BRITISH STANDARD

BS 5446-1:2000
Incorporating
Amendment No. 1

Fire detection and fire alarm devices for dwellings —

Part 1: Specification for smoke alarms

ICS 13.220.20

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee FSH/12, Fire detection and alarm systems, upon which the following bodies were represented:

British Cables Association
British Entertainments and Discotheque Association
British Fire Consortium
British Fire Protection Systems Association
British Nuclear Fuels plc
British Telecommunications plc
Chartered Institution of Building Services Engineers
Consumer Policy Committee of BSI
Department of the Environment, Transport and the Regions (Building Research Establishment)
Department of the Environment, Transport and the Regions (Construction Directorate)
Electrical Contractors' Association
Health and Safety Executive
Home Office
Institution of Electrical Engineers
Institute of Fire Prevention Officers
Institute of Fire Safety
Institute of Petroleum
Line of Fire
London Fire and Civil Defence Authority
Loss Prevention Council
Maritime and Coastguard Agency
Ministry of Defence
National Association of Fire Officers
National Caravan Council Ltd.
National Inspection Council for Electrical Installation Contracting
Nuclear Industry Fire Safety Coordination
Royal Society of Health
Trades Union Congress

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

BSI Testing
Electricity Association
Energy Industries Council
Maritime and Coastguard Agency
Royal National Institute for Deaf People

This British Standard, having been prepared under the direction of the Health and Environment Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 June 2000

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Contents

Foreword

This part of BS 5446 has been prepared by Technical Committee FSH/12. It supersedes BS 5446-1:1990, which is withdrawn. It specifies the requirements for smoke alarms intended for use in dwellings.

Guidance on siting, installation, maintenance and user actions are given in BS 5839-6.

This revision includes new fire tests which bring this standard into line with prEN 54-7 for point type smoke detectors (to be published as BS EN 54-7), which are no longer included within the scope of BS 5446-1.

The tests are type tests and are not intended as manufacturers' tests to maintain uniformity of quality in production, which is dealt with in the BS EN ISO 9000 series. While the tests are intended to assess the most important features of the design and construction of smoke alarms they cannot remove the necessity for regular inspection and maintenance, which is essential for reliable operation.

Product certification. Users of this British Standard are advised to consider the desirability of third-party certification of product conformity with this British Standard. Appropriate conformity attestation arrangements are described in the appropriate part of the BS EN ISO 9000 series. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

For a period of one year from the date of publication of this revision of BS 5446-1, new product certification submissions may be carried out either to this edition or the previous edition of the standard. After this one year period, all new submissions for product certification will be made to this edition of the standard.

Any product certified to the previous edition of the standard can retain its certification up to a maximum of three years after publication of this edition. After this period, only products certified to this edition of the standard will be able to bear the approval mark.

NOTE Devices giving a non-continuous alarm signal, although not precluded by this standard, may not conform to the requirements of some regulations.

Annex A, Annex B, Annex D, Annex F, Annex G, Annex H, Annex I, Annex J and Annex K are normative. Annex C and Annex E are informative.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 35 and a back cover.

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1 Scope

This part of BS 5446 specifies requirements and test methods for smoke alarms using scattered light, transmitted light, or ionization intended for permanent installation on ceilings or walls of dwellings for the purpose of life safety.

It also covers smoke alarms suitable for use in leisure accommodation vehicles (LAVs).

NOTE 1 Equipment conforming to this standard may not be suitable for use in boats due to the corrosive atmosphere.

NOTE 2 Although not covered by this standard, equipment is available for use with smoke alarms in order to provide a suitable warning system for use by the deaf and hearing impaired.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 1474:1987, *Specification for wrought aluminium and aluminium alloys for general engineering purposes: bars, extruded round tubes and sections.*

BS 4422 (all parts), *Glossary of terms associated with fire.*

BS 5445-7, *Components of automatic fire detection systems — Part 7: Specification for point-type smoke detectors using scattered light, transmitted light or ionization.*

BS 5839-6:1995, *Fire detection and alarm systems for buildings — Part 6: Code of practice for the design and installation of fire detection and alarm systems in dwellings.*

BS 7671, *Requirements for electrical installations — IEE Wiring Regulations — Sixteenth edition.*

BS EN 60065:1998, *Audio, video and similar electronic apparatus — Safety requirements.*

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

IEC 68-2-42:1982, *Environmental testing — Part 2: Tests — Test Kc: Sulphur dioxide test for contacts and connections.*

3 Terms and definitions

For the purposes of this standard the terms and definitions given in BS 4422 and BS 5839-6 and the following apply.

3.1
smoke alarm
device containing within one housing all the components, except possibly the energy source, necessary for detecting smoke and for giving an audible alarm

3.2
fixed sensitivity alarm
alarm, the response threshold of which cannot be varied manually after the completion of the manufacturing process without the breakage of a seal or some equivalent permanent indication of adjustment, and in which any such breakage is clearly visible during servicing

3.3
adjustable sensitivity alarm
alarm, the response threshold of which can be varied within specified limits without permanent indication of such variation

NOTE Limits are specified in **10.2**.

3.4
response threshold
smoke concentration at which the alarm changes to its alarm condition

NOTE For the purposes of this standard, response threshold is determined in accordance with Clause **8**.

3.5
energized condition
state in which the alarm is supplied with power

3.6
normal condition
condition in which the alarm is energized but is not giving either a fire alarm signal or a fault warning, although able to give such signals if the occasion arises

3.7
alarm condition
condition in which the alarm is giving a signal specified by the manufacturer's requirements as indicating the existence of a fire

3.8
fault warning
signal intended to indicate an actual or incipient fault that might prevent the emitting of a fire alarm signal

3.9
manufacturer's requirements
requirements specified by the manufacturer and/or supplier

NOTE See Clause **5**.

3.10
alarm silence facility
means of temporarily disabling or desensitizing a smoke alarm

4 Marking

NOTE Marking and safety information may be required by legislation. For alarms containing radioactive material, advice should be sought from the National Radiological Protection Board, Chilton, Didcot, Oxfordshire OX11 0RQ.

Each alarm shall be indelibly marked with the following:

a) the number and date of this British Standard, i.e. BS 5446-1:2000;[1)]

b) the name or trade mark of the manufacturer or supplier;

c) the type of alarm;

d) the date of manufacture, or the batch number;

e) the address of an organization capable of being responsible for servicing or repair;

f) the manufacturer's recommended date for replacement, subject to normal, regular maintenance;

g) smoke alarms incorporating user replaceable batteries: the type or numbers of batteries recommended by the manufacturer and an instruction to the user "Test the alarm for correct operation using the test facility, whenever the battery is replaced."; which shall be visible during the operation of changing the batteries;

h) smoke alarms incorporating non-replaceable batteries: the warning "WARNING — Battery not replaceable — See instruction manual" which shall be visible during normal use.

Conformity shall be checked by visual inspection. The indelibility and durability of the marking shall be checked by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit. After this test the marking shall still be legible and labels shall not be removable and shall have no curling.

[1)] Marking BS 5446-1:2000 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

5 Provision of information

Information supplied on or with smoke alarms shall include instructions on siting, installation, maintenance and user actions in accordance with the recommendations in BS 5839-6:1995, Clause **22**.

The information provided with smoke alarms incorporating user-replaceable batteries shall include specific guidance on changing the batteries. This guidance shall include any advice which is necessary to ensure that the battery is properly connected. It shall also include a recommendation that the operation of the alarm is tested with the test facility whenever the batteries are replaced.

NOTE It is recommended that the guidance should also state that if the alarm fails to operate correctly, the advice of the manufacturer should be sought.

For smoke alarms incorporating non-replaceable batteries, information shall be given on the action to be taken if a battery fault warning is emitted.

Information for interconnectable smoke alarms shall state the maximum number that may be interconnected. Details of suitable cables shall also be given.

Information for smoke alarms intended for connection to mains supplies shall include a warning that draws attention to the hazards associated with mains voltages and recommends that the smoke alarm, together with any associated supply and interconnect wiring, be installed in accordance with BS 7671, published by the Institution of Electrical Engineers[2)].

Information shall include a warning that if there is any question as to the cause of an alarm it should be assumed that the alarm is due to an actual fire and the dwelling should be evacuated immediately.

If it is claimed that the smoke alarm is also suitable for use in leisure accommodation vehicles (LAVs) this shall be clearly stated in the information supplied on or with the smoke alarm (see also Clause **30**).

6 Constructional requirements

6.1 Visual indication of operation

NOTE Visual indication of operation may be fitted.

Alarm indicators shall be red and shall be separate from the mains power supply indicator. Mains-powered apparatus shall include a power supply indicator. This shall be coloured green and shall be continuously illuminated when mains power is present. The failure of any indicator lamp shall not prevent the emitting of a fire alarm signal.

6.2 Terminals for external conductors

The alarm or base, as appropriate, if intended to have external connections, shall provide for the connection of conductors by means of screws, nuts or equally effective devices. For mains-powered alarms which utilize a “flying lead”-type connector, this connector shall be regarded as a conductor. If terminals are provided, they shall allow the connection of conductors having nominal cross-sectional areas of between 0.4 mm^2 and 1.5 mm^2. Disconnection of the conductors, or access to the conductors for disconnection, shall not be possible without the use of a tool. Terminals shall be designed so that they clamp the conductor between metal surfaces without rotation of those surfaces but with sufficient contact pressure and without damage to the conductor.

6.3 Alignment of alarms

Where separate bases are used, a means to prevent incorrect alignment of the alarm in the base shall be provided.

6.4 Failure of components

A fault warning shall be given on the failure of any component, apart from the battery, which would prevent the emitting of an alarm signal and for which the mean time before failure is less than five years. Any such warning shall be readily distinguishable from the alarm signal.

2) BS 7671, *Requirements for electrical installations, IEE Wiring Regulations, Sixteenth edition.* Available from Station House, Nightingale Rd, Hitchin, Herts.

6.5 Battery removal indication

The removal of any user-replaceable battery used to power, or provide back-up power, for the smoke detection circuit/sounder, from a battery or mains powered d.c. backed smoke alarm, shall result in a visual, mechanical or audible warning that the battery has been removed. The visual warning shall not depend upon a power source.

NOTE Conformity may be achieved by, but is not restricted to, one of the following examples:

a) a warning flag that will be exposed with the battery removed and the cover closed;

b) a hinged cover or battery compartment that cannot be closed when the battery is removed;

c) a unit that cannot be replaced upon its mounting with the battery removed.

7 Testing

7.1 Test specimens

Thirteen smoke alarms shall be provided for use in the tests described in Clauses **9** to **34**. Additional samples may be required for Clauses **26** and **28**.

7.2 Test schedule

The alarms shall be numbered as specified in Clause **10**. The tests on each alarm indicated in Table 1 shall be carried out in the order in which they are listed.

The battery installation test shall be conducted on alarms selected in accordance with **34.3** from amongst the 13 samples provided for test.

7.3 Associated equipment

In all tests requiring the alarm to be in an operating condition, any associated equipment (such as control equipment or power supplies) shall satisfy the manufacturer's requirements.

7.4 Warm-up and resetting times

Where the manufacturer places requirements on the warm-up or resetting times of the alarm, these shall be observed in all tests unless otherwise specified for particular tests.

7.5 Power supply during test

If a test requires a specimen to be operational, the specimen shall be connected to a suitable power source with characteristics as required by the manufacturer's data. Unless otherwise specified in the test method, the power source 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.

NOTE The details of the power source used should be given in the test report.

7.6 Tolerances

If a specific tolerance or limit is not specified in a method of test a tolerance of ±5 % shall be applied.

Table 1 — Test schedule

Test	Clause	Alarm number												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Directional dependance	**9**	One alarm selected at random												
Preliminary test	**10**	x	x	x	x	x	x	x	x	x	x	x	x	x
Repeatability	**11**	x												x
Supply voltage	**12**	x												x
Air movement	**13**	x												x
Ambient light	**14**	x												x
Temperature	**15**	x												x
Humidity	**16**			x								x		
Corrosion	**17**				x						x			
Impact	**18**					x				x				
Vibration	**19**								x					
Fire sensitivity	**20**	x	x										x	x
Final test	**21**	x	x										x	x
Battery fault warning	**22**						x							
Sound output	**24**							x						
Tests on interconnectable smoke alarms	**26**						x							
Test on alarm silence facility	**27**						x							
Battery reversal	**29**							x						
Additional tests for alarms suitable for installation in LAVs	**30**													
Vibration	**30.2**								x					
Temperature cycle	**30.3**			x										

8 Measurement of response threshold

8.1 Apparatus

8.1.1 *Wind tunnel*, as specified in Annex A with, unless otherwise specified for particular tests, an air velocity of (0.2 ± 0.05) m/s and an air temperature of (22 ± 3) °C.

8.2 Smoke generation

Generate test smoke by heating filter paper[3)] with a mass between 80 g/m^2 and 110 g/m^2, on an electric heating element. Adjust the amount of paper used and the temperature of the heating element so that the optical density of the smoke increases at a rate not exceeding 0.2 dB/m per minute to a maximum level of at least 1.5 dB/m, when determined using an instrument as specified in Annex B.

NOTE Care should be taken to ensure that the rate of generation of smoke is similar in all tests of a given alarm type.

8.3 Method of test

Mount the alarm in the wind tunnel, with the tunnel clear of smoke, and leave the alarm in its normal condition for at least 15 min, unless otherwise specified for particular tests. Mount alarms intended for ceiling mounting and alarms intended for wall mounting in the same position in the wind tunnel, and oriented as described in **8.4**. Generate smoke as described in **8.2** and determine the smoke density at the moment of transition to the alarm condition. Record this as the response threshold of the alarm.

NOTE The measuring instrument used to determine the response threshold of the alarm should work on the same principle as the alarm, in accordance with the recommendations in Annex C.

[3)] A Whatman No. 2 filter paper is suitable.

8.4 Orientation of the alarm

Before commencing the tests described in Clauses **10** to **34** determine the orientation of the alarm giving the lowest response threshold in accordance with Clause **9**. Carry out all measurements of the response threshold in the remaining tests with the alarm in this orientation, unless otherwise specified for particular tests.

9 Directional dependence

9.1 Method of test

Select one alarm at random from those submitted for testing. Mount the alarm in the wind tunnel in an arbitrary orientation relative to the direction of the air flow, and measure the response threshold as described in Clause **8**. Rotate the alarm through 45° about an axis perpendicular to the mounting surface and measure the response threshold again. Repeat this procedure until measurements have been made with the alarm in eight different orientations. Note the orientation giving the highest response threshold and the lowest response threshold.

9.2 Requirements

The ratio of the highest response threshold of the alarm to the lowest response threshold shall not exceed 1.5.

10 Preliminary test and numbering

10.1 Fixed sensitivity alarms

10.1.1 *Method of test*

Determine the response threshold of each alarm in accordance with Clause **8**. Number the alarms in the order 1 to 13, such that number 1 has the lowest response threshold, number 13 has the highest.

10.1.2 *Requirements*

The ratio of the response thresholds of alarms 1 and 13 shall not exceed 2.

10.2 Adjustable sensitivity alarms

10.2.1 *Method of test*

Adjust each alarm to its maximum response threshold setting, and measure this using the method described in Clause **8**. Number the two alarms with the highest response thresholds number 12 and number 13, number 13 having the higher threshold. Adjust each alarm to its minimum response threshold setting and measure this in accordance with Clause **8**. Number the remaining alarms in the order 1 to 11 such that number 1 has the lowest response threshold and number 11 has the highest. Re-adjust alarms 12 and 13 to their maximum threshold settings. Retain these sensitivity settings for other tests.

10.2.2 *Requirements*

The ratio of the minimum response threshold of any alarm to that of any other alarm shall not exceed 2. The ratio of the maximum response threshold of any alarm to that of any other alarm shall not exceed 2.

11 Repeatability

11.1 Method of test

Measure the response threshold of the alarm in accordance with Clause **8**. Clear the tunnel and alarm of smoke and reset the alarm. After 15 min, or a longer period if specified in accordance with Clause **5**, measure the response threshold again. Repeat this procedure until six measurements have been obtained.

11.2 Requirements

The ratio of the highest response threshold of the alarm to the lowest response threshold shall not exceed 1.5.

12 Supply voltage

12.1 Voltage limits

12.1.1 For battery-operated smoke alarms, the tests shall be carried out with a supply voltage corresponding to that of a new battery, and also with a supply voltage of V_E as determined in **22.2.3**.

12.1.2 For smoke alarms intended for operation from mains supplies, the alarm shall be tested with supply voltages of 0.85 times the lower limit and 1.1 times the upper limit of the nominal supply voltage range specified in the manufacturer's requirements. If the smoke alarm is provided with a rechargeable battery, sufficient time shall be allowed for the battery voltage to stabilize before the response threshold is measured.

12.1.3 For smoke alarms intended to operate from any external supply other than mains, the manufacturer shall specify a maximum and minimum voltage. Tests shall be conducted at the maximum and minimum voltage.

12.2 Method of test

Measure the response threshold of the alarm twice, in accordance with Clause **8**, making one measurement with the supply voltage set to the higher level and the other with the supply voltage set to the lower level, determined in accordance with **12.1**.

12.3 Requirements

The ratio of the response thresholds measured in accordance with **12.2** to the mean of those measured on the same alarm in accordance with Clause **11** shall be not less than 0.67 and not greater than 1.5. During the test the smoke alarm shall not respond before the density reaches 0.05 dB/m.

13 Air movement

13.1 Method of test

13.1.1 Test the alarm in accordance with **13.1.2** and **13.1.3**.

13.1.2 Measure the response threshold of the alarm in accordance with Clause **8**, but using an air velocity of (1 ± 0.2) m/s.

13.1.3 Mount the alarm in the tunnel in the orientation having the lowest response threshold (i.e. in the most sensitive orientation) determined in accordance with **9.1**, and subject it to an air velocity of (8 ± 0.8) m/s for a period of 2 min in the absence of smoke.

13.2 Requirements

The ratio of the response threshold measured in accordance with **13.1.2** to the mean of those measured on the same alarm in accordance with Clause **11** shall be not less than 0.67 and not greater than 1.5. No false alarms or fault warnings shall be given in the test described in **13.1.3**.

14 Ambient light

14.1 Method of test

Mount the alarm in its normal operating position in the testing tunnel specified in Annex A in such a way as to permit the alarm to be illuminated by the apparatus specified in Annex D. Switch the illumination on for 5 s, then on and off at a rate of 0.5 s on, 0.5 s off for a period of 10 s. Then leave the illumination on for a period of 10 min. Measure the response threshold as described in Clause **8**, with the alarm illumination remaining on. Rotate the alarm through 90° about the vertical axis and repeat the procedure.

14.2 Requirements

No false alarm or fault warning shall be given during the tests described in **14.1**. The ratio of the response thresholds measured to the mean of the response thresholds measured in accordance with Clause **11** shall be not less than 0.67 and not greater than 1.5.

15 Elevated and depressed temperature

15.1 Method of test

Place the alarm in the apparatus recommended in Annex E. Raise the air temperature from (22 ± 3) °C to (40 ± 3) °C at a rate not exceeding 1 °C/min. Hold the air temperature at (40 ± 3) °C for 15 min, then generate smoke as described in **8.2** and measure the response threshold using the same measuring instrument as used in Clause **11**. Lower the air temperature to (0 ± 3) °C at a rate not exceeding 1 °C/min, hold it at that temperature for 15 min and measure the response threshold again.

During the elevation and depression of the temperature, ensure that the humidity is controlled so that no condensation forms on or inside the alarm.

15.2 Requirements

No false alarm or fault warning shall be given during the test described in **15.1**. The ratio of the response thresholds at 0 °C and 40 °C to the mean of those measured in accordance with Clause **11** shall be not less than 0.5 and not greater than 2.

16 Humidity

16.1 Method of test

Dry the alarm at a temperature of (40 ± 3) °C and a relative humidity of less than 45 % for a period of at least 24 h without energizing. Energize the alarm and, after a 15 min stabilization period, increase the relative humidity over a period of 1 h to (92 ± 3) %, keeping the temperature at (40 ± 3) °C. Maintain this temperature and humidity for a period of 10 days. At the end of this period reduce the temperature to (30 ± 3) °C keeping the humidity at (92 ± 3) %. Reset the alarm if it emits an alarm signal or gives a fault warning. Maintain these conditions for 24 h and measure the response threshold in accordance with Clause **8**. Keep the alarm for three days at a temperature of (22 ± 3) °C and a relative humidity of (60 ± 3) % and measure the response threshold again.

For smoke alarms incorporating an alarm silence facility, make a further measurement of the response threshold in accordance with **27.2.3**.

If a smoke alarm is claimed to be suitable for use in LAVs (see Clause **5**) apply the temperature cycle test in **30.3**.

16.2 Requirements

The ratio of the response thresholds of each alarm measured in accordance with **16.1**, to the response threshold measured on the same alarm in accordance with Clause **10** shall be not less than 0.67 and not greater than 1.5. No false alarm or fault warning shall be given during exposure to high humidity at temperatures below 33 °C or during the three day drying period.

17 Corrosion

17.1 Method of test

The test procedure and the test apparatus shall be as specified in IEC 68-2-42:1982, Test Kc, except that the conditioning shall be as described in a) to d). Mount the alarm in its normal operating position. The alarm shall not be supplied with power during the conditioning but it shall have untinned copper wires, of appropriate diameter, connected to sufficient terminals to allow the final measurement to be made without making further connections to the specimen.

The following conditioning shall be applied:

a) temperature: (25 ± 2) °C;

b) relative humidity: (93 ± 3) %;

c) SO_2 concentration: (25 ± 5) ppm (by volume);

d) duration: four days.

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 1 h at the standard laboratory conditions. Then measure the response threshold in accordance with Clause **8**.

For smoke alarms incorporating an alarm silence facility, make a further measurement of the response threshold in accordance with **27.2.3**.

17.2 Requirements

The ratio of the response threshold measured after corrosion to the response threshold measured on the same alarm in accordance with Clause **10** shall be not less than 0.67 and not greater than 1.5.

18 Impact

18.1 Apparatus

18.1.1 *Swinging hammer*, having a rectangular-section aluminium alloy head (aluminium alloy $AlCu_4SiMg$ conforming to ISO 209-1, 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.

18.2 Method of test

Mount the alarm on a rigid surface by means of its normal fastenings and in its operating position and initially in its normal operating condition. Strike the alarm with the hammer. Deliver the blow in a horizontal direction with the point of impact on the upper half of the impact face. Choose the azimuthal direction and impact point relative to the specimen as that most likely to impair the correct operation of the alarm. The kinetic energy and velocity of the hammer immediately before impact shall be 1.9 J ± 10 % and 1.5 m/s ± 10 % respectively. After the impact measure the response threshold in accordance with Clause **8**.

NOTE A suitable apparatus incorporating the swinging hammer is described in BS 5445-7.

18.3 Requirements

The ratio of the response threshold measured after the test to that measured in accordance with Clause **10** shall be not less than 0.67 and not greater than 1.5 unless, within 30 s of the impact, the alarm gives a fault warning that cannot be reset. The impact shall not detach the alarm from its mounting.

19 Vibration

19.1 Method of test

Mount the alarm on a vibrating platform secured by its normal fastenings and in its normal operating position. Apply sinusoidal vibration in a direction perpendicular to the plane of the mounting base while the alarm is in its normal condition. Sweep the frequency of vibration from 5 Hz to 60 Hz at a rate of (1.8 ± 0.2) octaves/h, making a single sweep of approximately 2 h duration, giving a peak acceleration of the alarm mounting, measured in metres per second squared (m/s^2), of $[0.7 \sqrt{(f)}]$ ± 10 % where f is the instantaneous frequency in hertz (Hz). After the vibration sweep remove the alarm from the platform and measure the response threshold as described in Clause **8**.

If a smoke alarm is claimed to be suitable for use in LAVs (see Clause **5**) apply the additional vibration test in **30.2**.

19.2 Requirements

No fire alarm signal or fault warning shall be given during the vibration. No defect that might lead to subsequent failure shall be observed after the vibration. The ratio of the response threshold to the response threshold measured in accordance with Clause **10** shall be not less than 0.67 and not greater than 1.5.

20 Fire sensitivity

20.1 Object

The object of the test is to demonstrate that the alarm has adequate sensitivity to a broad spectrum of smoke types as required for general application in buildings.

20.2 Principle

The specimens are mounted in a standard fire test room and exposed to a series of test fires designed to produce smoke representative of a wide spectrum of types of smoke and smoke flow conditions.

20.3 Test procedure

20.3.1 *Fire test room*

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

a) length: 9 m to 11 m;

b) width: 6 m to 8 m;

c) height: 3.8 m to 4.2 m.

The fire test room shall be equipped with the following measuring instruments as described in BS 5445-7 and arranged as indicated in Annex F:

— measuring ionization chamber (MIC);

— obscuration meter;

— temperature probe.

NOTE The obscuration meter as described in BS 5445-7 operates at a different wavelength from the instrument described in Annex B.

20.3.2 *Test fires*

The specimens shall be subjected to the four test fires TF2 to TF5[4]. The type, quantity and arrangement of the fuel, the method of combustion, the end of test condition and the required profile curve limits for each fire test shall be as described in Annex G, Annex H, Annex I and Annex J.

In order to be a valid test fire, the development of the fire shall be such that the profile curves of m against y, and m against time fall within the specified limits, up to the time when all 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 the test shall be deemed to be invalid and shall be repeated.

NOTE It is permissible, and may be necessary, to adjust the quantity and arrangement of the fuel to obtain valid test fires.

20.3.3 *Mounting of the specimens*

For alarms intended for ceiling mounting only, the four specimen numbers 1, 2, 12 and 13 shall be mounted on the fire test room ceiling in the designated area (see Annex F).

For alarms intended for wall mounting only, the four specimens shall be mounted within 0.5 m of the middle of the long walls as shown in Annex F with specimens 1 and 13 at the least distance below the ceiling and specimens 2 and 12 at the greatest distance below the ceiling consistent with the manufacturer's instructions supplied in accordance with Clause **5**.

For alarms intended for either ceiling or wall mounting, specimens 1 and 2 shall be mounted on the ceiling within the designated area and specimens 12 and 13 shall be mounted on the walls as described above.

Each specimen shall be connected to its supply and shall be allowed to stabilize in its quiescent condition before the start of each test fire.

NOTE Alarms 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 alarms at the start of each test is representative of their normal quiescent state.

[4] The test fire (TF) numbers have been retained from BS 5445-9.

20.3.4 ***Initial conditions***

Before each test fire the room shall be ventilated with clean air until it is free from smoke.

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:

— temperature (T) = (23 ± 5) °C (see note);

— air movement: negligible;

— y: ≤ 0.05;

— m: ≤ 0.02 dB/m.

NOTE The stability of the air and temperature affects the smoke flow within the room. This is particularly important for the test fires which produce low thermal lift for the smoke (e.g. TF2 and TF3). It is therefore recommended that the difference between the temperature near the floor and the ceiling is <2 °C 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 the test fire, they should leave as soon as possible, taking care to produce the minimum disturbance to the air.

20.3.5 ***Recording of the fire parameters and response values***

During each test, the parameters in Table 2 shall be recorded against the time from the start of the test. Each parameter shall be recorded continuously or at least once per second.

Table 2 — Fire parameters

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

The time of response of each specimen shall be recorded along with the fire parameters ΔT_a, y_a and m_a at the moment of response. The response of the alarm after the end of test condition has been reached shall be ignored.

20.4 Requirements

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

21 Final test

21.1 Method of test

After all other tests on alarms numbers 1, 2, 12 and 13 have been completed, measure the response thresholds of these alarms in accordance with Clause **8**.

21.2 Requirements

The ratio of the response threshold of each alarm to the response threshold measured on the same alarm in accordance with Clause **10** shall be not less than 0.67 and not greater than 1.5.

22 Battery fault warning

22.1 General

Smoke alarms incorporating a battery shall give an audible fault warning before an increase in the internal resistance or decrease in the terminal voltage of the battery prevents correct operation.

22.2 Method of test

22.2.1 Connect the alarm as shown in Figure 1 and apply the tests described in **22.2.2**, **22.2.3**, **22.2.4** and **22.2.5**.

22.2.2 With the series resistor R set to zero and the supply voltage V set to the rated battery voltage V_R, measure the response threshold of the alarm in accordance with Clause **8**.

22.2.3 With the series resistor R set to zero, decrease the supply voltage V in stages of 0.1 V at intervals of at least 1 min, until the fault warning is given. Record the supply voltage at which the fault warning is given as V_E and measure the response threshold of the alarm in accordance with Clause **8**.

22.2.4 With the supply voltage V set at V_R, increase the resistance of the series resistor R from zero in increments of 0.1 Ω at intervals of at least 1 min until the fault warning is given. Record the resistance of the series resistor at which the fault warning is given as R_A and measure the response threshold of the alarm in accordance with Clause **8**

22.2.5 Repeat the procedure described in **22.2.4** with the supply voltage V set at 0.75 $(V_R - V_E) + V_E$, 0.5 $(V_R - V_E) + V_E$, and 0.25 $(V_R - V_E) + V_E$ in turn, and record the resistances of the series resistor at which the fault warning is given as R_B, R_C and R_D, respectively.

22.3 Requirements

The ratio of the response thresholds measured in **22.2.3**, **22.2.4** or **22.2.5** to the response threshold measured in **22.2.2** shall be not less than 0.67 and not greater than 1.5.

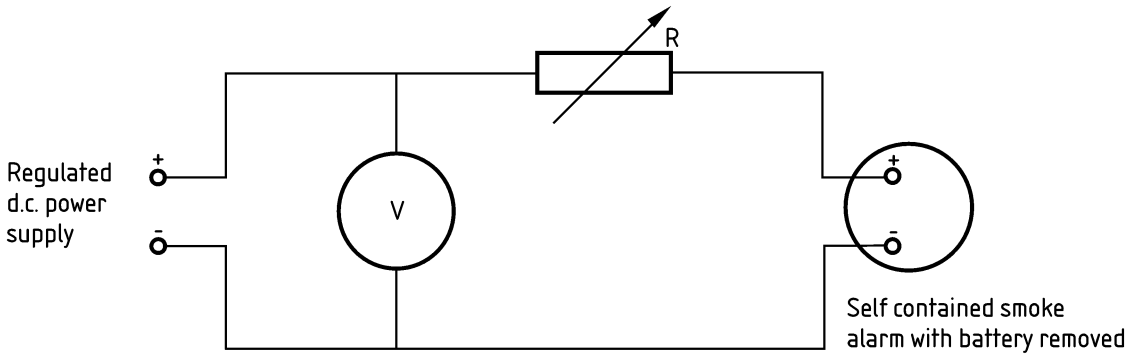


Figure 1 — Battery fault warning test circuit

23 Battery capacity

For battery powered smoke alarms, i.e. those not connected to an external power supply, the battery(ies) shall be capable of supplying the quiescent load of the smoke alarm together with the additional load resulting from routine weekly testing, for at least 1 year before the battery fault warning is given. At the point when the battery fault warning commences, the battery(ies) shall have sufficient capacity to give an alarm signal as specified in **24.1** for at least 4 min in the event of fire, or in the absence of fire a battery fault warning for at least 30 days.

In the absence of suitable test procedures to verify battery capacity, data concerning the smoke alarm loads and the battery characteristics shall be submitted to indicate that the above requirement can be met.

24 Sound output

24.1 General

A smoke alarm shall be capable of providing an output of at least 85 dBA at 3 m while connected to a source of rated voltage and frequency and mounted on a wooden board as described in **24.2** with the front of the smoke alarm at 90° with the horizontal and facing the microphone.

24.2 Method of test

At least two samples shall be tested. Units intended additionally for multiple-station interconnection shall be tested in that configuration with the maximum line resistance and the sound output measured on the smoke alarm subject to an abnormal smoke condition. For a battery operated (or equivalent) unit the battery shall be depleted to a point just above or at the battery fault warning level.

The measurement shall be made in a free field condition to minimize the effects of reflected sound energy. The ambient noise level shall be at least 10 dB below the measured level produced by the alarm.

NOTE 1 Free field conditions may be simulated by mounting the unit on a wooden surface at least 125 mm by 150 mm, not less than 3 m from the ground and with the microphone located 3 m from the unit and directly in front, and conducting the test outdoors on a clear day with a wind velocity of not more than 8 km/h and an ambient temperature of 15 °C to 25 °C.

NOTE 2 Alternatively an anechoic chamber of not less than 28 m^3, with no dimension less than 2 m and with an absorption factor of 0.99 or greater from 100 Hz to 10 kHz for all surfaces, may be used for this measurement.

24.3 Requirements

For battery operated alarms, the sound output shall be at least 85 dBA after 1 min of alarm operation and at least 82 dBA after 4 min of alarm operation.

For mains powered alarms, the sound output shall be at least 85 dBA after 4 min of alarm operation.

25 Routine testing facility

Provision shall be made in the construction of the smoke alarm, and/or in the manufacturer's instructions, for testing at regular intervals. Such testing shall include the whole of the operating system of the smoke alarm, e.g. by shielding the radiation source in an ionization alarm or by inserting a "scatterer" into the chamber of an optical scatter alarm or by injecting an aerosol.

If the smoke alarm has an alarm silence facility the method of routine testing adopted shall make it possible to confirm that the sensitivity has been correctly restored after the period of alarm silence.

26 Interconnectable smoke alarms

26.1 General

If a means of connecting a number of smoke alarms to give a general alarm signal is provided the following shall apply.

a) The audible alarm signal shall be emitted by all of the interconnecting smoke alarms when the smoke is detected by any one or more of them. If the smoke alarms are provided with an alarm silence facility, initiation of the alarm silence period of one of the smoke alarms shall not prevent the audible alarm signal being emitted by that smoke alarm when the smoke is detected by any of the other alarms.

b) The interconnection of the maximum number of smoke alarms allowed by the manufacturer shall not have a significant effect on the sensitivity of the smoke alarms nor their ability to meet the battery capacity or sound output requirements (see Clauses **23** and **24**).

c) For battery operated smoke alarms, open or short-circuits of the interconnecting leads either shall not prevent the smoke alarms from functioning individually or shall result in an alarm condition or fault warning.

NOTE This requirement does not apply to mains, or mains/battery supplied smoke alarms, for which the supply and interconnect wiring should be installed in accordance with BS 7671, published by the Institution of Electrical Engineers (see Clause **5**).

26.2 Method of test

26.2.1 Connect the alarm under test with the maximum number of smoke alarms allowed in the manufacturer's instructions (see Clause **5**).

NOTE If more than five smoke alarms may be interconnected it is permissible to interconnect a minimum of five alarms and simulate the remainder by an equivalent electrical load.

Trigger one smoke alarm into the alarm condition and check all of the interconnected alarms for an audible alarm signal.

If the smoke alarms have an alarm silence facility, operate the alarm silence control on one smoke alarm and, during the alarm silence period, trigger another smoke alarm into the alarm condition. Check the interconnected smoke alarms for an audible alarm signal, including the smoke alarm in the alarm silence condition.

26.2.2 With the smoke alarms interconnected in accordance with **26.2.1**, measure the response threshold of the alarm under test in accordance with Clause **8**.

26.2.3 For battery-operated smoke alarms repeat the test in **26.2.2** with the interconnecting leads short-circuited.

26.2.4 With smoke alarms interconnected in accordance with **26.2.1**, repeat the sound output test in Clause **24** on one of the smoke alarms. During this test ensure that the other interconnected smoke alarms are sufficiently screened or distanced so that their audible alarm signals do not influence the measurement.

26.2.5 For battery-operated smoke alarms repeat the test in **26.2.4** with interconnecting leads short-circuited.

26.2.6 Reassess the battery capacity requirements taking into account the load introduced by interconnecting the maximum permitted number of smoke alarms.

26.3 Requirements

26.3.1 All the interconnected smoke alarms shall give an audible alarm signal when tested in accordance with **26.2.1**.

26.3.2 The ratio(s) of the response thresholds measured in accordance with **26.2.2** and, for battery operated smoke alarms the response thresholds measured in accordance with **26.2.3**, to the response threshold measured in accordance with **22.2.2** shall be between 0.67 and 1.5.

26.3.3 The sound output shall be at least 85 dBA when measured in accordance with **26.2.4** and, for battery-operated smoke alarms, when measured in accordance with **26.2.5**.

26.3.4 The assessment in Clause **26.2.6** shall indicate that the battery capacity requirements specified in Clause **23** can still be met.

27 Alarm silence facility

27.1 General

If means of temporarily disabling or desensitizing a smoke alarm are provided the following shall apply.

a) The initiation of the alarm silence period shall require the operation of a manual control.

NOTE 1 This control may be the same as a manual control provided for routine testing (see Clause **25**).

b) Operation of the alarm silence control shall desensitize the smoke alarm for at least 5 min. The sensitivity of the smoke alarm shall be restored within 15 min of operation of the alarm silence control. If the alarm silence period is adjustable it shall not be possible to set it to less than 5 min or to more than 15 min.

c) Continuous operation of the alarm silence control shall not lead to the smoke alarm being desensitized for more than 15 min without an audible warning being given.

NOTE 2 This requirement is intended to prevent the permanent loss of sensitivity due to accidental or deliberate jamming of the control.

27.2 Method of test

27.2.1 Generate smoke in accordance with **8.2**, in the wind tunnel specified in Annex A, with an air velocity of (0.2 ± 0.05) m/s and an air temperature of (22 ± 3) °C, but increase the smoke density to three times the response threshold recorded for alarm number 6 (m_6 or y_6), when tested in accordance with **10.1.1**. Using alarm number 6, with a supply voltage corresponding to that of a new battery, operate the alarm silence control, immediately insert the alarm into the smoke-filled wind tunnel and maintain the smoke density between three and four times m_6 or y_6 for at least 15 min.

27.2.2 Repeat the test in **27.2.1** but with a supply voltage of V_E, as determined in **27.2.3**.

27.2.3 With the supply voltage corresponding to that of a new battery, put alarm number 6 into the alarm silence condition by the operation of the alarm silence control. Measure the response threshold as described in Clause **8** but with the smoke generation commencing $15^{+0.25}_{0}$ min after the operation of the alarm silence control.

27.2.4 Repeat the test described in **27.2.3** but with a supply voltage of V_E, as determined in **22.2.3**.

27.2.5 Repeat the test in **27.2.3** but, after operating the alarm silence control, hold the control on continuously for the remainder of the test.

27.3 Requirements

27.3.1 When tested in accordance with **27.2.1** and **27.2.2**, the alarm shall not emit an alarm signal during the first 5 min after the alarm silence control is operated.

27.3.2 The ratio of the response thresholds measured in accordance with **27.2.3** and **27.2.4** to the response threshold recorded for alarm number 6 when tested in accordance with **10.1.1** shall be not less than 0.67 and not greater than 1.5.

27.3.3 When tested in accordance with **27.2.5** either:

a) within 15 min of the initial operation of the alarm silence control the alarm shall emit an audible signal (alarm or battery fault warning) for as long as the control is held on; or

b) the ratio of the response threshold measured during the test to the response threshold recorded for the same alarm when tested in accordance with **10.1.1** shall be not less than 0.67 and not greater than 1.5.

28 Safety

28.1 The apparatus shall be designed and constructed so as to present no danger when used for its intended purpose, either in normal use or under fault conditions, particularly providing protection against:

— hazardous currents passing through the human body (electric shock);

— excessive temperature;

— start and spread of fire.

28.2 The apparatus shall be constructed so as to ensure adequate protection against electric shock by the provision of either earthing of accessible metal parts (Class I construction) or special insulation methods (Class II construction) or by operation from a supply not greater than 34 V (peak or d.c.) which is either independent of the supply mains, or isolated from it by double or reinforced insulation.

28.3 For mains powered equipment, the rated supply voltage, or range of supply voltages, shall include 230 V a.c, 50 Hz.

28.4 In general, conformity shall be checked under normal operating conditions and under fault conditions, as specified in BS EN 60065:1998, **4.2** and **4.3**, by performing all of the tests given in Annex K.

29 Battery reversal

29.1 General

The battery reversal test shall be applied to smoke alarms incorporating replaceable batteries if there is any possibility of the smoke alarm being subjected to reversed polarity of the supply during normal battery replacement.

29.2 Method of test

With a new battery fitted in the alarm, measure the response threshold in accordance with Clause **8**. Remove the battery and apply it to the alarm with reverse polarity for 10 s to 15 s. Refit the battery in the alarm with the correct polarity and measure the response threshold again. Apply a voltage to the alarm of $V_E + \begin{smallmatrix}0\\-5\end{smallmatrix}$ % as determined in **22.2.3**.

29.3 Requirements

The ratio of the response threshold measured before the battery reversal test to the response threshold measured after the test shall be not less than 0.67 and not greater than 1.5. When voltage of V_E is applied, the low battery voltage warning shall be given.

30 Alarms suitable for installation in leisure accommodation vehicles (LAVs)

30.1 General

If the manufacturer claims that a smoke alarm is suitable for installation in LAVs, the additional tests described in **30.2** and **30.3** shall be applied.

30.2 Vibration (additional)

30.2.1 *Method of test*

After the test in Clause **19** has been conducted, apply the following vibration conditioning with the battery fitted to the alarm and the alarm rigidly mounted on the vibrating platform:

a) frequency range: 10 Hz to 150 Hz;

b) acceleration amplitude: 9.81 m/s^2:

c) number of axes: three;

d) number of sweep cycles per axis: 20.

Measure the response threshold of the smoke alarm in accordance with Clause **8**.

30.2.2 *Requirement*

The ratio of the response threshold measured in accordance with **30.2.1** to the response threshold measured in accordance with Clause **10** shall be not less than 0.67 and not greater than 1.5.

30.3 Temperature cycle test

30.3.1 *Method of test*

After the test in Clause **16** has been conducted, stabilize the alarm at (25 ± 2) °C and apply the following temperature cycle 10 times.

a) Raise the temperature to (65 ± 2) °C in (2 ± 0.5) h.

b) Hold the temperature at (65 ± 2) °C until 8.5 h after the beginning of the cycle.

c) Reduce the temperature to (−10 ± 2) °C in (4 ± 1) h.

d) Hold the temperature at (−10 ± 2) °C until 19.5 h after the beginning of the cycle.

e) Increase the temperature to (25 ± 2) °C in (2 ± 0.5) h.

f) Hold the temperature at (25 ± 2) °C until 24 h after the beginning of the cycle.

After this temperature cycle conditioning has been applied, measure the response threshold of the smoke alarm in accordance with Clause **8**.

30.3.2 *Requirements*

The specimen shall not emit an alarm signal during the conditioning at −10 °C [see **30.3.1**d)].

The ratio of the response threshold measured in accordance with **30.3.1** to the response threshold measured in accordance with Clause **10** shall not be less than 0.67 and not greater than 1.5.

31 Battery connections

Any leads connecting the terminal connectors of batteries in smoke alarms to the smoke alarm circuit board shall be provided with strain relieving devices adjacent to both battery terminal connectors and the smoke alarm circuit board so that when the leads are subjected to a pull of 20 N without jerks for 1 min in any direction allowed by the design, the pull is not transmitted to the joints between the leads and the battery terminal connectors or between the leads and the smoke alarm circuit board.

32 Smoke alarms with additional facilities, and smoke alarms incorporated into other equipment

Facilities additional to those specified in this standard shall not prevent the correct operation of the smoke alarm or compliance with any of the clauses of this standard.

33 Back-up power source

33.1 General

For smoke alarms intended for connection to an external power supply, for which an integral back-up/standby power facility is provided, the following requirements shall apply.

a) Primary cell battery back-up: the back-up power supply shall be capable of meeting the requirements of Clause **23**.

b) Rechargeable back-up power sources: the back-up power source shall be capable of supplying the quiescent load of the smoke alarm for a minimum period of 72 h followed by an alarm signal as specified in **24.3** for at least 4 min in the event of fire, or in the absence of a fire, a fault warning for at least 24 h.

In the absence of suitable test procedures to verify the back-up power source, data concerning the smoke alarm loads and the back-up facility characteristics shall be submitted to indicate that the requirements of a) and b) can be met.

33.2 Monitoring of back-up power source

33.2.1 *General*

The back-up power source shall be monitored for fault conditions. These conditions shall include low back-up, open circuit and short circuit failure of the back-up.

33.2.2 *Low back-up*

The test procedures set out in **22.2** shall be used to simulate the depletion of the back-up power source to the point where a low back-up warning is given.

A low back-up signal shall be obtained both with mains power to the unit and without mains power to the unit.

33.2.3 *Open circuit*

The back-up power supply shall be disconnected or removed as appropriate and mains power applied to the unit.

The alarm shall give an audible and/or visual warning.

33.2.4 *Short-circuit*

The back-up power supply shall be disconnected and replaced with a short-circuit between the back-up terminals and the mains power applied to the unit.

The alarm shall give an audible and/or visual warning.

34 Battery installation

34.1 General

The battery installation test shall be conducted on any smoke alarm that incorporates user-replaceable batteries.

34.2 Principle

A selection of alarms is checked against a selection of batteries for correct operation after the battery has been replaced.

34.3 Selection of alarms

Five alarms shall be chosen at random.

34.4 Battery supply

A supply of 20 batteries recommended by the manufacturer of the alarm shall be used for this test. A random selection shall be made from the recommended batteries available at sales outlets.

34.5 Selection of batteries

Select the five batteries which will give the most adverse combinations of dimensions between the battery, its holder and the connector.

34.6 Method of test

Fit all the selected batteries to all the selected alarms so that all combinations are tried, following the manufacturer's fitting instructions. Reasonable steps to imitate misuse shall be taken, including allowances made for fitting the battery at arms length, overhead on a ceiling or high on a wall.

Test each combination of battery and alarm for correct operation, using the test facility of the alarm.

34.7 Requirements

All 25 combinations of batteries and alarms tested shall operate correctly.

Annex A (normative)
Wind tunnel

The wind tunnel used in the measurement of response threshold shall be of the closed circuit recirculating type, with a horizontal working section. The air velocity shall be substantially uniform within the working section and shall be adjustable at least from 0.2 m/s to 1 m/s and preferably up to 8 m/s. Means shall be provided in the return section for generating smoke as described in **8.2** and in the working section for mounting the alarm under test and the measuring instruments described in Annex B and Annex C. The cross-sectional area of the working section shall be at least 10 times the cross-sectional area of the alarm perpendicular to the airflow, in order to reduce air velocity changes due to partial blocking of the tunnel.

NOTE An example of suitable apparatus is shown in Figure A.1.

Dimensions are in millimetres

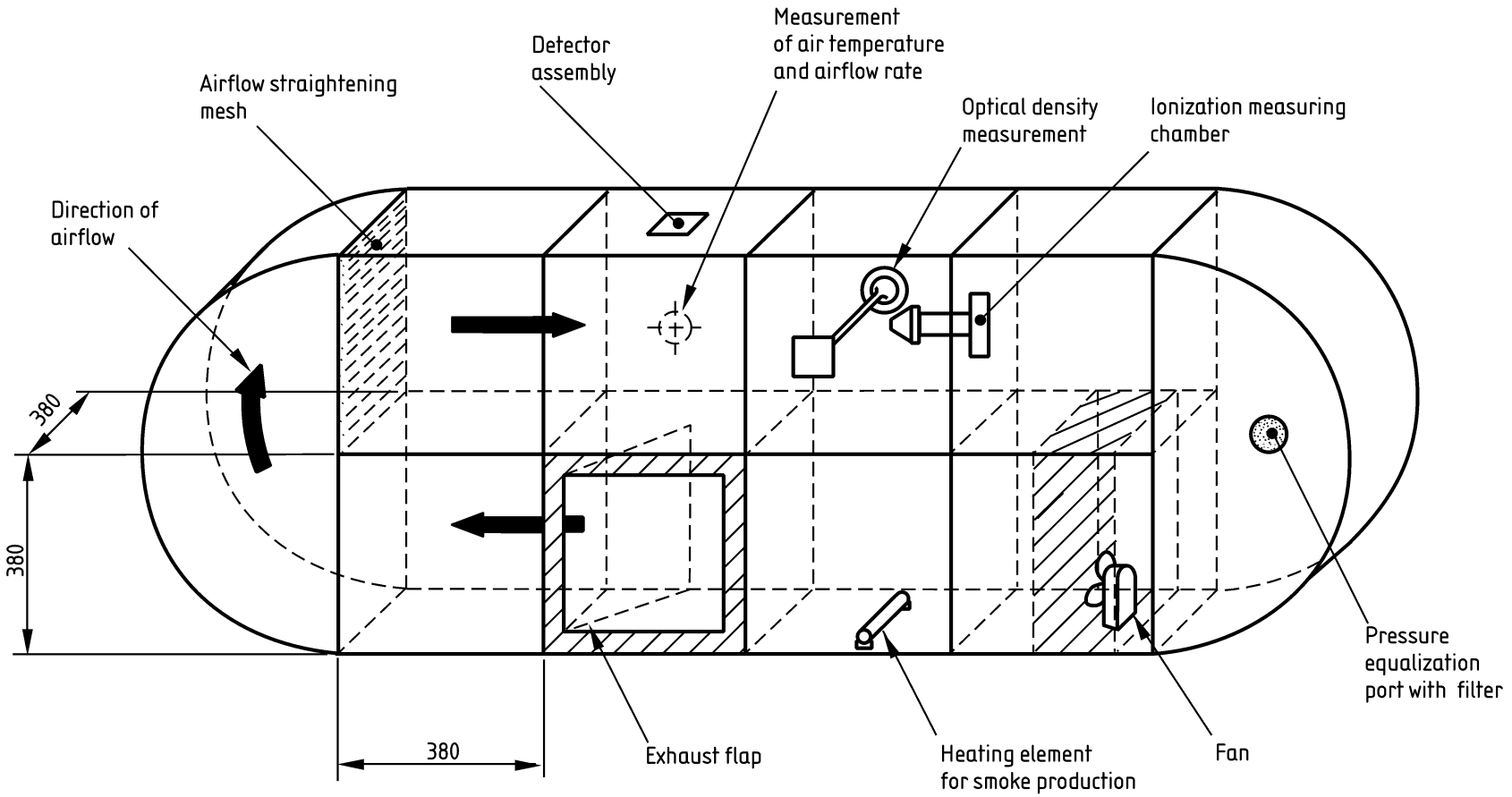


Figure A.1 — A suitable wind tunnel for the measurement of response threshold

Annex B (normative)
Determination of optical density

B.1 Measuring instrument

The optical density of the smoke shall be measured by an instrument of the type shown in Figure B.1.

The peak spectral sensitivity of the instrument shall lie at a wavelength of between 530 nm and 570 nm.

NOTE Adjustment to this range may be either by a suitable choice of light source and sensor or by the insertion of a suitable filter into the light path.

The aperture of the diaphragms D_1 and D_2 and the focal lengths of the collimating lenses L_2 and L_3 shall be such that light scattered by more than 5° from its original path is not received by the light sensor.

B.2 Calculation

The optical density of the smoke is given by:

$$m = \frac{10}{l} \log_{10} (I_o/I)$$

where

m is the optical density of the smoke in decibels per metre (dB/m);
l is the length of the light path affected by the smoke in metres (m);
I is the light intensity reaching the sensor with smoke;
I_o is the light intensity reaching the sensor without smoke.

NOTE Several other units have been used in the past for the measurement of optical density of smoke. These have included optical density per metre (expressed directly, without the factor of 10 used in the above equation), percentage obscuration in a 1 m path and percentage obscuration in a 1 ft path. Table B.1 gives the equivalents in these units to the optical density expressed in decibels per metre.

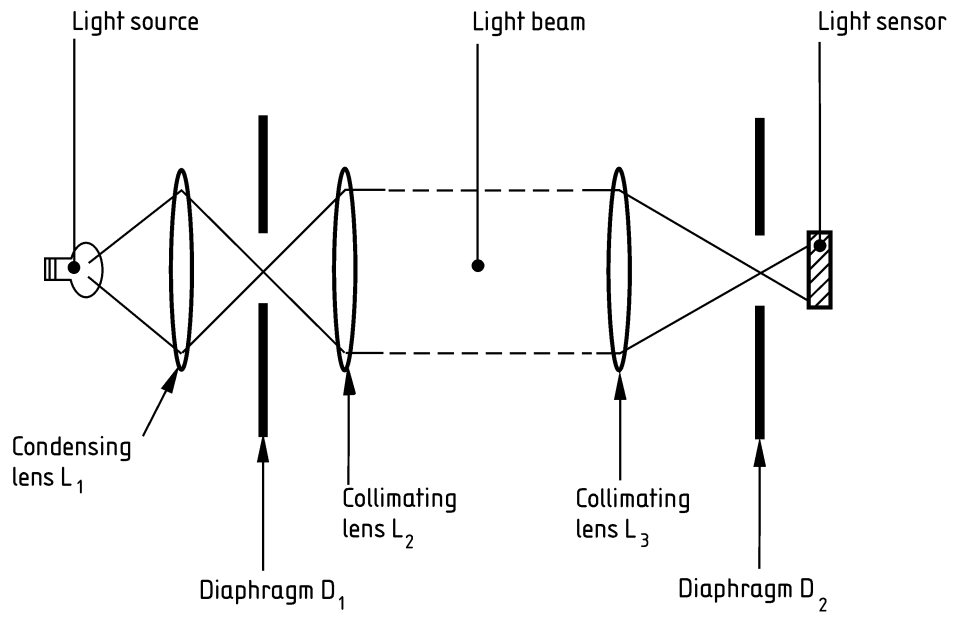


Figure B.1 — Schematic diagram of optical density meter

Table B.1 — Equivalent smoke densities

dB/m	Optical density per metre	Percentage obscuration in 1 m	Percentage obscuration in 1 ft
0	0	0	0
0.05	0.005	1.14	0.35
0.1	0.01	2.28	0.70
0.2	0.02	4.50	1.39
0.3	0.03	6.67	2.08
0.4	0.04	8.80	2.77
0.5	0.05	10.87	3.45
0.6	0.06	12.90	4.12
0.7	0.07	14.89	4.79
0.8	0.08	16.82	5.46
0.9	0.09	18.72	6.12
1.0	0.10	20.57	6.82
1.1	0.11	22.38	7.47
1.2	0.12	24.14	8.12
1.3	0.13	25.87	8.76
1.4	0.14	27.56	9.40
1.5	0.15	29.21	10.03

Annex C (informative)
Smoke density measuring instruments for tunnel tests

C.1 Sensitivity

In this standard wherever a requirement for the measurement of the response threshold is specified, that measurement is used only in the comparison of sensitivity with another alarm or with the same alarm in another test. Since such comparisons are always made as ratios in this standard, the sensitivity of the measuring instrument does not need to be known absolutely. It is important, however, that the sensitivity is known to be stable with time and with any variation of environmental conditions that might occur between two measurements.

C.2 Operating principle

In order to minimize the importance of any variations in the smoke used in different measurements, the operating principle of the measuring instrument should be as close as possible to that of the alarm under test. Thus, an ionization chamber measuring instrument should be used in tests on an ionization chamber smoke alarm and an optical measuring instrument should be used in tests on optical smoke alarms.

NOTE Optical smoke alarms include both scattered light and transmitted light types.

C.3 Linearity

C.3.1 *General*

The instrument should give a reading that is directly proportional to the smoke concentration. This reading may be obtained either directly or by mathematical manipulation of the direct output of the instrument.

C.3.2 *Ionization chamber instruments*

For ionization chamber type measuring instruments, provided that the voltage applied to the electrodes is sufficiently low for the voltage/current characteristic of the chamber to be linear, satisfactory linearity of the reading can usually be obtained from the relationship:

$$y = \frac{I_o}{I_s} - \frac{I_s}{I_o}$$

where

y is the reading proportional to smoke concentration;

I_o is the chamber current under clean air conditions;

I_s is the chamber current under smoky conditions.

C.3.3 *Optical measuring instruments*

When optical smoke alarms are being tested, obscuration type or scatter type measuring instruments may be used. When obscuration type instruments are being used, the relationship given in **B.2** will give a reading proportional to smoke concentration. When optical scatter instruments are used, the proportion of light scattered by the smoke will normally be proportional to smoke concentration, provided that the optical density of the smoke and the dimensions of the instrument are sufficiently small to prevent appreciable light obscuration within the instrument.

Annex D (normative)
Ambient light test apparatus

The apparatus shall consist of four 32 W circular fluorescent tubes, of a type giving a nominally white light, and their ancillary equipment. Each tube shall have a nominal luminous flux of 1 300 lm. One of the tubes shall be mounted on the ceiling of the test tunnel, surrounding the alarm mounting, one on each of the side walls of the tunnel and one 350 mm below the ceiling mounted tube and parallel to it. Before use in the test, the tubes shall be aged for at least 100 h of normal running.

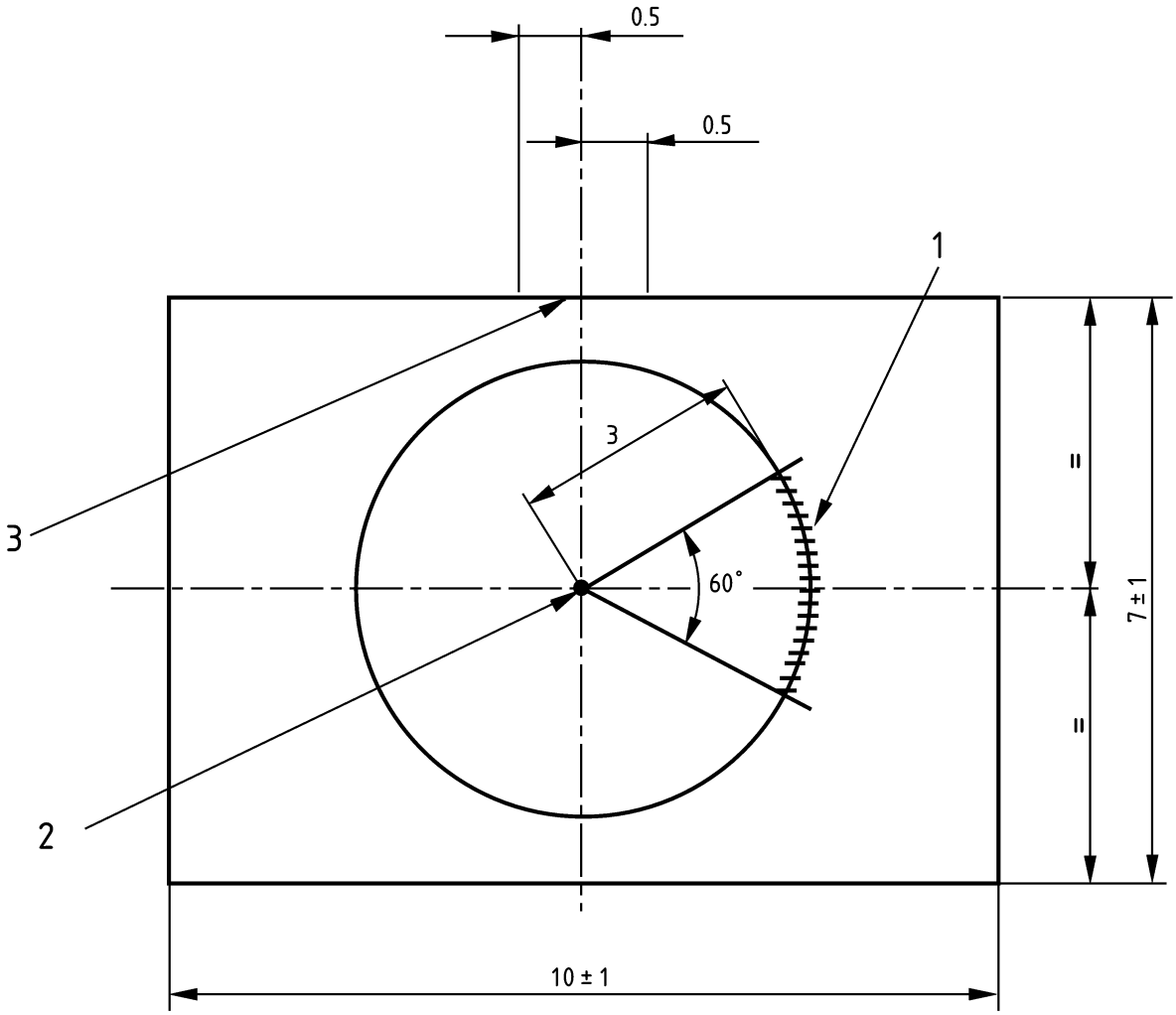
Annex E (informative)
Temperature test apparatus

The temperature test apparatus should preferably be the testing wind tunnel, suitably modified by having provision for heating to 40 °C and cooling to 0 °C. Where such modifications are not possible the temperature test may be carried out in any suitable climatic chamber, with provision for the mounting of alarms in their normal positions and for the generation, circulation and measurement of smoke.

Annex F (normative)
Fire test room

The specimens to be tested, the MIC, the temperature probe and the measuring part of the obsucration meter shall all be located within the volume shown in Figure F.1 and Figure F.2.

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



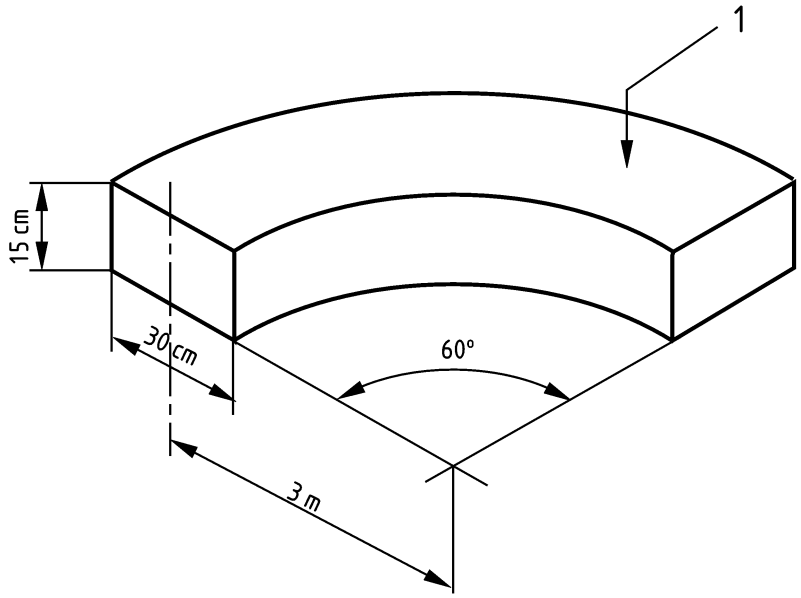
Key

1 Ceiling mounted specimens and measuring instruments (see Figure F.2)

2 Position of test fire

3 Wall mounted specimens

Figure F.1 — Plan view of the fire test room



Key
1 Ceiling

Figure F.2 — Mounting positions for instruments and ceiling mounted specimens

Annex G (normative)
Smouldering (Pyrolysis) wood fire (TF2)

The smouldering (Pyrolysis) wood test fire (TF2) shall be conducted as follows.

a) **Fuel**

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

b) **Hotplate**

The hotplate 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 hotplate shall have a rating of approximately 2 kW.

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

c) **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 G.1.

d) **Heating rate**

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

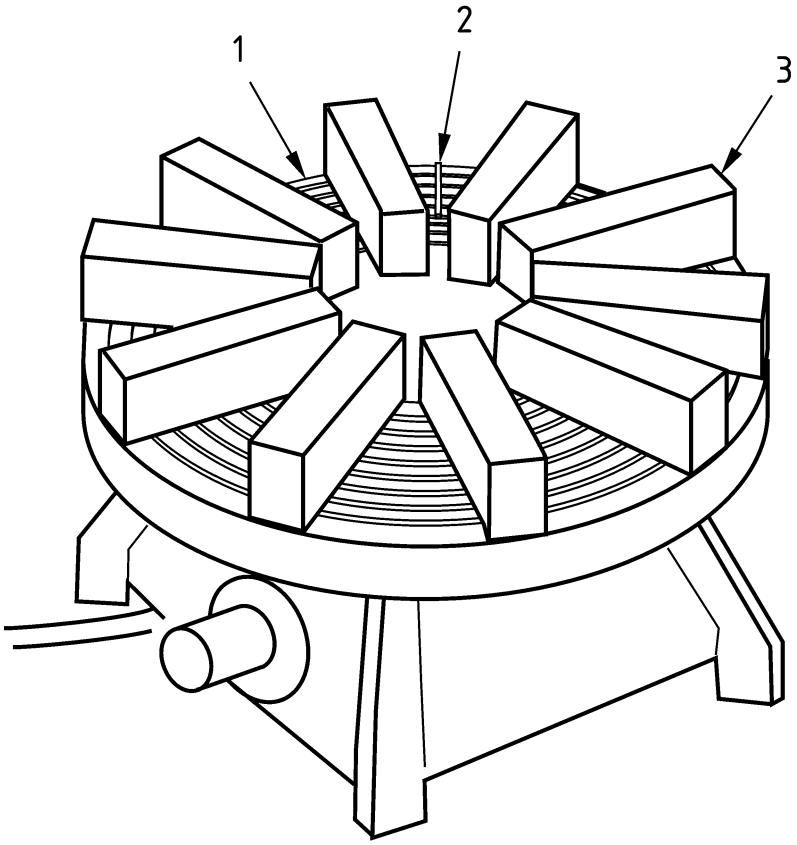
e) **End of test condition**.

m_E = 2 dB/m.

f) **Test validity criteria**

The fire shall develop so that the curves of m against y, and m against time, fall within the limits shown in Figure G.2 and Figure G.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, whichever is the earlier.

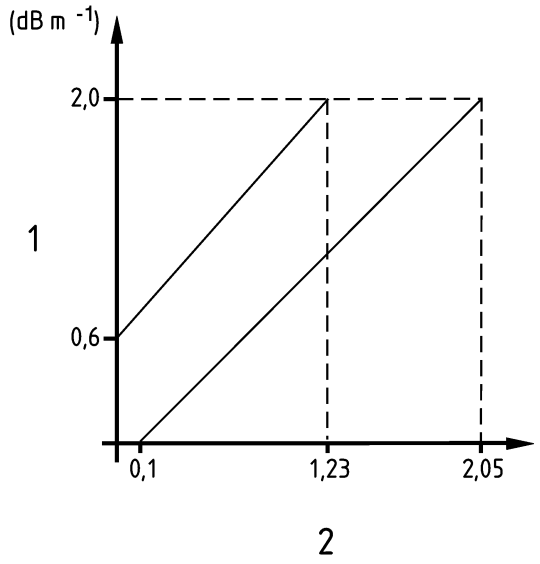
If the end of test condition m_E = 2 dB/m is reached before all the specimens of ionization chamber alarms have responded, the test is only deemed to be valid if a y value of 1.6 has been reached.



Key

1 Grooved hot plate
2 Temperature sensor
3 Wooden sticks

Figure G.1 — Arrangement of sticks on the hotplate

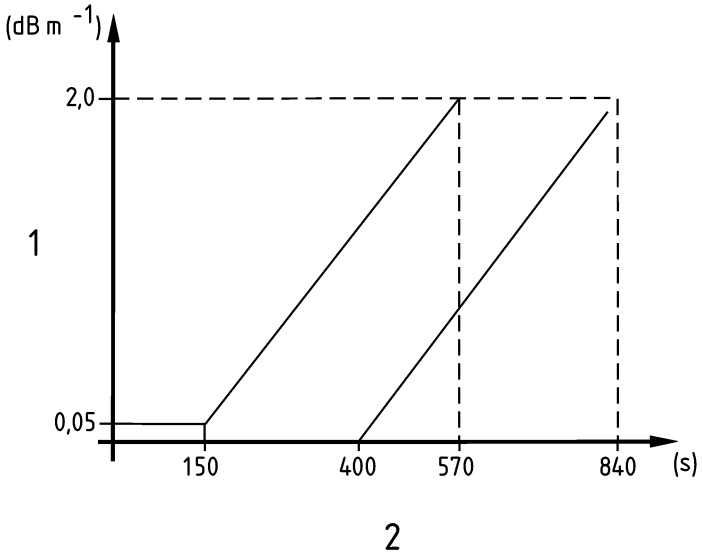


Key

1 m value

2 y value

Figure G.2 — Smouldering wood fire: fire development m against y



Key

1 m value

2 Time

Figure G.3 — Smouldering wood fire: fire development m against time

Annex H (normative)
Glowing smouldering cotton fire (TF3)

The glowing smouldering cotton test fire (TF3) shall be conducted as follows.

a) **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.

b) **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 H.1.

c) **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.

d) **End of test condition**

m_E = 2 dB/m

e) **Test validity criteria**

The fire shall develop so that the curves of m against y, and m against time, fall within the limits shown in Figure H.2 and Figure H.3 respectively, up to the time when all of the specimens have generated an alarm signal, or m = 2 dB/m, whichever is the earlier.

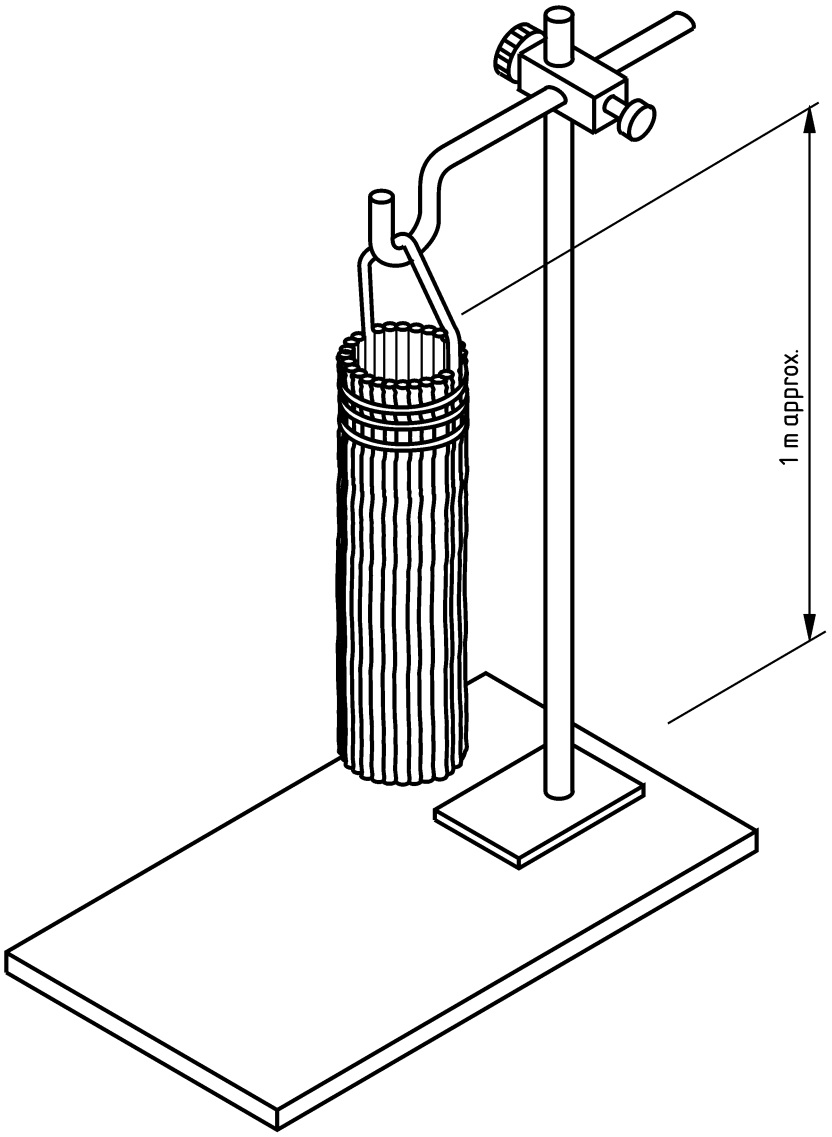
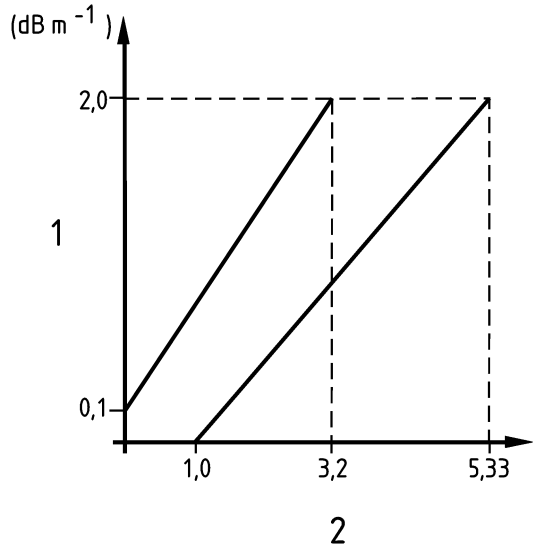


Figure H.1 — Arrangement of the cotton wicks

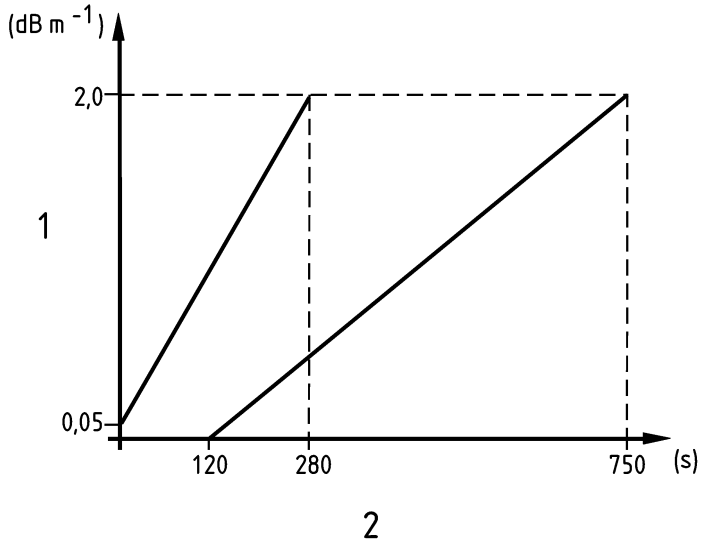


Key

1 m value

2 y value

Figure H.2 — Glowing smouldering cotton fire: fire development m against y



Key

1 m value

2 Time

Figure H.3 — Glowing smouldering cotton fire: fire development m against time

Annex I (normative)
Flaming plastics (polyurethane) fire (TF4)

The flaming plastics (polyurethane) test fire (TF4) shall be conducted as follows.

a) **Fuel**

Soft polyurethane foam, without flame retardant additives and having a density of approximately 20 kg/m^3.

NOTE Three mats, approximately 50 cm × 50 cm × 2 cm, are usually found to be sufficient, however the exact fuel quantity may be adjusted to obtain valid tests.

b) **Arrangement**

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

c) **Ignition**

The mats shall normally be ignited at a corner of the lower mat, however the exact position of ignition may be adjusted to obtain valid tests.

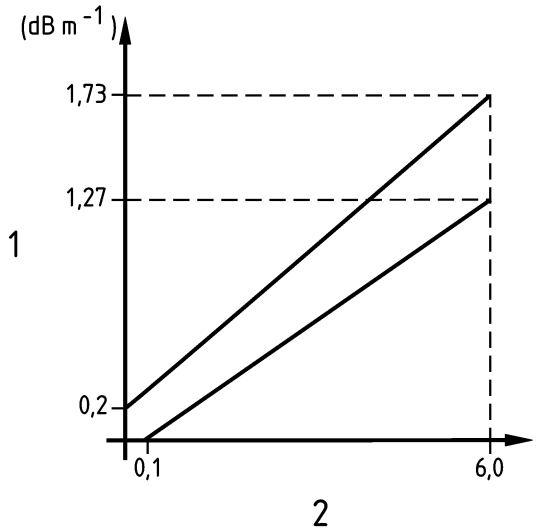
NOTE A small quantity of clean burning material (e.g. 5 cm^3 of methylated spirit) may be used to assist the ignition.

d) **End of test condition**

$y_E = 6$.

e) **Test validity criteria**

The fire shall develop so that the curves of m against y, and m against time, fall within the limits shown in Figure I.1 and Figure I.2 respectively, up to the time when all of the specimens have generated an alarm signal, or $y = 6$, whichever is the earlier.

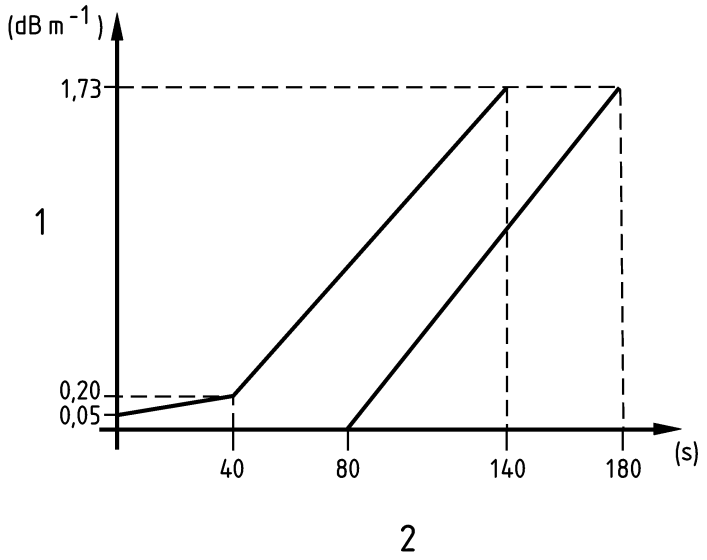


Key

1 m value

2 y value

Figure I.1 — Flaming plastic: fire development m against y



Key
1 m value
2 Time

Figure I.2 — Flaming plastic: fire development m against time

Annex J (normative)
Flaming liquid (n-heptane) fire (TF5)

The flaming liquid (n-heptane) fire test (TF5) shall be conducted as follows.

a) **Fuel**

Approximately 650 g of a mixture of n-heptane (purity ≥ 99 %) with approximately 3 % of toluene (purity ≥ 99 %) by volume.

NOTE The precise quantities may be varied to obtain valid tests.

b) **Arrangement**

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

c) **Ignition**

Ignition shall be by flame or spark etc.

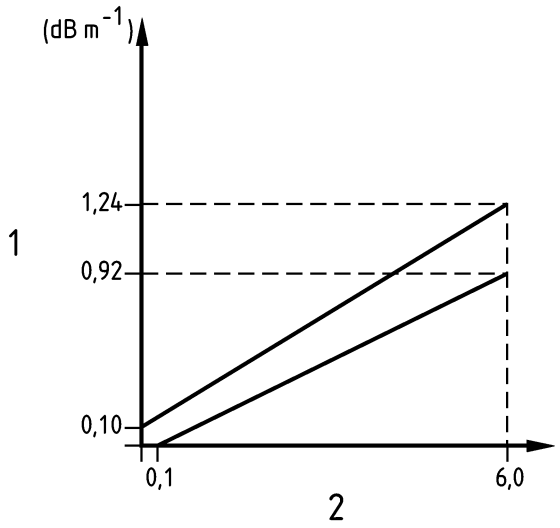
d) **End of test condition**

$y_E = 6$.

e) **Test validity criteria**

The fire shall develop so that the curves of m against y, and m against time, fall within the limits shown in Figure J.1 and Figure J.2 respectively, up to the time when all of the specimens have generated an alarm signal, or $y = 6$, whichever is the earlier.

If the end of test condition, $y_E = 6$, is reached before all the specimens of alarms using scattered or transmitted light have responded, the test shall only be deemed to be valid if an m value of 1.1 dB/m has been reached.

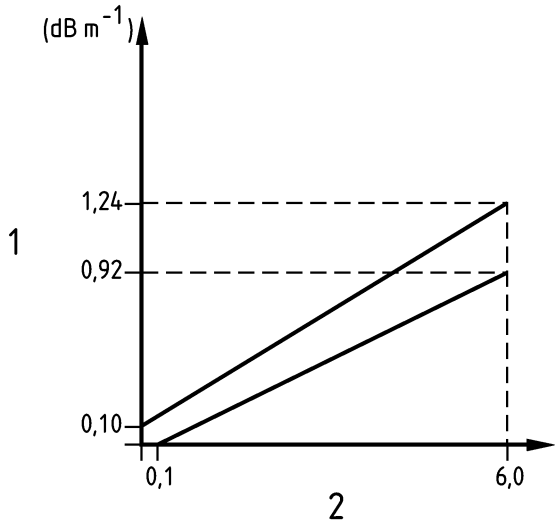


Key

1 m value

2 y value

Figure J.1 — Flaming liquid: fire development m against y



Key

1 m value

2 Time

Figure J.2 — Flaming liquid: fire development m against time

Annex K (normative)
Assessment and testing to determine the adequacy of personal protection against hazardous currents passing through the human body (electric shock), excessive temperature and the start and spread of fire

K.1 Marking

The apparatus shall be marked in accordance with BS EN 60065:1998, Clause **5**.

NOTE The required markings may be on any external part of the apparatus but it is not necessary for the specified markings to be visible after installation.

For class I apparatus, the following information shall be given close to the mains input terminals:

"WARNING — THIS APPARATUS MUST BE EARTHED"

If live parts are made accessible when a cover is removed or opened, a warning shall be displayed which is visible before the cover is removed or opened.

K.2 Heating under normal operating conditions

The apparatus shall conform to the requirements of BS EN 60065:1998, Clause **7**.

K.3 Shock hazard under normal operating conditions

The apparatus shall conform to the requirements of BS EN 60065:1998, Clauses **8** and **9** when mounted in any orientation on a vertical surface and when mounted on the underside of a horizontal surface.

NOTE The requirement of BS EN 60065:1998, **9.1.6** applies to the pins of an appliance inlet on the apparatus following withdrawal of the connector attached to the mains supply wires.

K.4 Insulation requirements

Apparatus intended to be operated from a supply greater than 34 V (peak or d.c.) shall conform to the requirements of BS EN 60065:1998, Clause **10** disregarding the test specified in **10.1** of that standard.

K.5 Fault conditions

The apparatus shall conform to the requirements of BS EN 60065:1998, Clause **11**.

K.6 Mechanical strength

The apparatus shall conform to the requirements of BS EN 60065:1998, Clause **12** disregarding **12.1.1** of that standard.

K.7 Clearances and creepage distances

The apparatus shall conform to the requirements of BS EN 60065:1998, Clause **13**.

K.8 Components

K.8.1 Resistors, capacitors, inductors and transformers, the short-circuiting or disconnecting of which would cause an infringement of the requirements for operation under fault conditions, in respect of overheating, fire or shock hazard, shall conform to the relevant requirements of BS EN 60065:1998, Clause **14**.

K.8.2 Protective devices, switches, safety interlocks, voltage setting devices and the housing arrangements for batteries shall conform to the relevant requirements of BS EN 60065:1998, Clause **14**.

K.8.3 The power, voltage and current ratings, as appropriate, of all components shall be suitable for the application in which they are used.

Conformity shall be checked by circuit measurement, analysis of the circuit design, measurements on the components in question and by inspection, as appropriate.

K.9 Protection against the start and spread of fire

The apparatus shall conform to the requirements of BS EN 60065:1998, Clause **20**.

Bibliography

BS 5445-9:1984, *Components of automatic fire detection systems — Part 9: Methods of test of sensitivity to fire.*

BS EN ISO 9000 (all parts), *Quality management and quality assurance standards.*

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