INTERNATIONAL STANDARD

ISO 5658-2

Second edition
2006-09-15

Reaction to fire tests — Spread of flame —

Part 2: Lateral spread on building and transport products in vertical configuration

Essais de réaction au feu — Propagation du feu —

Partie 2: Propagation latérale sur les produits de bâtiment et de transport en position verticale

Reference number
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Foreword

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

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

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

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

ISO 5658-2 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

This second edition of ISO 5658-2 cancels and replaces the first edition (ISO 5658-2:1996), which has been technically revised.

ISO 5658 consists of the following parts, under the general title *Reaction to fire tests — Spread of flame:*

— *Part 1: Guidance on flame spread* [Technical Specification]

— *Part 2: Lateral spread on building and transport products in vertical configuration*

— *Part 4: Intermediate-scale test of vertical spread of flame with vertically oriented specimen*

Introduction

This part of ISO 5658 is based on the method of the International Maritime Organization (IMO) published as IMO Resolution A.653 (16)[4], and has been developed as an International Standard in order to allow its wider use. The major differences between ISO 5658-2 and the IMO test are that ISO 5658-2 is limited in scope to testing the spread of flame over vertical specimens and does not include the stack for estimating heat release rate. The second edition of this part of ISO 5658 avoids the use of acetylene for the pilot flame and uses the propane pilot flame in an impinging mode. The current IMO flame spread procedure is still based on ISO 5658-2:1996.

ISO/TS 5658-1[2] describes the development of standard tests for flame spread and explains the theory of flame spread for various orientations. This part of ISO 5658 provides a simple method by which lateral surface spread of flame on a vertical specimen can be determined for comparative purposes. This method is particularly useful for research, development and quality control purposes.

Fire is a complex phenomenon: its behaviour and its effects depend upon a number of interrelated factors. The behaviour of materials and products depends upon the characteristics of the fire, the method of use of the materials and the environment to which they are exposed. The methodology of "reaction-to-fire" tests is explained in ISO/TR 3814[1].

A test such as is specified in this part of ISO 5658 deals only with a simple representation of a particular aspect of the potential fire situation typified by a radiant-heat source and flame; it cannot alone provide any direct guidance on behaviour or safety in fire.

Annexes A and F form integral parts of this part of ISO 5658. Annexes B to E are for information only. A precision statement based on inter-laboratory trials using this test method is given in Annex E.

This test procedure does not rely on the use of asbestos-based materials.

The attention of all users of the test is drawn to the introductory caution statement.

Reaction to fire tests — Spread of flame —

Part 2:
Lateral spread on building and transport products in vertical configuration

CAUTION — So that suitable precautions can be taken to safeguard health, the attention of all concerned in fire tests is drawn to the possibility that toxic or harmful gases can be evolved during exposure of test specimens. The advice on safety given in Annex A should also be noted.

1 Scope

This part of ISO 5658 specifies a method of test for measuring the lateral spread of flame along the surface of a specimen of a product orientated in the vertical position. It provides data suitable for comparing the performance of essentially flat materials, composites or assemblies that are used primarily as the exposed surfaces of walls in buildings and transport vehicles, such as ships and trains. Some profiled products (such as pipes) can also be tested under specified mounting and fixing conditions.

This part of ISO 5658 is applicable to the measurement and description of the properties of materials, products or assemblies in response to radiative heat in the presence of a pilot flame under controlled laboratory conditions. It is not suitable to be used alone to describe or appraise the fire hazard or fire risk of materials, products or assemblies under actual fire conditions.

2 Normative references

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

ISO 13943:2000, *Fire safety — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943:2000 and the following apply.

3.1
assembly
fabrication of materials, products and/or composites

EXAMPLE Sandwich panels.

NOTE The assembly may include an air gap.

3.2
average heat for sustained burning
average of the values of heat for sustained burning, measured at a number of specified positions

NOTE The average heat for sustained burning is expressed in megajoules per square metre (MJ/m^2).

3.3
backing board
non-combustible board with the same width and length as the test specimen and (12,5 ± 3) mm thick, used in every test to back the specimen

NOTE 1 See 9.7.

NOTE 2 A non-combustible board is one that, when tested to ISO 1716[10], yields a gross calorific potential (PCS) of ⩽ 2,0 MJ/kg.

3.4
composite
combination of materials that are generally recognized in building construction as discrete entities

EXAMPLE Coated or laminated materials.

3.5
critical heat flux at extinguishment
CFE
incident heat flux at the surface of a specimen at the point along its horizontal centreline where the flame ceases to advance and may subsequently go out

NOTE 1 The heat flux value reported is based on interpolations of measurements with a non-combustible calibration board.

NOTE 2 The critical heat flux at extinguishment is expressed in kilowatts per square metre (kW/m^2).

3.6
exposed surface
that surface of the specimen subjected to the heating conditions of the test

3.7
flame front
furthest extent of travel of a sustained flame centrally along the length of the test specimen

3.8
flashing
existence of flame on or over the surface of the specimen for periods of less than 1 s

3.9
heat for sustained burning
product of the time from the start of exposure of a specimen to the arrival of the flame front at a specified position and the incident radiant heat flux corresponding to that position measured on a non-combustible calibration board

NOTE 1 The heat for sustained burning is expressed in megajoules per square metre (MJ/m^2).

NOTE 2 The positions are specified in Table 1.

3.10
irradiance
⟨at a point of a surface⟩ quotient of the radiant heat flux incident on an infinitesimal element of surface containing the point, by area of that element

3.11
material
single substance or uniformly dispersed mixture

EXAMPLES Metal, stone, timber, concrete, mineral fibre and polymers.

3.12
product
material, composite or assembly about which information is required

3.13
radiant heat flux
power emitted, transferred or received in the form of radiation

3.14
specimen
representative piece of the product that is tested together with any substrate or treatment

NOTE The specimen may include an air gap.

3.15
spread of flame
propagation of a flame front over the surface of a product under the influence of imposed irradiance

3.16
substrate
material that is used, or is representative of that used, immediately beneath a surface product

EXAMPLE Skimmed plasterboard beneath a wall-covering.

3.17
sustained flaming
existence of flame on or over the surface of the specimen for periods of more than 4 s

3.18
transitory flaming
existence of flame on or over the surface of the specimen for periods of between 1 s and 4 s

3.19
lateral spread of flame
progression of the flame front in a lateral direction over the specimen length

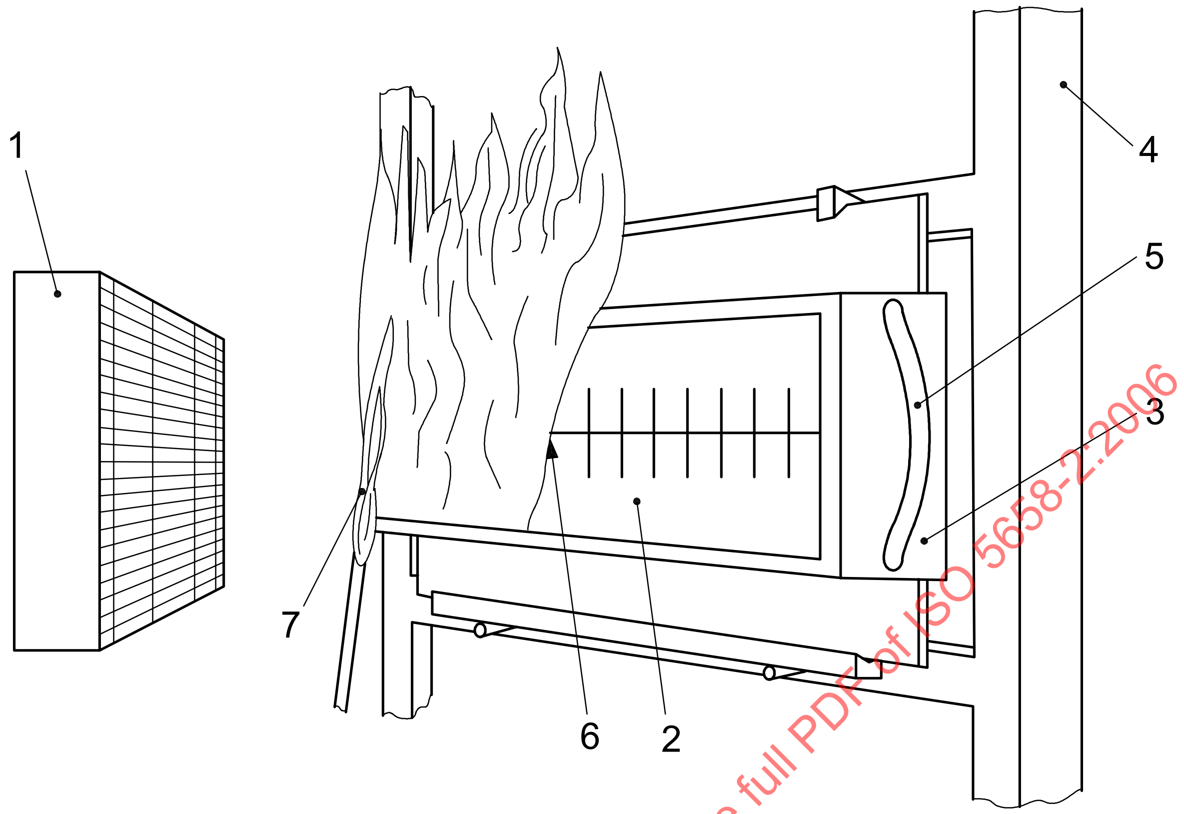
4 Principle

4.1 The test method consists of exposing conditioned specimens in a well-defined field of radiant heat flux and measuring the time of ignition, the lateral spread of flame and its final extinguishment.

4.2 A test specimen is placed in a vertical position adjacent to a gas-fired radiant panel where it is exposed to a defined field of radiant heat flux. A pilot flame is sited close to the hotter end of the specimen to ignite volatile gases issuing from the surface (see Figure 1).

4.3 Following ignition, any flame front that develops is noted and a record is made of the progression of the flame front horizontally along the length of the specimen in terms of the time it takes to travel various distances.

4.4 The results are expressed in terms of flame spread distance versus time, flame front velocity versus heat flux, the critical heat flux at extinguishment and the average heat for sustained burning.



Key

1 vertical radiant panel at an angle of 15° to the specimen
2 specimen
3 specimen holder
4 framework supporting specimen holder
5 handle
6 flame front
7 pilot flame

Figure 1 — Schematic of test

5 Suitability of a product for testing

5.1 Surface characteristics

5.1.1 A product having one of the following characteristics is suitable for evaluation using this method:

a) an essentially flat exposed surface, i.e. all surface irregularities are within ± 1 mm of plane;

b) a surface irregularity that is evenly distributed over the exposed surface provided that

1) at least 50 % of the surface of a representative square area, 155 mm × 155 mm, lies within a depth of 6 mm from a plane across the highest points of the exposed surface, and/or

2) any cracks, fissures or holes do not exceed 8 mm in width or 10 mm in depth and the total area of such cracks, fissures or holes at the surface does not exceed 30 % of a representative square area, 155 mm × 155 mm, of the exposed surface.

5.1.2 Where a product has areas of its surface that are distinctly different, but each of these separate areas satisfies the surface characteristics specified in 5.1.1, then each of these separate areas shall be tested to evaluate the product fully.

5.1.3 When an exposed surface does not comply with the requirements of either 5.1.1 a), or 5.1.1 b), the product may be tested in a modified form with an essentially flat exposed surface. The modification shall be stated in the report.

5.2 Thermally unstable products

The test method may not be suitable for assessing products that react in particular ways under exposure to the specified heating conditions (see 11.12). Products showing these characteristics should be assessed using other test methods, as given in, for example, ISO 9705[3].

6 Test specimens

6.1 Exposed surface

The product shall be tested on that face that is normally exposed in use, taking account of the following.

a) If it is possible for either or both of the faces to be exposed in use then, if the core is asymmetrical, both faces shall be tested.

b) If the face of the product contains a surface irregularity that is specifically directional, e.g. corrugations, grain or machine-induced orientation that can, in use, run horizontally or vertically, the product shall be tested in both orientations.

c) If the exposed face contains distinct areas of different surface finish or texture, then the appropriate number of specimens shall be provided for each distinct area of such finish or texture to be evaluated.

d) Textile materials shall be tested for spread of flame in both the warp and the weft directions.

If a bright, metallic-faced specimen is to be tested, it shall be tested both as-received and also finished with a thin coat of lamp black or colloidal graphite, applied before conditioning for test. Alternatively, spray the exposed top surface of the specimen with a single coat of flat black paint that is designed to withstand temperatures of (540 ± 10) °C. Prior to testing, cure the paint coating by conditioning the specimen at a temperature of (23 ± 3) °C and a relative humidity of (50 ± 5) % for 48 h. This coating is applied to ensure surface absorption of the imposed radiant heat flux.

6.2 Number and size of specimens

6.2.1 At least six specimens shall be provided for test.

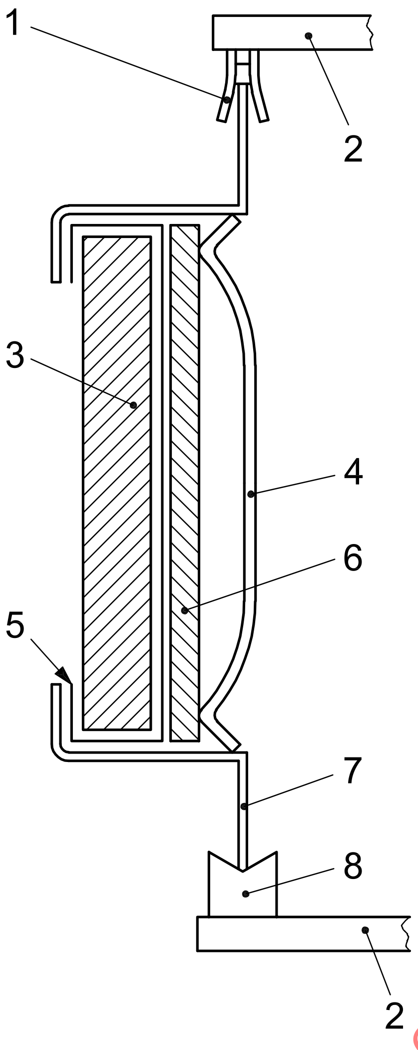
6.2.2 Three specimens shall be tested for each potentially exposed surface or orientation.

With products that can be exposed from either side and that also have directional irregularities on one side only, at least nine specimens are needed (see 11.10).

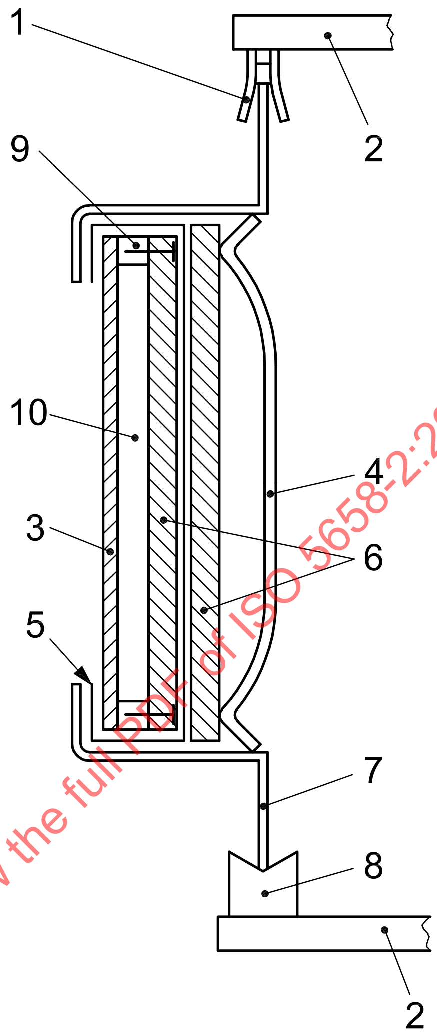
6.2.3 The specimens shall be $(800\ ^{0}_{-5})$ mm long $\times$ $(155\ ^{0}_{-5})$ mm wide and shall be representative of the product.

6.2.4 The thickness of specimens of products with irregular surfaces (see 6.1) shall be measured from the highest point of the surface. Products of a thickness of 50 mm or less shall be tested using their full thickness. For products of normal thickness greater than 50 mm, the unexposed face shall be cut away to reduce the thickness to $(50\ ^{0}_{-3})$ mm.

For products of thicknesses in the range of 50 mm to 70 mm, it is necessary to use an extension clip or restraint at the rear of the specimen holder (see Figure 2).



a) **Specimen with backing board**



b) **Specimen with backing boards and spacers forming an air gap**

Key

1 fork
2 specimen holder guide
3 specimen
4 spring clip or restraint
5 aluminium foil
6 backing board(s)
7 specimen holder
8 groove
9 spacer screwed to backing board
10 air gap

Figure 2 — Typical mounting of specimens

6.3 Construction of specimens

6.3.1 For thin materials or composites used in the fabrication of an assembly, the presence of air or an air gap and/or the nature of any underlying construction can significantly affect the characteristics of the exposed surface. The influence of the underlying layers should be understood and care taken to ensure that the test result obtained on any assembly is relevant to its use in practice.

6.3.2 When the product is a surface coating, it shall be applied to the selected substrate using a method and application rate recommended for its end use.

6.3.3 When the product is a material or composite that would normally be attached to a substrate, it shall be tested in conjunction with the selected substrate using the recommended fixing technique, e.g. bonded with the appropriate adhesive or mechanically fixed. The procedure for fixing the specimens to the substrate shall be clearly stated in the test report [see 13 f)].

6.3.4 Parts of a test specimen may be joined in various ways according to the orientation of the joint in end-use application conditions. If the product is constructed with horizontal joints, a horizontal joint shall be positioned at the horizontal centreline of the test specimen. If the product is constructed with vertical joints, a vertical joint shall be positioned at 100 mm from the hot end of the test specimen.

Joints should be constructed as closely as possible to the end-use application conditions; for example, sealants and adhesives should be applied at similar coverage weights to practical systems.

6.4 Conditioning

6.4.1 All specimens shall be conditioned to constant mass at a temperature of (23 ± 2) °C, and a relative humidity of (50 ± 5) %, and maintained in this condition until required for testing. Constant mass is considered to be attained when two successive weighing operations, carried out at an interval of 24 h, do not differ by more than 0,1 % of the mass of the specimen, or 0,1 g, whichever is the greater.

6.4.2 Backing boards and spacers (see 9.7) shall be conditioned for at least 12 h before use under the conditions specified in 6.4.1.

6.5 Preparation

6.5.1 Reference line

Mark a horizontal line centrally at half height along the length of each specimen. Draw vertical marks every 50 mm along the line. The zero mark shall correspond with the start of the exposed area of the specimen (see 7.4). Care shall be taken to avoid the possibility of the line influencing the performance of the specimen, for example by damaging the surface, or increasing its absorbency.

NOTE Some materials discolour or burn so that the line and/or the marks are obscured. The use of a stainless steel grid approximately 10 mm above the surface of the specimen allows the position of the flame front to be determined.

6.5.2 Products without air gaps

If a product is normally used without an air gap behind it, then, after the conditioning procedures specified in 6.4, the edges and the rear face of the specimen shall be wrapped in a single rectangular sheet of aluminium foil of a thickness of 0,02 mm to 0,03 mm and dimensions of $(175 + 2a)$ mm × $(820 + 2a)$ mm, where a is the thickness of the specimen, so that about 10 mm of foil laps evenly over the edges of the front face of the specimen. The foil shall be pressed down flat onto the front face of the specimen [see Figure 2 a)]. The specimen, wrapped in foil, shall then be placed on a backing board and both shall be inserted in a specimen holder (see Figure 3).

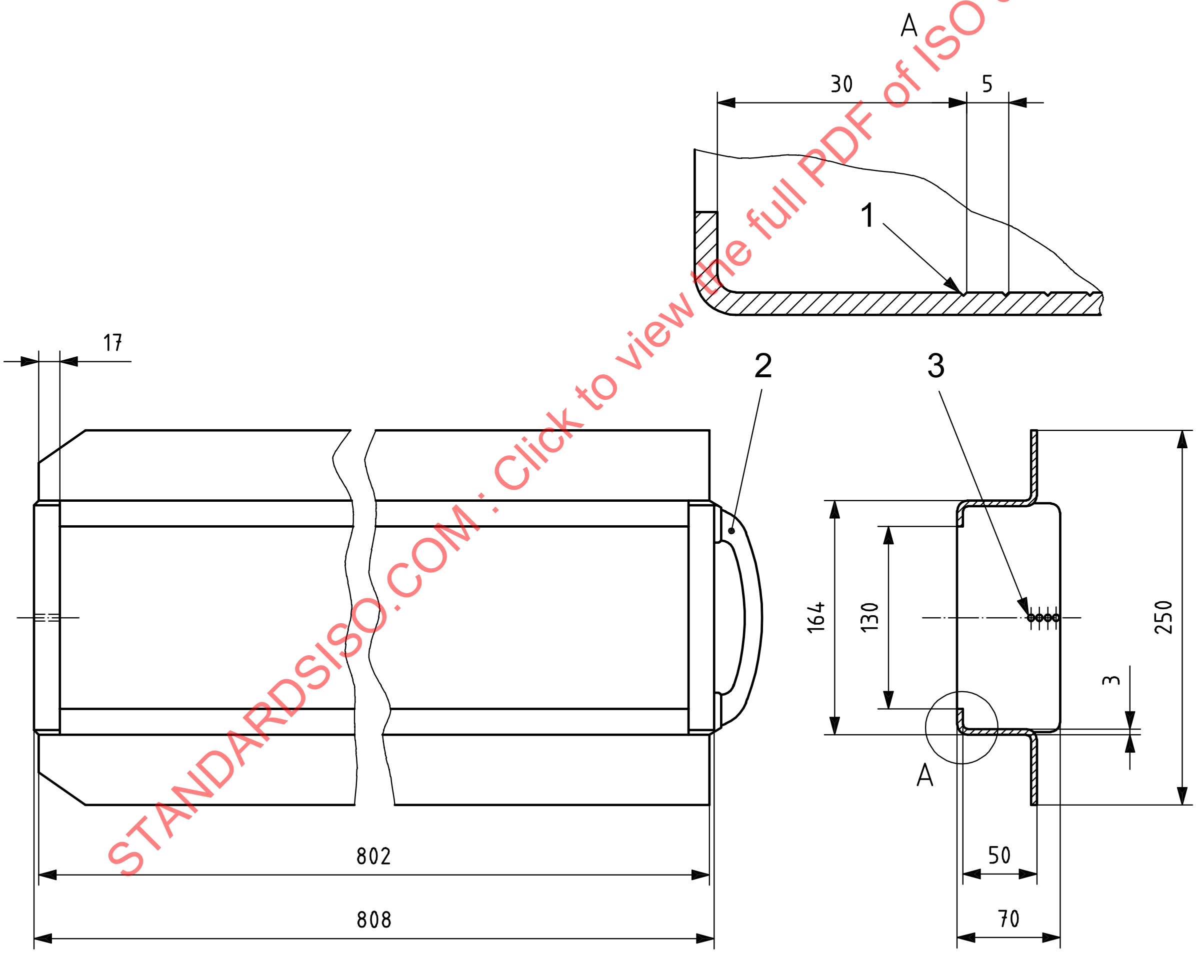
6.5.3 Products with air gaps

Where a product is normally used with an air gap behind it, after the conditioning procedures specified in 6.4, the specimen shall be placed over conditioned spacers positioned around its perimeter (see [Figure 2 b)] and mounted on a backing board so that a (25 ± 2) mm air gap is provided between the unexposed face of the specimen and the backing board (see 9.7). The rear edges of the whole assembly shall then be wrapped in a single rectangular sheet of aluminium foil of a thickness of 0,02 mm to 0,03 mm and dimensions of $(175 + 2b)$ mm × $(820 + 2b)$ mm, where b is the total thickness of the assembly of specimen, spacers and backing board, so that about 10 mm of foil laps evenly over the edges of the front face of the specimen. The foil shall be pressed down flat onto the front face of the specimen [see Figure 2 b]. The assembly, wrapped in foil, shall then be placed on a backing board and both shall be inserted in a specimen holder (see Figure 3).

Products containing air gaps smaller than 25 mm should preferably be tested under their end-use conditions.

A suitable technique for mounting thin, flexible materials is to staple the specimen closely along the edges to the spacers on the perimeter of the backing board.

Dimensions in millimetres



Key

1 four grooves 60°× 0,5 mm deep to locate spring

2 handle

3 holes in end plate for securing the spring

Figure 3 — Construction of a typical specimen holder

6.5.4 Storage of specimens

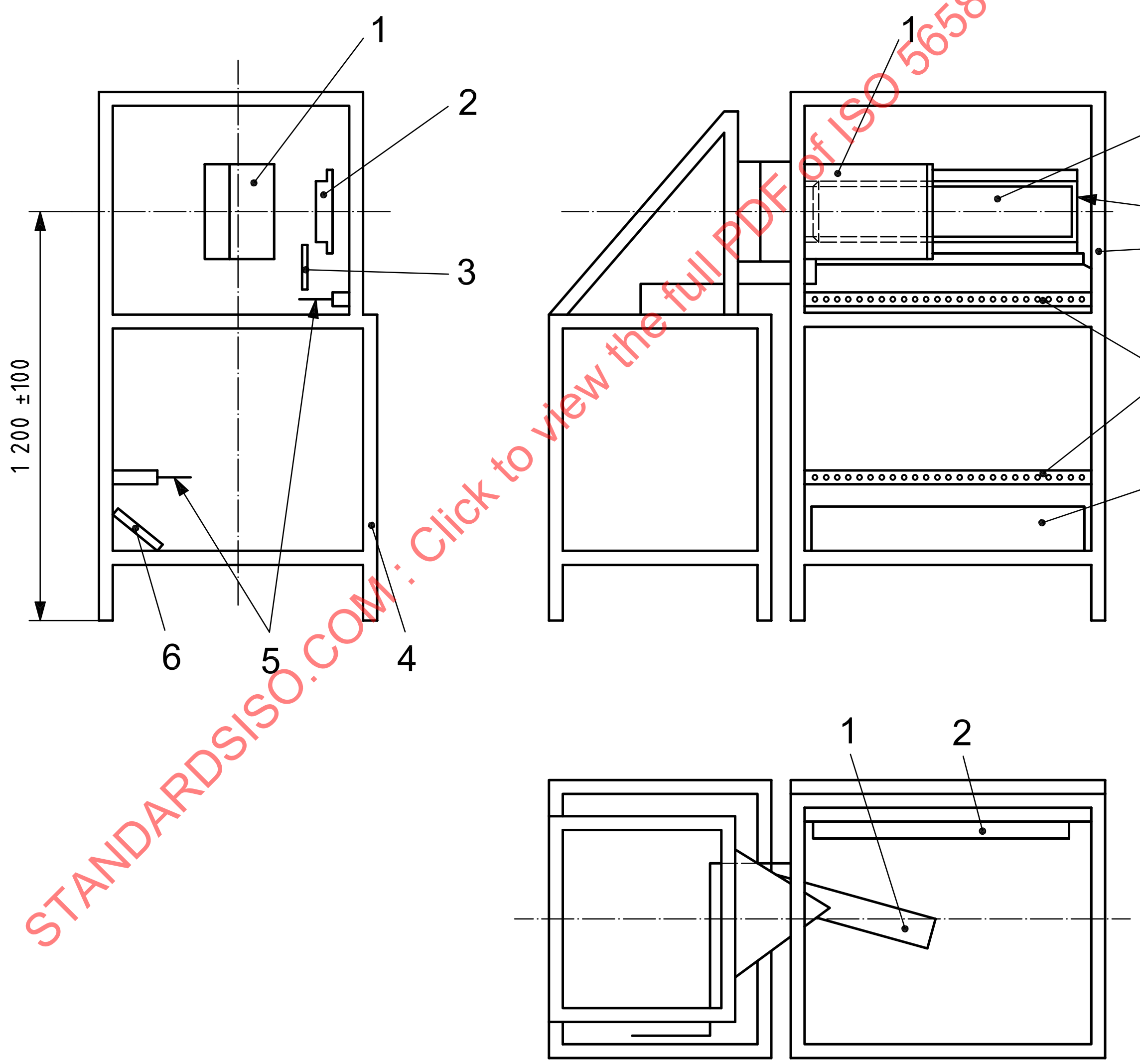
The wrapped assemblies of specimen, backing board and spacers prepared as specified in 6.5.2 or 6.5.3 shall be stored until required for testing in the conditioning atmosphere specified in 6.4.1.

7 Test apparatus

7.1 General

The test apparatus (see Figure 4) consists of four main components: a radiant panel support framework and a specimen support framework, which are linked together to bring the test specimen into the required configuration in relation to the radiant panel, the specimen holder and a pilot flame burner.

Dimensions in millimetres



Key

1 radiant panel
2 specimen holder
3 pilot burner
4 rectangular hollow steel frame
5 viewing rakes
6 mirror
7 specimen
8 holder support

Figure 4 — Schematic of test apparatus

7.2 The radiant panel support framework

This framework provides the support for the radiant panel, together with the necessary pipework for air and gas, safety devices, regulators and flowmeters.

7.2.1 Tubular steel frame

This frame shall consist of 40 mm × 40 mm, square-section steel tube, as shown in Figure 4, and shall support the radiant panel with its centre (1 200 ± 100) mm above floor level, with the radiating face of the panel vertical. The angle between the face of the panel and the front face of the support framework shall be (15 ± 3)°.

7.2.2 Radiant panel

This panel shall consist of an assembly of porous refractory tiles mounted evenly over the radiating surface at the front of a stainless steel plenum chamber to provide a flat radiating surface of dimensions approximately 480 mm × 280 mm. The plenum chamber shall contain baffle plates and diffusers to distribute the gas/air mixture evenly over the radiating surface. A wire screen shall be provided immediately in front of the radiating face of the panel to increase irradiance.

7.2.3 Gas and air supplies

The combustion gas and air shall be fed to the radiant panel via suitable pressure and flow regulators, safety equipment and flow control system.

NOTE 1 The gas/air mixture enters the plenum chamber through one of the shorter sides to facilitate easy connection when the panel is mounted from the tubular steel frame.

A suitable supply system includes the following:

a) supply of natural gas, methane or propane with a flow rate of at least 1,0 l/s at a pressure sufficient to overcome the friction losses through the supply lines, regulators, control valve, flow control system, radiant panel, etc.;

b) air supply with a flow rate of at least 9 l/s at a pressure sufficient to overcome the friction losses through the supply lines, etc.;

c) separate isolation valves for gas and air;

d) non-return valve and pressure regulator in the gas supply line;

e) electrically operated valve to shut off the gas supply automatically in the event of failure of electrical power, failure of air pressure or decrease in temperature at the burner surface;

f) particulate filter and a flow-control valve in the air supply;

g) flow-control system for natural gas, methane or propane suitable for indicating flows of 0,5 l/s to 1,5 l/s at ambient temperature and pressure to a resolution of 1 % or better (an absolute calibration is unnecessary);

NOTE 2 This is used to assist in setting the gas flow to a value that gives a suitable panel temperature.

h) flow control system for air suitable for indicating flows of 5 l/s to 15 l/s at ambient temperature and pressure to a resolution of 1 % or better (an absolute calibration is unnecessary).

NOTE 3 All the above items can normally be accommodated within, and supported by, the tubular steel framework.

7.3 Specimen support framework

7.3.1 General

This framework incorporates the guide rails that support the specimen holder and locate it at the required position of test, the pilot flame burner, a mirror and the viewing rakes.

7.3.2 Tubular steel frame

This frame shall consist of 40 mm × 40 mm square-section steel tube as shown in Figure 4, and shall be linked to the radiant panel support framework by means of adjustable fixing bolts and spacer tubes. It shall be capable of adjustment to vary the angle between the panel and the front face of the specimen from 12° to 18°.

7.3.3 Specimen holder guides

Guides, as shown in Figure 2, shall be provided for locating the top and bottom edges of the specimen holder. They shall be made of steel capable of resisting heat and corrosion during a large number of tests. The lower guide shall be 700 mm long and shall have a groove machined in one of its narrow faces. The top edge of the specimen holder shall be located by means of one or more forks. The guides shall be mounted from one side of the tubular steel framework by lengths of steel studding and fixing nuts, which enable their positions to be adjusted in relation to the support frame and to each other.

7.3.4 Viewing mirror

A mirror 750 mm long × 120 mm wide shall be pivoted from the bottom of the side of the support frame opposite to that supporting the specimen holder. The location and angular position shall be such that it is possible to view the specimen in the mirror under the radiant panel, with the viewing rakes (see 7.3.5) superimposed across the face of the specimen (see Figure 5).

NOTE A video camera, placed at a location to provide a clear view of the whole front surface of the test specimen, along with an appropriate video recording device, can be used to supplement the visual observations of the operator, such as those made with the assistance of the viewing mirror and rakes.

7.3.5 Viewing rakes

Viewing rakes are used to increase the precision of timing of the progress of the flame front along the specimen.

They shall be heat-resistant steel members 700 mm long and provided with 100 mm long steel pins fixed along one edge at 50 mm intervals. The rakes shall be fixed from the bottom specimen holder guide so that the pins project horizontally in front of the line of the mounted test specimen.

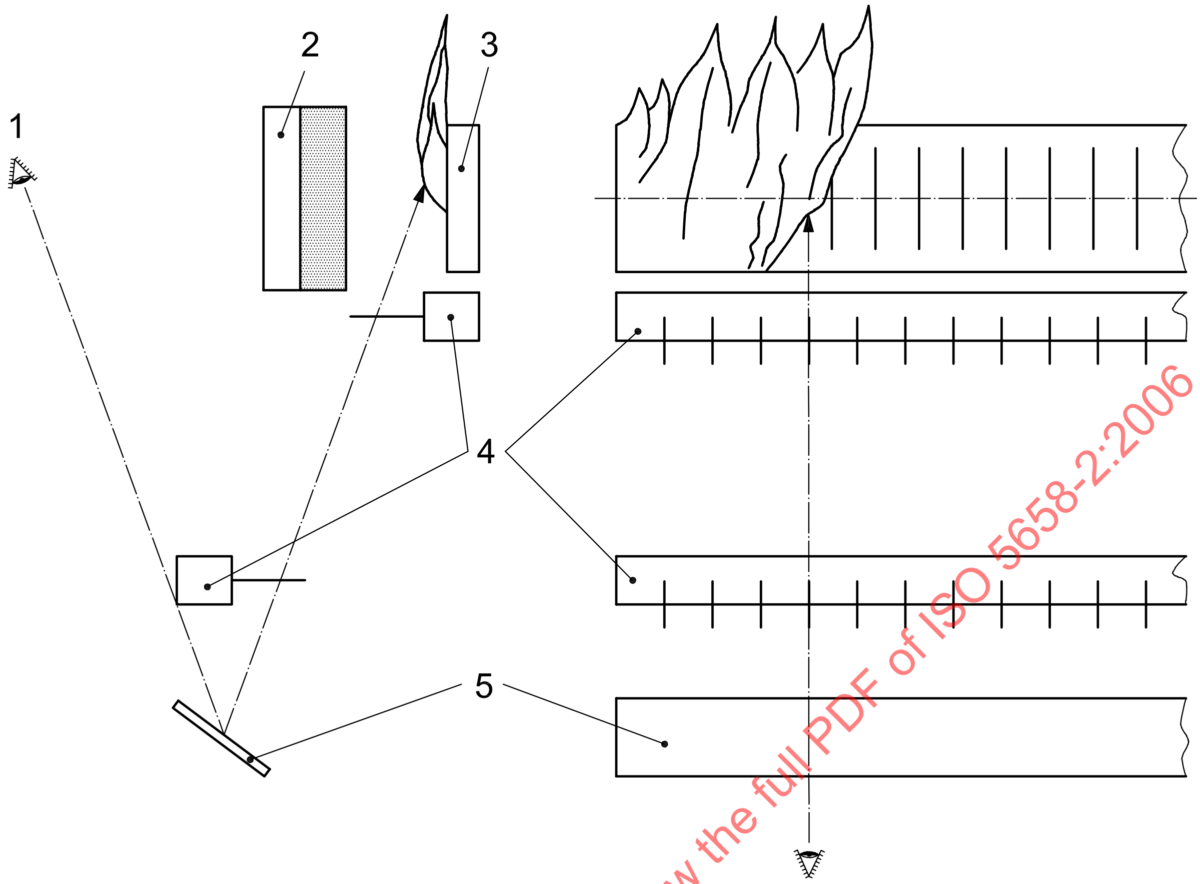
NOTE In some circumstances, it can be more satisfactory to use the V-marks on the specimen holder to facilitate observation of flame spread.

7.4 Specimen holder

The specimen holder shall be made from (3 ± 0,2) mm thick stainless steel to the dimensions given in Figure 3. It shall be provided with a quick-action clamp to retain the test specimen in position and to press it against the front flanges.

The front flanges shall be provided with serrated edges together with V-marks at 50 mm intervals to facilitate observation of flame spread. The zero mark shall correspond to the edge of the vertical flange at the end of the specimen adjacent to the radiant panel.

The number of specimen holders required depends on the amount of testing envisaged, but a minimum of three is recommended in addition to the one which is used to hold the dummy specimen.



Key

1 viewing position

2 radiant panel

3 specimen

4 viewing rake

5 mirror

Figure 5 — Schematic of apparatus for the measurement of the time of arrival of the flame front

7.5 Pilot flame burner

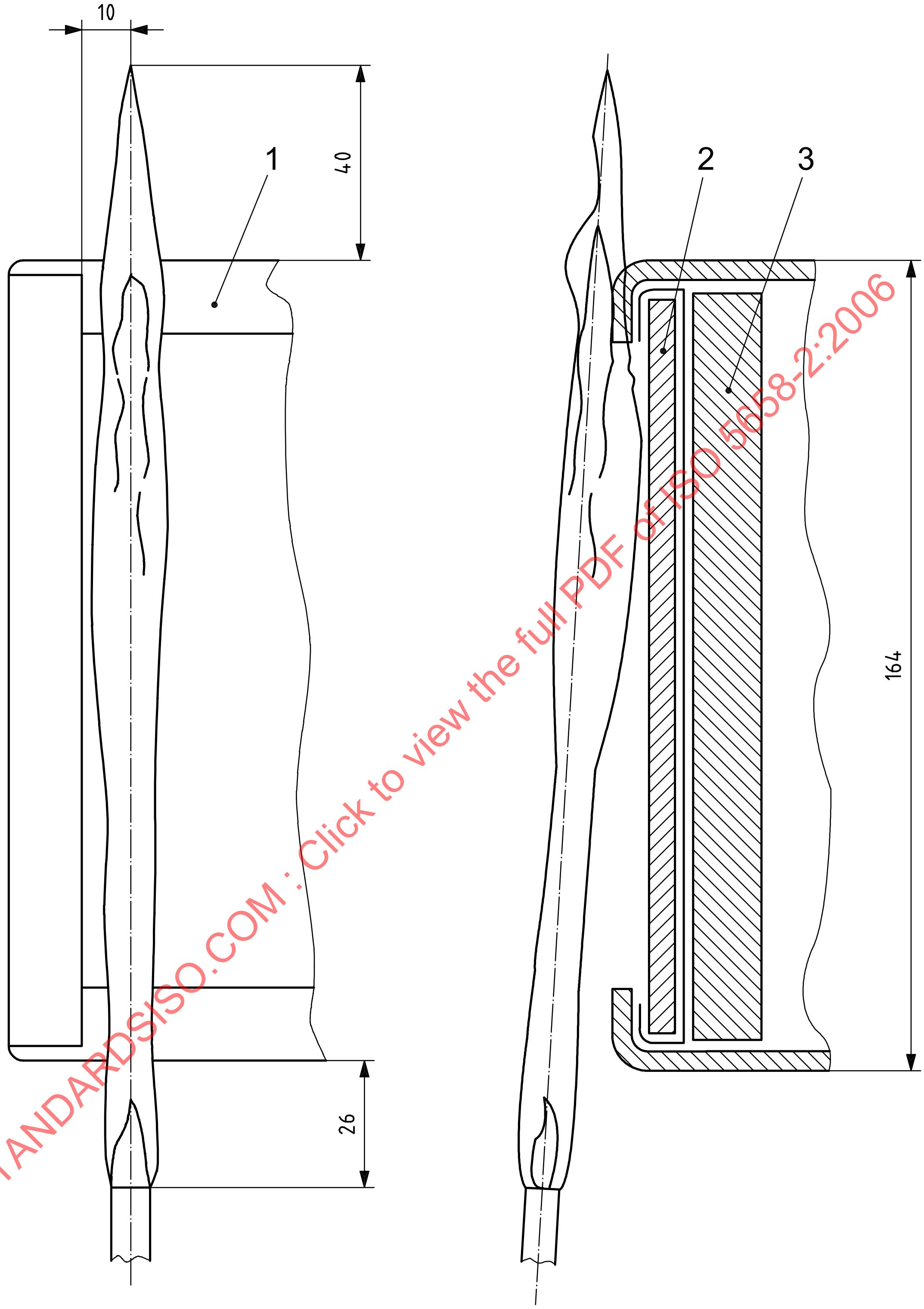
The pilot flame burner shall be an approximately 200 mm length of twin-bore porcelain, 6 mm in diameter, with each longitudinal bore 1,5 mm in diameter.

NOTE The porcelain insulator normally used for sleeving thermocouple wire is suitable.

It shall be mounted from a bracket on the tubular steel frame of the specimen support framework (7.3.2) so that its position relative to the face of the test specimen is as shown in Figure 6. The pilot flame burner shall be supplied with a mixture of propane and air, via suitable control and regulating valves and flowmeters (see Figure 7). The purity of the propane gas used shall be equal to or more than 95 %.

Other gases (e.g. methane) may be substituted for propane but the flame characteristics are different and can influence the ignition behaviour of specimens. In cases of dispute, it is essential that propane be used.

Dimensions in millimetres



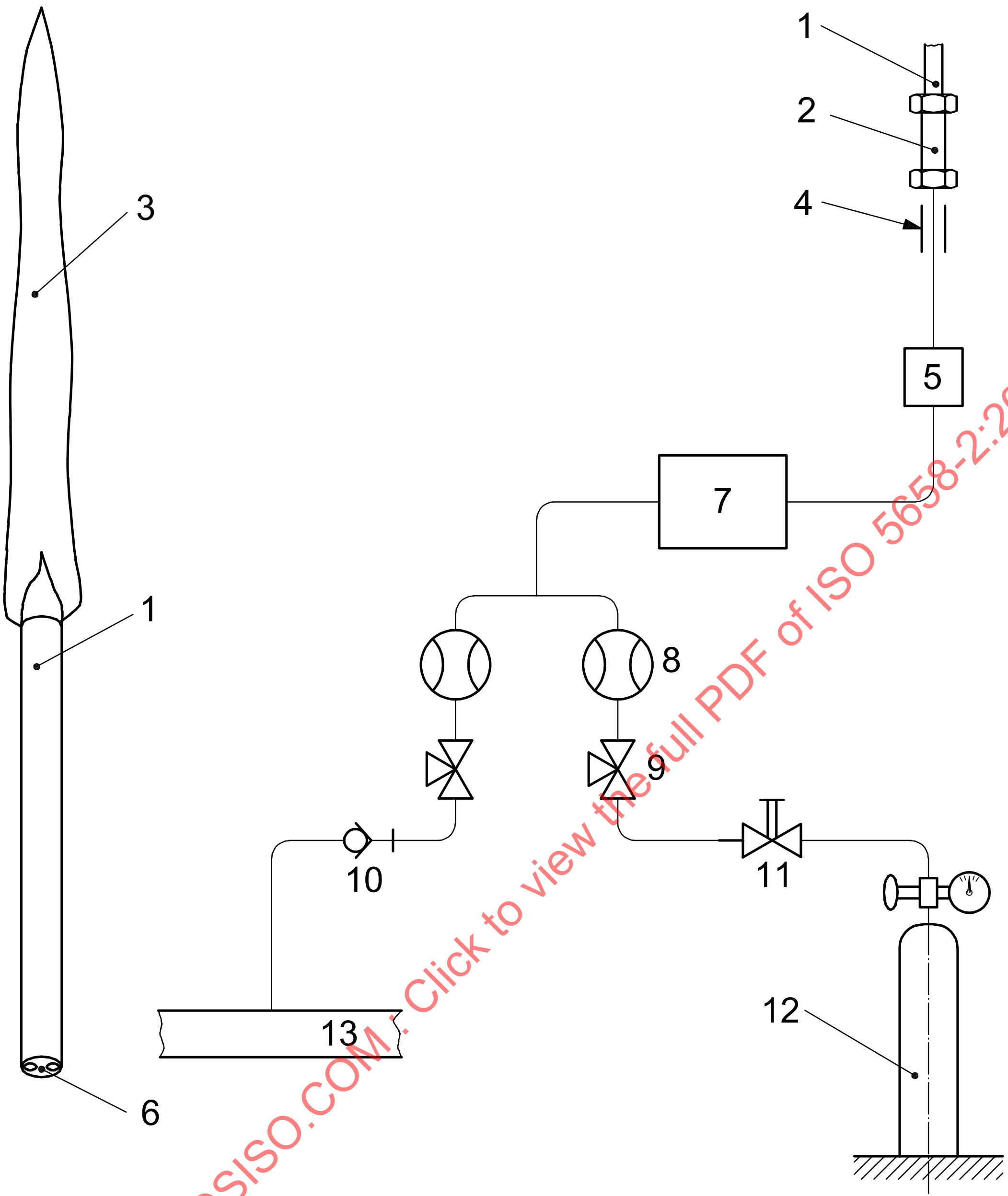
Key

1 specimen holder

2 specimen

3 backing board

Figure 6 — Position of pilot flame burner and impinging pilot flame



Key

1 pilot flame burner
2 connector
3 flame (230 ± 20) mm long
4 location of burner support
5 flame arrester
6 twin-bore porcelain tube (200 ± 10) mm long
7 pressure damping chamber
8 flow meter
9 needle valve
10 non-return valve
11 on-off valve
12 propane gas cylinder
13 air line to panel

Figure 7 — Pilot flame, burner and gas/air connections (schematic)

8 Test environment

8.1 The dimensions of the room in which the tests are carried out are not critical provided it is large enough. A room of volume 45 m^3 with a ceiling height of not less than 2,4 m and an appropriate fume exhaust system has been found suitable.

A fume exhaust system should be installed above the ceiling and should have a capacity of at least 0,5 m^3/s. The ceiling grill opening to this exhaust system should be surrounded by a refractory fibre fabric curtain hanging from a square on the ceiling 1,3 m × 1,3 m down to (1,7 ± 0,1) m from the floor of the room. The specimen support frame and radiant panel should be located beneath this hood in such a way that all combustion fumes are withdrawn from the room.

8.2 The apparatus shall be sited in an environment substantially free from draughts, with a clearance of at least 1 m between it and the walls of the test room. Material on the ceiling, floor or walls having a combustible finish shall not be located within 2 m of the radiant heat source.

8.3 The exterior air supply to replace that removed by the exhaust system for fumes shall be arranged in such a way that the ambient temperature remains reasonably stable and within the range 10 °C to 30 °C.

8.4 Measurements shall be taken of air speeds near a dummy specimen while the exhaust system for fumes is operating but with the radiant panel and its air supply turned off. The air flow perpendicular to the lower edge and at the mid-length of the specimen shall not exceed 0,2 m/s in any direction, when measured at a distance of 100 mm from the specimen.

9 Additional equipment and instrumentation

9.1 Heat-flux meter

At least three heat-flux meters of the Schmidt-Boelter (thermopile) type with a nominal range of 0 kW/m^2 to 50 kW/m^2 shall be provided, one to form a working instrument and two to be retained as reference standards.

NOTE 1 Suitable instruments are commercially available and are sometimes referred to as “heat-flux transducers” or “heat-flux gauges”.

The sensing surface shall be flat, occupying an area not more than 10 mm in diameter, and shall be coated with a durable matt black finish. It shall be contained within a water-cooled body whose front face shall be flat, circular, at least 25 mm in diameter and coincident with the plane of the sensing surface. The whole front of the water-cooled body shall be highly polished. Radiation shall not pass through a window before reaching the sensing surface. The temperature of the cooling water should be controlled so that the heat-flux meter body temperature remains above the local dew point temperature.

NOTE 2 Water cooling of the heat-flux meter is required to standardize and define the measurement. The relationship between output voltage and total heat flux that is established when the meter is calibrated depends on the cooling water temperature. Thus, it is necessary that the same temperature be used both at calibration and use. The water cooling is also necessary to safeguard the heat-flux meter. Failure to supply water cooling can result in overheating and damage to the receiver and loss of calibration of the heat-flux meter. In some cases, repairs and re-calibration are possible.

If heat-flux meters with a diameter less than 25 mm are used, these shall be inserted into a copper sleeve of 25 mm outside diameter in such a way that good thermal contact is maintained between the sleeve and the water-cooled heat-flux meter body. The front of the sleeve and the receiving face of the heat-flux meter shall lie in the same plane.

The heat-flux meters shall be robust, simple to set up and use, and stable in calibration. They shall have an accuracy of ± 6 % and repeatability to ± 0,5 % in accordance with ISO 14934-3[8]. The calibration of the working heat-flux meter shall be checked every two months by comparison with the two reference standard heat-flux meters (see Annex C), which shall be kept securely and not used for any other purpose.

9.2 Total radiation pyrometer

The pyrometer used shall have a sensitivity substantially constant between the wavelengths of 1 µm and 9 µm.

9.3 Recorder

The output from the radiation pyrometer and the heat-flux meter(s) shall be recorded using an appropriate method.

A strip chart recording millivoltmeter having an input resistance of at least 1 MΩ is suitable. The sensitivity should be selected to require less than full-scale deflection with the total-radiation pyrometer or heat-flux meter chosen. The effective operating temperature of the radiant panel does not normally exceed 935 °C.

NOTE A small digital millivoltmeter capable of indicating signal changes of 10 µV or less is convenient for monitoring changes in operating conditions of the radiant panel.

9.4 Timing devices

A chronograph and either an electric clock with a sweep second hand or a digital clock shall be provided to measure time of ignition and flame advance.

The chronograph for timing ignition and initial flame advance may be a strip chart recorder with a paper speed of at least 5 mm/s.

Both the chronograph paper drive and the electric clock shall be operated through a common switch to initiate simultaneous operation when the specimen is exposed. This may be hand-operated or actuated automatically as a result of complete specimen insertion.

9.5 Dummy specimen

The dummy specimen shall be cut from a non-combustible board (for example, calcium silicate board) of oven-dry density of (950 ± 100) kg/m^3, and shall measure 800 mm long, 155 mm wide and (25 ± 2) mm thick. Thinner, non-combustible boards of the same density can also be used if they are fixed together to make a (25 ± 2) mm thick board without any noticeable gap. The dummy specimen shall remain in the specimen position during operation of the equipment and shall be removed only when a test specimen is to be inserted.

9.6 Calibration board

The calibration board shall be made of non-combustible board (for example, calcium silicate board) (25 ± 2) mm thick of oven-dry density (950 ± 100) kg/m^3. Thinner non-combustible boards of the same density can also be used if they are fixed together to make a (25 ± 2) mm thick board without any noticeable gap. The calibration board shall be provided with eight 25 mm diameter holes at the positions given in Figure 8 to accommodate a heat-flux meter for measuring the irradiance in the plane corresponding to the exposed surface of a specimen under test. Either a single heat-flux meter may be used, inserted in each hole in turn, or a number of heat-flux meters may be used, but holes that are not occupied by a heat-flux meter shall be filled with removable plugs of the same material as the calibration board.

The receiving face(s) of the heat-flux meter(s) shall (all) be in the plane of the exposed surface of the calibration board.

The calibration board shall be mounted in a specimen holder (see Figure 3) with the first heat-flux-meter position 50 mm from the exposed end of the board, measured to the centre of the heat-flux-meter receiver.

NOTE Approximately 14 mm of the hotter end of the board is covered by the end flange.

9.7 Backing boards and spacers

Backing boards shall be cut from non-combustible board (for example, calcium silicate board) (12,5 ± 3) mm thick with the same dimensions as the dummy specimen and an oven-dry density of (950 ± 100) kg/m^3. Spacers used to create the air gap specified in 6.5.3 shall be made of the same material as the backing board, cut into (25 ± 2) mm wide strips and attached to the whole perimeter of the backing board.

Backing boards and spacers may be re-used if combustible residues do not contaminate them. Immediately before re-use, however, they shall be conditioned in the atmosphere specified in 6.4.1 for at least 24 h. If there is any doubt about the cleanliness of a backing board or spacer, it shall be placed in a ventilated oven at a temperature of approximately 250 °C for a period of 2 h to remove any volatile residue. If there is still any doubt about the condition, it shall be discarded.

10 Setting-up and calibration procedure

10.1 Setting-up

Most of the adjustments of the components of the test apparatus may be made in the cold condition. Both in the original adjustment of the operating conditions for the test and in the periodic verification of this adjustment, the heat flux at the surface of the specimen is the controlling criterion. It should be noted that the reading of the heat-flux meter is affected slightly by rising currents of air, warmed from the calibration board. This heat flux is measured by a heat-flux meter mounted in the calibration board (see Figure 8).

The initial position of the refractory surface of the radiant panel with respect to the specimen shall correspond to the dimensions shown in Figure 9.

The procedure for setting the test conditions initially shall be as follows.

a) Set an air flow rate of about 8 l/s through the panel. Turn on the gas supply, light the radiant panel and allow it to come to thermal equilibrium with a dummy specimen mounted in front of it.

   NOTE 1 When operating correctly there is no visible flaming from the panel except when viewed parallel to the surface from one side. From this direction, a thin blue flame very close to the surface of the panel is observed. An oblique view of the panel after a 15 min warm-up period normally shows a bright orange radiating surface.

b) Adjust the gas flow rate until the heat flux measured with the water-cooled heat-flux meter(s) mounted in the calibration board correspond(s) to the values shown in Table 1 for the 50 mm and 350 mm positions. If necessary, make small changes in the air flow rate to achieve no significant flaming from the panel surface. After making each adjustment, allow the calibration board to reach temperature equilibrium before measuring the radiant heat flux. It may be necessary to make small changes in the longitudinal position of the specimen.

c) Once the values shown for the 50 mm and 350 mm positions have been achieved, determine the heat flux for each of the other positions given in Table 1 and ensure that the values are within the given tolerances.

   NOTE 2 In processing the results of the test, it is assumed that the heat flux at a given position on an actual test specimen is equal to that measured at the same position with the calibration board.

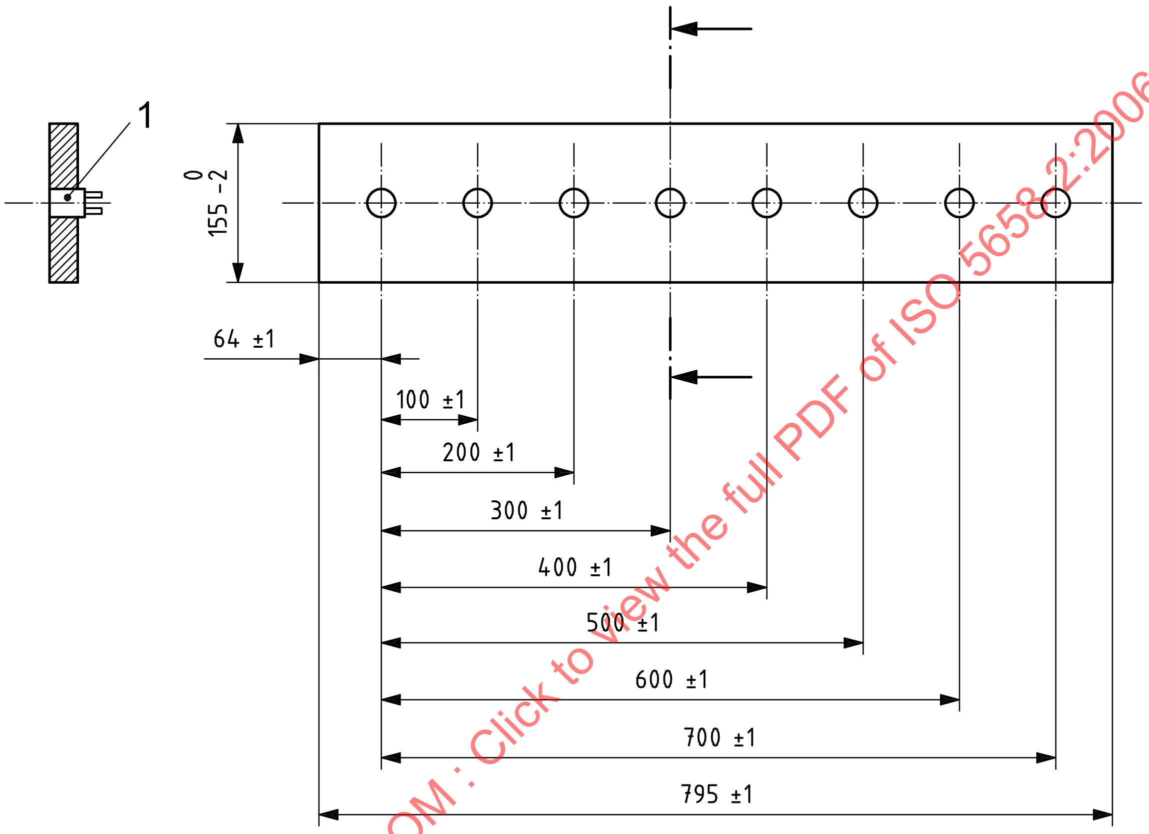
d) If a change in panel-specimen axial position is necessary to meet the requirements for heat flux at the 50 mm and 350 mm positions, this shall be accomplished by adjusting the screws connecting the two frames, so that the position of the pilot flame in relation to the specimen remains unchanged.

   NOTE 3 The specimen stop screw adjustment can be changed to meet the heat flux requirements, in which case the position of the pilot burner mount can require adjustment to maintain the pilot burner flame spacing of (10 ± 2) mm in front of the specimen surface.

e) Once the operating conditions have been achieved, all future panel operation shall take place with the air flow rate needed to attain them, and with the gas flow rate being varied to achieve the required heat flux.

If a total-radiation pyrometer is used to monitor panel operation, the instrument should be mounted on the specimen support frame in such a manner that it can be used to view a centrally-located area on the panel surface of about 150 mm × 300 mm. A record of its signal shall be kept following successful completion of this calibration procedure.

Dimensions in millimetres

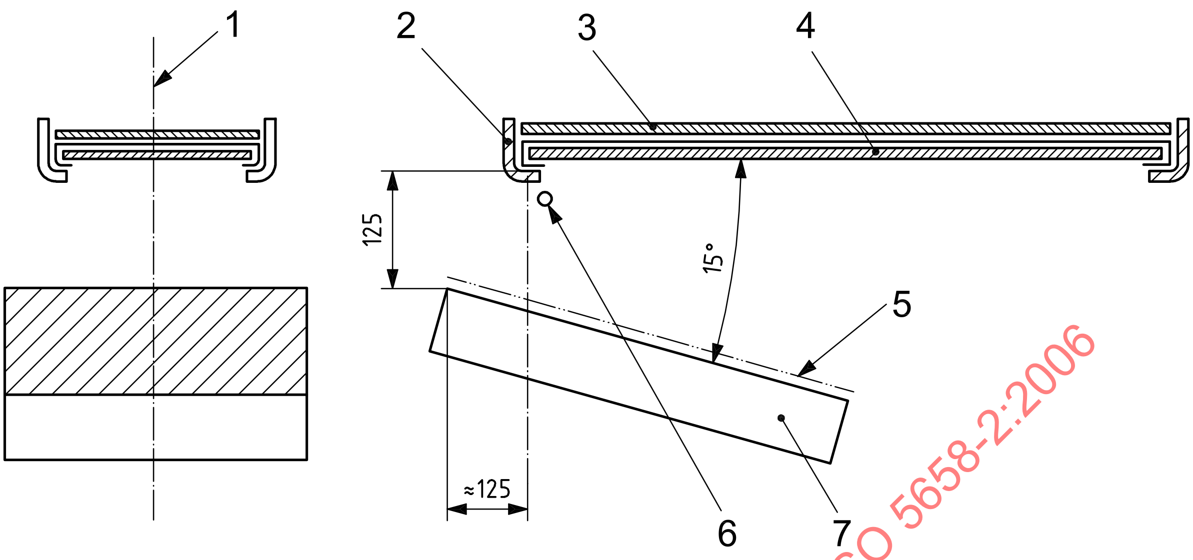


Key

1 heat-flux meter fitting closely in 25 mm diameter hole (such as for measurement at 300 mm)

Figure 8 — Calibration board for heat flux measurements

Dimensions in millimetres, unless otherwise specified



Key

1 centre line of specimen and panel
2 specimen holder
3 backing board
4 specimen
5 wire screen
6 pilot flame burner
7 radiant panel

Figure 9 — Position of radiant panel in relation to specimen

Table 1 — Standardization of heat flux along the calibration board

Position [a] mm	Heat flux kW/m^2	Tolerance on heat flux kW/m^2
0	49,5	b
50	50,5	± 0,5
100	49,5	b
150	47,1	± 2,4
200	43,1	b
250	37,8	± 1,9
300	30,9	b
350	23,9	± 0,2
400	18,2	b
450	13,2	± 0,7
500	9,2	b
550	6,2	± 0,6
600	4,3	b
650	3,1	± 0,3
700	2,2	b
750	1,5	± 0,3

[a] Distance of heat flux meter from hot end of board.

[b] These positions, for which tolerances are not specified, are used for the initial setting-up of operating conditions only and the values of heat flux at these positions are given to aid the production of a smooth heat flux/distance relationship. The heat-flux meter may be located at these positions by withdrawing the specimen holder 50 mm.

10.2 Verification

Confirm the heat flux distribution (see Table 1) on the calibration board by calibrations at daily and monthly intervals, as follows:

a) Daily verification: measure the heat flux at positions 50 mm and 350 mm from the exposed end;

b) Monthly verification: measure the heat flux at positions 50 mm, 150 mm, 250 mm, 350 mm, 450 mm, 550 mm, 650 mm and 750 mm from the exposed end.

10.3 Adjustment of the pilot flame

Adjust the propane gas and air flow rates to about 0,4 l/min and 1,0 l/min respectively to provide a flame length of (230 ± 20) mm in the vertical orientation. When viewed in a darkened room, the flame should extend about 40 mm above the vertical specimen holder (see Figure 6). Record the flow rates of propane and air to the pilot burner.

Adjust the impingement zone of the flame onto the dummy specimen by moving the burner tube towards or away from the plane of the exposed surface of the dummy specimen. Rotate the pilot burner tube in its holder until the flame impinges over the top half of the exposed specimen height.

The pilot flame shall be checked and, if necessary, adjusted in the way stated above every day. The nature of some specimens may make this necessary more frequently.

11 Test procedure

11.1 Mount the dummy specimen in a specimen holder in the position facing the radiant panel and start the fume exhaust system.

11.2 Operate the radiant panel to realise the test conditions specified in Table 1.

11.3 When the radiant panel has attained thermal equilibrium, light the pilot flame, set the normal flow rates of fuel and air to it, check the flame length and, if necessary, adjust the fuel and air flow rates.

11.4 Insert a conditioned specimen, wrapped in aluminium foil and placed on a backing board as specified in 6.5.2 or 6.5.3, in a cool specimen holder away from the heat of the panel, and insert the clamp to press the specimen against the front flanges.

11.5 Remove the dummy specimen holder and insert the specimen in the test position, taking no more than 15 s to complete the operation. Immediately start the clock, the chronograph and, if using one, the video-camera clock (see note in 7.3.4).

11.6 Operate the event marker of the chronograph to indicate the time of ignition and arrival of the flame front at the first few positions during the initial, rapid burning of the specimen. Record the time of arrival at each given position of the flame front as the time at which it coincides with the longitudinal centreline of the specimen and with the position of two corresponding pins of the viewing rakes. Record these times manually, both from measurements on the chronograph chart and observations of the clock. As far as possible, the arrival of the flame front at each 50 mm position along the specimen shall be recorded. Record both the time and the position along the centreline of the specimen at which the flame ceases to advance.

In cases where the marked line is obscured by the surface of a specimen scorching in advance of the flame, the operator shall judge the centreline of the specimen by eye.

11.7 Throughout the exposure of the specimen, make no change in the fuel supply rate to the radiant panel to compensate for variations in its operating level.

11.8 Terminate the test if

a) the specimen fails to ignite after a 10 min exposure;

b) the flame ceases to spread along the specimen and is extinguished and no further flaming of any type ensues within the next 10 min;

c) the surface flaming reaches the end of the specimen;

d) the specimen burns in one position only and the flame front does not spread from this position within 30 min of the test starting.

11.9 When the test is terminated, remove the specimen and reinsert the dummy specimen in its holder.

11.10 Repeat the operations described in 11.4 to 11.9 for the additional specimens, allowing the radiant panel to attain temperature equilibrium before each test.

a) If the specimens have no directional irregularities on the exposed side, test two additional specimens in the same orientation.

b) If the specimens have a directional irregularity on the exposed side, test one additional specimen in the direction perpendicular to the first. The test that gives the lowest CFE (see 3.5) shall be repeated four times in that direction.

11.11 Conditions of re-test are as follows.

a) If one of the three specimens does not ignite, test one further specimen.

b) If two or three of the first set of specimens do not ignite following exposure for 10 min, test one further specimen. If this specimen ignites, test two additional specimens. In this case, the test report shall clearly state that repeatable ignition was not obtained.

c) If a specimen shows extensive loss of incompletely burned material during testing, test at least one additional specimen that is restrained in the test frame by wire mesh of approximately 0,3 mm diameter wire and 25 mm mesh. The data obtained using this wire mesh shall be reported separately.

11.12 The test method shall be deemed to be inappropriate if the specimen exhibits behaviour such that the exposed surface is not available for the measurement of flame spread, such as

a) any softening, melting or disintegration of material resulting in the specimen sagging out of the specimen holder;

b) detachment of the facing from the substrate.

The test method is, however, appropriate if ignition of the exposed surface occurs within the resulting flame front before the onset of the inappropriate behaviour as described in a) and b).

11.13 Throughout the test, careful observation shall be made of the behaviour of the product and a special note shall be made of the following phenomena:

a) flashing;

b) transitory flaming (unstable flame front).

Observations shall also be made of other phenomena, such as debris falling away from the specimen and whether or not it is flaming (sustained or transitory), intumescence and/or deformation of the specimen, separations, spalling, fissures and cracks, sparks, melting, changes in form, etc. Guidelines on the reporting of unusual behaviour are given in Annex D.

12 Expression of fire performance of a product

Report experimental results in terms of the radiant heat fluxes measured with the calibration board in place. Do not compensate for changes in thermal output of the radiant panel during the exposure of the specimen. Derive and list the following data from the test results for each specimen tested:

— average heat for sustained burning (Q_{sb}): the average of the values of heat for sustained burning (see 3.2 and 3.9) measured at 50 mm intervals, the first at 150 mm and then at each subsequent position up to and including the 400 mm position (or the final position if the test is terminated before the 400 mm position is reached);

— critical heat flux at extinguishment (CFE): When test specimens do not ignite, these specimens shall be considered to have a CFE of 50 kW/m^2.

Calculate the average of the results of Q_{sb} and of CFE for the specimens tested in all orientations.

a) For test specimens with no directional irregularities where ignition occurred with each specimen, calculate the means of three test specimens.

b) For test specimens with no directional irregularities where some non-ignitions occurred, calculate the means based on all specimens tested. When calculating the average of Q_{sb}, exclude those specimens that did not ignite or those where the flame spread is less than 150 mm.

c) For test specimens with directional irregularities, calculate the means from the set of results for the five specimens tested in the same directional orientation. In performing this calculation, exclude the two extremes (highest and lowest) for each parameter.

13 Test report

The test report shall include the time for the flame front to pass each of the standard 50 mm positions, the observations made on each specimen tested and the derived fire characteristics. The following information shall also be supplied:

a) reference to this part of ISO 5658;

b) name and address of testing laboratory;

c) name and address of sponsor;

d) name and address of manufacturer/supplier;

e) full description of the product tested, including trade name, together with its construction, orientation, thickness, density and, where appropriate, the face subjected to test; in the case of specimens that have been painted or varnished, the quantity and number of coats applied shall be recorded as well as the nature of the supporting materials;

f) description of the substrate used and method of fixing the specimen onto the substrate, including how any joints were constructed;

g) data from the test including:

1) number of specimens tested,

2) gas used in the pilot flame,

3) ignition time(s),

4) duration of each test (see 11.8),

5) observations of the movement of the flame front recorded in accordance with 11.6,

6) other observations of the behaviour of the product (see 11.12 and 11.13), including duration of flaming debris if it occurs,

7) derived fire characteristics as described in Clause 12;

h) limiting use statement, such as: “These test results relate only to the behaviour of the product under the particular conditions of this test and they are not intended to be the sole criterion for assessing the potential fire hazard of the product in use”;

i) explanation of any reason for tests to be deemed invalid.

Annex A
(normative)

Safety precautions

A.1 Hazards of gases

Gases can form explosive mixtures with air over a range of concentrations (see Table A.1)

Table A.1 — Fire and explosion hazards of gases

Gas	Explosive limits %		Ignition temperature °C
	Lower	Upper	
Methane	5	15	537
Propane	2,2	9,5	468

A.2 Ignition hazards

The use of this test method involves the generation of high irradiances, which can cause ignition of some materials such as clothing following even brief exposures. It is important that precautions are taken to avoid accidental ignitions of this type.

A.3 Toxic fume hazards

The attention of the user of this test is drawn to the fact that the fumes from burning materials usually include carbon monoxide and other noxious gases. In many instances, other toxic products can be produced. It is important that precautions are taken to avoid exposure to these fumes.

A.4 Eye protection

The possibility of the violent ejection of molten hot material or sharp fragments from some kinds of specimens when irradiated cannot totally be discounted and the operator should use eye protection.

Annex B
(informative)

Specimen construction

B.1 Effect of thermal characteristics on the performance of assemblies

The presence of an air gap and the nature of any underlying construction can significantly affect the ignition and spread of flame performance of the exposed surface of thin materials or composites, particularly those with a high thermal conductivity. Increasing the thermal capacity of the underlying construction increases the "heat sink" effect and can delay ignition of the exposed surface and slow flame spread. Any backing provided to the test specimen and in contact with it, such as the non-combustible spacers (see 9.7), can alter this "heat sink" effect and can be fundamental to the test result itself. The influence of the underlying layers on the performance of the assembly should be understood and care should be taken to ensure that the result obtained on any assembly is relevant to its use in practice.

B.2 Preparation of test specimens

The following advice is offered on the construction and preparation of test specimens.

a) Where the thermal properties of the product are such that no significant heat loss to the underlying layers can occur, e.g. a material/composite greater than approximately 6 mm thick of high thermal capacity and/or low thermal conductivity, the product should be tested backed only by the backing board.

b) Where the product is normally used as a free-standing sheet and the characteristics noted in a) do not apply, an air space should be provided at the back of the product by spacers of non-combustible insulation board (see 6.5.3).

c) Where the product is to be used over a low-density, non-combustible substrate and the characteristics noted in a) do not apply, the product should be tested in conjunction with that substrate.

d) Where the product is to be used over a combustible substrate and the characteristics noted in a) do not apply, the product should be tested in conjunction with that substrate.

Annex C
(informative)

Calibration of the working heat-flux meter

The use of two reference standard instruments provides a safeguard against change in the sensitivity of the reference instrument, as explained in detail in ISO 14934-3:2006, Annex D[8]. One of the reference standard instruments shall be fully calibrated at yearly intervals according to one of the methods of ISO 14934-2[7].