2.2 Design detail

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

a) an overview of the whole system configuration, including all software and hardware components;
b) a description of each module of the program, containing at least:
   1) the name of the module;
   2) a description of the tasks performed;
   3) a description of the interfaces, including the type of data transfer, the valid data range and the checking for valid data.
c) full source code listings, as hard copy or in machine-readable form (e.g. ASCII-code), including all global and local variables, constants and labels used, and sufficient comment for the program flow to be recognized;
d) details of any software tools used in the design and implementation phase (e.g. CASE-tools, compilers).

4.10.3 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.

4.10.4 The storage of programs and data

The program necessary to comply with this standard and any pre-set data, such as manufacturer's settings, shall be held in non-volatile memory. Writing to areas of memory containing this program and data shall only be possible 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 which will retain data for at least two weeks without external power to the detector, unless provision is made for the automatic renewal of such data, following loss of power, within 1 h of power being restored.

5 TEST METHODS

5.1 General

5.1.1 Atmospheric conditions for tests

Unless otherwise stated in a test procedure, the testing shall be carried out after the test specimen has been allowed to stabilize in the standard atmospheric conditions for testing as described in IEC 60068-1:1988+A1:1992 as follows:

a) temperature: (15 to 35) °C;
b) relative humidity: (25 to 75) %;
c) air pressure: (86 to 106) kPa.

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

5.1.2 Operating conditions for tests

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

NOTE: The details of the supply and monitoring equipment and the alarm criteria used should be given in the test report.

5.1.3 Mounting arrangements

The specimen shall be mounted by its normal means of attachment and in its normal orientation in accordance with the manufacturer's instructions. If these instructions describe more than one method of mounting, or more than one acceptable orientation, 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 requirement or test procedure does not specify a tolerance or deviation limits, then deviation limits of ± 5 % shall be applied.

5.1.5 Measurement of response threshold value

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

Before commencing each measurement, the CO tunnel shall be purged to ensure that the tunnel and the specimen are free from CO.

The air velocity in the proximity of the specimen shall be (0.35 ± 0.15) m s^{-1} during the measurement, unless otherwise specified in the test procedure.

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

The specimen shall be connected to its supply and monitoring equipment as described in 5.1.2, and shall be allowed to stabilise for a period of at least 15 min, unless otherwise specified by the manufacturer.

CO shall be introduced into the tunnel such that the rate of increase of CO concentration is between 1 ppm min^{-1} and 6 ppm min^{-1}. 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.

The CO concentration at the moment that the specimen gives an alarm shall be recorded as *c* (ppm). This shall be taken as the response threshold value.

5.1.6 Provision for tests

The following shall be provided for testing compliance with this standard:

a) For detachable detectors: twenty-four detector heads and bases;
For non-detachable detectors: twenty-four specimens;
b) The data required in 4.9.

NOTE 1: Detachable detectors comprise 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.

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

NOTE 2: This implies that the mean response threshold value of the twenty-four specimens, found in the reproducibility test should also represent the production mean, and that the limits specified in the reproducibility test should also be applicable to the manufacturer's production.

5.1.7 Test schedule

The specimens shall be tested according to the following test schedule (see Table 1). After the reproducibility test, the four least sensitive specimens (i.e. those with the highest response thresholds) shall be numbered 21 to 24, and the others shall be numbered 1 to 20 arbitrarily:

Table 1 – Test schedule

Test	Clause	Specimen No(s)
Repeatability	5.2	one chosen arbitrarily
Directional dependence	5.3	one chosen arbitrarily
Reproducibility	5.4	all specimens
Long term stability	5.5	1
Variation in supply parameters	5.6	2
Air movement	5.7	3
Dry heat (operational)	5.8	4
Cold (operational)	5.9	5
Damp heat, cyclic (operational)	5.10	6
Damp heat, steady state (endurance)	5.11	7
Low humidity, steady state (endurance)	5.12	8
Sulphur dioxide SO_2 corrosion (endurance)	5.13	9
Shock (operational)	5.14	10
Impact (operational)	5.15	11
Vibration, sinusoidal (operational)	5.16	12
Vibration, sinusoidal (endurance)	5.17	12
Electrostatic discharge (operational)	5.18	13[1)]
Radiated electromagnetic fields (operational)	5.18	14[1)]
Conducted disturbances induced by electromagnetic fields (operational)	5.18	15[1)]
Fast transient bursts (operational)	5.18	16[1)]
Slow high energy voltage surge (operational)	5.18	17[1)]
Fire sensitivity	5.19	21, 22, 23, 24
Exposure to chemical agents at environmental concentrations	5.20	18
Exposure to chemical agents that may be present during a fire	5.21	19
Exposure to high levels of carbon monoxide	5.22	20

[1)] In the interests of test economy, it is permitted to use the same specimen for more than one EMC test. In that case, intermediate functional test(s) on the specimen(s) used for more than one test may be deleted, and the full functional test conducted at the end of the sequence of tests. However it should be noted that in the event of a failure, it may not be possible to identify which test exposure caused the failure (see clause 4 of EN 50130-4:1995+A1:1998).

5.2 Repeatability

5.2.1 Object

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

5.2.2 Test procedure

The response threshold value of the specimen to be tested shall be measured as described in 5.1.5 six times.

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

The maximum response threshold value shall be designated c_{max}, the minimum value shall be designated c_{min}.

5.2.3 Requirements

The ratio of the response threshold values c_{max} : c_{min} shall be not greater than 1.6.

The lower response threshold value c_{min} shall be not less than 30 ppm

5.3 Directional dependence

5.3.1 Object

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

5.3.2 Test procedure

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

The maximum response threshold value shall be designated c_{max} , the minimum value shall be designated c_{min} .

The orientations, for which the maximum and minimum response threshold values were measured, shall be noted.

In the following tests the orientation for which the maximum response threshold was measured is referred to as the least sensitive orientation, and the orientation for which the minimum response threshold was measured is referred to as the most sensitive orientation.

5.3.3 Requirements

The ratio of the response threshold values $c_{max} : c_{min}$ shall not be greater than 1.6.

The lower response threshold value c_{min} shall not be less than 30 ppm.

5.4 Reproducibility

5.4.1 Object

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.

5.4.2 Test procedure

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

The mean of these response threshold values shall be calculated and shall be designated $\bar{c}$.

The maximum response threshold value shall be designated c_{max} the minimum value shall be designated c_{min} .

5.4.3 Requirements

The ratio of the response threshold values $c_{max} : \bar{c}$ shall not be greater than 1.33, and the ratio of the response threshold values $\bar{c} : c_{min}$ shall not be greater than 1.5.

The minimum response threshold value c_{min} shall not be less than 30 ppm.

5.5 Long term stability

5.5.1 Object

To confirm that the detectors are stable over long periods of time.

5.5.2 Test procedure

Connect the detector to suitable supply and monitoring equipment and place it in an environment free of CO and atmospheric contaminants. Measure the response threshold value, as described in 5.1.5, at 28 days, 56 days and 84 days from the start of the test. Designate the highest of the values measured in this test and that measured for the same detector in the reproducibility test as c_{max}. Designate the lowest of the values measured in this test and that measured for the same detector in the reproducibility test as c_{min}.

5.5.3 Requirements

The detector shall emit neither alarm nor fault signals during the test when in air free of CO.

The ratio of the response threshold values c_{max} : c_{min} shall not be greater than 1.6.

The lowest response threshold value c_{min} shall not be less than 30 ppm.

5.6 Variation in supply parameters

5.6.1 Object

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.

5.6.2 Test procedure

The response threshold value of the specimen shall be measured 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.

The maximum response threshold value shall be designated c_{max} and the minimum value shall be designated c_{min} .

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

5.6.3 Requirements

The ratio of the response threshold values c_{max} : c_{min} shall not be greater than 1.6.

The lower response threshold value c_{min} shall not be less than 30 ppm.

5.7 Air movement

5.7.1 Object

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

5.7.2 Test Procedure

The response threshold value of the specimen to be tested shall be measured as described in 5.1.5 in the most and least sensitive orientations, and shall be appropriately designated $c_{(0.35)max}$ and $c_{(0.35)min}$

These measurements shall then be repeated but with an air velocity, in the proximity of the detector, of (1 ± 0.2) m s^{-1}. The response threshold values in these tests shall be designated $c_{(1.0)max}$ and $c_{(1.0)min}$

5.7.3 Requirements

The following shall apply:

$$0.625 \leq \frac{c_{(0.35)\,max} + c_{(0.35)\,min}}{c_{(1.0)\,max} + c_{(1.0)\,min}} \leq 1.6$$

5.8 Dry heat (operational)

5.8.1 Object

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

5.8.2 Test procedure

The specimen to be tested shall be installed in the CO tunnel described in annex A, in its least sensitive orientation, with an initial air temperature of (23 ± 5) °C, and shall be connected to its supply and monitoring equipment.

The air temperature in the tunnel shall then be increased to (55 ± 2) °C, at a rate not exceeding 1 $Kmin^{-1}$, and maintained at this temperature for 2 h.

The response threshold value shall then be measured as described in 5.1.5 but with the temperature at (55 ± 2) °C.

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

5.8.3 Requirements

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

The ratio of the response threshold values $c_{max} : c_{min}$ shall not be greater than 1.6.

5.9 Cold (operational)

5.9.1 Object

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

5.9.2 Test procedure

The specimen to be tested shall be installed in the CO tunnel described in annex A, in its least sensitive orientation, with an initial air temperature of (23 ± 5) °C, and shall be connected to its supply and monitoring equipment.

The air temperature in the tunnel shall then be decreased to (-10 ± 3) °C, at a rate not exceeding 1 $Kmin^{-1}$, and maintained at this temperature for 2 h.

The response threshold value shall then be measured as described in 5.1.5 but with the temperature at (-10 ± 3) °C.

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

5.9.3 Requirements

No alarm or fault signal shall be given during the transition to the conditioning temperature or during the period at the conditioning temperature until the response threshold value is measured.

The ratio of the response threshold values $c_{max} : c_{min}$ shall not be greater than 1.6.

5.10 Damp heat, cyclic (operational)

5.10.1 Object

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

5.10.2 Test procedure

5.10.2.1 Reference

The test apparatus and procedure shall be as described in IEC 60068-2-30:1980 +A1:1985, using the Variant 1 test cycle and controlled recovery conditions, and as described below.

5.10.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 5.1.3 and shall be connected to supply and monitoring equipment as described in 5.1.2.

5.10.2.3 Conditioning

The following severity of conditioning (IEC 60068-2-30 Severity 1) shall be applied:

Lower temperature:	(25 ± 3) °C
Upper temperature:	(40 ± 2) °C
Relative Humidity:	
a) at lower temperature	≥ 95%
b) at upper temperature	(93 ± 3) %
Number of cycles	2

5.10.2.4 Measurements during conditioning

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

5.10.3 Final measurements

After the recovery period the response threshold value of the specimen shall be measured as described in 5.1.5

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

5.10.4 Requirements

No alarm or fault signal shall be given during the conditioning until the response threshold value is measured.

The ratio of the response threshold values $c_{max} : c_{min}$ shall not be greater than 1.6.

5.11 Damp heat, steady state (endurance)

5.11.1 Object

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 cell electrolyte etc.)

5.11.2 Test procedure

5.11.2.1 Reference

The test apparatus and procedure shall be as described in IEC 60068-2-56:1988 Test Cb or IEC 60068-2-3:1969+A1:1984 Test Ca, and as described below.

5.11.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 5.1.3 but shall not be supplied with power during the conditioning.

5.11.2.3 Conditioning

The following conditioning shall be applied:

Temperature:	(40 ± 2) °C
Relative Humidity:	(93 ± 3) %
Duration:	21 days

5.11.2.4 Final measurements

After a recovery period, of between 1 h and 2 h in standard laboratory conditions, the response threshold value shall be measured as described in 5.1.5.

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

5.11.3 Requirements

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

The ratio of the response threshold values c_{max} : c_{min} shall not be greater than 1.6.

5.12 Low humidity, steady state (endurance)

5.12.1 Object

To demonstrate the ability of the detector to withstand long periods of low humidity in the service environment. (i.e. to evaluate its resistance to the drying out of electrolyte in the electrochemical cell.)

5.12.2 Test procedure

5.12.2.1 State of the specimen during conditioning

The specimen shall be mounted as described in 5.1.3 but shall not be supplied with power during the conditioning.

5.12.2.2 Conditioning

The following conditioning shall be applied:

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.

5.12.2.3 Final measurements

After a recovery period of between 1 h and 2 h in standard laboratory conditions, the response threshold value shall be measured as described in 5.1.5.

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

5.12.3 Requirements

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

The ratio of the response threshold values c_{max} : c_{min} shall not be greater than 1.6.

5.13 Sulphur dioxide SO_2 corrosion (endurance)

5.13.1 Object

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

5.13.2 Test procedure

5.13.2.1 Reference

The test apparatus and procedure shall be as described in IEC 60068-2-42:1982 Test Kc, except that the conditioning shall be as described below.

5.13.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 5.1.3. It shall not be supplied with power during the conditioning, but it shall have untinned copper wires, of the appropriate diameter, connected to sufficient terminals, to allow the final measurement to be made, without making further connections to the specimen.

5.13.2.3 Conditioning

The following conditioning shall be applied:

Temperature:	(25 ± 2) °C
Relative humidity:	(93 ± 3) %
SO_2 concentration:	(25 ± 5) ppm (by volume)
Duration:	21 days

5.13.2.4 Final measurements

Immediately after the conditioning, the specimen shall be subjected 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, the response threshold value shall be measured as described in 5.1.5.

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

5.13.3 Requirements

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

The ratio of the response threshold values c_{max} : c_{min} shall not be greater than 1.6.

5.14 Shock (operational)

5.14.1 Object

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

5.14.2 Test procedure

5.14.2.1 Reference

The test apparatus and procedure shall be as described in IEC 60068-2-27:1987 Test Ea, except that the conditioning shall be as described below.

5.14.2.2 State of the specimen during conditioning

The specimen shall be mounted as described in 5.1.3 to a rigid fixture, and shall be connected to its supply and monitoring equipment as described in 5.1.2.

5.14.2.3 Conditioning

For specimens with a mass ≤ 4.75 kg the following conditioning shall be applied:

- Shock pulse type: Half sine
- Pulse duration: 6 ms
- Peak acceleration: 10 (100 - 20*M*) m s^{-2} (Where *M* is the specimen's mass in kg)
- Number of directions: 6
- Pulses per direction: 3

No test is applied to specimens with a mass >4.75 kg.

5.14.2.4 Measurements during conditioning

The specimen shall be monitored during the conditioning period and for a further 2 min to detect any alarm or fault signals.

5.14.2.5 Final measurements

After the conditioning the response threshold value shall be measured as described in 5.1.5.

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

5.14.3 Requirements

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

The ratio of the response threshold values c_{max} : c_{min} shall not be greater than 1.6.

5.15 Impact (operational)

5.15.1 Object

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

5.15.2 Test procedure

5.15.2.1 Apparatus

The test apparatus shall consist of a swinging hammer incorporating a rectangular-section aluminium alloy head (Aluminium alloy Al Cu_4 Si Mg complying with ISO 209-1:1989, solution treated and precipitation treated condition) with the plane impact face chamfered to an angle of 60° to the horizontal, when in the striking position (i.e. when the hammer shaft is vertical). The hammer head shall be (50 ± 2.5) mm high, (76 ± 3.8) mm wide and (80 ± 4) mm long at mid height as shown in Figure E.1. A suitable apparatus is described in annex C.

5.15.2.2 State of the specimen during conditioning

The specimen shall be rigidly mounted to the apparatus by its normal mounting means and shall be positioned 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). The azimuthal direction and position of impact, relative to the specimen shall be chosen as that most likely to impair the normal functioning of the specimen. The specimen shall be connected to its supply and monitoring equipment as described in 5.1.2.

5.15.2.3 Conditioning

The following conditioning shall be applied:

Impact energy:	(1.9 ± 0.1) J
Hammer velocity:	(1.5 ± 0.13) m s^{-1}
Number of impacts:	1

5.15.2.4 Measurements during conditioning

The specimen shall be monitored during the conditioning period and for a further 2 min to detect any alarm or fault signals.

5.15.2.5 Final measurements

After the conditioning the response threshold value shall be measured as described in 5.1.5.

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

5.15.3 Requirements

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

The ratio of the response threshold values $c_{max} : c_{min}$ shall not be greater than 1.6.

5.16 Vibration, sinusoidal, (operational)

5.16.1 Object

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

5.16.2 Test procedure

5.16.2.1 Reference

The test apparatus and procedure shall be as described in IEC 60068-2-6:1995+Corr.:1995 Test Fc, and as described below.

5.16.2.2 State of the specimen during conditioning

The specimen shall be mounted on a rigid fixture as described in 5.1.3 and shall be connected to its supply and monitoring equipment as described in 5.1.2. The vibration shall be applied in each of three mutually perpendicular axes, in turn. The specimen shall be mounted so that one of the three axes is perpendicular to its normal mounting plane.

5.16.2.3 Conditioning

The following conditioning shall be applied:

Frequency range:	(10 to 150) Hz
Acceleration amplitude:	5 m s^{-2} ($\approx$ 0.5 g_n)
Number of axes:	3
Sweep rate:	1 octave min^{-1}
Number of sweep cycles:	1 per axis

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

5.16.2.4 Measurements during conditioning

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

5.16.2.3 Final measurements

The final measurements, as specified in 5.16.2.4, are normally made after the vibration endurance test and only need be made here if the operational test is conducted in isolation.

5.16.3 Requirements

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

The ratio of the response threshold values c_{max} : c_{min} shall not be greater than 1.6.

5.17 Vibration, sinusoidal (endurance)

5.17.1 Object

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

5.17.2 Test procedure

5.17.2.1 Reference

The test apparatus and procedure shall be as described in IEC 60068-2-6:1995+Corr.:1995 Test Fc, and as described below.

5.17.2.2 State of the specimen during conditioning

The specimen shall be mounted on a rigid fixture as described in 5.1.3, but shall not be supplied with power during conditioning. The vibration shall be applied in each of three mutually perpendicular axes, in turn. The specimen shall be mounted so that one of the three axes is perpendicular to its normal mounting axis.

5.17.2.3 Conditioning

The following conditioning shall be applied:

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^{-1}
Number of sweep cycles:	20 per axis

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

5.17.2.4 Final measurements

After the conditioning the response threshold value shall be measured as described in 5.1.5.

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

5.17.3 Requirements

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

The ratio of the response threshold values c_{max} : c_{min} shall not be greater than 1.6

5.18 Electromagnetic Compatibility (EMC), Immunity tests (operational)

The following EMC immunity tests shall be carried out, as described in EN 50130-4:1995+A1:1998:

a) Electrostatic discharge;
b) Radiated electromagnetic fields;
c) Conducted disturbances induced by electromagnetic fields;
d) Fast transient bursts;
e) Slow high energy voltage surges.

For these tests the criteria for compliance specified in EN 50130-4:1995+A1:1998 and the following shall apply:

1) The functional test, called for in the initial and final measurements, shall be as follows:
- The response threshold value shall be measured as described in 5.1.5.
- The greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test, shall be designated c_{max} , and the lesser shall be designated c_{min} .;

2) The required operating condition shall be as described in 5.1.2;
3) The acceptance criteria for the functional test after the conditioning shall be as follows:
- The ratio of the response threshold values c_{max} : c_{min} shall not be greater than 1.6.

5.19 Fire sensitivity

5.19.1 Object

To show that the detector has adequate sensitivity to a range of fire types known to produce potentially dangerous levels of CO and which a detector would be required to detect for application in fire detection systems for buildings.

5.19.2 Principle

The specimens are mounted in a standard fire test room and are exposed to a series of test fires designed to produce smoke and CO.

5.19.3 Test procedure

5.19.3.1 Fire test room

The fire sensitivity tests shall be conducted in a rectangular room with a flat horizontal ceiling, and the following dimensions:

Length: 9 m to 11 m;
Width: 6 m to 8 m;
Height: 3.8 m to 4.2 m.

The fire test room shall be equipped with the following measuring instruments arranged as indicated in annex D:

Measuring ionization chamber (MIC);
Obscuration meter;
Temperature probe.
CO monitor

5.19.3.2 Test fires

The specimens shall be subjected to the three test fires as described in annexes E to G. The first two fires are based on TF2 and TF3 from EN54-7:2000 while the third is specific to CO fire detectors. (see annexes E to G). The type, quantity and arrangement of the fuel and the method of ignition are described in annexes E to G, for each test fire, along with the end of test condition and the required profile curve limits.

In order to be a valid test fire, the development of the fire shall be such that the profile curves of *c* against *m,* and *c* against time 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.

5.19.3.3 Mounting of the specimens

The four specimens (Nos. 21, 22, 23, 24) shall be mounted on the fire test room ceiling in the designated area (see annex D). The specimens shall be mounted 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.

Each specimen shall be connected to its supply and monitoring equipment, as described in 5.1.2, and shall be allowed to stabilize in its quiescent condition before the start of each test fire.

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

5.19.3.4 Initial conditions

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

The ventilation system shall then be switched off and all doors, windows and other openings shall be closed. The air in the room shall then be allowed to stabilize, and the following conditions shall be obtained before the test is started:

Air temperature *T*:	(23 ± 5) °C;
Air movement:	negligible;
Smoke density (ionization)	$y \leq 0.05$;
Smoke density (optical):	$m \leq 0.02$ dB m^{-1};
CO concentration:	$c \leq 3$ ppm

NOTE The stability of the air, and temperature gradients, affects the flow of smoke and CO within the room. This is particularly important for the test fires in this standard, all of which produce low thermal lift for the smoke and CO. It is therefore recommended that the difference between the temperature near the floor and the ceiling is < 2 K, and that 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.

5.19.3.5 Recording of the fire parameters and response values

During each test fire the following fire parameters shall be recorded continuously or at least once per second.

Parameter	**Symbol**	**Units**
Temperature change	ΔT	K
Smoke density (ionization)	y	Dimensionless
Smoke density (optical)	m	dB m^{-1}
CO concentration	c	ppm

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.

The time of response of each specimen shall be recorded along with the fire parameters y_a, m_a, and c_a, at the moment of response.

5.19.4 Requirements

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

5.20 Assessment of exposure to chemical agents at environmental concentrations

5.20.1 Object

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

5.20.2 Test procedure

5.20.2.1 State of the specimen during conditioning

The specimen shall be mounted as described in 5.1.3 and shall be connected to supply and monitoring equipment as described in 5.1.2.

5.20.2.2 Conditioning

The specimen shall be subjected to each of the chemical exposures specified in Table 2

Table 2

Test	Chemical Agent	Concentration	Exposure period (hrs)	Recovery period (hrs)
1	Carbon Monoxide	15ppm ± 10%	24	1-2
2	Nitrogen Dioxide	5ppm ± 10%	96	1-2
3	Sulphur Dioxide	5ppm ± 10%	96	1-2
4	Chlorine	2ppm ± 10%	96	1-2
5	Ammonia	50ppm ± 10%	1	1-2
6	Heptane	100ppm ± 10%	1	1-2
7	Ethanol	500ppm ± 10%	1	24-25
8	Acetone	1500ppm ± 10%	1	24-25

5.20.2.3 Measurements during conditioning

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

5.20.2.4 Final measurements

After each exposure the specimen shall be allowed to recover at the standard laboratory conditions, for a period at least equal to the period given in Table 2, after which the response threshold value shall be measured as described in 5.1.5.
For each exposure, the greater of the response threshold value measured in this test and that measured for the same specimen in the reproducibility test, shall be designated c_{max} , and the lesser shall be designated c_{min} .

5.20.3 Requirements

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

For each exposure, the ratio of the response threshold values $c_{max} : c_{min}$ shall not be greater than 1.6.

5.21 Assessment of exposure to chemical agents which may be present during a fire

5.21.1 Object

To demonstrate that chemical agents that may be present during a fire do not unduly affect the ability of the detector to detect the CO produced by the fire, nor cause permanent changes in sensitivity.

5.21.2 Test procedure

5.21.2.1 State of the specimen during conditioning

The specimen shall be mounted as described in 5.1.3 and shall be connected to supply and monitoring equipment as described in 5.1.2.

5.21.2.2 Conditioning

Measurements of the detector’s response threshold shall be taken during and after exposure to the chemical agents in Table 3 in order to determine if there is a detrimental effect on the detector’s sensitivity.

Table 3

Test	Chemical Agent	Concentration	Exposure Period (hrs)
1	Carbon Dioxide	5000ppm ± 10%	1
2	Nitrogen Dioxide	800ppm ± 10%	0.5
3	Sulphur Dioxide	500ppm ± 10%	0.5

5.21.2.3 Measurements during conditioning

The specimen shall be monitored during each exposure to detect any alarm or fault signals. During each exposure, the response threshold value shall be measured as described in 5.1.5.

5.21.2.4 Final measurements

Following each exposure, after a recovery period of between 1 h and 2 h at the standard laboratory conditions, the response threshold value shall be measured as described in 5.1.5.

The greatest of the response threshold values measured during each exposure and that measured after each exposure shall be designated c_1 and that measured for the same specimen in the reproducibility test, shall be designated c_0

5.21.3 Requirements

No fault signal shall be given during the conditioning.

The ratio of the response threshold values $c_1 : c_0$ shall not be greater than 1.6

5.22 Assessment of exposure to high concentrations of carbon monoxide

5.22.1 Object

To demonstrate the ability of the detector to withstand exposure to high levels of carbon monoxide which may be encountered during a fire condition.

5.22.2 Test procedure

5.22.2.1 State of the specimen during conditioning

The specimen shall be mounted as described in 5.1.3 and shall be connected to supply and monitoring equipment as described in 5.1.2.

5.22.2.2 Conditioning

The specimen shall be subjected to an atmosphere containing 500 ppm ±10% carbon monoxide for a period of 1 h.

5.22.2.3 Measurements during conditioning

The specimen shall be monitored to detect any alarm or fault signals.

During the last five minutes of the conditioning the detector shall be reset in accordance with the manufacturers’ instructions.

5.22.2.4 Final measurements

After a recovery period of between 1 h and 2 h at the standard laboratory conditions, the response threshold value shall be measured as described in 5.1.5.

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

5.22.3 Requirements

The detector shall remain in the alarm condition during the conditioning and shall generate an alarm signal within 1 min of being reset at the end of the conditioning period.

The ratio of the response threshold values c_{max} : c_{min} shall not be greater than 1.6

6 PUBLICATIONS REFERRED TO:

This Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

ISO/IEC Publication	Year	Title	EN/HD	Year
-	-	Fire detection and fire alarm systems - Part 1: Introduction.	EN 54-1	1996
-	-	Alarm Systems, Electromagnetic compatibility - Product family standard: Immunity requirements for components of fire, intruder and social alarm systems + A1:1998.	EN 50130-4	1995
IEC 60068-1	1988	Environmental testing - Part 1: General and guidance (sixth edition) + A1:1992.	EN 60068-1	1994
IEC 60068-2-1	1990	Environmental testing - Part 2: Tests — Tests A: Cold (fifth edition), + A1:1993, A2:1994.	EN 60068-2-1	1993
IEC 60068-2-3	1969	Basic environmental testing procedures - Part 2: Tests - Test Ca: Damp heat, steady state (third edition) + A1:1984.	HD 323.2.3 S2	1987
IEC 60068-2-6	1995	Environmental testing - Part 2: Tests - Test Fc: Vibration, sinusoidal (sixth edition) + Corr.:1995.	EN 60068-2-6	1995
IEC 60068-2-27	1987	Basic environmental testing procedures - Part 2: Tests - Test Ea & Guidance: Shock (third edition).	EN 60068-2-27	1993
IEC 60068-2-42	1982	Basic environmental testing procedures - Part 2: Tests - Test Kc: Sulphur dioxide test for contacts and connections (second edition).	-	-

IEC 60068-2-56	1988	Basic Environmental testing procedures - Part 2: Tests - Test Db & Guidance: Damp heat, cyclic (12 + 12 hour cycle), +A1:1985.	HD 323.2.30 S3	1988
IEC 60068-2-30	1980	Environmental testing - Part 2: Tests - Test Cb: Damp heat steady state, primarily for equipment (first edition).	HD 323.2.56 S1	1990
ISO 209-1	1989	Wrought aluminium and aluminium alloys - Chemical composition and forms of products - Part 1: Chemical composition (first edition).	-	-

ANNEX A (normative) – CO tunnel for response threshold value measurements

The following specifies those properties of the CO tunnel which are of primary importance for making repeatable and reproducible measurements of response threshold values of CO fire detectors. The purpose of the tunnel is to subject the specimen under test to a controlled flow of air carrying a known concentration of CO. However, since it is not practical to specify and measure all parameters which can influence the measurements, the background information in annex H should be carefully considered and taken into account when a CO tunnel is designed and used to make measurements in accordance with this standard.

The tunnel shall have a horizontal working section containing a working volume. The working volume is a defined part of the working section where the air temperature and air flow are within the required test conditions. Conformance with this requirement shall be regularly verified under static conditions, by measurements at an adequate number of points distributed within and on the imaginary boundaries of the working volume. The working volume shall be large enough to fully enclose the detector to be tested and the sensing parts of the measuring equipment. The detector to be tested shall be mounted in its normal operating position on the underside of a flat board aligned with the airflow in the working volume. The board shall be of such dimensions that the edge(s) of the board are at least 29 mm from any part of the detector, The detector mounting arrangement shall not unduly obstruct the air flow between the board and the tunnel ceiling.

Means shall be provided for creating an essentially laminar airflow at the required velocities (i.e. 0.35 ± 0.15) m s^{-1} or (1.0 ± 0.2) m s^{-1} through the working volume.

It shall be possible to control the temperature at the required values and to increase the temperature at a rate not exceeding 1 K min^{-1} to 55 ^{0}C, and to decrease the temperature at a rate not exceeding 1 K min^{-1} to -10°C.

Means shall be provided for the introduction of CO such that a homogeneous concentration is obtained in the working volume. The CO measurement, *c*, shall be made in the working volume in the proximity of the detector.

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

ANNEX B (normative) – CO and smoke measuring instruments

B.1 CO measuring instrument

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.

The instrument used for the measurement of CO in the tunnel shall have a measurement error not exceeding 3 ppm + 5% of the measured CO concentration, for concentrations up to 300 ppm. 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 ppm.

B.2 Obscuration meter

The obscuration meter shall have characteristics as defined in EN54-7:2000, annex C.

ANNEX C (informative) – 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 is of dimensions 76 mm wide, 50 mm high and 94 mm long (overall dimensions) and is manufactured from aluminium alloy (Al Cu_4 Si Mg to ISO 209-1:1989), solution treated and precipitation treated condition. 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 walls (1.6 ± 0.1) mm thick.

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

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

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

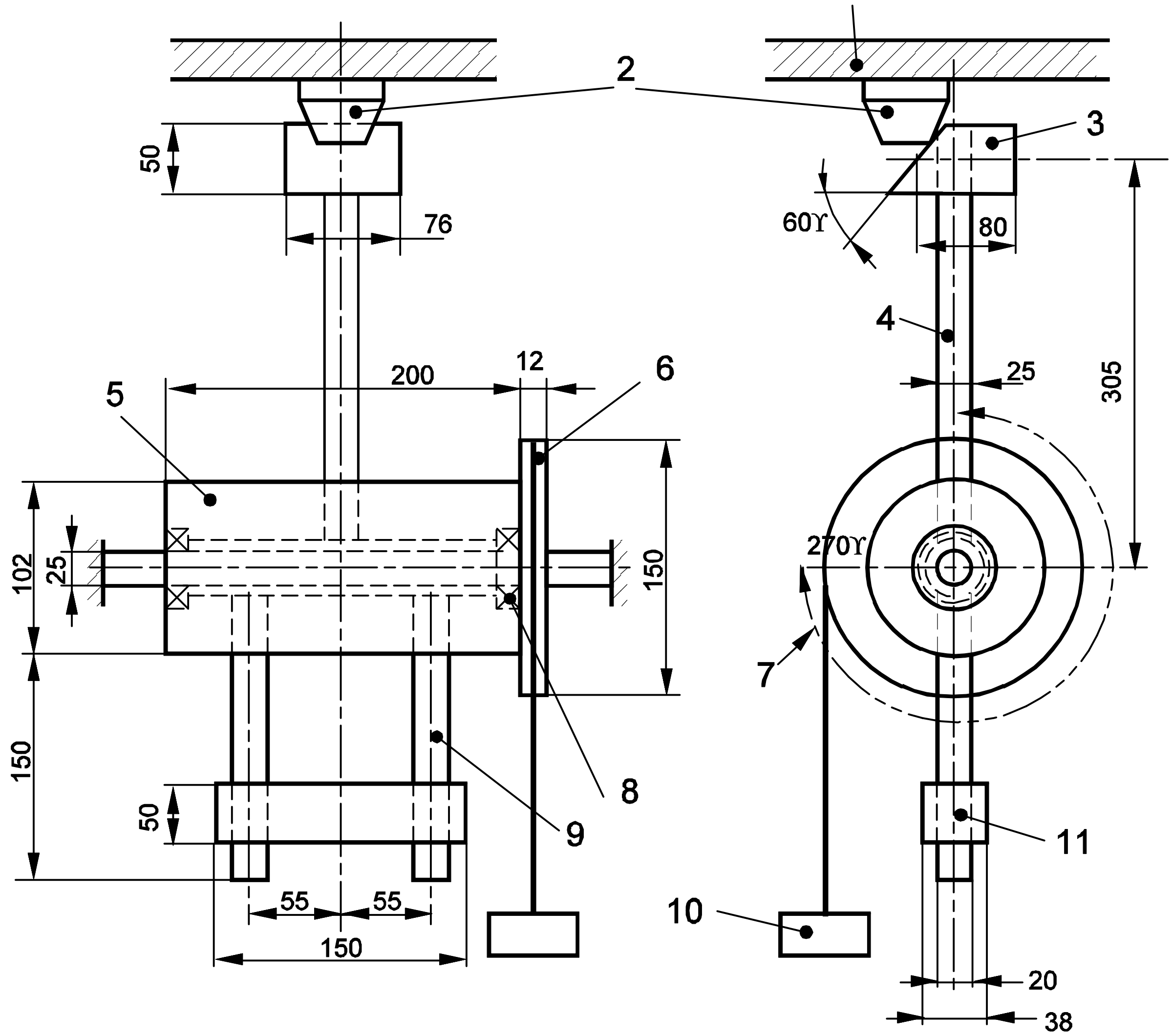
To operate the apparatus the position of the specimen and the mounting board is first adjusted as shown in Figure C.1 and the mounting board is then secured rigidly to the frame. The hammer assembly is then balanced carefully by adjustment of the counter balance weight with the operating weight removed. 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 will spin the hammer and arm through an angle of $3\pi/2$ radians to strike the specimen. The mass of the operating weight to produce the required impact energy of 1.9 J equals:

$$\frac{0.388}{3\pi r} \text{ kg}$$

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 the standard calls for a hammer velocity at impact of (1.5 ± 0.13) m s^{-1} the mass of the hammer head will need to be reduced by drilling the back face sufficiently to obtain this velocity. It is estimated that a head of mass of about 0.79 kg will be required to obtain the specified velocity, but this will have to be determined by trial and error.

Dimensions in millimetres



1 mounting board
2 detector
3 striker
4 striker shaft
5 boss
6 pulley
7 270° angle of movement
8 ball bearings
9 counter balance arms
10 operating weight
11 counter balance weight

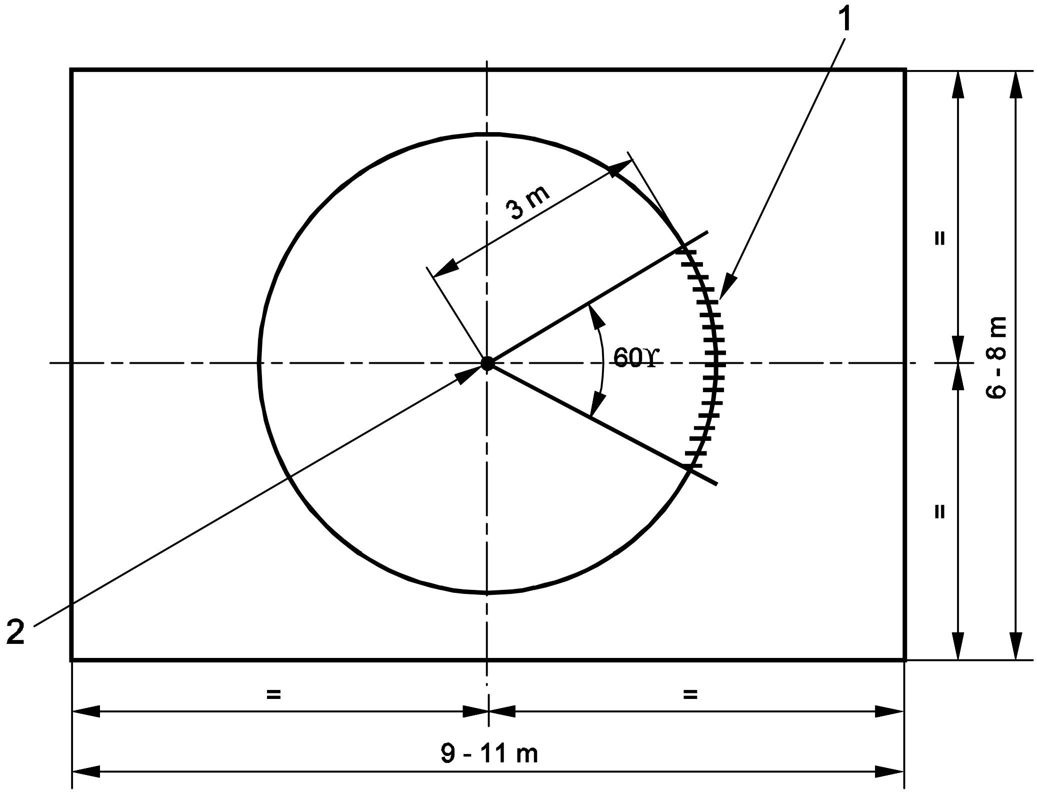
NOTE: The dimensions shown are for guidance, apart from those relating to the hammer head.

Figure C1 — Impact apparatus

ANNEX D (normative) – Fire test room

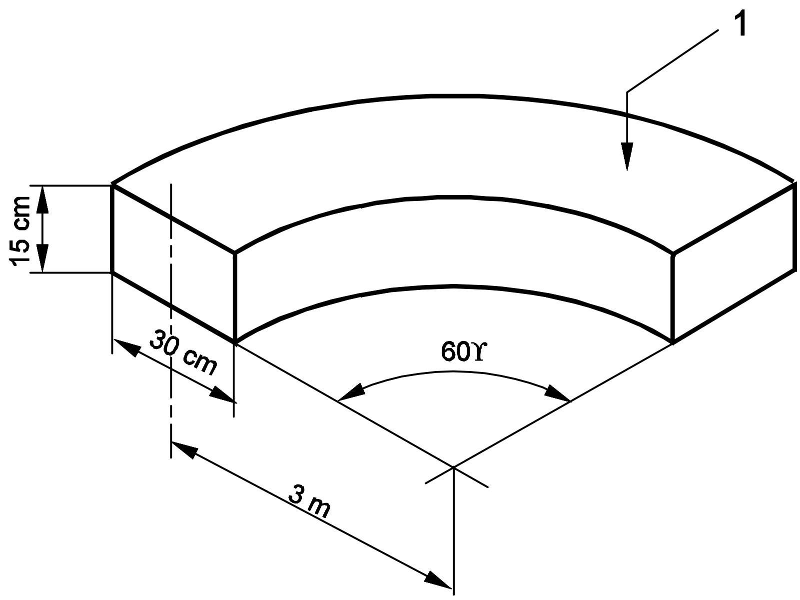
The specimens to be tested, the MIC, the temperature probe, the measuring part of the obscuration meter, and the CO measuring instrument, shall all be located within the volume shown in Figures D.1 & D.2.

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



1 specimens and measuring instruments (see Figure F.2)
2 position of test fire

Figure D1 — Plan view of the fire test room



1 ceiling

Figure D2 — Mounting position for specimens and measuring instruments

ANNEX E (normative) – Smouldering (pyrolysis) wood fire[2]

E.1 Fuel

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

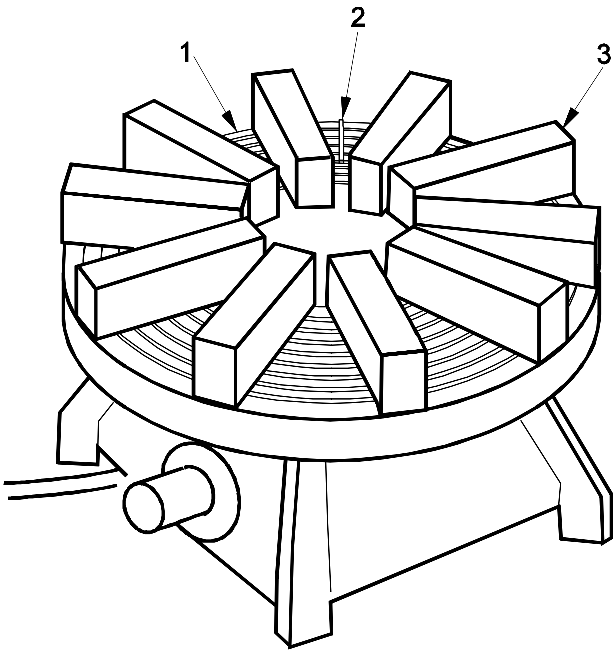
E.2 Hotplate

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

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

E.3 Arrangement

The sticks shall be arranged 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.



1 grooved hot plate
2 temperature sensor
3 wooden sticks

Figure E.1 — Arrangement of the sticks on the hotplate

[2] This fire test is based on TF2 of EN54-7:2000, with some modifications to the test criteria to make it suitable for evaluating CO fire detectors.

E.4 Heating rate

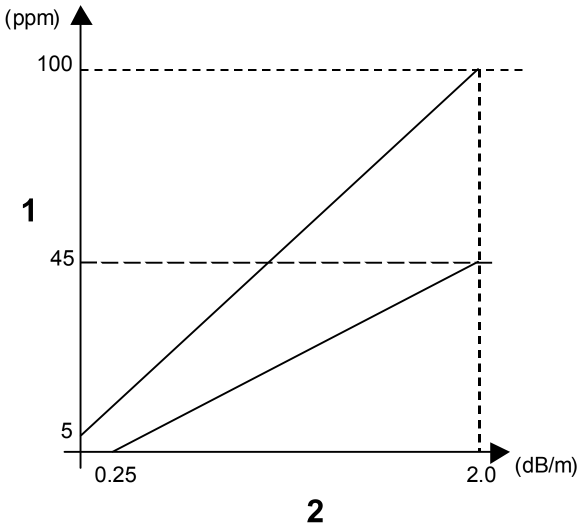
The hot plate shall be powered such that its temperature rises from ambient to 600 °C in approximately 11 min.

E.5 End of test condition

m_E=2 dB m^{-1}

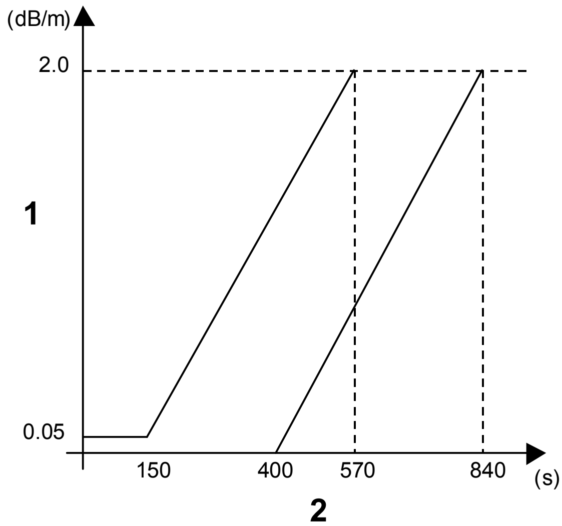
E.6 Test validity criteria

The development of the fire shall be such that the curves of *c* against *m*, and *c* against time, fall within the limits shown in Figures E.2 and E.3 respectively and no flaming occurs, up to the time when all of the specimens have generated an alarm signal, or *m*=2 dB m^{-1}, whichever is the earlier.



1 c-value
2 *m*-value

Figure E.2 — Limits for *c* against *m*, smouldering (pyrolysis) fire



1 *m*-value
2 Time

Figure E.3 — Limits for *m* against time, smouldering (pyrolysis) fire

ANNEX F (normative) – Glowing smouldering cotton fire[3]

F.1 Fuel

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

F.2 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.

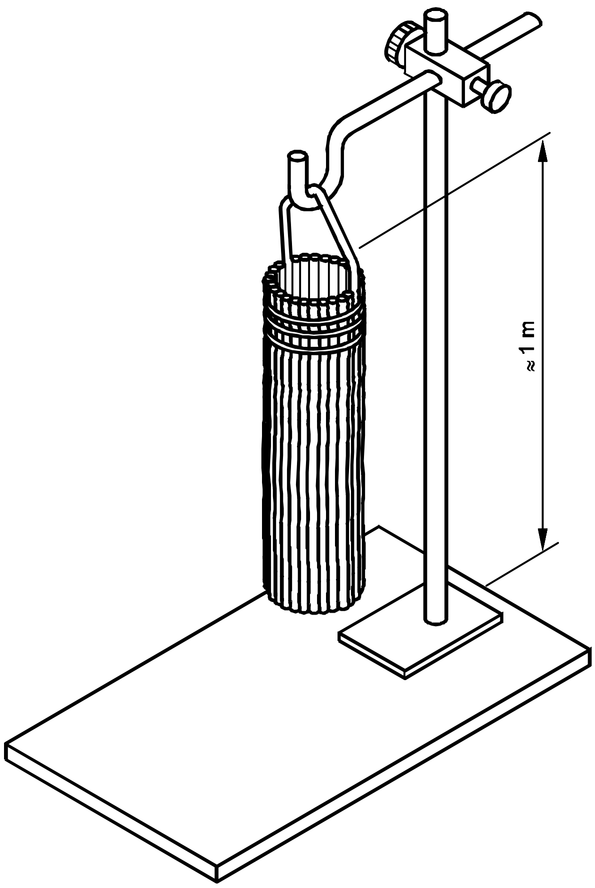


Figure F.1 — Arrangement of the cotton wicks

[3] This fire test is based on TF3 of EN54-7:2000, with some modifications in the test criteria to make it suitable for evaluating CO fire detectors.

F.3 Ignition

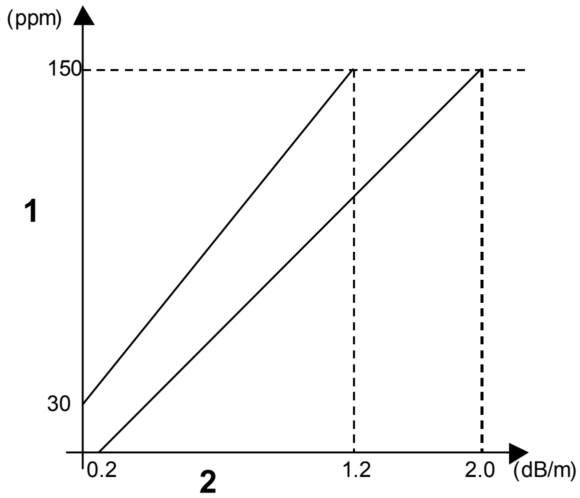
The lower end of each wick shall be ignited so that the wicks continue to glow. Any flaming shall be blown out immediately. The test time shall start when all wicks are glowing.

F.4 End of test condition

m_E=2 dB m^{-1}

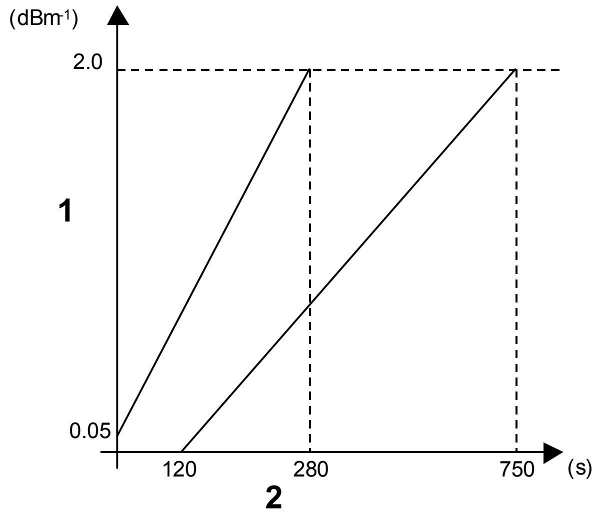
F.5 Test validity criteria

The development of the fire shall be such that the curves of *c* against *m*, and *m* against time, fall within the limits shown in figures F.2 and F.3 respectively, up to the time when all of the specimens have generated an alarm signal, or *m*=2 dB m^{-1}, whichever is the earlier.



1 *c*-value
2 *m*-value

Figure F.2 — Limits for *c* against *m*, Glowing smouldering cotton fire



1 *m*-value
2 Time

Figure F.3 — Limits for *m* against time, Glowing smouldering cotton fire

ANNEX G (normative) – Deep-seated smouldering cotton fire

G.1 Fuel

An unused white towel, made from 100% cotton, having dimensions 50cm x 100cm, and a density of 540 gm^{-2}. The fuel shall be dried in an oven at 40°C for a period of at least 12 hrs.

G.2 Arrangement

The towel shall be folded three times to give a rectangle 30cm x 25cm, the first fold being on the long dimension. The towel shall be placed on a base formed from aluminium foil with the edges folded up to form a tray. The ignition source shall consist of approximately 2m of resistance wire, having a specific resistance of approximately 4 Ω m^{-1}, formed as shown in Fig G.1.

The ignition source shall be placed inside the centre fold of the towel, such that the ends of the resistance wire are completely covered by the towel. There shall be no free air path to the ignition source.

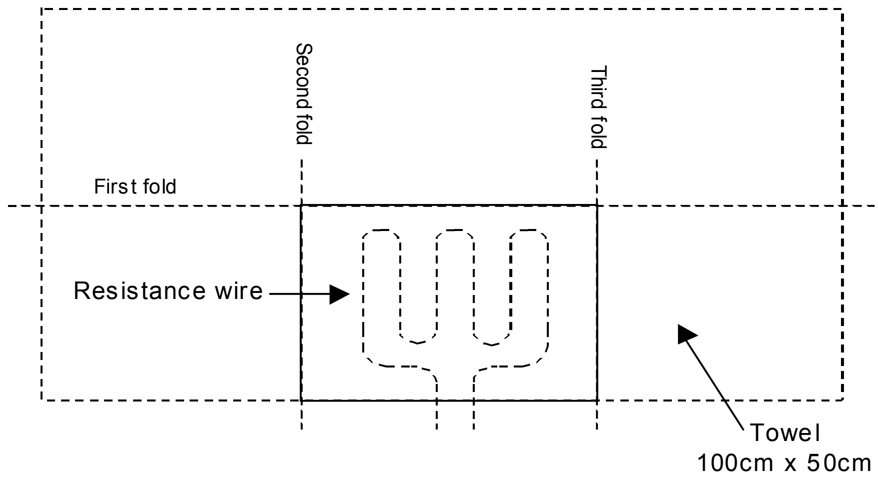


Figure G.1 - Arrangement of the cotton towel and ignition source

G.3 Ignition

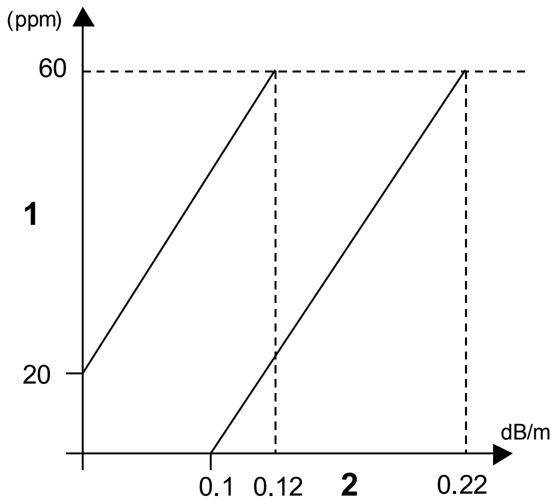
The resistance wire of the ignition source shall be connected to a 20V/5A power supply. The start of the test corresponds with the instant of switching on the supply. Power shall be supplied to the ignition source throughout the test.

G.4 End of test condition

c_E = 60 ppm

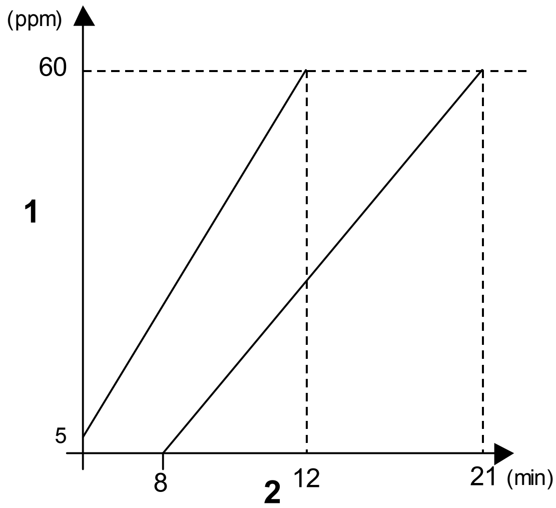
G.5 Test validity criteria

The development of the fire shall be such that the curves of *c* against *m*, and *c* against time, fall within the limits shown in figures G.2 and G.3 respectively, and no flaming occurs, up to the time when all of the specimens have generated an alarm signal, or *c* = 60 ppm, whichever is the earlier.



1 *c*-value
2 *m*-value

Figure G.2 — Limits for *c* against *m*, Deep-seated smouldering cotton fire



1 *c*-value
2 Time

Figure G.3 — Limits for *c* against time, Deep-seated smouldering cotton fire

ANNEX H (informative) – Information concerning the construction of the CO tunnel

CO fire detectors respond when the signal(s) from one or more CO sensors fulfils certain criteria. The CO concentration at the sensor(s) is related to the CO 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 CO concentration etc. The relative change of the response threshold value measured in the tunnel is the main parameter considered when the stability of CO fire detectors is evaluated by testing in accordance with this standard.

Many different tunnel designs are suitable for the tests specified in this standard, but the following points should be considered when designing and characterising the CO tunnel.

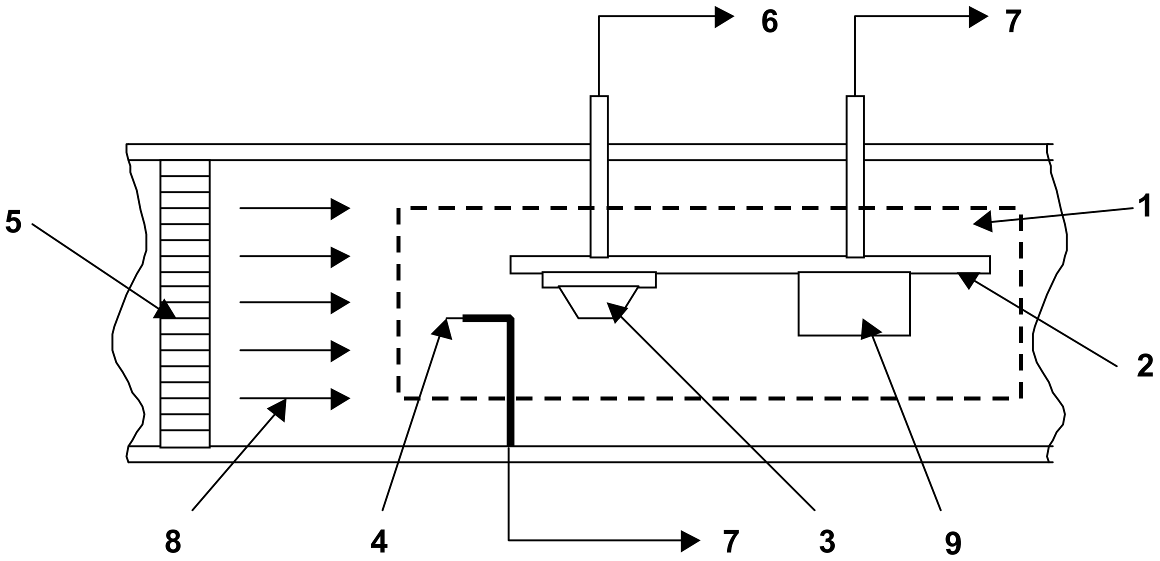
The response threshold value measurements require that the CO concentration be increased until the detector responds. This can best be facilitated in a closed circuit CO tunnel. A purging system is required to purge the tunnel after each CO exposure. Some means to maintain the pressure inside the tunnel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

The air flow created by a fan in the tunnel will be turbulent, and needs to pass through an air straightener to create a nearly laminar and uniform air flow in the working volume (see Figure H.1). This can be facilitated by using a filter, honeycomb or both, in line with, and upstream of the working section of the tunnel. Care should be taken to ensure that the airflow is well mixed to give a uniform temperature and CO concentration before entering the flow straightener. Efficient mixing can be obtained by feeding the CO into the tunnel upstream of the fan.

The test gas may be provided as a known concentration of CO in air that can be injected into the tunnel at a suitable rate to achieve the required rate of rise of CO concentration. A mixture containing 1% CO in air is suitable for this purpose.

Means for heating and cooling the air before it enters the working section are required. The tunnel should have a system capable of controlling the heating and cooling 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 CO, or the oxidation of CO to CO_2.

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.



Key

1 working volume
2 mounting board
3 detector(s) under test
4 temperature sensor
5 flow straightener
6 supply and monitoring equipment
7 control and measuring equipment
8 air flow
9 CO measuring instrument

Fig H.1 – CO tunnel, working section, side view

Amendments Issued Since Publication

DOCUMENT NO.	AMENDMENT DETAILS	SIGNATURE	DATE
LPS 1265-1.1	1. New front cover 2. Title added to header 3. Contents page moved to Page 1 4. Notes added on Page 4 5. Repagination 6. Changes to copyright information	DC	Jan.2014