BRITISH STANDARD

BS 476-3:2004
Incorporating Amendments Nos. 1 and 2

Fire tests on building materials and structures —

Part 3: Classification and method of test for external fire exposure to roofs

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BSI British Standards

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee FSH/22, Fire resistance tests, to Subcommittee FSH/22/8, Test procedures for external fire exposure to roofs, upon which the following bodies were represented:

Association of British Roofing Felt Manufacturers
BRE — Building Research Establishment
BRE/LPC Laboratories
British Rigid Urethane Foam Manufacturers' Association
Concrete Tile Manufacturers Association
Eurisol (UK Mineral Wool Association)
Fibre Cement Manufacturers Association Ltd.
Flat Glass Manufacturers' Association
Flat Roofing Alliance
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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 14 June 2004

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First published June 1958
Second edition November 1975
Third edition June 2004

Amendments issued since publication

Amd. No.	Date	Comments
16169	18 January 2006	Amendment to **4.2.3**
16924	30 April 2007	See foreword

The following BSI references relate to the work on this British Standard:
Committee reference FSH/22/8
Draft for comment 03/109613

ISBN 0 580 43794 9

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Foreword

This Part of BS 476-3 has been prepared by Subcommittee FSH/22/8. It is based on BS 476-3:1958 and it supersedes BS 476-3:1975 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1] 〈A1]. Tags indicating changes to text carry the number of the amendment. For example, text altered by Amendment No. 1 is indicated by [A1] 〈A1].

The tests described in this part of BS 476 are designed to give information concerning the hazard that exists of fires spreading to the roof of a building from a nearby fire outside the building itself. The tests are not concerned with the behaviour of a roof when subjected to the effects of fire on its underside.

A preliminary test is made in which a specimen section of the roof is subjected to the effects of flame in the absence of radiation. Unless the specimen is so affected by this test that it is obvious it would not pass the principal tests, i.e. the penetration and the spread of flame tests, these are then carried out using the radiated heat apparatus.

When subjected to the penetration test, specimens are exposed to radiation of intensity 12 kW/m^2 measured on the surface of the specimen. This can be regarded as, for example, the intensity incident on a roof 7.6 m above ground level from a fire 13.7 m away in a building with a facade of 15.2 m × 15.2 m and 50 % window openings. Because wind will tend to carry any surface flames through any fissures in a roof, provision is made in the test to simulate the effect of a wind of 6.7 m/s (15 miles per hour) by applying suction to the lower side of the roof specimen during the test.

In the spread of flame test, however, the intensity of radiation varies over the exposed surface of the specimen. The distance to which the fire spreads downwards over the specimen thus gives a measure of the minimum intensity required to ignite the surface when a small ignition source such as a brand is present.

NOTE This intensity can be interpreted as being equivalent to the distances given in Table B.1, between an exposed roof 7.6 m above ground level and a burning building with a facade 15.2 m × 15.2 m and 50 % window openings.

This British Standard calls for the use of substances and/or procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

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

Compliance with a British Standard cannot confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 11 and a back cover.

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1 Scope

The tests given in this British Standard are designed to enable measurement of:

a) capacity of a representative section of a roof to resist penetration by fire when the external surface is exposed to radiation and flame; and

b) distance of the spread of flame on the outer surface of the roof covering under certain conditions.

Roofs are graded according to the angle at which they are tested, the time for which they resist penetration by fire, and the distance of superficial spread of flame on their external surface.

[A2] An additional test for rooflights is given in Annex C. [A2]

2 Normative references

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

BS EN 13238, *Reaction to fire tests for building products — Conditioning procedures and general rules for selection of substrates.*

BS EN 13501-1, *Fire classification of construction products and building elements — Part 1: Classification using test data from reaction to fire tests.*

3 Terms and definitions

For the purpose of this British Standard, the following terms and definitions apply.

3.1
penetration by fire
appearance of glowing or flaming on the underside of the specimen other than that of the test flame

NOTE In the text, this term has been shortened to "penetration".

3.2
non-combustible
product which is reaction to fire Euroclass A1, as described in BS EN 13501-1

4 Classification

4.1 Roof system

Roof systems shall be designated by the letters EXT. F. or EXT. S. to indicate whether the test results apply to a flat (horizontal) or an inclined roof system, respectively.

[A2] NOTE For special roof pitch applications at other specified angles, the test results need no such designation. [A2]

4.2 Fire resistance of roof system

4.2.1 *Coding system*

Roof systems subject to conditions of external fire shall be classified according to both the time of penetration and the distance of spread of flame along their external surface.

Each category designation shall consist of two letters, e.g. AA, AC, BB, these being determined as specified in **4.2.2** and **4.2.3**.

4.2.2 *Fire penetration (first letter)*

A. Those specimens that have not been penetrated within one hour.

B. Those specimens that are penetrated in not less than 30 min.

C. Those specimens that are penetrated in less than 30 min.

D. Those specimens that are penetrated in the preliminary flame test.

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4.2.3 *Spread of flame (second letter)*

A. Those specimens on which there is no spread of flame.

〉A1〈 B. Those specimens on which the spread of flame is less than or equal to 533 mm, with averaged results rounded up or down to whole number, as normally practised.

C. Those specimens on which the spread of flame is greater than 533 mm, with averaged results rounded up or down to whole number, as normally practised. 〈A1〉

D. Those specimens that continue to burn for five minutes after the withdrawal of the test flame or spread more than 381 mm across the region of burning in the preliminary test.

4.2.4 *Suffix "X"*

Attention shall be drawn to dripping from the underside of the specimen, any mechanical failure, and any development of holes, by adding a suffix "X" to the designation to denote that one or more of these took place during the test.

EXAMPLE 1 EXT. F. AA is a flat roofing system with one hour fire penetration resistance on which there was no spread of flame.

EXAMPLE 2 EXT. S. CCX is an inclined roofing system with less than 30 min fire penetration resistance, on which the spread of flame exceeded 533 mm and further deterioration took place.

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5 Three stage test method incorporating burning brands, wind and supplementary radiant heat

5.1 Apparatus

5.1.1 *Brands*, comprising a simulated town gas flame (55.2 % hydrogen, 27.4 % natural gas, 17.4 % nitrogen), (230 ± 10) mm long from a (9.5 ± 0.1) mm diameter orifice that shall be set prior to application on the test specimen.

5.1.2 *Wind*. Provision shall be made in the test to simulate the effect of a wind speed of 6.7 m/s, generated by applying suction to the lower side of the roof specimen. Apparatus shall be provided, capable of reducing the pressure on the underside of the specimen by (1.5 ± 0.1) mm of water below that on the upper side, for the duration of the test. The suction under the specimen shall be measured. An inclined tube manometer may be used for this purpose.

5.1.3 *Radiant panel*, (915 ± 5) mm square. It shall be provided capable of being supported either at an angle of 45° or horizontal according to the test required, and shall comprise four (300 ± 5) mm square surface combustion panels with their centres arranged at the corners of a square of (480 ± 5) mm side (see Figure A.1).

The radiation intensity incident on the specimen shall be established with the radiant panel in the test position and the calibration element set at a perpendicular distance of (585 ± 5) mm from the radiant panels. The radiant panels shall be capable of providing a total heat flux distribution on the surface of the calibration element such that the heat flux at the four major axes, as shown in Figure A.2, is (12 ± 1.5) kW/m2, when all four radiant panels are used for the penetration test (stage 3, see **5.7.3**).

When required for the spread of flame test (stage 2, see **5.7.2**) the heat flux distribution on the surface of the calibration element shall be such that the heat flux at the four major axes, as shown in Figure A.2, is as follows:

a) locations 1 and 2: (8.5 ± 1.0) kW/m^2;

b) locations 3 and 4: (3.5 ± 1.0) kW/m^2.

A 25 mm diameter Schmit Boelter heat flux meter, with a design range of (0 – 50) kW/m^2 shall be used to establish the heat flux distribution on the surface of the calibration element. The target receiving radiation from the radiant panels shall be flat, circular and coated with a durable matt black finish. The target shall be water cooled. Radiation shall not pass through any window before reaching the target. The instrument shall be robust, simple to set up and use, and stable in calibration. The instrument shall have an accuracy of within ±3 % and a repeatability within 0.5 %.

The calibration of the heat flux meter shall be checked by comparison with two instruments of the same type as the working heat flux meter and of similar range, held as reference standards and not used for any other purpose. One of the reference standards shall be fully calibrated at a competent laboratory at yearly intervals.

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5.1.4 *Calibration element*, consisting of a smooth, flat (20 ± 2) mm thick board of calcium silicate material having the dimensions (840 ± 10) mm square and a density of (870 ± 100) kg/m^3.

5.1.5 *Timing device*, with an accuracy of ±5 s over 24 h.

5.1.6 *Specimen holder*. A metal specimen cover with a ⟩A2⟨ georgian polished wired glass observation window ⟩A2⟨ is fixed to the framing (Figure A.1 and Figure A.3) and a non-combustible material is laid around the sides of the specimen frame to provide an air seal when the specimen is placed in position. Any small holes around the edges of specimen and its frame shall be sealed with mortar (3:1 sand:cement mix).

5.2 Calibration

Each time the radiant panel is ignited, achieve stable conditions and adjust the radiant panel to obtain a total heat flux distribution on the surface of the calibration element as specified in **5.1.3**. The minimum period of time of stabilization for calibration of the radiant panel shall be 60 min.

5.3 Test conditions

Mount the test specimens: ⟩A2⟨ *Text deleted* ⟩A2⟨

⟩A2⟨ a) at an angle of 45º, for an inclined test;

b) horizontally, to represent flat roofs; or

c) at a selected unique angle of pitch, to meet the requirements of a special roof pitch application, where requested by the sponsor for limited use. The classification so obtained shall only apply to the roof specimen when used at the special angle of pitch. ⟩A2⟨

5.4 Test specimen

5.4.1 *Number of test specimens*

5.4.1.1 *Preliminary ignition test with burning brands (stage 1)*

One specimen shall be tested.

5.4.1.2 *Spread of flame test with burning brands and supplementary radiant heat (stage 2)*

Three specimens shall be tested.

5.4.1.3 *Penetration test with burning brands, wind and supplementary radiant heat (stage 3)*

Three specimens shall be tested.

5.4.2 *Construction of specimens*

Apply each test to a specimen of the roof structure (840 ± 10) mm square. The specimens shall be representative of the complete "end use" roof construction including at least one specimen of any joints used in each of the materials to be tested.

Where necessary the specimen shall be made rigid by providing a frame at the boundaries of the specimen constructed from non-combustible materials. Any gaps between the specimen and the frame shall be sealed with mortar (3:1 sand:cement mix) to provide an air seal. The specimen and its frame shall also form an air seal with the specimen cover of the test apparatus. See Figure A.1 and Figure A.3.

5.5 Conditioning

Condition the specimens in accordance with BS EN 13238. Erect and test them as soon as possible after leaving the conditioning atmosphere. The time between leaving the conditioning atmosphere and testing shall not exceed four hours.

5.6 Test environment

Carry out the testing in a draught-free area. The temperature in the enclosure shall be (20 ± 10) °C prior to the fire test. If any measures are taken to remove products of combustion from the test laboratory, they shall be in operation during the calibration period and maintained during the test.

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5.7 Test procedure

5.7.1 *Preliminary ignition test with burning brands (stage 1)*

Apply the test brand (see **5.1.1**) for 60 s at the centre of the upper surface of the specimen and direct it up the slope with the nozzle resting on the centre of the specimen and inclined at an angle of nominally 5° to it. For specimens which are tested horizontally, the direction of the flame shall correspond to that used for a sloping roof as indicated by the arrow in Figure A.1. For the purposes of this stage, mount the specimen in the specimen holder but do not expose it to any radiant heat.

5.7.2 *Spread of flame test with burning brands and supplementary radiant heat (stage 2)*

Bring the specimen, after mounting for test, in not longer than five seconds, from a position at room temperature to a position where its upper surface is exposed to radiated heat (see **5.1.3**). Immediately the specimen is exposed to radiated heat, apply the burning brand (see **5.1.1**) to the specimen for three minutes. The orifice of the brand shall be on the upper edge of the specimen (115 ± 5) mm from the centre line and the flame directed along the edge, the angle between the nozzle and the specimen being nominally 5°. For specimens tested flat, position the "upper" edge "A" as shown in Figure A.1.

5.7.3 *Penetration test with burning brands, wind and supplementary radiant heat (stage 3)*

Bring the specimen, after mounting for test, in not longer than five seconds, from a position at room temperature to a position where its upper surface is exposed to radiated heat (see **5.1.3**). Immediately the specimen is exposed to the radiated heat, reduce the pressure on the underside as detailed in **5.1.2**.

At five minutes from the start of the test, apply the burning brand in the direction shown by the arrow in Figure A.1 for 60 s, moving once up and once down the centre of the specimen at a rate of 0.3 m/10 s.

5.7.4 *End of test*

Terminate the test and extinguish the fire if there is a risk to the safety of personnel or impending damage to equipment, or if any of the following occur.

a) Preliminary ignition test with burning brands (stage 1):

— at one minute, in the event of no ignition of the specimen. If ignition occurs, once all flaming on the specimen has ceased.

b) Spread of flame test with burning brands and supplementary radiant heat (stage 2):

— at three minutes, in the event of no ignition of the specimen. If ignition occurs, once all flaming on the specimen has ceased.

c) Penetration test with burning brands, wind and supplementary radiant heat (stage 3):

— at one hour, in the event that no penetration occurs, or earlier if penetration occurs as defined in **3.1**.

5.8 Observations and measurements

5.8.1 *General*

During the test, the parameters given in **5.8.2**, **5.8.3** and **5.8.4** shall be observed, measured and recorded. Dimensions shall be expressed in millimetres.

Progress of all flaming, regardless of duration, shall be estimated with respect to the base of the flame, in contact with the exposed surface, and not with respect to the flame envelope.

5.8.2 *Preliminary ignition test with burning brands (stage 1)*

— Duration of flaming, if this has occurred and exceeds five minutes.

— Extent of flame spread in any direction and whether the maximum distance in any direction exceeds 381 mm.

— The time and nature of penetration as defined in **3.1**, if this has occurred.

5.8.3 *Spread of flame test with burning brands and supplementary radiant heat (stage 2)*

— The maximum distance of spread of flame down each specimen. Measurements shall be continued until flames have ceased.

— The average of the maximum spread of flame on each of the three specimens shall be used for determining the classification.

— Any marked variability between the three specimens.

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5.8.4 ***Penetration test with burning brands, wind and supplementary radiant heat (stage 3)***

— The time at which any penetration, as defined in **3.1**, occurs.

— If failure of all specimens occurs within one hour, the average time for fire to penetrate the three specimens shall be used in determining the classification. If one or two of the specimens have not failed at one hour, this time shall be used in computing the average time of penetration.

— Any marked variability between the three specimens.

— Occurrence of melting of the test specimens and the production of molten droplets or debris (flaming and/or non-flaming).

— Any mechanical failure, or the development of holes, without penetration by fire.

5.9 Test report

The test report shall provide all information relevant to the selected procedures, the products tested and the results obtained.

NOTE Photographs are strongly recommended to illustrate the test results.

The report shall include the following.

a) Reference to this test method, i.e. BS 476-3:2004.

b) Name and address of the test laboratory and the date of the test.

c) Names of the sponsor, the product and the manufacturer of the specimen and its component parts, if known. If unknown, this shall be stated.

d) Full description of the product tested with, if applicable, a description of the test roof deck. This shall include, where applicable:

— method of attaching the roof covering, e.g. nails, fixings, spacing, adhesives, etc.;

— density or mass per unit area of materials;

— moisture content of the materials used.

Building material classes (e.g. with reference to standards). The nature and quantity of adhesives or their rate of application might also be necessary to define the product uniquely.

e) For each tested specimen, information concerning:

— the roof pitch;

— room temperature at the beginning of the test, in degrees centigrade.

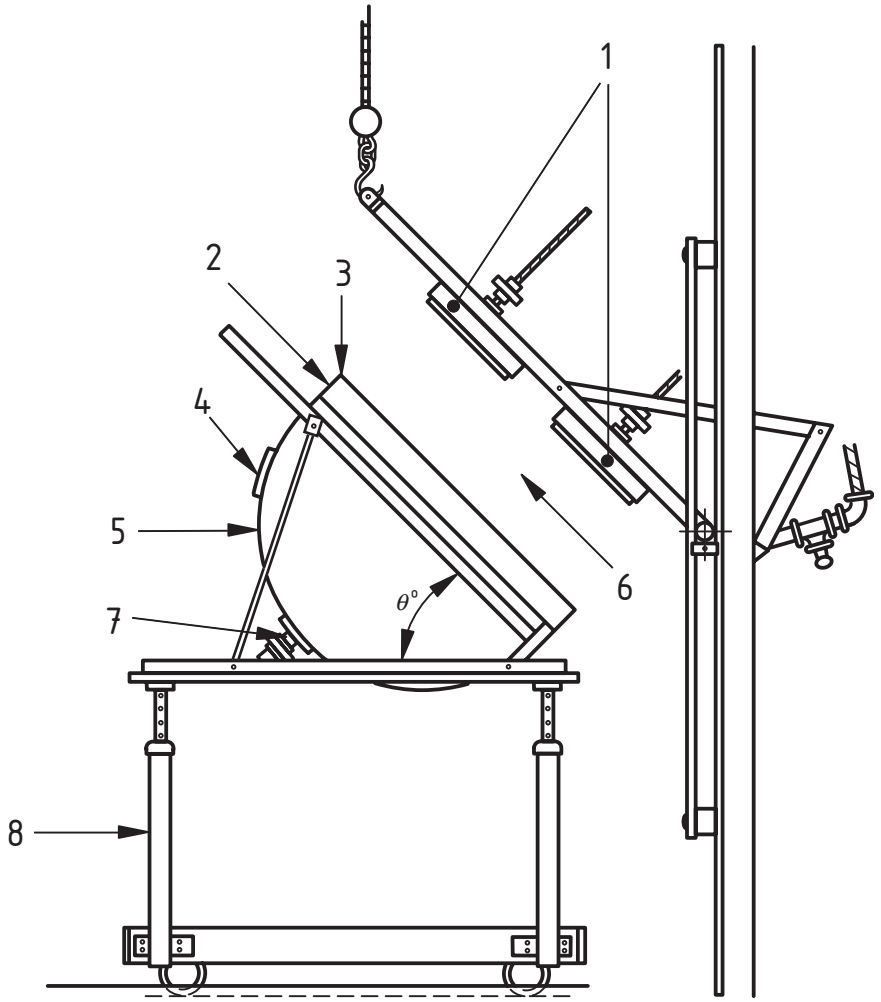
f) For each tested specimen, any observations and measurements recorded during the test as specified in **5.8**.

g) The classification achieved by the product as detailed in Clause **4**.

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Annex A (informative)
Apparatus for roof test

The apparatus is shown in Figure A.1.



Key

1 Surface combustion heaters
2 Roof specimen
3 Edge "A"
4 [A2] georgian polished wired glass observation window [A2]
5 Specimen cover
6 Direction of flame
7 Suction pipe
8 Trolley

Angle $\theta = 45°$ for inclined test
$\theta = 0°$ for horizontal test
[A2] θ = specified angle, for restricted special roof pitch applications [A2]

Figure A.1 — Typical roof test apparatus

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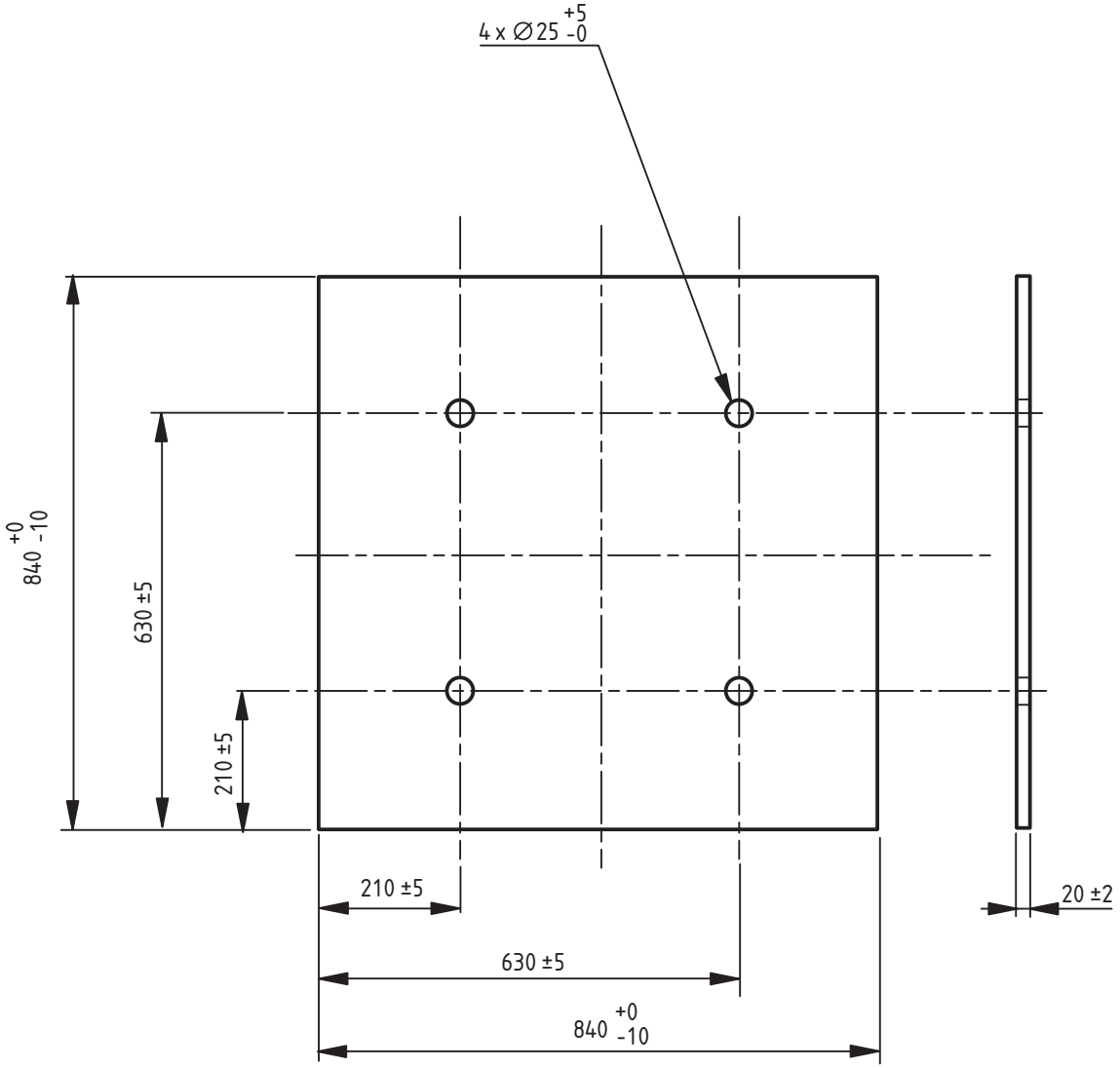
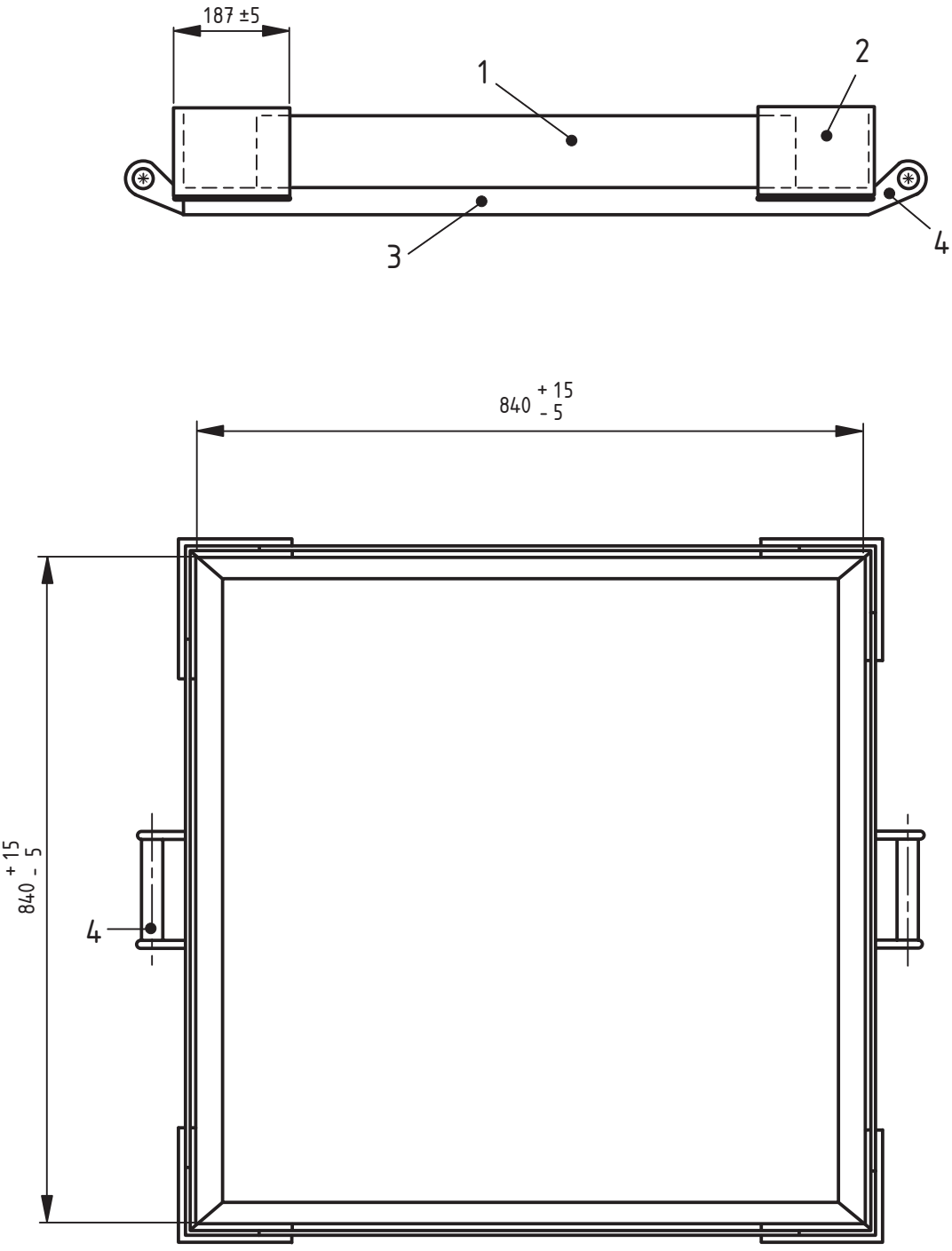


Figure A.2 — Instrument locations for the calibration element

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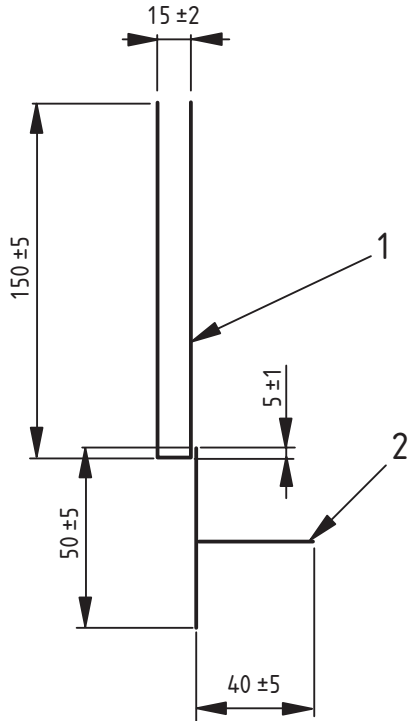
Key

1 Non-combustible board
2 Steel
3 Base frame
4 Handle

Figure A.3 — Specimen holder

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Key

1 Non-combustible board

2 Steel

Figure A.3 — Specimen holder *(continued)*

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Annex B (informative)
Intensity of radiated heat on specimen

The intensity of radiated heat is shown in Table B.1.

Table B.1 — Intensity of radiated heat

Radiation intensity on specimen kW/m2	Equivalent distance from a 15.2 m × 15.2 m facade with 50 % window openings to an adjacent roof m
7.95	21.3
9.21	18.3
9.21	18.3
7.95	21.3
5.86	24.4
4.19	27.4
2.51	36.6
2.51	36.6

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A2 Annex C (normative)
The testing and classification of roof lights, roof windows and integrated panels for external fire exposure

C.1 Installation into the test specimen holder

Where roof lights, roof windows and integrated panels cannot be produced to the test specimen size as required in BS 476-3:2004, the roof lights, roof windows and integrated glass faced panels with the dimensions nearest to those required by the test standard shall be used.

Where the specimens do not fit the existing test frames, they shall be constructed and fitted to the specimen holder such that the required reduction in pressure to the underside of the test specimen shall be maintained for the duration of the test as specified in **5.1.2**.

C.2 General

All roof lights, roof windows and integrated panels shall be tested in the closed position.

The preliminary ignition test shall be applied for 1 min to the upper surface of the test specimen, and repeated at various locations, such that the different principal elements and/or materials are investigated.

NOTE 1 This should typically involve no more than three locations.

NOTE 2 This ensures that items such as joints, edge details and ventilation grilles will be investigated.

C.3 Number and exposure conditions for the test specimens

If the surface of the test specimen has more than a 50 mm height variation/surface irregularity in the exposed plane, the thermal exposure conditions shall be set such that a minimum of 70 % of the exposed surface area achieves (12 ± 1.5) kW/m^2.

As an alternative where the height variation is significant, or a minimum of 70 % of the exposed surface area cannot meet (12 ± 1.5) kW/m^2, the surface/joint shall be mounted so that any surrounding exposed areas subject to exposure conditions greater or less than (12 ± 1.5) kW/m^2 shall be tested alone for penetration with the high exposed surface area protected by a non combustible board (Euro class A1) and an extra test of the specimen itself shall be made. A2

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[A2] The centre point of the test specimen shall be identified and this shall be used as the central reference point for the radiant heat exposure of the specimen. The reference points for the flame application shall be in relation to the centre point of the exposed specimen.

— Two specimens shall be tested for spread of flame following the procedure in **5.7.2**.

— Two specimens shall be tested for fire penetration. The test conditions shall be applied and maintained at the application rate as specified in **5.7.3**.

NOTE 1 The above might lead to a change in the total exposure period due to the need for flame application along any larger specimen being tested.

Then the corner/edge detail shall be located such that the corner detail is within the radiant heat exposure zone to ensure the maximum radiant heat coverage of the joint detail between the specimen and the surrounding roof.

— Spread of flame application shall follow the procedure in **5.7.2**.

— Flame application in the penetration test shall be applied and maintained at the application rate as specified in **5.7.3**.

NOTE 2 The above might lead to a change in the total exposure period due to the need for flame application along any larger specimen being tested.

Where the specimen includes a joint between the roof lights, roof windows or integrated glass faced panels and the roof system including any kerb details:

— a third test specimen shall be tested for spread of flame; and

— a third test specimen shall be tested for fire penetration.

C.4 Classification

The observation and measurement shall be made according to **5.8** and the classification made in accordance with Clause **4**.

Where a difference in classification arises based on individual test results for surface and joint exposure conditions, a further specimen(s) shall be tested to repeat the worst performing configuration(s). The average of the two poorest results shall be used for the purpose of classification.

C.5 Direct application

The classification obtained in this test shall cover all sizes of roof lights, roof windows and integrated panels having identical construction when used as an element of a roofing system subjected to external fire exposure to BS 476-3:2004. [A2]

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