INTERNATIONAL STANDARD

ISO 5658-4

First edition
2001-06-01

Reaction to fire tests — Spread of flame —

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

Essais de réaction au feu — Propagation du feu —

Partie 4: Essais à échelle intermédiaire de la propagation de la flamme avec éprouvette orientée verticalement

Reference number
ISO 5658-4:2001(E)

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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 3.

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 part of ISO 5658 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 5658-4 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

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 Report)

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

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

Annexes A, B and D form a normative part of this part of ISO 5658. Annexes C and E are for information only.

Introduction

ISO/TR 5658-1 describes the development of standard tests for flame spread and explains the theory of flame spread for various orientations.

ISO 5658-2 provides a simple method by which the 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.

This part of ISO 5658 provides an intermediate-scale method by which the ignitability and vertical surface spread of flame on a vertical specimen can be determined. The specimen is sufficiently large to obtain a measure of lateral flame spread. Downward flame spread can also be examined as a wind-opposed spread on the specimen surface or by the observation of any flaming drips.

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 in which they are exposed. The methodology of reaction-to-fire tests is explained in ISO/TR 3814.

A test such as 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.

The attention of all users of the test is drawn to the warning given before clause 1.

Reaction to fire tests — Spread of flame —

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

WARNING — 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 may be evolved during exposure of test specimens. The advice on safety given in annex A should also be noted.

1 Scope

1.1 This part of ISO 5658 specifies an intermediate-scale method of test for measuring the vertical spread (upward and downward) of flame over a specimen of a product orientated in the vertical position. A measure of lateral spread can also be obtained. It provides data suitable for comparing the performance of materials, composites or assemblies, which are used as the exposed surfaces of walls or other vertically orientated products in construction applications. Some products with profiled surfaces can also be tested with a modified procedure representative of the end-use conditions of the product.

1.2 Upward flame spread is not limited to surfaces which are vertical. It is recognized that an enhanced form of upward, wind-aided flame spread can also occur on surfaces at an angle greater than 20° from the horizontal without any external ventilation. This type of flame spread can occur in both planar sloping surfaces and stepped surfaces such as stairs. Flame spread in these situations can become very rapid and can cause serious problems in escape ways such as staircases. When assessing stepped or sloping surface materials, it may be more appropriate to use a vertical flame spread test rather than a test in which the specimen is horizontal.

1.3 This part of ISO 5658 is applicable to the measurement and description of the properties of materials, products, composites or assemblies in response to radiative heat in the presence of non-impinging pilot flames under controlled laboratory conditions. The heat source may be considered to represent a single burning item such as a wastepaper bin or an upholstered chair within an enclosure, and this scenario would generally be considered to apply during the early developing stage of a fire (see ISO/TR 11696-1 and ISO/TR 11696-2). This part of ISO 5658 should not be used alone to describe or appraise the fire hazard or fire risk of materials, products, composites or assemblies under actual fire conditions.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 5658. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 5658 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications.*

ISO/TR 11696-1, *Uses of reaction to fire test results — Part 1: Application of test results to predict fire performance of internal linings and other building products.*

ISO/TR 11696-2, *Uses of reaction to fire test results — Part 2: Fire hazard assessment of construction products.*

ISO 13943, *Fire safety — Vocabulary.*

ISO/TR 14697, *Fire tests — Guidance rules on the choice of substrates for building products.*

3 Terms and definitions

For the purposes of this part of ISO 5658, the terms and definitions given in ISO 13943 apply, together with the following.

3.1
assembly
fabrication of materials and/or composites, for example sandwich panels

NOTE The assembly may include an air gap (see 6.3.6).

3.2
backing board
board with the same dimensions as the specimen and used to back the specimen so as to represent end-use conditions

NOTE See 7.10.

3.3
burned area
that part of the damaged area of a material which has been destroyed by either combustion or pyrolysis, under specified test conditions

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

EXAMPLE Coated or laminated materials.

3.5
damaged area
total of the area of material affected by thermal phenomena under specified test conditions

NOTE See 10.11.

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

3.7
flame front
boundary of the combustion zone in the gaseous phase at the surface of a material

NOTE For vertical flames, the flame front is the tip of continuous flames, disregarding any detached transitory flame-segments.

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

3.9
irradiance
⟨at a point of a surface⟩ quotient of the radiant heat flux incident on an infinitesimal element of surface containing the point, and the area of that element

3.10
material
single substance or uniformly dispersed mixture

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

3.11
product
material, composite or assembly about which information is required

3.12
radiant heat flux
power emitted, transferred or received in the form of radiation

3.13
specimen
representative piece of the product which is to be tested together with any substrate or treatment

NOTE The specimen may include an air gap. The specimen may also be tested as a stand-alone product without substrates if this is representative of end-use conditions.

3.14
spread of flame
propagation of a flame front over the surface of a product under the influence of imposed irradiance and non-impinging pilot flames

3.15
substrate
material which is used or is representative of that used, immediately beneath a surface product in end-use

EXAMPLE Skimmed plasterboard beneath a wall-covering.

3.16
sustained flaming
existence of flame on or over the surface of the specimen for periods of more than 4 s

3.17
transitory flaming
existence of flame on or over the surface of the specimen for periods of between 1 s and 4 s

3.18
lateral flame spread
progression of the flame front in a lateral direction over the specimen width

3.19
vertical flame spread
progress of the flame front in a vertical direction (upwards or downwards) over the specimen height

4 Principle

4.1 The test method consists of exposing conditioned vertically-orientated specimens to a single well-defined field of radiant heat flux (see Figure 1) and measuring the time of ignition, vertical spread of flame and, where appropriate, observing other fire spread effects such as flaming drips or debris and lateral spread.

4.2 A test specimen is placed in a vertical position adjacent to a gas-fired radiant panel which exposes the lower part to a defined field of radiant heat flux. A non-impinging line pilot burner is positioned above the radiated area of the specimen to ignite volatile gases issuing from the surface (see Figures 2 and 3).

4.3 Following ignition, any flame front which develops is noted and a record is made of the progression of the flame front vertically over the height of the specimen in terms of the time it takes to travel to various distances.

4.4 The results are expressed in terms of ignition time and flame spread distance versus time.

Mass loss, heat release and smoke data may also be measured if required. For these measurements, the apparatus should be positioned underneath a calibrated hood/duct facility; for example, see ISO 9705.

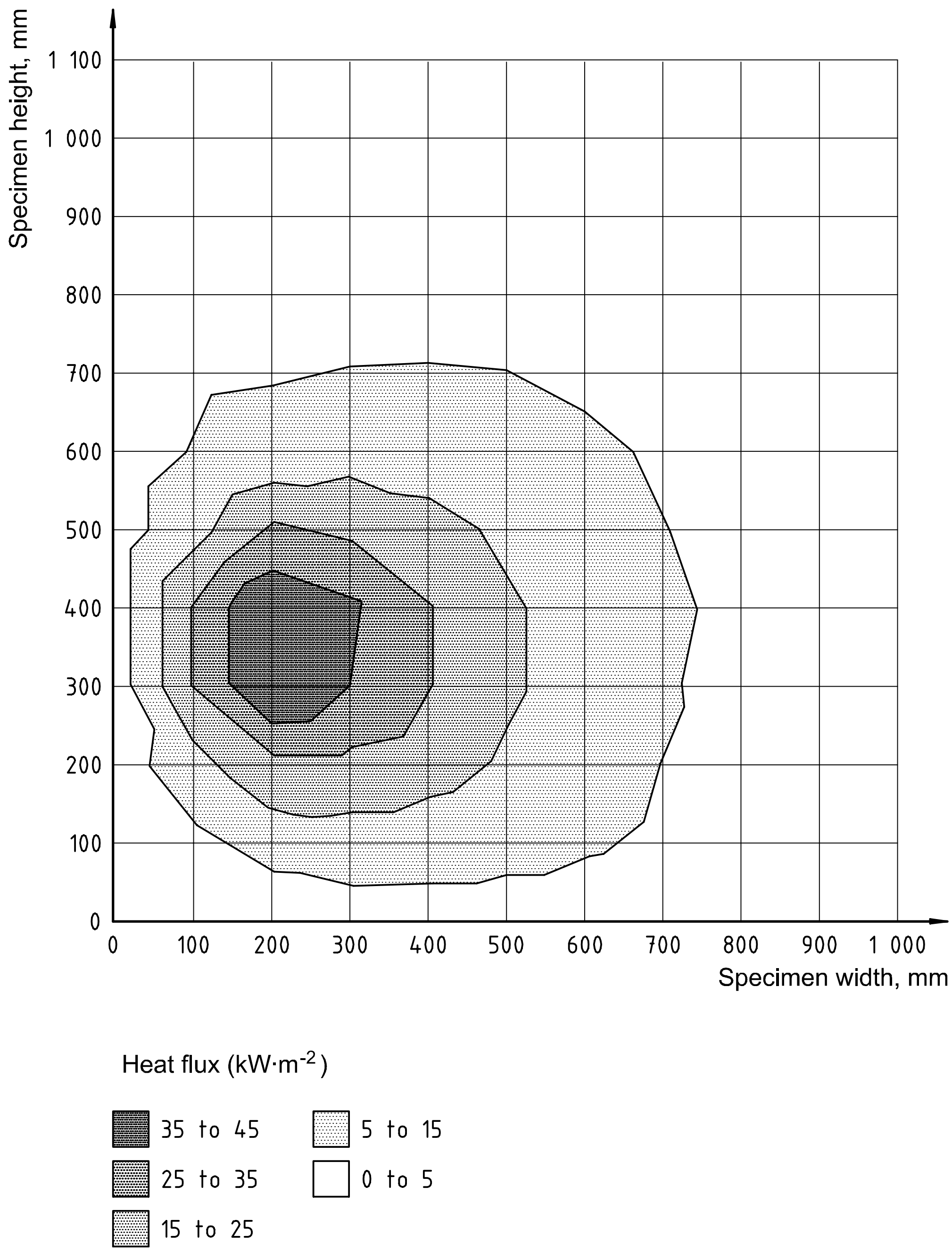
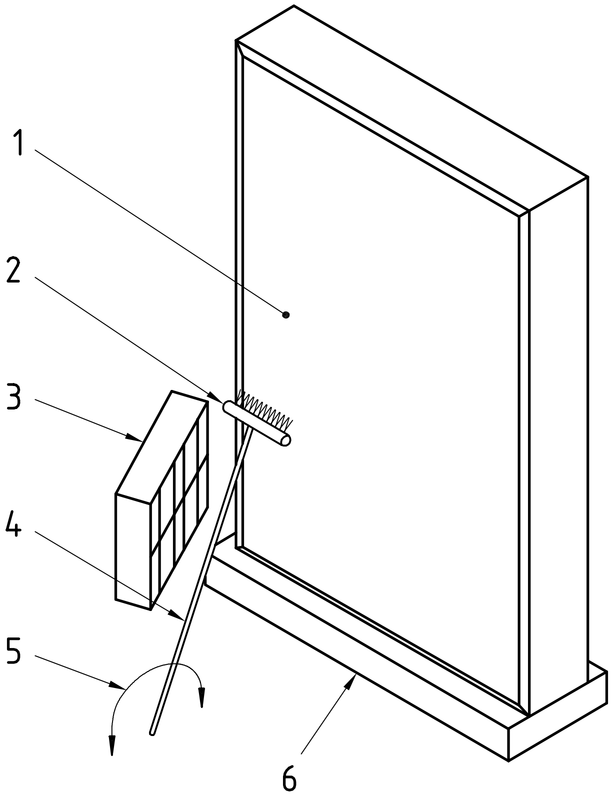


Figure 1 — Heat flux distribution on the calibration board

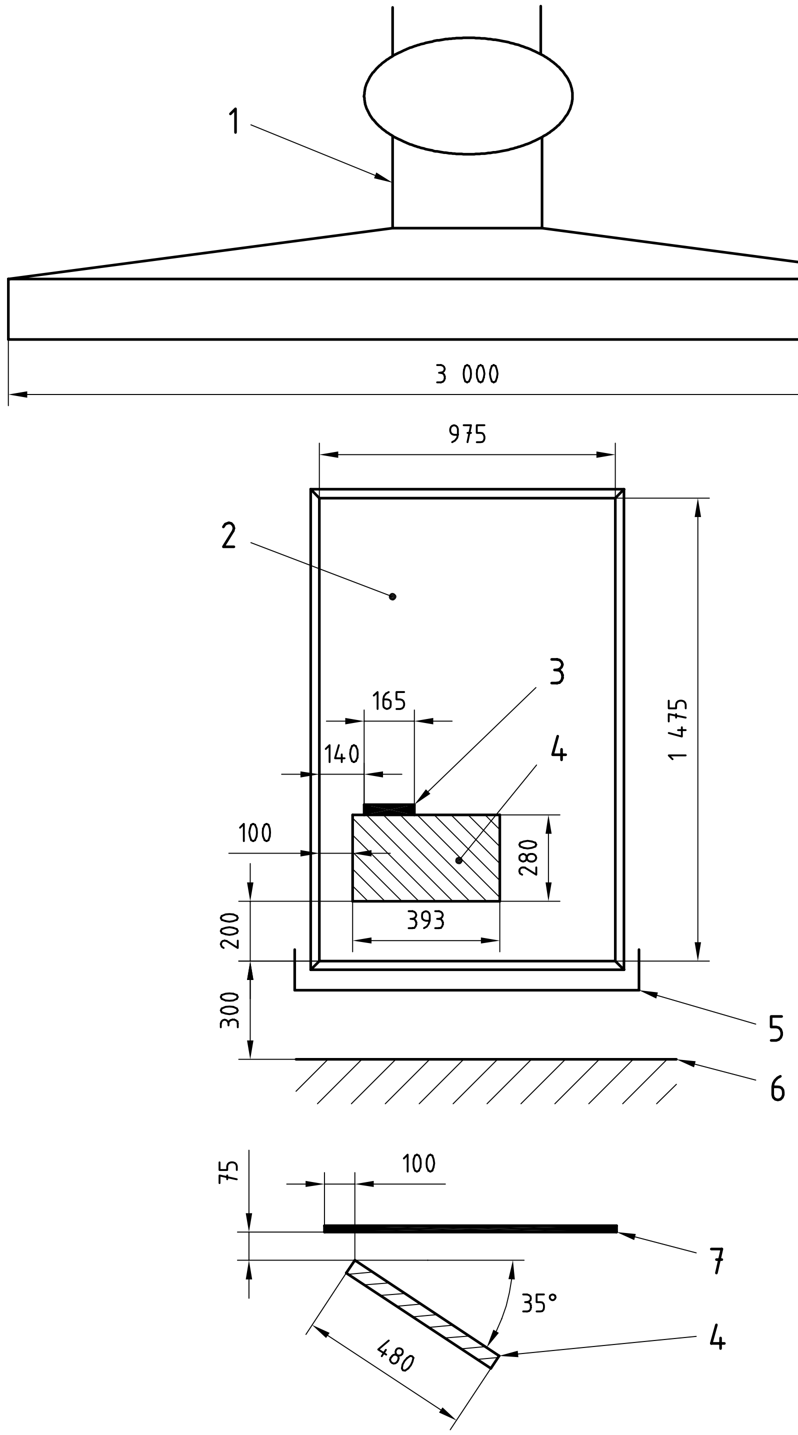


Key

1 Test specimen
2 Pilot flame burner
3 Vertical radiant panel at an angle of 35° to the specimen
4 Supply pipe
5 Direction of rotation of supply pipe
6 Debris collection tray

Figure 2 — Test apparatus

Dimensions in millimetres



Key

1 Exhaust hood
2 Exposed area of specimen
3 Pilot flame burner
4 Radiant panel
5 Debris collection tray
6 Floor level
7 Specimen

Figure 3 — Schematic of test apparatus

5 Suitability of a product for testing

A product having one of the following surface characteristics is suitable for evaluation by this method:

a) an essentially flat exposed surface;

b) a surface irregularity which is evenly distributed over the exposed surface provided that 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 area 155 mm square of the exposed surface;

c) products with profiled surfaces (e.g. ducting, panels, pipes) may also be tested in end-use conditions but it should be recognized that flame spread rates and distances are then not directly comparable to those obtained from essentially flat products.

6 Test specimens

6.1 Exposed surface

The product shall be tested on that face which will normally be exposed in practice, taking account of the following.

a) For asymmetric products where it is possible for either or both of the faces to be exposed in end-use, 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 which may, in practice, 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) If the product is a pile carpet or other surface which is compressible by the flange of the pilot burner, a check shall be made by presenting the specimen to the pilot burner without gas in the test position. If necessary, the flange shall be adjusted so that the distance between the burner tube and the specimen is 25 mm.

6.2 Number and size of specimens

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

6.2.2 The specimens shall be (1 525 ± 25) mm long by (1 025 ± 25) mm wide by their end-use thickness. They shall be representative of the product. The specimens may be constructed from a number of components suitably jointed together. For specimens containing one or more vertical joints, one joint shall be placed at a distance of 250 mm from the left (or hot) edge of the exposed specimen. For specimens containing one or more horizontal joints, one joint shall be placed at a distance of 350 mm from the lower edge of the exposed specimen.

6.2.3 The thickness of specimens of products with irregular surfaces (see 6.1) shall be measured from the highest point of the surface. Products of normal thickness 300 mm or less shall be tested using their full thickness.

6.3 Construction of specimen assemblies

6.3.1 For thin materials or composites used in the fabrication of an assembly, the presence of 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. Whenever possible, the specimen should be assembled in the specimen holder (see 7.4). However, some specimens may be particularly bulky or heavy (e.g. brick wall substrates). In these cases, the specimen may be assembled on the floor, with the exposed surface the usual distance above the floor and the radiant panel presented to the specimen according to the principles shown in Figure 3.

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

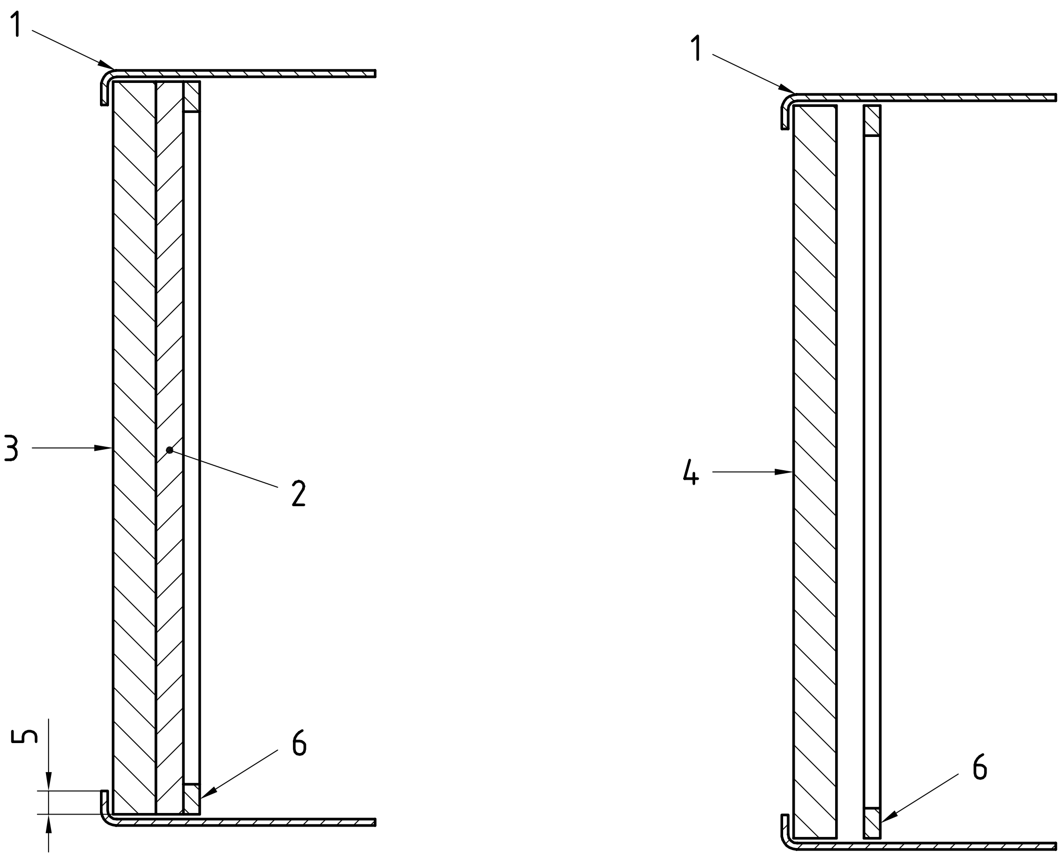
6.3.3 When the product is a material or composite which would normally be attached to a substrate, then it shall be tested in conjunction with the selected substrate (see annex B) using the recommended fixing technique (e.g. bonded with the appropriate adhesive or mechanically fixed). The procedure for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

6.3.4 Where a product will normally be used without an air gap behind it, then after the conditioning procedures specified in 6.4, place the specimen on a backing board and insert both in a specimen holder [see Figure 4a)].

6.3.5 Where a product will normally be used in its end use as a free-standing structural product (such as partitioning, sandwich panels, glazing), insert the specimen alone into a specimen holder [See Figure 4b)].

6.3.6 Where a product will normally be used with an air gap behind it, after the conditioning procedures specified in 6.4, place the specimen over conditioned spacers positioned around its perimeter and mount 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. Place the product on a backing board and insert both in a specimen holder (see Figure 5). Products containing air gaps of <25 mm should preferably be tested under their end-use conditions.

A technique for mounting thin flexible materials is to staple the specimen closely to the backing board.

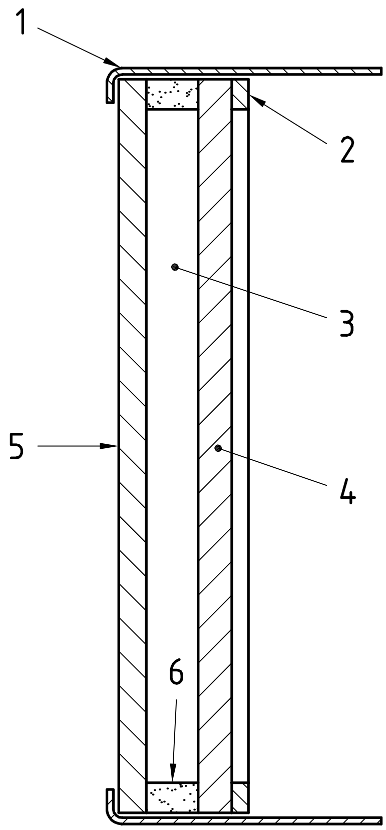


Key

1 Specimen holder
2 Backing board
3 Specimen (which may include a substrate)
4 Specimen
5 Overlap edge of specimen holder
6 Pushing frame

a) With backing board **b) Without substrate or backing board**

Figure 4 — Typical mounting of specimen



Key

1 Specimen holder
2 Pushing frame
3 Air gap
4 Backing board
5 Specimen
6 Spacer

Figure 5 — Typical mounting of specimen with backing board and spacers forming an air gap

6.4 Conditioning

6.4.1 All specimens shall be conditioned before test at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) %, according to one of the following options (see ISO 554).

a) Conditioning for at least 4 days, until constant mass[1)] is achieved.

b) Conditioning for at least 3 weeks. Use of this option is not allowed for wood-based products, cement-based products and gypsum-based products.

c) Conditioning for at least 4 weeks. The final mass and the relative mass difference of two successive weighing operations, carried out (24 ± 2) h and (2 ± 2) h before the test shall be reported.

6.4.2 Backing boards and spacers (see 7.10) shall be dry and maintained for at least 2 days before use under the same conditions as the test specimens (see 6.4.1).

The specimens shall be arranged within the conditioning environment such that air can circulate around each side of each specimen.

1) 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.

6.4.3 The parts that compose a specimen (the product and the backing board on which it is fixed) shall be conditioned separately or as a mounted specimen. Specimens that are glued to the backing board shall be glued before conditioning.

6.4.4 The total test procedure (see clause 10) shall be carried out within 2 h after removal of the specimens from the conditioned environment.

6.5 Reference lines

6.5.1 Mark two lines on the cut specimen to identify the lower and vertical edges of the specimen to be exposed in the vicinity of the radiant panel [see Figure 6a)]. These lines should correspond to the specific overlap edge of the specimen holder.

6.5.2 Mark two additional lines on the surface of the specimen to be exposed, as follows:

a) a horizontal line at 480 mm above the horizontal line drawn in 6.5.1; this will be referred to as the Y0 reference line;

b) a vertical line at 200 mm from the vertical line drawn in 6.5.1; this will be referred to as the X0 reference line.

The intersection of the X0 and Y0 lines will be referred to as the zero point and this location shall be used to set up software for the flame spread monitoring [see Figure 6b)].

6.5.3 Mark additional horizontal lines on the surface to be exposed at heights of 80 mm, 680 mm, 880 mm, 1 080 mm and 1 280 mm above the horizontal line drawn in 6.5.1.

6.5.4 Mark additional vertical lines on the surface to be exposed at distances of 400 mm, 600 mm and 800 mm from the vertical line drawn in 6.5.1 [see Figure 6c)].

Care should be taken to avoid the possibility of the line influencing the performance of the specimen, for example by damaging the surface, or increasing its absorbance.

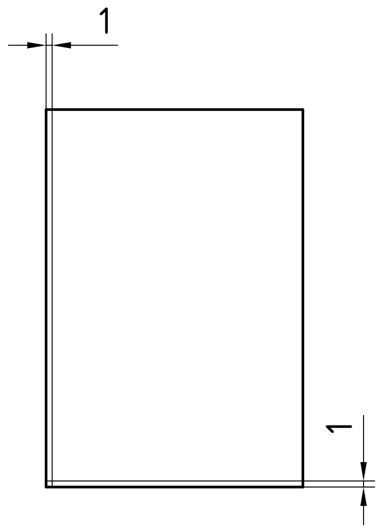
NOTE Some materials discolour on thermal exposure so that the lines and/or marks may be obscured.

6.5.5 Other reference lines (see Figure 15) may be added to allow the flame spread to be recorded by computer data-logging techniques. If flame spread is recorded by use of additional reference lines, an optional thermocouple may be mounted on the lower front edge of the specimen holder and the test data-logging started automatically when this thermocouple measures an increase in temperature of 10 °C (see Figure 16). These methods may also allow vertical and lateral flame spread rates to be calculated (see clause 11). If the test is performed without using any software, then the same level of repeatability and reproducibility as in the interlaboratory test (see annex E) may not be achieved.

6.6 Storage of specimen assemblies

The assemblies of specimen, backing board and spacers prepared as specified in 6.3 shall be stored until required for testing in the conditioning atmosphere specified in 6.4.1.

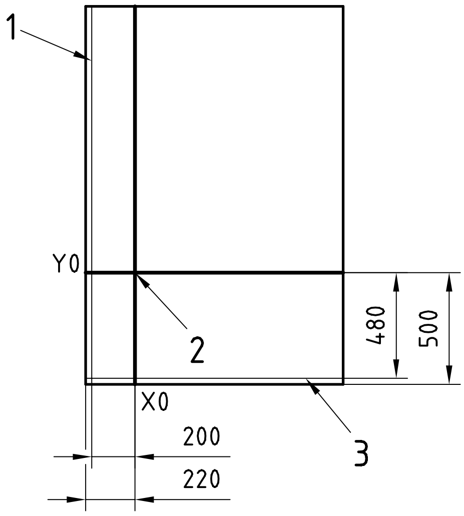
Dimensions in millimetres



Key

1 Overlap edge distance

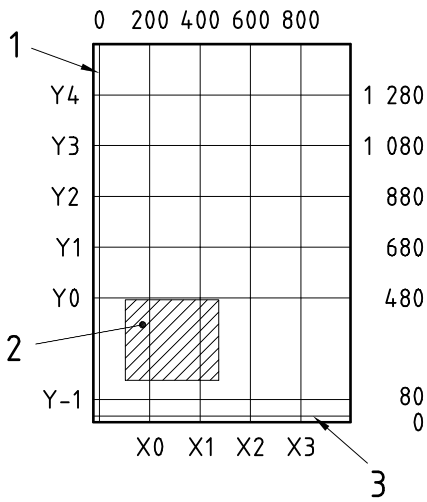
a) Location of areas overlapped by the specimen holder on test specimen



Key

1 Exposed side edge of specimen
2 Zero point
3 Lower exposed edge of specimen

b) Location of zero point on test specimen



Key

1 Exposed side edge of specimen
2 Position of radiant panel
3 Lower exposed edge of specimen

c) Location of reference lines on test specimen

Figure 6 — Location of zero point and reference lines

7 Test apparatus

The test apparatus consists of four main components: a radiant panel, support frame and a specimen support trolley assembly, which allows the test specimen to be brought into the required configuration in relation to the radiant panel, the specimen holder and a pilot flame burner.

7.1 Radiant panel support framework, providing the support for the radiant panel, together with the necessary pipework for air and gas, safety devices, regulators and flowmeters.

7.1.1 Radiant panel support, supporting the radiant panel, with its lower edge at least 500 mm above floor level to ensure free ventilated test conditions.

The radiating face of the panel shall be vertical and the angle between the face of the panel and the front face of the specimen shall be (35 ± 3)°.

7.1.2 Radiant panel, consisting of an assembly of porous refractory tiles mounted at the front of a stainless-steel plenum chamber to provide a flat radiating surface of dimensions (480 ± 5) mm by (280 ± 5) mm.

The plenum chamber shall contain baffle plates and diffusers to distribute the gas/air mixture evenly over the radiating surface.

A wire screen fixed immediately in front of the radiating face of the panel has been found to increase the irradiance and to protect the panel from falling debris. A typical wire screen may be made from 3 mm diameter stainless-steel rods with overall dimensions of 500 mm by 285 mm; 20 horizontally orientated, equally spaced rods may be welded at all contacts with four vertically orientated cross-rods. Screen support brackets mounted to the sides of the plenum chamber allow the screen to be held about 15 mm from the face of the radiant panel.

7.2 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 flowmeters. 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) a supply of natural gas, methane or propane with a flow rate of at least 0,3 l s^{-1} at a pressure sufficient to overcome the friction losses through the supply lines, regulators, control valve, flow meters, radiant panel, etc.;

b) an air supply with a flow rate of at least 5 l s^{-1} at a pressure sufficient to overcome the friction losses through the supply lines, etc.;

c) separate isolation valves for gas and air;

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

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

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

g) a flowmeter for natural gas, methane or propane suitable for indicating flows of 0,3 l s^{-1} to 1,5 l s^{-1} at ambient temperature and pressure to a resolution of 1 % or better;

NOTE 1 This is used to assist in setting the gas flow to a value which gives a suitable panel temperature. An absolute calibration of the flowmeter is unnecessary. Flow rates for the various fuel gases will be different to achieve the required black body temperature and heat flux distribution on the surface of the test specimen.

h) a flowmeter for air suitable for indicating flows of 1 l s^{-1} to 12 l s^{-1} at ambient temperature and pressure to a resolution of 1 % or better. An absolute calibration is unnecessary.

NOTE 2 All the above items can normally be accommodated within and supported from a tubular steel framework located remote from the radiant panel.

7.3 Specimen support trolley, incorporating the trolley and the guide rail which locate the specimen holder at the required position of test in relation to the radiant panel and the pilot flame burner.

The trolley shall allow the specimen holder to be readily moved towards the radiant panel to the required angle of orientation (see 7.1.1 and Figure 7). The trolley shall also have a debris collection tray fixed below the lower edge of the specimen holder (see Figure 7).

The specimen holder transport system may be manually or automatically operated to achieve the requirements of 7.1.1. Movement of the trolley shall be consistently achieved to the required tolerances by means of a guide rail (see Figure 7).

7.4 Specimen holder, typically made from (2 ± 0,5) mm thick stainless steel to the dimensions given in Figure 8 so that the exposed surface of the specimen shall be (1 475 ± 25) mm high by (975 ± 25) mm wide.

It shall be provided with quick-action bolts or clamps to retain the test specimen in position and press it against the front flanges. Tapered fittings which locate into sockets on the trolley shall be used to mount the specimen holder.

The number of specimen holders required will depend upon the amount of testing envisaged. For specimens thicker than 200 mm, an additional specimen holder and wider debris tray will be required. The debris tray should extend 100 mm in front of the specimen base (see Figure 13).

7.5 Pilot flame burner, comprising a (160 ± 5) mm length of stainless steel tube with (10 ± 1) mm internal diameter and (12 ± 1) mm external diameter, having 15 evenly spaced 1 mm diameter holes drilled radially along the centreline (see Figure 9). The gas supply pipe connecting with the T-section of the pilot burner shall be made from continuous stainless steel tubing with a minimum wall thickness of 2 mm. In operation the propane flow shall be adjusted to about 0,6 l min^{-1} flow rate (see 9.3). The gas used in the test shall be commercial grade propane having a heating value of approximately 83 $MJ{\cdot}m^{-3}$.

The pilot burner shall be mounted so that its position relative to the face of the test specimen is in line with the top of the radiant panel as shown in Figure 3. The distance between the burner tube and the face of the specimen shall be (25 ± 1) mm (see Figure 10).

It is important to keep the holes in the pilot burner clean. A soft wire brush has been found suitable to remove surface contaminants. Nickel-chromium or stainless steel wire, 0,5 mm outside diameter, is suitable for opening the holes.

The attainment of a satisfactory gas flow to the pilot burner should be done with a dummy specimen in the test position (see 7.13, 9.3 and Figure 10).

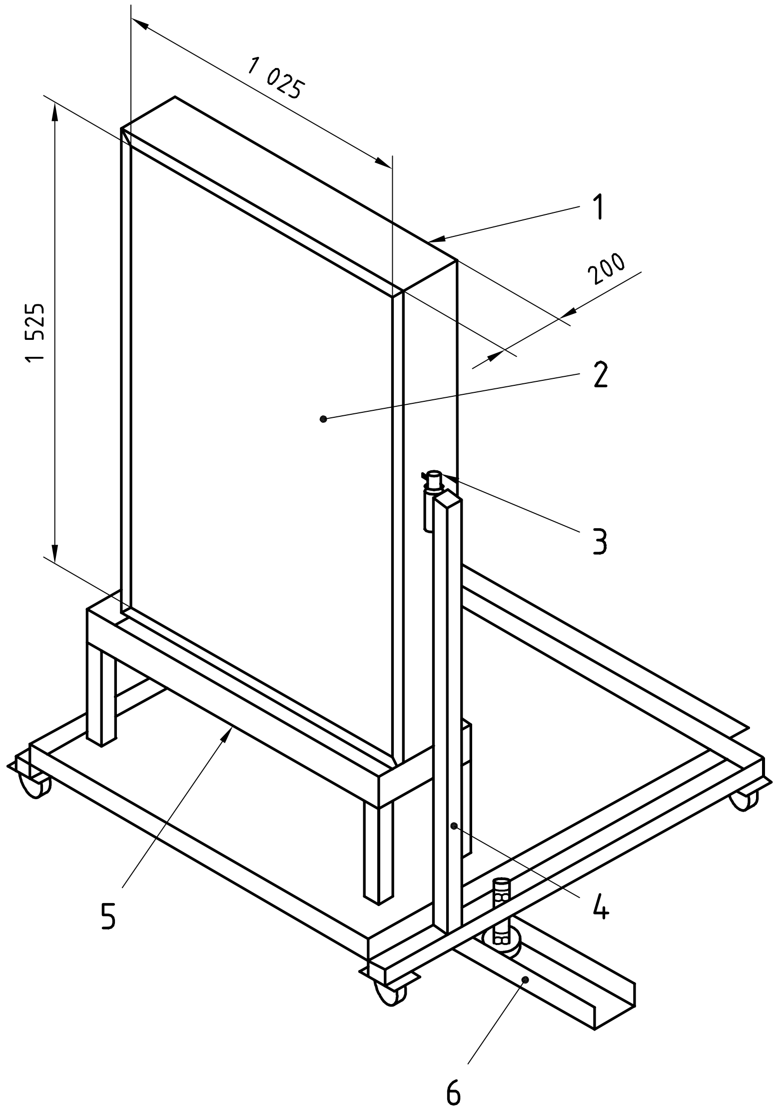
For specimens which are readily compressible by the weight of the pilot flame burner (e.g. high pile carpets), it may be necessary to carry out a dummy run with no flames on the burner so that the 25 mm separation between the pilot burner tube and the surface of the specimen can be achieved by adjustment of the flanges on the burner [see Figures 9b) and 9c)].

7.6 Heat flux meters

At least two heat flux meters of the Schmidt-Boelter (thermopile) type with a nominal range of 0 $kW{\cdot}m^{-2}$ to 50 $kW{\cdot}m^{-2}$ and a time constant of not more than 3 s (corresponding to a time to reach 95 % of final output of not more than 10 s) shall be provided, one to form a working instrument and one to be retained as a reference standard.

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

Dimensions in millimetres

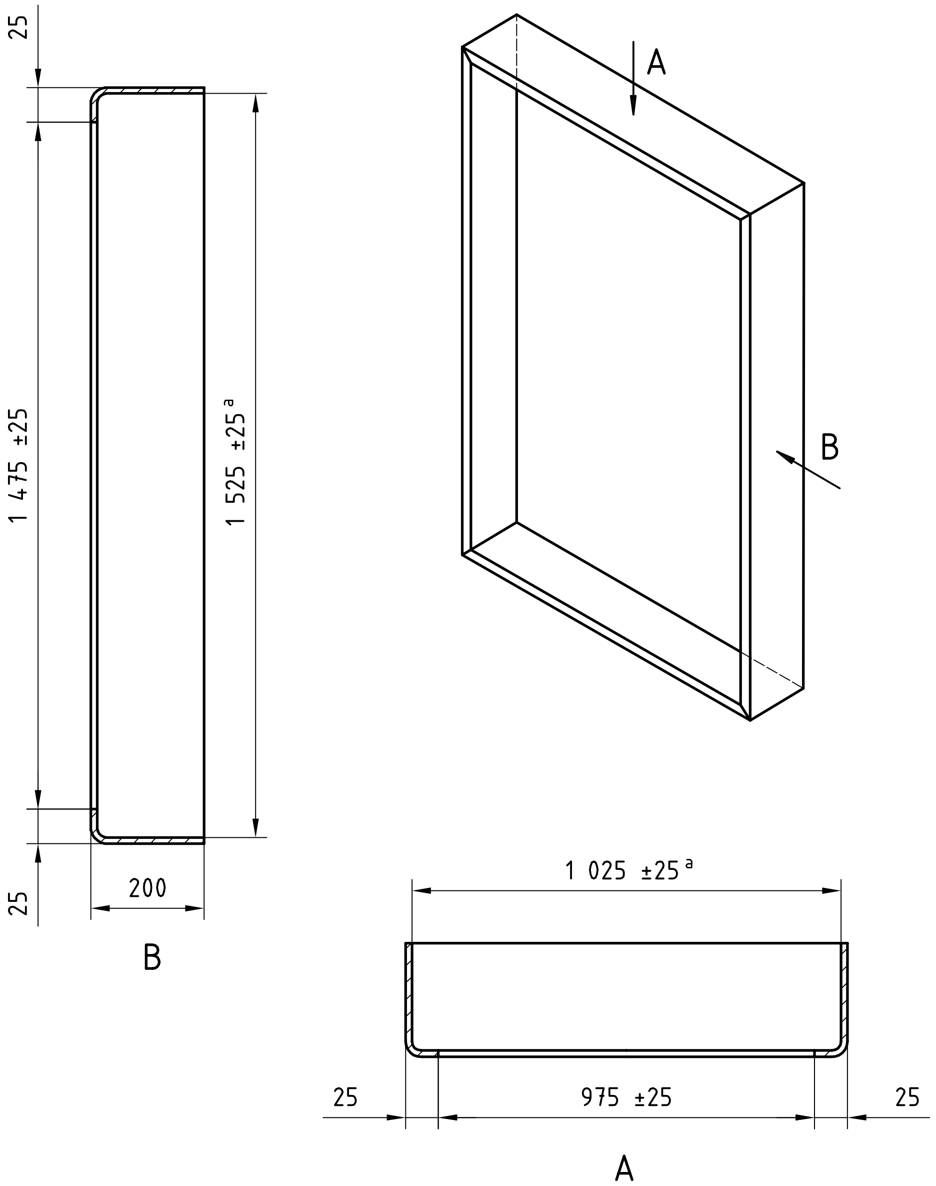


Key

1 Specimen holder
2 Test specimen
3 Tapered fitting on each side of specimen holder (locates with sockets on trolley framework)
4 Trolley framework supporting specimen holder
5 Debris collection tray
6 Guide rail

Figure 7 — Typical specimen holder and trolley assembly

Dimensions in millimetres

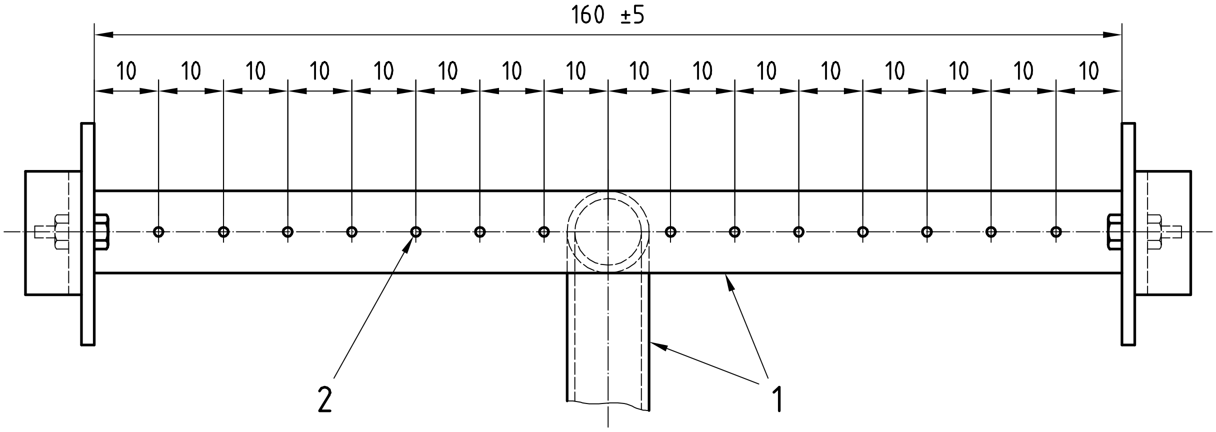


Key

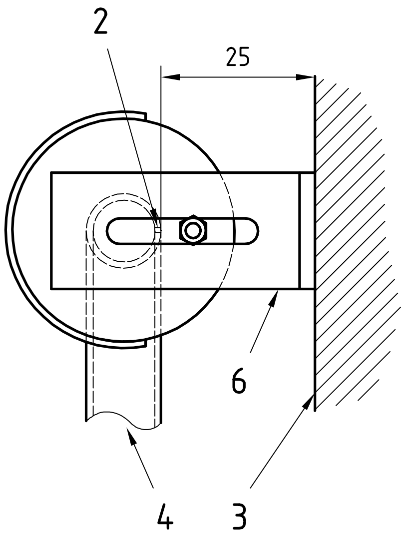
a Internal

Figure 8 — Typical specimen holder

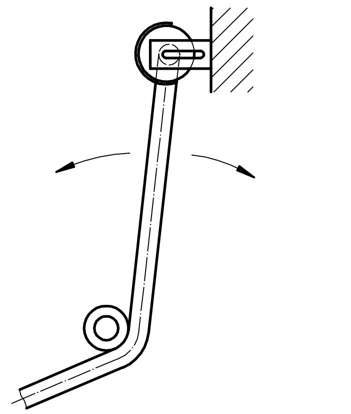
Dimensions in millimetres



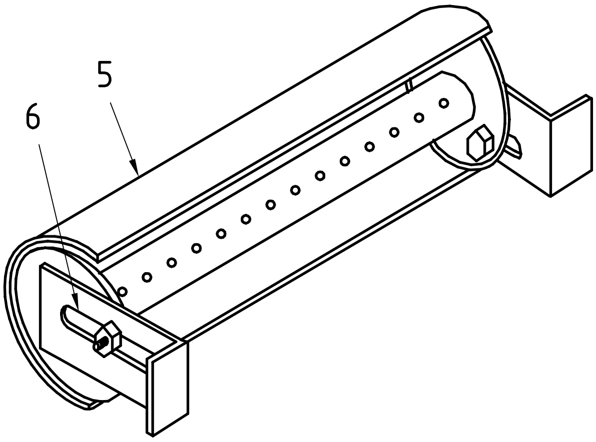
a) Hole separations on burner tube (front view with draught screen omitted)



b) Burner position to specimen surface [side view on a)]



c) Moving pilot flame



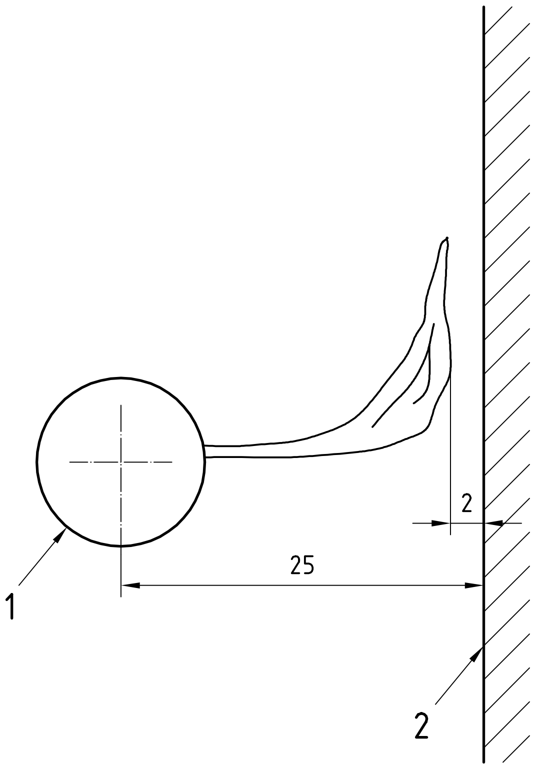
d) General arrangement of pilot flame burner

Key

1 Steel tube, 12 mm OD, 10 mm ID
2 15 1-mm holes
3 Specimen surface
4 Propane supply
5 Draught screen
6 Adjustable flange

Figure 9 — Pilot flame burner

Dimensions in millimetres



Key

1 Pilot burner tube
2 Front surface of specimen

Figure 10 — Position of non-impinging pilot burner flame to specimen

The target sensing radiator shall be flat, shall occupy an area not more than 10 mm diameter, and shall be coated with a durable matt black finish. It shall be contained within a water-cooled body[2)] whose front face shall be flat, circular, 25 mm in diameter and coincident with the plane of the receiving face and the target. The whole front of the water-cooled body shall be highly polished. Radiation shall not pass through a window before reaching the target. The temperature of the cooling water should be controlled so that the heat flux meter body temperature remains within a few degrees of room temperature to prevent condensation on the surface.

If heat flux meters of diameter smaller 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 end 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, insensitive to draughts and stable in calibration. They shall have an accuracy of within (± 3) % and a repeatability within (± 0,5) %.

The calibration of the working heat flux meter shall be checked every 2 months by comparison with the reference standard heat flux meter (see annex C), which shall be kept securely and not used for any other purpose.

7.7 Recorder

The output from the heat flux meter(s) shall be recorded by any 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 heat flux meter chosen. The effective operating temperature of the radiant panel would not normally exceed 900 °C.

A small digital millivoltmeter capable of indicating signal changes of 10 μV or less will also be found convenient for monitoring changes in operating conditions of the radiant panel.

7.8 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 comprise a strip chart recorder with paper speed of at least 5 mm s^{-1}.

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.

7.9 Calibration board and support trolley

The calibration board shall be made of non-combustible board (e.g. calcium silicate board) of dimensions (1 025 ± 25) mm by (650 ± 5) mm by (11 ± 2) mm thick and of oven-dry density (750 ± 100) kg·m^{-3}. The calibration board shall be provided with five 25 mm diameter holes at the positions given in Figure 11 to accommodate a heat flux meter for measuring the irradiance in the plane corresponding to the exposed surface of a specimen under test. The five holes in the calibration board shall align with the centre line of the radiant panel (e.g. they would be positioned 640 mm above floor-level in the arrangement shown in Figure 3). 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 which are not occupied by a heat flux meter shall be filled with removable plugs of the same material as the calibration board.

2) Water cooling of the heat flux meter is required to standardize and define the measurement and 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 recalibration are possible.

Dimensions in millimetres

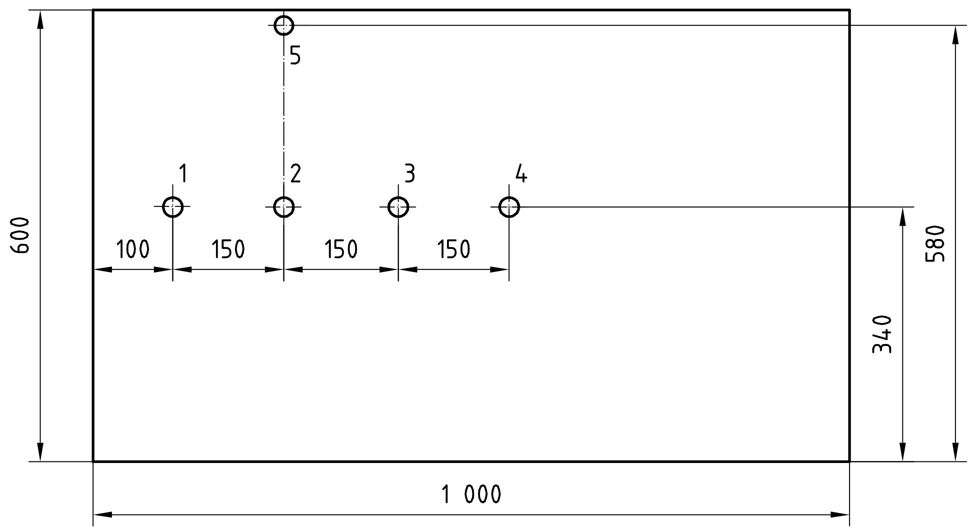


Figure 11 — Positions of heat flux meter in exposed area of calibration board

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 dummy specimen holder (see Figure 12) and located on a specimen support trolley (see 7.13).

7.10 Backing boards and spacers

Backing boards shall be cut from non-combustible board (e.g. calcium silicate board) (11 ± 2) mm thick with the same dimensions as the test specimen and an oven-dry density of (750 ± 100) kg m^{-3} (see ISO/TR 14697). Spacers used to create the air gap specified in 6.3.6 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 they are not contaminated by combustible residues. Immediately before re-use, however, they shall have been conditioned in the atmosphere specified in 6.4.1. 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 (60 ± 5) °C for a period of 2 h in an attempt to remove any volatile residue. If there is still any doubt about the condition, it shall be discarded.

7.11 Video camera

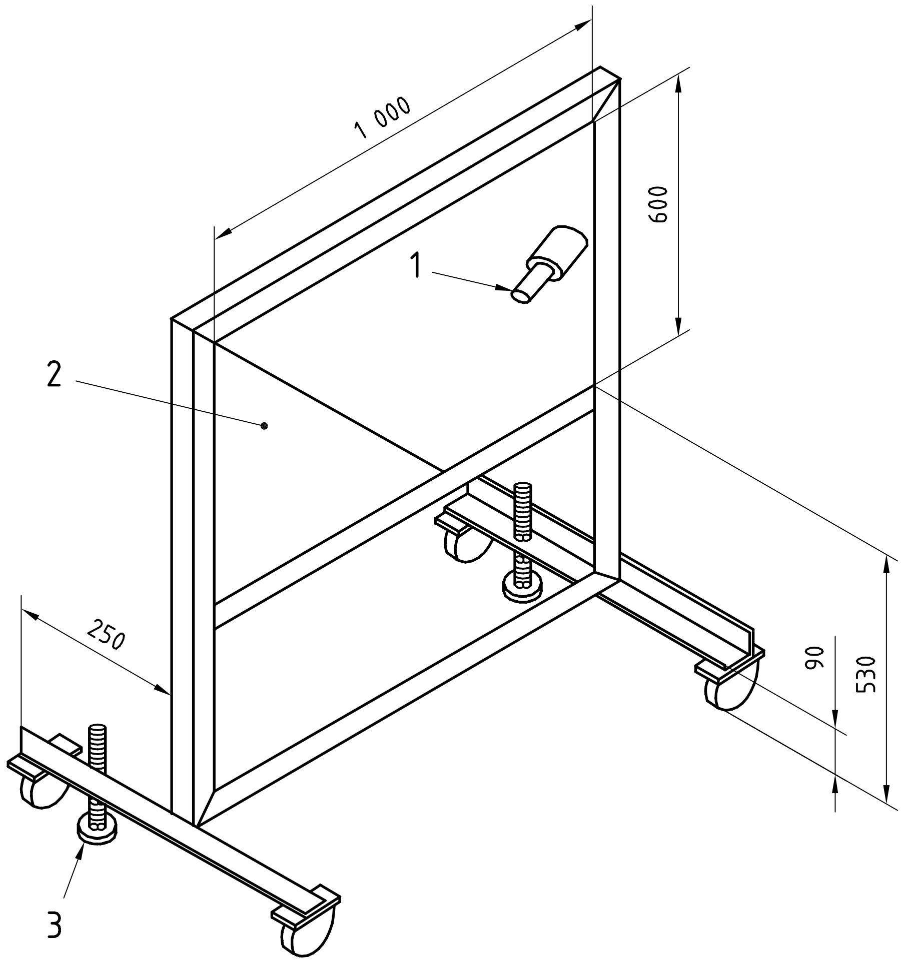
A video camera, placed at a location [see 9.1 e)] to provide a clear view of the whole test specimen, along with an appropriate video recording device shall be used.

7.12 Pyrometer

A radiation pyrometer with a range of 700 °C to 850 °C (black body temperature) and an accuracy of ± 5 °C suitable for viewing a circular area (30 ± 5) mm in diameter at a distance of about 750 mm shall be used to control the thermal output of the radiant panel. The sensitivity of the pyrometer shall be substantially constant between the wave lengths of 1 mm and 9 mm.

The pyrometer may be positioned on the dummy specimen trolley (see 7.13 and Figure 12) for convenience of operations.

Dimensions in millimetres



Key

1 Pyrometer

2 Dummy specimen mounted from rear

3 Bearings for guide rail

Figure 12 — Typical dummy specimen trolley

7.13 Dummy specimen and support trolley

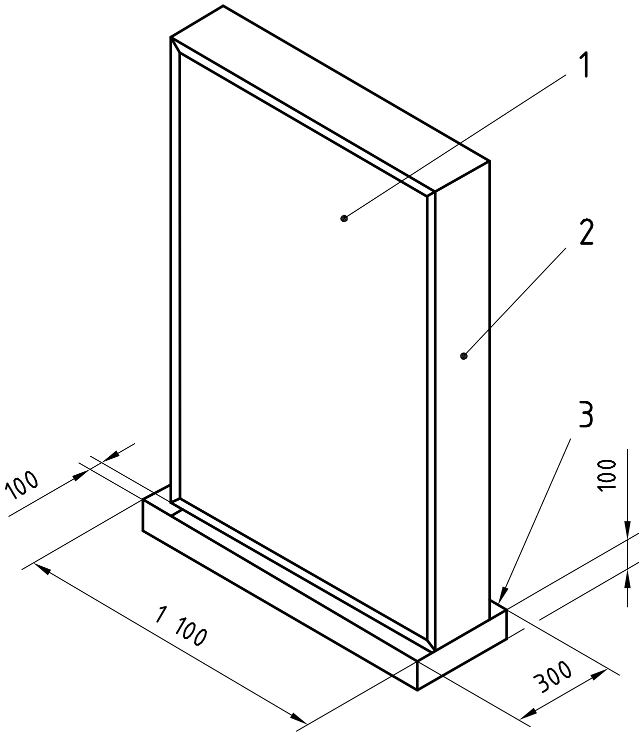
The dummy specimen shall be cut from a non-combustible board (e.g. calcium silicate board) of oven-dry density (950 ± 100) kg·m^{-3}, and shall measure (1 025 ± 25) mm wide, (650 ± 5) mm high and (25 ± 2) mm thick. Thinner non-combustible boards of the same density can also be used if they are fixed together to make a (25 ± 2) mm board without any noticeable gap. The dummy specimen shall remain in the specimen position for 10 min prior to operation of the equipment and shall be removed only when a test specimen is to be inserted in front of the radiant panel.

The dummy specimen may be mounted on a support trolley (see Figure 12) in a similar manner to the calibration board.

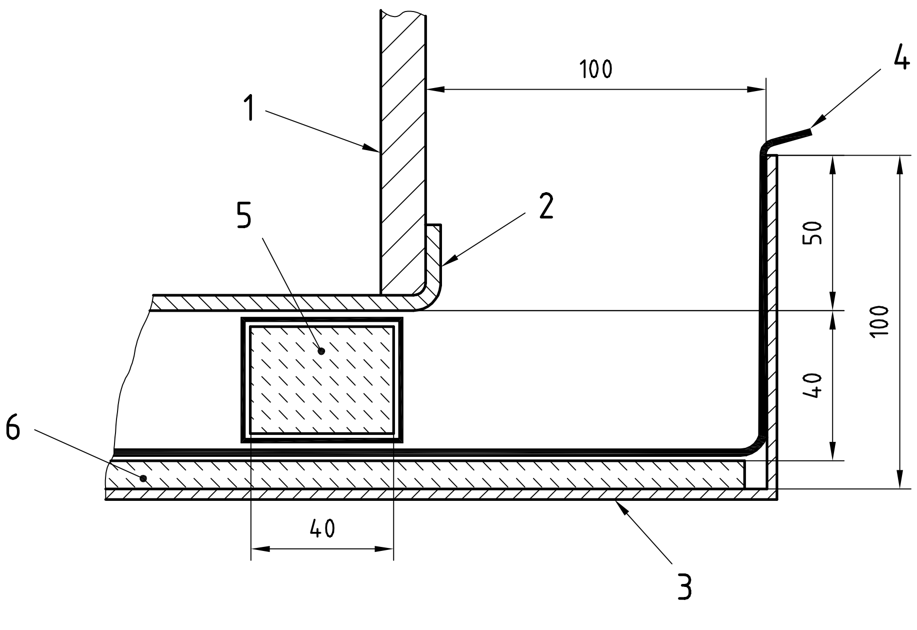
7.14 Debris collection tray

A 1 mm thick steel tray of dimensions (1 100 ± 5) mm long by (300 ± 5) mm wide by (100 ± 5) mm deep shall be fixed to the specimen support trolley (see Figures 7 and 13) so that the base of the tray is 50 mm below the bottom edge of the specimen holder. The tray shall contain 10 mm calcium silicate board lined with aluminium foil and with a strip of 40 mm thick by 40 mm by 1 095 mm calcium silicate board wrapped in aluminium foil [see Figure 13b)].

Dimensions in millimetres



a) General arrangement



b) Position of debris collection tray and showing lining to tray

Key

1 Specimen
2 Specimen holder
3 Debris collection tray
4 Aluminium foil
5 Calcium silicate board wrapped in aluminium foil
6 Calcium silicate board

Figure 13 — Debris collection tray

8 Test enclosure

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

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

8.3 Measurements shall be taken of air speeds near a dummy specimen while the fume exhaust system 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 point of the specimen shall not exceed 0,3 $m \cdot s^{-1}$ in any direction, when measured at a distance of 100 mm from the specimen.

8.4 To ensure safety of operators, the exhaust flow rate shall be 0,3 $m^3 \cdot s^{-1}$ to remove smoke and fumes from the test enclosure (see A.2).

9 Setting-up and calibration procedure

9.1 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 11).

The initial position of the refractory surface of the radiant panel with respect to the specimen shall correspond with the dimensions shown in Figure 3.

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

a) Set an air flow rate of about 5 $l \cdot s^{-1}$ through the panel. Turn on the gas supply, light the radiant panel and allow it to come to thermal equilibrium as indicated by steady temperatures measure by the pyrometer.

   When operating correctly there should be 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 will be observed. An oblique view of the panel after a 15 min warm-up period should show 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 corresponds to the values shown in Table 1 for positions 1 and 2. If necessary, make small changes in airflow rate to achieve no significant flaming, e.g. less than 20 mm flame length from the panel surface. After making each adjustment allow the calibration board to reach temperature equilibrium before measuring the radiant heat flux.

c) Once the values shown for positions 1 and 2 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.

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

e) Position the video camera at a distance of approximately 3 m in front of the test specimen so that the full area of the specimen will be in focus without moving the camera during the test. Check that all the reference lines on the test specimen can be clearly seen on the video-recorder.

Table 1 — Heat flux along the calibration board

Position (see Figure 11)	**Heat flux** $kW \cdot m^{-2}$	**Tolerance on heat flux** $kW \cdot m^{-2}$
1	25	± 3
2	40	± 3
3	25	± 3
4	15	± 3
5	13	± 3

9.2 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 1 and 2 (see Figure 11).

b) Monthly verification: measure the heat flux at positions 1, 2, 3, 4 and 5 (see Figure 11).

9.3 Adjustment of the pilot flame

Check that the spacing of the pilot burner nozzles from a dummy non-combustible specimen surface is (25 ± 1) mm.

Adjustment of the spacing may be done by inserting a dummy specimen cut from a non-combustible board (e.g. calcium silicate board) of oven-dry density (950 ± 100) $kg \cdot m^{-3}$ into a specimen holder or by using the dummy specimen trolley (see Figure 12).

Adjust the propane supply so that the flames along the burner tube are about 2 mm separated from the surface of the dummy specimen and note the propane flow rate. Check the adjustment of the pilot flames at least every day.

For readily compressible materials such as high-pile carpets [see 6.1 d)], the flange spacers on the pilot burner may need to be adjusted to leave a gap of about 25 mm between the surface of the specimen and the burner tube. This adjustment shall be done with the specimen in the test position, with no propane supply to the burner. The propane flow rate required is about 0,6 $l \cdot min^{-1}$ (see 7.5).

10 Test procedure

10.1 Mount the specimen in a specimen holder located on the support trolley, locate the debris collection tray (see 7.14) and start the fume exhaust system.

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

10.3 When the radiant panel has attained thermal equilibrium (see 9.1), light the pilot burner with the normal flow rate of propane to it.

10.4 Move the specimen support trolley smoothly at about 1,5 $m \cdot s^{-1}$ into the test position (see Figure 3) and operate the pilot flame burner to bring it immediately towards the surface of the specimen. Immediately start the clock, the chronograph and the video camera clock.

10.5 Record the ignition time of the specimen as the time to sustained flaming (see 3.16) and record any other flaming effects, such as transitory flaming (see 3.17) and formation of flaming drips or debris, and whether any flaming debris continues to burn after its collection in the debris tray.

10.6 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.

10.7 Operate the event marker of the chronograph to indicate the time of arrival of any sustained flame (see 3.16), either by vertical or lateral spread, at the reference lines on the specimen surface [see Figure 6c)] and the edges of the specimen.

10.8 Maintain the pilot flame for the duration of the test.

10.9 Withdraw the specimen trolley if

a) the specimen fails to ignite after a 20 min exposure, or

b) flame ceases to spread along the specimen and goes out and no further flaming of any type ensues within the next 5 min, or

c) the specimen has been totally consumed, or

d) 30 min have elapsed since the start of the test and flaming is still observable.

10.10 If the specimen is still showing signs of combustion (e.g. flaming or glowing), extinguish this combustion carefully using a hand-held water-spray after a further 30 min have elapsed since withdrawal of the specimen trolley.

Care should be taken not to spray water onto electrical components or onto the radiant panel.

Record the burned area and type of damage to the specimen both photographically and with a detailed sketch (see Figure 14 and 3.3 and 3.5).

When the term “damaged area” is used, specify the types of damage observed.

Discolourations, soot and changes in structure such as distortions, sintering, curling of the edge area, formation of bubbles etc., are not taken into consideration. For specimens with protective intumescing agents or layers, changes in these intumescents as a result of carbonisation are not taken into account. To determine a residual undamaged length of a protected building material (see Figure 14), the protective layers are removed (e.g. by scratching or washing off).

10.11 Repeat operations specified in 10.1 and 10.4 to 10.11 for two additional specimens, allowing the radiant panel to attain temperature equilibrium before each test.

10.12 Careful observation shall be made of the behaviour of the specimen and a special note shall be made of the following phenomena:

a) flashing;

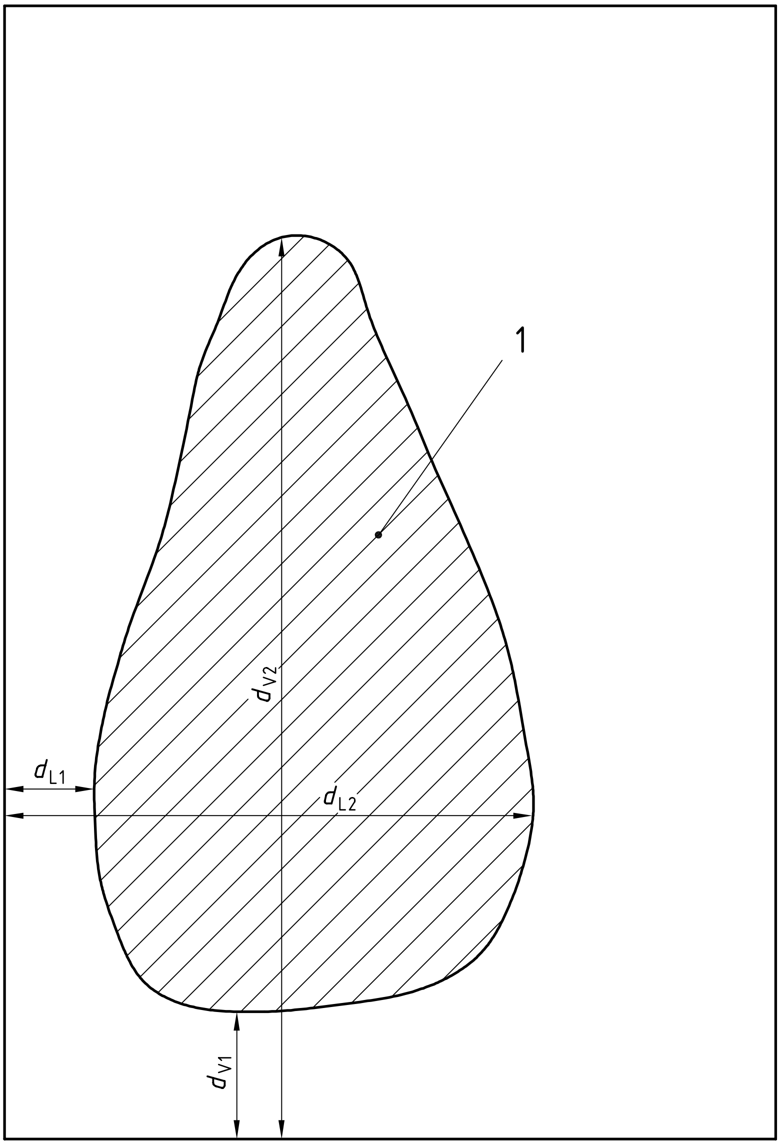
b) transitory flaming (unstable flame front);

c) smouldering;

d) glowing sustained for periods of more than 4 s.

Observations shall also be made of other phenomena such as debris falling away from the specimen and whether or not it is flaming or glowing as defined by a duration of 4 s, intumescence and/or deformation of the specimen, separations, spalling, fissures and cracks, sparks, melting, changes in form, etc. Debris may contain drips or droplets; if these are flaming, observe the duration of flaming.

Guidelines on the reporting of unusual behaviour are given in annex D.



Key

1 Burned area

Maximum vertical burned length = $d_{V2} - d_{V1}$

Maximum lateral burned length = $d_{L2} - d_{L1}$

Figure 14 — Damage measurements to be taken on all specimens

11 Derived flame spread characteristics (optional)

11.1 General

Determine average flame spread rates (vertical and lateral) according to the appropriate method as indicated below where the flame spread distances are measured from the X0 and Y0 reference lines:

11.2 Method 1

Where the specimen burns for more than 180 s:

$$R_V = \frac{d}{180}$$

$$R_L = \frac{d}{180}$$

where

R_V is the vertical burning rate, in millimetres per second (mm·s^{-1});

R_L is the lateral burning rate, in millimetres per second (mm·s^{-1});

d is the distance, in millimetres (mm), burned in the time from ignition to 180 s.

11.3 Method 2a)

Where the specimen burns to the Y4 reference line before 180 s,

$$R_V = \frac{800}{t_V - t_{ig}}$$

where

R_V is the vertical burning rate, in millimetres per second (mm·s^{-1});

t_V is the time, in seconds (s), for the flame front to reach the 800 mm reference line;

t_{ig} is the ignition time, in seconds (s).

11.4 Method 2b)

Where the specimen burns to the X3 reference line before 180 s:

$$R_L = \frac{600}{t_L - t_{ig}}$$

where

R_L is the lateral burning rate, in millimetres per second (mm·s^{-1});

t_L is the time, in seconds (s), for the flame front to reach the 600 mm reference line;

t_{ig} is the ignition time, in seconds (s).

11.5 Method 3

Where the maximum distance reached is less than the distance to the Y4 or X3 reference line of the specimen in under 180 s:

$$R_V = \frac{d_{V,max}}{t_{V,max} - t_{ig}}$$

where

R_V is the vertical burning rate in millimetres per second (mm·s^{-1});

$d_{V,max}$ is the distance, in millimetres (mm), of the furthest Y reference line reached by the flame front;

$t_{V,max}$ is the time, in seconds (s), for the flame front to reach the furthest Y reference line;

t_{ig} is the ignition time, in seconds (s).

$$R_L = \frac{d_{L,max}}{t_{L,max} - t_{ig}}$$

where

R_L is the lateral rate, in millimetres per second (mm·s^{-1});

$d_{L,max}$ is the distance, in millimetres (mm), of the furthest X reference line reached by the flame front;

$t_{L,max}$ is the time, in seconds (s), for the flame front to reach the furthest X reference line;

t_{ig} is the ignition time, in seconds (s).

12 Precision

The variability in the ignition time and flame spread measurements during tests has been investigated in an inter-laboratory trial (see annex E).

13 Test report

The test report shall include the following information:

a) reference to this international standard;

b) name and address of testing laboratory;

c) name and address of sponsor;

d) name and address of manufacturer/supplier;

e) a 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 which have been painted or varnished, the quantity and number of coats applied shall be recorded as well as the nature of the supporting materials; in the case of products with profiled surfaces, a diagram of the test specimen shall be included (see clause 5);

f) substrate used, and method of fixing the specimen onto the substrate;

g) data from the test including:

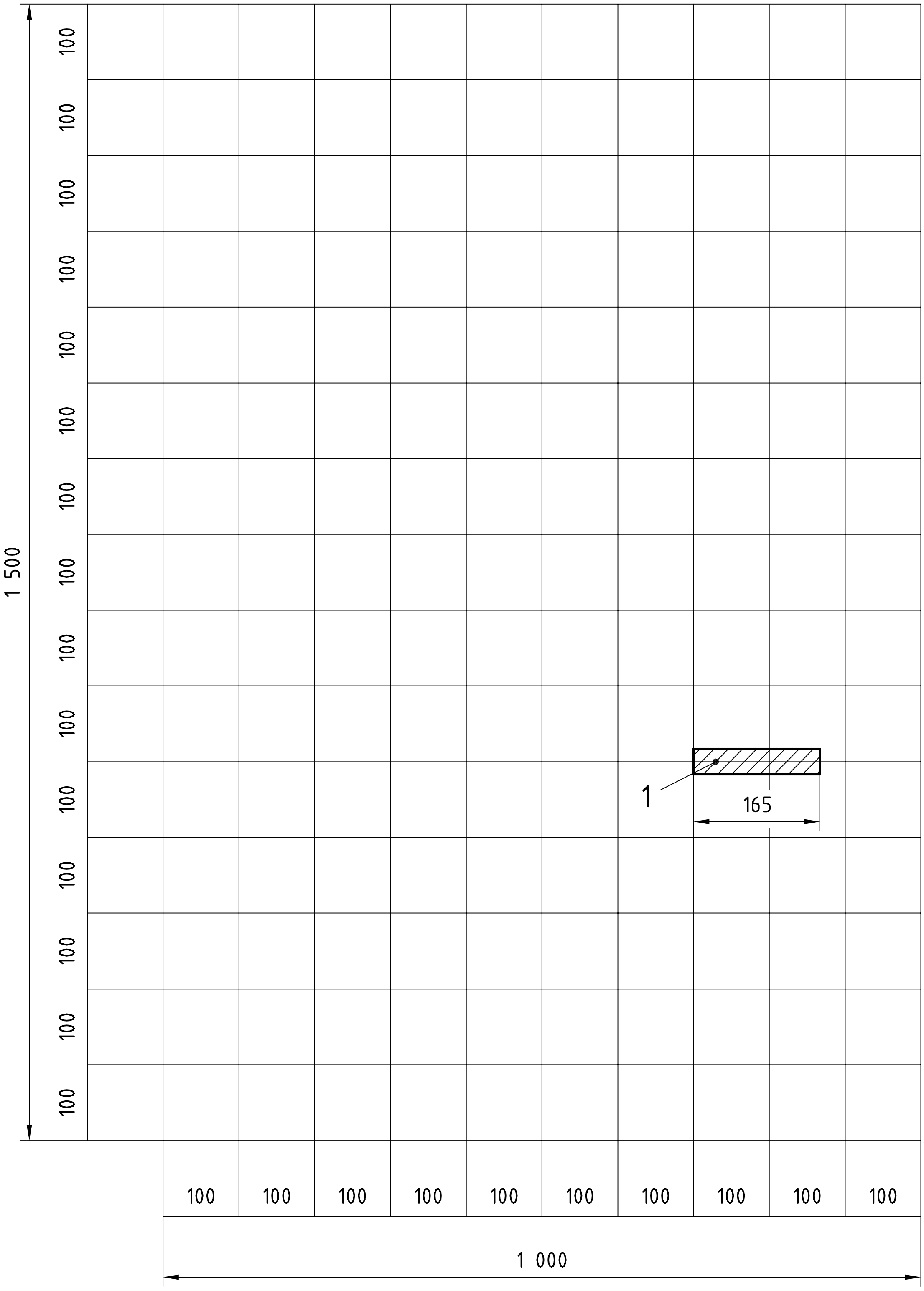
- number of specimens tested;
- duration of each test (10.9);
- time of ignition (10.5);
- observations of the movement of the flame front at the reference lines and edges of the specimen recorded in accordance with 10.7;

  NOTE The video record of the test may be used by the testing laboratory to verify the times of the flame front at the reference lines. The video film is not regarded as a mandatory part of the test report; it may be retained optionally as a further record of any unusual behaviour (see annex D).

- other observations of the behaviour of the product (see 10.12);
- derived flame spread characteristics as described in clause 11 (optional);
- a burned area and damage sketch together with photographs (see 10.12);

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

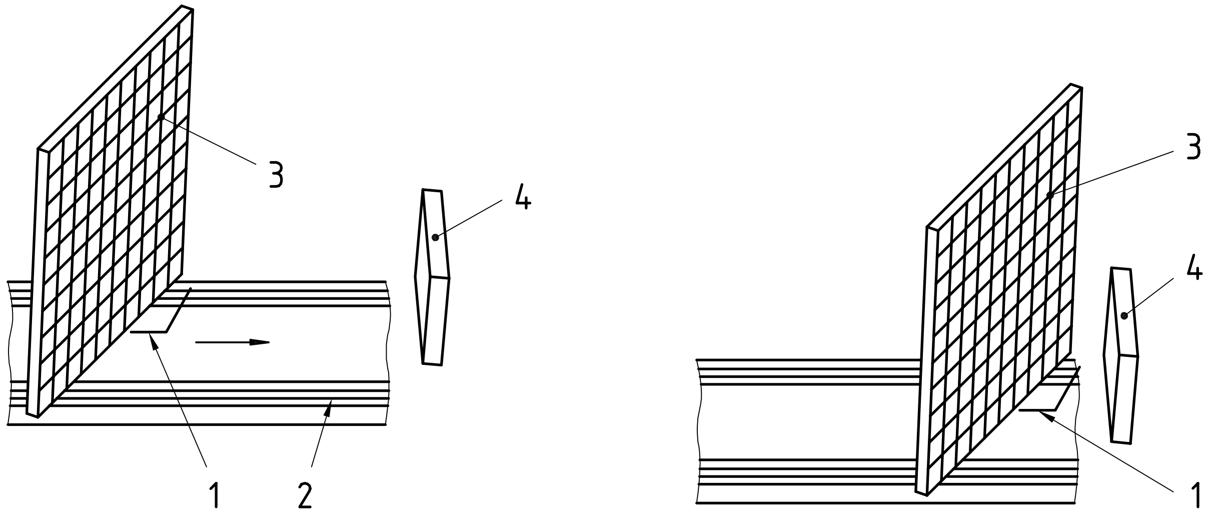
Values in millimetres



Key

1 Position of pilot flame

Figure 15 — Reference lines on specimen (optional)



a) Specimen advance to radiant panel

b) Test position

Key

1 Start temperature thermocouple
2 Guide rails
3 Specimen
4 Radiant panel

Figure 16 — Schematic of test showing use of optional thermocouple to initiate software for start of test

Annex A
(normative)

Safety precautions

A.1 Ignition hazards

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

A.2 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. More toxic products may in many instances be produced. It is important that precautions be taken to avoid exposure to these fumes.

A.3 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 eye protection shall be used by the operator.

Annex B
(normative)

Specimen construction

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

With thin materials or composites, particularly those with a high thermal conductivity, the presence of an air gap and the nature of any underlying construction may significantly affect the ignition and spread of flame performance of the exposed surface. Increasing the thermal capacity of the underlying construction increases the "heat sink" effect and may delay ignition of the exposed surface and slow flame spread. Any backing provided to the test specimen and in intimate contact with it, such as the non-combustible spacers (see 7.10), may alter this "heat sink" effect and may 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), then 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, then an air space should be provided at the back of the product by spacers of non-combustible insulation board (see 6.3.6).

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

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

The advice on selection of substrates given in ISO/TR 14697 should also be followed.

Annex C
(informative)

Calibration of the working heat flux meter

The inter-comparison of instruments specified in 7.6 may be made using the test apparatus with each instrument mounted in turn in a calibration board at the standard positions (1 and 2) care being taken to allow the whole apparatus and calibration boards to attain thermal equilibrium (see ISO 14934-1). Alternatively a specially built comparison apparatus may be used (see BS 6809).

The use of two reference standard instruments provides more of a safeguard against change in sensitivity of the reference instrument, as explained in detail in appendix E of BS 6809:1987. One of the reference standard instruments shall be fully calibrated at a standardizing laboratory at yearly intervals.

Annex D
(normative)

Interpretation of results of this test procedure

The objective of this annex is to provide information on the uniform interpretation of results of the fire test procedure.

	Unusual behaviour	Method for reporting
1	Flashing or transitory flaming, no steady flame	Report furthest progress of flame and time
2	Explosive spalling, no flashing or flame	Report severity of spalling
3	Rapid flash or transitory flame over surface, later steady flame progress	Report result for both flame fronts
4	Specimen or surface-coating melts and drips off, no flame	Report behaviour and extend of damage on specimen
5	Explosive spalling, and flame on exposed part of specimen	Report explosions and flame progress
6	Specimen or surface-coating melts, burns and drips off	Report flame front and extent of damage. Also report whether flaming drips were observed
7	Pilot flame extinguished	Report occurrence and repeat test
8	Very short ignition delay which could be caused by protrusion of specimen above holder surface, reducing space to pilot flame	Report behaviour (see 10.12)
9	Specimen breaks up, and falls out of holder	Report behaviour
10	Sudden release of combustible pyrolysis gases from specimen, adhesive or bonding agents	Report behaviour
11	Small flame remaining along the edge of specimen	Report behaviour and terminate the test after 30 min [see 10.9 d)]
12	Flaming of specimen in discrete areas	Report extent and position of flaming
13	Specimens with air-gaps (see Figure 5) form flaming debris or drips, which fall behind specimen inside air-gap into spacer.	Report behaviour and observe if debris continues to burn inside the air-gap

Annex E
(informative)

Variability in the ignitability and flame spread measured in an interlaboratory test

The precision of the method specified in this part of ISO 5658 was examined in an interlaboratory trial in 1997. Eleven laboratories from eight countries participated, which involved the testing of 16 products. Each product was tested with six replicate specimens. The flame spread results were recorded using special software, which allowed the recording of flame spread into 100 mm by 100 mm zones drawn as a grid over the whole of the exposed specimen (see 5.5).

The test results were analysed according to ISO 5725:1994. The essential repeatability and reproducibility values for qualifying a test procedure are the coefficients of variation of repeatability and reproducibility, expressed as percentages (see Table E.1).

The values for the coefficient of variation are shown in Table E.2 for the means of time to ignition and area of flame spread. The ranges of variations for both parameters are summarized in Table E.1.

Table E.1 — Summary of variability of parameters

Parameter	Coefficient of variation (CV)	Range %	Average %
Time to ignition	repeatability	12 to 46	26
	reproducibilty	28 to 133	59
Area of flame spread	repeatability	0 to 36	17
	reproducibilty	0 to 61	31

The repeatability limit (r) and the reproducibility limit (R) are defined below:

— r is the the value below which the absolute difference between two single test results obtained under repeatability conditions (interlaboratory) may be expected to lie with a probability of approximately 95 %;

— R is the value below which the absolute difference between two single test results obtained under reproducibility conditions (interlaboratory) may be expected to lie with a probability of approximately 95 %.

The repeatability limit, r, is calculated as 2,8 s_r, where s_r is the repeatability standard deviation. The reproducibility limit, R, is calculated as 2,8 s_R, where s_R is the reproducibility standard deviation.

This interlaboratory trial has shown that the ignitability of some materials was more variable than others. The variability increased particularly for fire-retarded materials (e.g. 2,15) and for faced materials (e.g. 3). For materials such as these, it may be desirable to utilize an impinging pilot flame to replace the standard non-impinging burner-flame.

The variability in the ignitability and flame spread demonstrated by this interlaboratory trial compares favourably with values found in previous interlaboratory trials on other reaction to fire parameters.

Table E.2 — Variations of test results

Product	Product description	Time to ignition s			Area of flame spread $m^2 \times 10^{-2}$		
		Mean	CV(r) %	CV(R) %	Mean	CV(r) %	CV(R) %
1	Paper-faced gypsum board	267	27	37	6,3	24	61
2	FR-EPS	141	31	101	91,2	17	31
3	Al-foil-faced PUR foam panel	243	42	133	5,3	25	35
4	PUR foam panel	3	46	82	150,0	0	0
5	Varnished wood (pine)	26	29	42	86,3	14	22
6	3-layer PC panel	89	27	51	18,7	36	48
7	Paper wall covering on gypsum board	41	16	43	35,1	12	23
8	PVC wall covering on gypsum board	19	15	30	44,3	13	53
9	Textile wall covering on gypsum board	47	31	68	62,9	26	41
10	Unvarnished wood (pine)	37	19	49	83,9	15	25
11	MF-faced MDF	76	12	28	79,1	10	16
12	NFR-chipboard	72	23	39	100,9	12	22
13	Paper wall-covering on chipboard	54	16	32	91,2	8	27
14	LD-fibreboard	11	29	44	144,3	3	5
15	FR-plywood	395	34	112	7,8	33	46
16	NFR-plywood	29	21	51	65,2	24	34

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ICS 13.220.50

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