British Standard

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Incorporating Amendment No. 1

Fire tests on building materials and structures —

Part 13: Method of measuring the ignitability of products subjected to thermal irradiance —

[ISO title: Fire tests — Reaction to fire — Ignitability of building products]

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Fire Standards Committee (FSM/-) to Technical Committee FSM/1 upon which the following bodies were represented:

Association of British Roofing Felt Manufacturers
Association of Building Component Manufacturers Ltd.
Association of Structural Fire Protection Contractors and Manufacturers
British Coal
British Fire Services Association
British Floor Covering Manufacturers' Association
British Plastics Federation
British Railways Board
British Rigid Urethane Foam Manufacturers' Association
British Wood Preserving Association
Cement and Concrete Association
Chemical Industries Association
Chief and Assistant Chief Fire Officers' Association
Concrete Society
Department of Education and Science
Department of the Environment (Building Research Establishment, Fire Research Station)
Department of the Environment for Northern Ireland
Department of the Environment (Housing and Construction Industries)
Department of the Environment (Property Services Agency)
Department of Transport (Marine Directorate)
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Eurisol (UK) Association of Manufacturers of Mineral Insulation Fibres
Fibre Building Board Organisation (FIDOR)
Fibre Cement Manufacturers' Association Ltd.
Fire Insurers Research and Testing Organisation (FIRTO)
Fire Offices Committee
Fire Protection Association
Flat Glass Manufacturers' Association
Flat Roofing Contractors' Advisory Board
Gypsum Products Development Association
Home Office
Institution of Fire Engineers
Mastic Asphalt Council and Employers' Federation
National Council of Building Materials Producers
National GRP Construction Federation
RAPRA Technology Ltd.
Royal Institute of British Architects
Steel Construction Institute
Timber Research and Development Association
United Kingdom Atomic Energy Authority
Warrington Fire Research Centre
Wood Wool Slab Manufacturers' Association
Yarsley Technical Centre Ltd.

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

Autoclaved Aerated Concrete Products Association
London Scientific Services
Phenolic Foam Manufacturers' Association
Thermal Insulation Manufacturers and Suppliers' Association (TIMSA)

This British Standard, having been prepared under the direction of the Fire Standards Committee, was published under the authority of the Board of BSI and comes into effect on
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Contents

National foreword

This Part of BS 476 has been prepared under the direction of the Fire Standards Committee. It is identical with ISO 5657-1986 "Fire tests — Reaction to fire — Ignitability of building products", published by the International Organization for Standardization (ISO).

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

The comma has been used as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the words "International Standard" appear, referring to this standard, they should be read as "Part of BS 476".

Wherever values for irradiance are given (e.g. in **9.1** and **9.2**) they are given in units of W/cm^2. In British Standards it is current practice to use kW/m^2, conversion to which requires that the value is multiplied by 10 (in the example given in **9.1** 5 W/cm^2 would be 50 kW/m^2 and in the example given in **9.2**, 10 W/cm^2 would be 100 kW/m^2).

Cross-references. The Technical Committee has reviewed the provisions of the following international standards, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this Part of BS 476. Related British Standards are given in parentheses.

ISO 291-1967, *(BS 2782 Methods of testing plastics — Method 1004:1977 Standard atmospheres for conditioning and testing).*

ISO 3261-1975, *(BS 4422 Glossary of terms associated with fire).*

ISO/TR 3814-1975, *(No British Standard).*

ISO 5725-1981, *(BS 5497 Precision of test methods — 1:1979, Guide for the determination of repeatability and reproducibility for a standard test method).*

ISO/TR 6585-1979, *(No British Standard).*

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 34, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

0 Introduction

0.1 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 philosophy of "reaction to fire" tests is explained in ISO/TR 3814.

0.2 A test such as is specified in this International Standard deals only with a simple representation of a particular aspect of the potential fire situation typified by a radiant heat source and a flame; it cannot alone provide any direct guidance on behaviour or safety in fire. A test of this type may, however, be used for comparative purposes or to ensure the existence of a certain quality of performance (in this case ignitability) considered to have a bearing on fire performance generally. It would be wrong to attach any other meaning to performance in this test.

0.3 The term "ignitability" is defined in ISO 3261 as the capability of a material of being ignited. It is one of the first fire properties to be manifest and should almost always be taken into account in any assessment of fire hazard. It may not, however, be the main characteristic of the material which affects the subsequent development of fire in a building.

0.4 This test does not rely upon the use of asbestos-based materials.

0.5 The attention of all users of the test is drawn to the following warning.

SAFETY WARNING — So that suitable precautions may 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, clause A.7 should also be noted.

1 Scope and field of application

This International Standard specifies a method for examining the ignition characteristics of the exposed surfaces of specimens of essentially flat materials, composites or assemblies not exceeding 70 mm in thickness, when placed horizontally and subjected to specified levels of thermal irradiance.

2 References

ISO 291, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 3261, *Fire tests — Vocabulary.*

ISO/TR 3814, *The development of tests for measuring "reaction to fire" of building materials.*

ISO 5725, *Precision of test methods — Determination of repeatability and reproducibility by inter-laboratory tests.*

ISO/TR 6585, *Fire hazard and the design and use of fire tests.*

3 Definitions

(See also clause **A.1** in Annex A.)

For the purposes of this International Standard, the definitions given in ISO 3261 apply, together with the following:

3.1
product

material, composite or assembly about which information is required

3.2
material

single substance or uniformly dispersed mixture, for example metal, stone, timber, concrete, mineral fibre, polymers

3.3
composite

combination of materials which are generally recognized in building construction as discrete entities, for example coated or laminated materials

3.4
assembly

fabrication of materials and/or composites, for example sandwich panels. This may include an air gap

3.5
exposed surface

that surface of the product subjected to the heating conditions of the test

3.6
specimen

representative piece of the product which is to be tested together with any substrate or treatment. This may include an air gap

3.7
essentially flat surface

surface whose irregularity from a plane does not exceed ± 1 mm

3.8
irradiance (at a point of a surface)

quotient of the radiant flux incident on an infinitesimal element of surface containing the point, by the area of that element

3.9
sustained surface ignition

inception of a flame on the surface of the specimen which is still present at the next application of the pilot flame

3.10
transitory surface ignition

inception of any flame at the surface of the specimen which is not sustained until the next application of the pilot flame

3.11
plume ignition

inception of any flame in the plume above the specimen, sustained or transitory

4 Principles of the test

(See also clause **A.2** in Annex A.)

Specimens of the product are mounted horizontally and exposed to thermal radiation on their upper surfaces at selected levels of constant irradiance within the range 1 to 5 W/cm^2.

A pilot flame is applied at regular intervals to a position 10 mm above the centre of each specimen to ignite any volatile gases given off. The time at which sustained surface ignition occurs is reported. Other types of ignition which occur are reported in **12.5**.

Convection transfer may also make a very small contribution (not more than a few per cent) to the heating at the centre of a specimen and to the reading of the radiometer during the calibration procedure. However, the term irradiance is used throughout this International Standard as best indicating the essentially radiative mode of heat transfer.

5 Suitability of a product for testing

(See also clause **A.3** in Annex A.)

5.1 Surface characteristics

5.1.1 A product having one of the following properties is suitable for testing:

a) an essentially flat exposed surface;

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

— at least 50 % of the surface of a representative 150 mm diameter area lies within a depth of 10 mm from a plane taken across the highest points on the exposed surface, and/or

— for surfaces containing cracks, fissures or holes not exceeding 8 mm in width nor 10 mm in depth, the total area of such cracks, fissures or holes at the surface does not exceed 30 % of a representative 150 mm diameter area of the exposed surface.

5.1.2 When an exposed surface does not meet the requirements of either **5.1.1** a) or **5.1.1** b), the product shall, if practicable, be tested in a modified form complying as nearly as possible with the requirements given in **5.1.1**. The test report shall state that the product has been tested in a modified form and clearly describe the modification (see clause **14**).

5.2 Asymmetrical products

A product submitted for this test could have faces which differ or could contain laminations of different materials arranged in a different order in relation to the two faces. If either of the faces can be exposed in use within a room, cavity or void, then both faces shall be tested.

6 Specimen construction and preparation

(See also clause **A.4** in Annex A.)

6.1 Specimens

6.1.1 Five specimens shall be tested at each level of irradiance selected and for each different exposed surface.

6.1.2 The specimens shall be representative of the product, square, with sides measuring $165^{\ 0}_{-5}$ mm.

6.1.3 Materials and composites of normal thickness 70 mm or less shall be tested using their full thickness.

6.1.4 For materials and composites of normal thickness greater than 70 mm, the requisite specimens shall be obtained by cutting away the unexposed face to reduce the thickness to $70^{\ 0}_{-3}$ mm.

6.1.5 When cutting specimens from products with irregular surfaces, the highest point on the surface shall be arranged to occur at the centre of the specimen.

6.1.6 Assemblies shall be tested as specified in **6.1.3** or **6.1.4** as appropriate. However, where thin materials or composites are used in the fabrication of an assembly, the presence of air or an air gap and/or the nature of any underlying construction may significantly affect the ignition 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 (see **A.4.1**).

When the product is a material or composite which would normally be attached to a well-defined substrate, then it shall be tested in conjunction with that substrate using the recommended fixing technique, e.g. bonded with the appropriate adhesive or mechanically fixed.

6.2 Baseboards

6.2.1 One baseboard will be required for each test specimen. However, since it will sometimes be possible to re-use the baseboard after test, the total number required will depend on the frequency of testing and the type of product being tested.

6.2.2 The baseboards shall be square with sides measuring 165^{0}_{-5} mm and shall be made of non-combustible insulation board of oven-dry density 825 ± 125 kg/m^3 and nominal thickness 6 mm.

6.2.3 Before use in a test, a baseboard shall be placed for at least 24 h in an atmosphere at a temperature of 23 ± 2 °C and a relative humidity of (50 ± 5) %, with free access of air to both sides.

6.3 Conditioning of specimens

(See also sub-clause **A.4.3** in Annex A.)

Before test the specimens shall be conditioned to constant mass[1)] at a temperature of 23 ± 2 °C, and a relative humidity of (50 ± 5) %.

6.4 Preparation

6.4.1 A conditioned specimen shall be placed on a baseboard treated according to **6.2.3** and the combination shall be wrapped in one piece of aluminium foil of nominal thickness 0,02 mm from which a circle 140 mm diameter has been previously cut (see Figure 1). The circular cut-out zone shall be centrally positioned over the upper surface of the specimen. After preparation the specimen-baseboard combination shall be returned to the conditioning atmosphere until required for test.

6.4.2 Where a product will normally be backed by air (see **6.1.6**), then the specimen shall, where practicable, be backed by an air gap in the test. The air gap shall be formed by including a spacer between the specimen and the baseboard. The spacer shall consist of a piece of non-combustible insulation board of the same size and density as the baseboard, from the centre of which a circular area 140^{0}_{-5} mm in diameter has been removed. The thickness of the spacer shall correspond to the size of the air gap, if this is known, except that the total thickness of the spacer plus specimen shall not exceed 70 mm. If the size of the air gap is not known or the total thickness of the air gap plus specimen exceeds 70 mm, then the specimen shall be tested with a spacer which will give a total thickness for the specimen and spacer of 70^{0}_{-3} mm.

The spacer and baseboard shall be placed for at least 24 h in an atmosphere at a temperature of 23 ± 2 °C and a relative humidity of (50 ± 5) %, with free access of air to both sides of each. The spacer shall then be interposed between the baseboard and the specimen and the combination shall be wrapped in aluminium foil as described in **6.4.1**. A clean spacer shall be used for each specimen tested. After preparation the combination shall be returned to the conditioning atmosphere until required for test.

6.4.3 Baseboards and/or spacers used to back the specimens may be re-used if they are not contaminated. Immediately before re-use, however, they should have been in the conditioning atmosphere specified in **6.2.3** and **6.4.2** for at least 24 h. If there is any doubt about the condition of a baseboard or spacer, it may be placed in a ventilated oven at a temperature of approximately 250 °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 Test apparatus

7.1 General

7.1.1 All dimensions given in the following description of test apparatus are nominal unless tolerances are specified.

[1)] Constant mass is considered to be reached 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 test piece or 0,1 g, whichever is the greater.

7.1.2 The test apparatus shall consist essentially of a support framework which clamps the test specimen horizontally between a pressing plate and a masking plate such that a defined area of the upper surface of the specimen is exposed to radiation. This radiation shall be provided by a radiator cone positioned above and supported from the specimen support framework. An automated pilot flame application mechanism shall be used to bring a test flame through the radiator cone to a position above the centre of the surface of the specimen. A specimen insertion and location tray shall be used to position the specimen accurately on the pressing plate of the specimen support framework and a screening plate shall be used to shield the surface of the specimen during its insertion into the apparatus.

7.1.3 A general arrangement of a suitable apparatus is shown in Figure 2, with detailed drawings in Figure 3 to Figure 6.

7.2 Specimen support framework, masking plate and pressing plate

7.2.1 The specimen support framework and the other parts of the system to hold the specimen in position shall be constructed from stainless steel. It shall consist of a rectangular base-frame made from 25 mm × 25 mm square tube of 1,5 mm wall thickness and shall have overall dimensions of 275 mm × 230 mm. A horizontal masking plate, 220 mm square and 4 mm thick, shall be mounted centrally and 260 mm above the top of the base-frame on four 16 mm diameter legs positioned at the corners of the masking plate. A 150 mm diameter circular opening shall be cut centrally in the masking plate, the edges of the hole being chamfered on the top surface of the plate at an angle of 45° and to a horizontal width of 4 mm.

7.2.2 Two vertical guide rods not less than 355 mm long of 20 mm diameter steel shall be mounted on the base-frame, one at the mid-length of each of the short sides of the frame. A horizontal adjustable bar 25 mm × 25 mm which can slide on the rods and be locked in position by bolts capable of being tightened by hand shall be mounted below the masking plate and between the vertical guide rods. A vertical central hole and sleeve in the adjustable bar shall be used to locate a sliding vertical rod of 12 mm diameter and 148 mm long, surmounted by a 180 mm square pressing plate 4 mm thick. The pressing plate shall be pushed upwards against the underside of the masking plate by the counterweighted pivot arm which shall be mounted below the adjustable horizontal bar and shall press against the bottom of the sliding vertical rod. This can be achieved by an arm about 320 mm long. It shall contain at one end a roller which shall bear against a boss on the bottom of the sliding vertical rod and at the other end an adjustable counterweight.

The counterweight shall be capable of compensating for different masses of specimens and of maintaining a force of approximately 20 N between the upper surface of the specimen and the masking plate. A counterweight of about 3 kg has been found to be suitable. An adjustable stop shall be provided to limit upward movement of the pressing plate, due to collapse, softening or melting of the specimen during its exposure, to 5 mm. Alternatively spacing blocks between the pressing plate and the masking plate may be used.

7.2.3 Figure 3 shows details of the specimen support framework.

7.3 Radiator cone

7.3.1 The radiator cone shall consist of a heating element, of nominal rating 3 kW, contained within a stainless steel tube, approximately 3 500 mm in length and 8,5 mm in diameter, coiled into the shape of a truncated cone and fitted into a shade. The shade shall have an overall height of 75 ± 1 mm, an internal diameter of 66 ± 1 mm and an internal base diameter of 200 ± 3 mm. It shall consist of two layers of 1 mm thick stainless steel with a 10 mm thickness of ceramic fibre insulation of nominal density 100 kg/m^3 sandwiched between them. The heating element shall be fastened to the inside face of the shade by steel pins. Clamps shall be used to prevent additional sagging of the lower coil below the base of the shade.

The upper turn of the heating element shall not obstruct the area of the top aperture of the shade by more than 10 % when projected vertically.

7.3.2 The radiator cone shall be capable of providing irradiance in the range 1 to 5 W/cm^2 at the centre of the aperture in the masking plate and in a reference plane coinciding with the underside of the masking plate, when measured as described in **11.2**. The distribution of irradiance provided by the cone at the reference plane shall be such that the variation of irradiance within a circle of 50 mm diameter, drawn from the centre of the masking plate aperture, shall be not more than ± 3 % of that at the centre; the variation of irradiance within a circle of 100 mm diameter shall be not more than ± 5 % of that at the centre.

The distribution of irradiance shall be determined from readings at the centres of 10 mm squares forming the grids shown in Figure 4d). The tolerances given shall apply to the readings within the grid comprising all the squares shown in Figure 4d).

For these measurements, the opening in the masking plate shall be completely filled; it is necessary to employ a number of calibration boards of special horizontal shapes and sizes.

7.3.3 The radiator cone shall be located and secured from the vertical guide rods of the specimen support framework by clamps which position the lower rim of the radiator cone shade 22 ± 1 mm above the upper surface of the masking plate.

7.3.4 Details of the radiator cone are shown in Figure 4b).

7.3.5 The temperature of the radiator cone shall be controlled by reference to the reading of a thermocouple (primary thermocouple) (**9.1**) in close and stable thermal contact with the heater element tube. A second thermocouple (secondary thermocouple) shall be attached similarly, mounted in a diametrically opposite position. The thermocouples shall have a speed of response not worse than that of a thermocouple with insulated hot junction in a stainless steel sheath 1 mm in diameter. Each thermocouple shall be attached to a coil of the heater element tube which places them between one-third and half way down from the top of the radiator cone. At least 8 mm of the end of the thermocouple shall lie in a region of approximately uniform temperature.

A description of methods of attaching thermocouples which have been found satisfactory in practice is given in Annex A (clause **A.5.1**).

7.4 Pilot flame application mechanism

(See also clause **A.5.2** in Annex A.)

7.4.1 The apparatus shall be provided with a mechanism which is capable of bringing a pilot flame from a re-ignition position outside the radiator cone to the test position within the cone. The mechanism shall be capable of taking the pilot flame through the radiator cone and through the aperture in the masking plate to a maximum distance of 60 mm below the underside of the masking plate.

7.4.2 The pilot flame shall issue from a nozzle made of stainless steel as specified in Figure 5, attached near the end of the pilot flame tube.

7.4.3 The normal position of the pilot flame shall be above the radiator cone and clear of the plume of smoke or decomposition products which may rise through the top of the cone. When in this position the pilot flame nozzle shall be adjacent to a secondary ignition source[2)] having a heat output not greater than 50 W which shall be capable of re-igniting the pilot flame should it be extinguished.

7.4.4 The normal position for the pilot flame shall be such that the flame issues horizontally over the centre point of the aperture in the masking plate and perpendicular to the plane of movement of the pilot arm, with the centre of the orifice in the nozzle positioned 10 ± 1 mm above the underside of the masking plate.

7.4.5 The application mechanism shall automatically bring the pilot flame to the "normal test position" once every $4^{+0,4}_{0}$ s.

The pilot flame shall not take longer than 0,5 s to travel from the opening at the top of the radiator shade to the test position where it shall remain for $1^{+0,1}_{0}$ s. The time taken for the pilot flame to travel back over the same distance shall not exceed 0,5 s.

7.4.6 The mechanism shall be provided with an adjustable stop which will restrict the lowest point of travel of the pilot flame to any position within the range from 20 mm above the test position to 60 mm below. When operating within this range, the vertical force exerted on the test specimen by the pilot flame nozzle shall be between 0,1 and 0,2 N. This is to be measured as the static force exerted with the mechanism stopped.

7.4.7 A suitable pilot flame application mechanism[3)] is shown in Figure 6a), Figure 6b), and Figure 6c).

7.5 Specimen insertion and location tray

7.5.1 The specimen insertion and location tray shall be used to facilitate rapid insertion of the specimen on to the pressing plate and to locate accurately the exposed area of the specimen in relation to the aperture in the masking plate.

7.5.2 It shall consist essentially of a flat metal plate having lugs on its upper surface to position and hold the specimen. Guides shall be fixed to the lower surface to locate the tray in the apparatus and a stop shall also be provided to bear against the pressing plate, thus limiting the distance of insertion. The tray should be provided with a handle to facilitate use.

[2)] The secondary ignition source can be a gas flame, hot wire or spark igniter. A propane flame, 15 mm long, from a nozzle with an internal diameter of 1 to 2 mm, has a heat output of approximately 50 W.

[3)] The pilot flame application mechanism should be constructed to a close tolerance since minor changes in the dimensions can lead to changes to the timing as specified in **7.4.5**. Small changes can, however, be accommodated by slight changes in the diameter of the slave roller.

7.5.3 A suitable device is shown in Figure 7.

7.6 Specimen screening plate

7.6.1 The screening plate shall be designed to slide over the top of the masking plate during the period of insertion of the specimen, thus shielding the specimen from radiation until commencement of the test.

7.6.2 The plate shall be made from 2 mm thick polished aluminium or stainless steel and shall have overall dimensions which allow it to cover the masking plate. It should be provided with a stop, to limit its insertion against the masking plate, and a handle.

7.6.3 A suitable design is shown in Figure 8.

8 Test environment

8.1 The test shall be carried out in an environment essentially free of air currents and protected, where necessary, by a screen. The air velocity close to the test apparatus should be not more than 0,2 m/s. The operator should be protected from any products of combustion generated by the specimen. The effluent gases shall be extracted without causing forced ventilation over the apparatus.

8.2 A suitable design for screening the apparatus from draughts and exhausting the effluent gases is shown in Figure 9.

9 Additional equipment

9.1 Temperature controller

The temperature controller for the radiator cone shall be of the proportional integral and derivative type ("3-term" controller) with thyristor stack fast-cycle or phase angle (see **A.5.3**) control of not less than 15 A maximum rating. Capacity for adjustment of integral times between about 10 s and 150 s, and differential times between about 2 s and 30 s, shall be provided to permit reasonable matching with the response characteristics of the heater. The temperature at which the heater is to be controlled shall be set on a scale capable of being read to ± 2 °C. An input range of temperature of about 0 to 1 000 °C is suitable. (An irradiance of 5 W/cm^2 will be given by a heater temperature in the region of 800 °C.) Automatic cold junction compensation for the thermocouple shall be provided.

Desirable features are a meter to indicate the output to the heater and a control which, in the event of an open circuit in the thermocouple line, will cause the temperature to fall to near the bottom of its range.

To monitor heater temperature, particularly to show the operator when the heater has attained temperature equilibrium, heater temperature shall be indicated by a meter capable of being read to ± 2 °C. This may be incorporated in the controller or separate.

9.2 Radiometer (heat flux meter)

The radiometer shall be of the Gardon (foil) type with a design range of about 10 W/cm^2. The target receiving radiation, and possibly to a small extent convection, shall be flat, circular, not more than 10 mm in diameter and coated with a durable matt black finish. The target shall be contained within a watercooled body the front face of which shall be of highly polished metal, flat, coinciding with the plane of the target and circular, with a diameter of about 25 mm.

Radiation shall not pass through any window before reaching the target. The instrument shall be robust, simple to set up and use, insensitive to draughts, and stable in calibration. The instrument shall have an accuracy of within ± 3 % and a repeatability within 0,5 %.

The calibration of the radiometer shall be checked whenever a recalibration of the apparatus is carried out (see **11.2**), by comparison with an instrument held as a reference standard and not used for any other purpose. The reference standard instrument shall be fully calibrated at yearly intervals.

9.3 Millivolt measuring device

This shall be compatible with the output from the radiometer specified in **9.2**. It shall have a full scale deflection, sensitivity and accuracy which enable the irradiance measured by the radiometer to be resolved to 0,05 W/cm^2.

9.4 Secondary thermocouple monitoring device

To monitor the secondary thermocouple, an instrument is required with a resolution equivalent to ± 2 °C. This may read directly in temperature or in millivolts. Allowance or automatic compensation for cold junction temperature shall be made. If a separate device is used to monitor heater temperature, this may, with a suitable switch connection, also be used to monitor the secondary thermocouple.

9.5 Timing device (timer)

This shall be capable of recording elapsed time to the nearest second and shall be accurate to within 1 s in 1 h.

9.6 Air and propane supplies

Air and propane shall be fed to the pilot flame (see **7.4**) via regulating valves, filters (if necessary), flow meters, non-return valves, a suitable junction connection and a flame arrester as shown in Figure 10.

9.6.1 *Gas regulating valves*

These shall be capable of adjusting the pressure and flow of propane and air to the pilot flame to the levels required by **10.2**.

9.6.2 *Filters*

Filters may need to be installed in the propane and/or air lines to avoid the readings of the flow-meters being affected by impurities (for example oil droplets) carried in the flow.

9.6.3 *Flow-meters*

These shall be capable of measuring the flow-rates of propane and air to the pilot flame to an accuracy of at least 5 %.

9.6.4 *Non-return valves*

A suitable non-return valve shall be included in both air and propane lines, sited as close to the junction point as possible.

9.6.5 *Flame arrester*

A flame arrester [see Figure 6a)] shall be mounted at the point of entry of the propane/air mixture to the pilot flame arm.

9.6.6 *Connections*

All connections with flexible tubing shall be firmly attached with suitable clips.

9.7 Calibration board

The board shall be made of ceramic fibre of density 200 ± 50 kg/m^3, and shall be square, with sides measuring $165\,^{0}_{-5}$ mm and of thickness not less than 20 mm.

A suitable hole or groove cut to fit closely around the radiometer shall be cut in the centre of the board. The target of the radiometer shall be in the plane of the upper surface of the board. If additional support for the radiometer is required, it shall be provided from below the calibration board.

9.8 Dummy specimen board

The dummy specimen board shall be constructed as specified in Figure 11. The necessary total thickness of ceramic fibre board may be built up from a number of thinner sheets attached to each other by adhesive or long fine pins.

9.9 Extinguishing board

The extinguishing board shall be made of the same material as the baseboards (**6.2**) and shall have nominal dimensions of 300 mm × 185 mm × 6 mm.

9.10 Oven

If it is necessary to meet the recommendation given in **6.4.3**, then a ventilated oven capable of maintaining a temperature of approximately 250 °C is required.

9.11 Specimen conditioning cabinet

The specimen conditioning cabinet shall be capable of maintaining a constant temperature of 23 ± 2 °C and a relative humidity of (50 ± 5) %.

9.12 Balance

The balance shall have a nominal capacity of 5 kg and shall be readable and accurate to 0,1 g.

10 Setting-up procedure and requirements

10.1 Siting the apparatus

The apparatus shall be placed in an environment essentially free of air currents (see clause **8**).

10.2 Pilot flame

(See also clause **A.5.2** in Annex A.)

The pilot flame nozzle (see **7.4**) shall be fed with a mixture of propane and air which is achieved by regulating the propane flow-rate to 19 to 20 ml/min and the air flow-rate to 160 to 180 ml/min. These flow-rates shall be measured after the pressure and flow regulating valves and shall be fed directly to the pilot flame from the flow meters so that the pressure is nominally atmospheric.

10.3 Electrical requirements

10.3.1 The heating element of the radiometer cone (**7.3**) shall be connected to the output from the thyristor of the temperature controller as shown in Figure 10. No element or wiring in this circuit shall be changed between calibration and testing. The primary thermocouple shall be connected to the temperature controller and its temperature-monitoring device. The secondary thermocouple shall be connected to its monitoring device (**9.4**).

10.3.2 The framework of the apparatus shall be provided with a good electrical earth.

10.4 Precautions against electrical interference

The radiometer shall be connected to the millivolt measuring device (**9.3**) using leads which should be screened to minimize any electrical interference to the signal. The radiometer shall be earthed back to the millivolt measuring device and by no other route (i.e. not to the earthed frame of the apparatus). All connections shall be thoroughly checked to ensure good electrical contact.

11 Calibration

11.1 Installation of radiometer

For calibration of the apparatus, the radiometer (**9.2**) shall be installed in the hole or groove of the calibration board (**9.7**).

11.2 Calibration procedure

Calibration procedure shall be as follows.

a) Set up the apparatus as described in clause **10**, except that the pilot flame mechanism shall be kept in the reignition position with gas supply turned off throughout the calibration procedure.

b) Place the calibration board (**9.7**) in the apparatus in the specimen position so that the target of the radiometer (**9.2**) is located centrally within the circular opening of the masking plate, in the plane of the bottom face of the masking plate.

c) Switch on the electricity supply and establish the temperature settings of the controller required to produce irradiances at the centre of the circular opening in the masking plate of 1, 2, 3, 4 and 5 W/cm^2. Adjustments near the final setting for heater temperature should be followed by a 5 min period without further adjustment to ensure that the remainder of the apparatus has attained sufficient temperature equilibrium.

At each full equilibrium, read and record the secondary thermocouple monitor. These readings are to enable a close and independent check to be made on the temperature of the heater during testing.

d) Carry out this procedure at least twice, the first time at settings of increasing temperature and the second time at decreasing settings.

The values should be repeatable to within ± 5 °C. Repeatability values outside these limits indicate possible defects in control of monitoring equipment, or significant changes in the test environment, which shall be corrected before further calibrations are carried out.

11.3 Calibration check

The irradiance produced by the temperature setting which the initial calibration has shown to correspond to an irradiance of 3 W/cm^2 shall be frequently checked (at least once every 50 operating hours) and the apparatus shall be recalibrated if such a check reveals a deviation greater than 0,06 W/cm^2.

12 Test procedure

12.1 Initial procedure

The initial procedure shall be as follows.

a) Set up the apparatus as described in clause **10**.

b) Weigh a prepared specimen-baseboard combination (**6.4.1**) and return to the conditioning atmosphere.

c) Adjust the counterweight mechanism to give a force of 20 ± 2 N between the upper surface of the specimen and the underside of the masking plate (see **7.2.2** and subclauses **A.6.1** and **A.6.2** in Annex A), when the specimen-baseboard combination is positioned on the pressing plate in the insertion and location tray. This adjustment may be made by the methods indicated in **A.6.1** but using a dummy of the same mass as the specimen-baseboard combination instead of a prepared and conditioned specimen.

d) Insert the dummy specimen board (**9.8**).

e) Adjust the temperature setting of the controller to the appropriate value established by the calibration procedure to correspond to 5 W/cm^2 (or other level as required).

f) Allow the apparatus to heat up to equilibrium. When the heater has attained temperature equilibrium, as shown by the indicating meter of the temperature controller, a further 5 min should be allowed to elapse before commencing exposure of a specimen.

g) Check that the reading of the secondary thermocouple is within the equivalent of ± 2 °C of the value established during the calibration procedure (**11.2**). A deviation outside this tolerance indicates the need for a complete recalibration.

h) Remove a prepared specimen from the conditioning cabinet (**9.11**) and place it on the insertion and location tray (**7.5**).

i) Place the specimen screening plate on top of the masking plate.

j) Start the pilot flame application mechanism (**7.4**).

k) Lower the pressing plate, remove the dummy specimen board and replace it with the insertion and location tray containing the specimen.

l) Release the pressing plate.

m) When the pilot flame is at the re-ignition position, simultaneously remove the specimen screening plate and start the timer (**9.5**).

12.2 Time permitted for test initiation

All operations detailed in **12.1** i) to m) shall be completed within 15 s.

12.3 Conduct and termination of test

12.3.1 If sustained surface ignition of the specimen occurs (see **3.9**), the timer shall be stopped. Any flames shall immediately be extinguished by placing the extinguishing board (**9.9**) on top of the masking plate and the pilot flame application mechanism shall be stopped. The tray and remains of the specimen shall then be quickly removed and replaced by the dummy specimen board. The extinguishing board shall then be removed as quickly as possible (see sub-clause **A.6.3** in Annex A).

12.3.2 If no sustained surface ignition of the specimen occurs within 15 min, the test shall be stopped by placing the extinguishing board on top of the masking plate and the pilot flame application mechanism shall be stopped. The specimen shall then be removed and replaced by the dummy specimen board. The extinguishing board shall then be removed as quickly as possible.

12.3.3 Transitory surface ignitions and/or plume ignitions should be noted as far as possible but should not cause the test to be terminated.

12.4 Repeat tests

12.4.1 Operations **12.1** h) to m) and **12.3** shall be repeated with four more specimens at the same irradiance after allowing sufficient time between applications to allow the apparatus to reach thermal equilibrium (see sub-clause **A.6.3** in Annex A).

12.4.2 If sustained surface ignition occurs with any specimen in a set of five at a given irradiance, a further set of five specimens shall be tested at the next lower level of irradiance (or at any other set lower level).

12.4.3 Operation **12.4.2** shall be repeated as necessary until a set of five specimens has been tested at each required irradiance.

12.4.4 If no sustained surface ignition occurs (see **12.3.2**) with all specimens in a set of five at a given irradiance, tests shall not be carried out at lower irradiances, unless specifically required (see sub-clause **A.6.2** in Annex A).

12.4.5 When adjusting the heater to the next level of irradiance, sufficient time shall be allowed for the apparatus to reach thermal equilibrium following the change in temperature setting (see clause **A.6.3** in Annex A).

At full equilibrium the reading of the secondary thermocouple should be within ± 2 °C of the value established during the calibration procedure (**11.2**).

12.5 Observations during test

12.5.1 For each specimen tested, the time at which sustained surface ignition occurs shall be noted (see **3.9**).

12.5.2 Observations shall be made during each test of the general behaviour of the specimen and, in particular, note should be made of the following:

a) the time, position and nature of other ignitions;

b) glowing decomposition of the specimen;

c) melting, foaming, spalling, cracking, expansion or shrinkage of the exposed surface of the specimen.

12.6 Special procedures

12.6.1 ***Soft and softening products***

12.6.1.1 For some soft products, especially low-density products such as glass- or mineral-fibre products with or without coatings, the pressure of the pressing plate may cause some compression of the edges of the specimen so that the exposed face of the specimen is not flat but convex upwards. This can occur even without heating from the radiator cone.

In order that the specimen should not be subjected to an irradiance higher than that for a flat, stable specimen, an adjustable stop should be installed and operated on the pressing plate mechanism to avoid the crushing of the aluminium foil wrapping, to maintain the surface of the specimen flat and to preserve the nominal thickness of the product. Alternatively, spacing blocks between the pressing plate and the masking plate may be used.

12.6.1.2 For specimens which are likely to contract, soften or melt away when heated it is necessary to prevent the pressing plate (**7.2.2**) from unduly crushing the aluminium foil wrapping on the edge of the specimen. This can be accomplished by an adjustable stop on the pressing plate mechanism or spacing blocks between the pressing plate and the masking plate.

12.6.1.3 With certain products the pilot flame application mechanism may not act satisfactorily. For example, some materials become sticky when heated and can be drawn up in threads, some materials are or become soft enough for the pilot flame arm to bury itself, some materials intumesce and produce a foamed char "crust" having little mechanical strength. With these products it will be necessary to operate the adjustable stop on the travel of the pilot flame application mechanism to bring it close to, but not touching, the exposed surface of the specimen (see sub-clause **A.6.4** in Annex A).

12.6.1.4 Certain materials (e.g. PVC) may contain high concentrations of flame retardants. With these products, the copious fumes generated on irradiating can extinguish the pilot flame and prevent its re-ignition by the secondary ignition source. If this situation occurs repeatedly within 15 min, when reasonable attempts to re-light the pilot flame have been made, the results should be given as "no sustained surface ignition under these test conditions: pilot flame repeatedly extinguished by decomposition products".

12.6.2 ***Assemblies containing an air gap***

When an assembly is to be used with an air gap behind the exposed surface, care shall be taken to ensure that the pilot flame nozzle cannot penetrate the surface of the specimen and enter the void behind. If necessary the adjustable stop shall be operated to prevent this from occurring.

12.6.3 ***Products with irregular surfaces***

When testing a product with an irregular surface [complying with **5.1.1**.b)] it may be necessary to operate the adjustable stop on the travel of the pilot flame application mechanism, to ensure that, initially, the flame issues from the nozzle orifice at a distance of 10 mm above the highest point of the specimen. If necessary, the adjustable stop should be operated to follow any change in surface shape.

13 Expression of results

13.1 At each irradiance, the time to sustained surface ignition, in seconds, shall be reported for each of the five specimens tested.

13.2 if for any specimen no sustained surface ignition occurs within 15 min (see **12.3.2**), the result for that specimen at that irradiance shall be given as "no sustained surface ignition".

13.3 if no sustained surface ignition occurs with all specimens in a set of five at a given irradiance, then tests at lower irradiances need not be carried out, but shall be reported as "not tested".

14 Test report

The test report shall be as comprehensive as possible and shall quote the individual specimen ignition times for each irradiance tested. Any observations made during the test and comments on any difficulties experienced during testing shall also be given. The following essential information shall also be given in the test report and shall additionally be included in a summary test report:

a) name and address of test laboratory;

b) name and address of sponsor;

c) name and address of manufacturer/supplier;

d) full description of the product tested including trade name, together with its composition, construction, orientation, thickness, density and mass of the conditioned specimen before test and where appropriate the face subjected to test (note particularly **5.1.2**). Details of substrates used and fixing methods shall be given. With composites and assemblies the thickness and density of each of the components shall be given, together with the apparent (i.e. overall) density of the whole;

e) for some products the date of manufacture and information about subsequent treatment and/or exposure may be of importance;

f) the statement: "The test results relate only to the behaviour of the test specimens of a product under the particular conditions of the test; they are not intended to be the sole criterion for assessing the potential fire hazard of the products in use".

A suggested summary test report is given in Annex B.

Annex A Commentary on the text and guidance notes for operators

A.0 Introduction

This annex aims to provide the test operator, and perhaps the user of the test result, with background information and more explicit details of some of the requirements and procedures given in this specification.

A.1 Definitions

For the purpose of clarity, the material which is the subject of investigation has been defined as a product, and this can be a single material, a composite or an assembly.

It is known that the ignition characteristics of a material may vary considerably when used in different conditions, for example a thin material backed with a lightweight insulating substrate will behave differently when backed by a dense high-conductivity material. It is important that consideration is given to the actual usage of the material in practice.

The definition of the three types of product allows clarification in the test report of the way in which a test was conducted on a building product.

A.2 Principles of test

This test method examines the ability of a surface, when exposed to radiant heat, to produce volatile gases which would sustain ignition in the presence of a small ignition source. It does not study the ability of the surface to resist ignition when subjected to direct flame impingement in the absence of additional impressed radiation, which will depend upon the application time of the igniting flame and the total energy release in the ignition flame.

It has been shown[4)] that before ignition substantial absorption of radiation can take place in the plume of decomposition products rising from a specimen exposed in this apparatus.

This could have an influence on the quantitative application of the test data.

A.3 Suitability of a product for testing

A.3.1 The test method and equipment, although designed to examine flat surfaces, can accept a limited amount of surface irregularity. Surface characteristics of certain building products have been identified and have been considered in two groups, i.e. regularly formed or grooved surfaces (for example corrugated sheets) and embossed, scarred or punctured surfaces (for example patterned mineral fibre tiles). Limiting dimensions have been chosen to ensure that an irregular surface is subjected to the same irradiance as a flat surface and that the majority of the irregular surface is at the test plane.

A.3.2 The test specimens shall be representative of the surface of the material to be tested. If a representative area cannot be obtained, it may be necessary to conduct more than one test for a full evaluation of the variation in the product's surface. Simulation of a product surface, which does not satisfy the dimensional limits, in modified flat form may also require more than one test for a full evaluation of the variation in the product's surface. In either case the test results shall be separately recorded.

A.3.3 When an assessment of the area of surface irregularity is required, this can be carried out by machining the surface to a depth of 10 mm below the highest point and estimating the machined surface area.

A.3.4 The results of the test with products of low absorptance (for example shiny metallic surfaces, glossy enamelled surfaces) need to be treated with caution (see Annex C).

A.3.5 It has to be realized that for large initial thicknesses of those kinds of materials which melt away on heating, the test is to some extent unsuitable since the irradiance at the melted material (on top of the baseboard) will be lower than at the original surface of the material, and the dwell time of the pilot flame close to the melted material will be reduced.

A.3.6 The test cannot be expected to yield a meaningful result with products which intumesce considerably, although some intumescence can be accommodated — nearly up to the plane of the bottom of the shade — if necessary with suitable manual adjustment of the diving pilot flame (**12.6.1.3**).

A.4 Specimen construction and preparation

A.4.1 Careful consideration should be given to the mounting of specimens to ensure that they represent the building product in practice.

[4)] See T. KASHIWAGI, Experimental Observation of Radiative Ignition Mechanisms, *Combustion and flame*, **34**, 1979, pp. 231-244.

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 ignition 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. Any backing provided to the test specimens and in intimate contact with them, such as the baseboards, may alter this "heat sink" effect and may be fundamental to the test result itself.

With thin materials or composites which in practice may be used with a variety of substrates it may be advisable to carry out tests with several types of substrate to obtain an indication of the likely ignition performance in practice. Both the "thermal inertia" (related to the product of thermal conductivity, density and specific heat) of the substrate and its combustibility may affect the ignition performance of the material or composite.

A.4.2 Further development work will be needed before problems associated with some unusual specimens can be resolved. For example a thin specimen of material which is normally backed by air should be tested with as realistic an air gap as possible.

It is possible that in some circumstances the use of a closed cavity in representing an air gap could create problems.

A.4.3 Constant mass is proof of satisfactory conditioning; cellulosic materials may require periods in excess of two weeks to reach equilibrium with the conditioning atmosphere, but plastics may take less time. Unless otherwise specified in established standards, each test specimen of plastics should be conditioned for at least 48 h at 23 ± 2 °C and (50 ± 5) % RH (see ISO 291) immediately prior to use.

A.5 Test apparatus

A.5.1 Three methods have been found suitable for the attachment of the thermocouples to the heater coil:

a) A type K (Ni-Cr/Ni-Al) or type R (Pt/Pt 13 % Rh) thermocouple in a 1 mm diameter stainless steel sheath, capable of continuous operation at 900 °C, with insulated hot junction, is inserted as a "push fit" in a hole in a stainless steel block brazed to the heater element with an alloy having a remelt temperature of more than 900 °C [see Figure 4c)].

b) A type K or R thermocouple in a 1 mm diameter stainless steel sheath, capable of continuous operation at 900 °C, with insulated hot junction, is held in contact with the heater element by means of a small stainless steel clamp [see Figure 4c)]. The clamp is tightened by pinching the projecting lug with pliers.

c) A type K insulated and glass-braided thermocouple having 0,5 mm diameter wires individually welded to the heater element. The thermocouple junction is formed by welding the individual wires to the heater element approximately 3 mm apart by a capacitor discharge welder [see Figure 4c)].

Both the clamp and the block should be roughened with emery paper and the heater run for several days at a temperature of 600 to 700 °C before calibration of the apparatus to encourage stabilization of a high emissivity. Until it is clear that stabilization has occurred, a new heater coil should be calibrated more frequently than is required in **11.3**.

The thermocouples may be inserted through the upper or lower apertures of the radiator cone, or through a hole in the shade. The thermocouples shall be securely held close to their entry into the radiator cone.

A.5.2 The mechanism for the pilot flame application in Figure 2 and Figure 6 can give the specified application time for the flame of $1\ ^{+0,1}_{0}$ s when the surface of the specimen remains dimensionally stable. If, however, the specimen swells and the surface rises, the application time will increase, and if the specimen shrinks downwards, the application time will decrease. It is thought that this should be accepted for the present, and only if experience shows it to be necessary should a mechanism be developed which will maintain an application time of $1\ ^{+0,1}_{0}$ s irrespective of surface movement. For the mechanism recommended, the variation of application time with position of surface will be reproducible between different apparatuses.

The flow rates specified in **10.2** should give a pilot flame about 10 mm long.

A.5.3 Whilst phase angle control is allowed for the temperature controller of the radiator cone, it should be noted that this will usually require electrical filtering to avoid noise on low-level signal lines.

A.6 Test procedure

A.6.1 A convenient way of setting the counterweight mechanism to give the force of approximately 20 N, as required by **12.1**, between the pressing plate and the masking plate, is to use the pivoted counterweight arm as a balance. If a 2 kg mass is temporarily suspended from the underside of the opposite end of the pivoted arm from the counterweight, the counterweight can then be set to produce a balance either by adding extra, removable, weights to it or by adjusting its position on the pivoted arm. The 2 kg mass can then be removed, hence giving the correct force on the bottom of the sliding rod which operates the pressing plate. Alternatively, the position of the counterweight on the pivoted arm could be calibrated against the mass of the specimen.

A.6.2 When testing more than one material at a time, it may be convenient and more expedient to continue tests at the same irradiance on another batch of five specimens prior to changing the irradiance setting of the apparatus. In this case it will be necessary to readjust the counterweight before each set of specimens.

A.6.3 Once ignition of a specimen has occurred, it should be extinguished as soon as possible to prevent excessive cooling of the radiator cone by the increased airflow through it. In between successive specimens, it is necessary to ensure that sufficient time interval is left to allow the apparatus to reach equilibrium. Attainment of temperature equilibrium of the heater is shown by the indicating meter and once this is obtained, a further period of not less than 3 min should elapse before the next test to ensure that the remainder of the apparatus has attained sufficient temperature equilibrium. This procedure, with a delay period of 3 min, is also applicable for a change in irradiance.

A.6.4 Careful observation of the behaviour of the surface of the specimen and the action of the pilot flame as it comes to the surface should be made. If the adjustable stop on the travel of the pilot flame application mechanism has to be used, it may require constant adjustment between subsequent applications of the pilot flame.

A.6.5 To avoid disturbance to the ambient air flow it is recommended that the operator should avoid excessive sudden movements.

A.7 Safety

A safety warning is given in the Introduction (see **0.5**) relating to the evolution of toxic or harmful gases during the exposure of test specimens. Attention should also be drawn to the hazards arising from the hot radiator cone, the use of a mains voltage electricity supply and the use of water to extinguish and cool down specimens after ignition. 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 should be used by the operator.

Annex B Summary test report

Name of laboratory: ..... Laboratory reference No.: .....

Address: ..... Date of test: .....

Telephone No.: ..... Telex No.: .....

Report of test to ISO 5657, ignitability test

Sponsor: .....

Address: .....

Manufacturer/supplier and address: .....

Description of product:

Material, composite or assembly: .....
Trade name and/or reference No.: .....
Composition: .....
Construction: .....
Orientation: .....
Thickness: .....
Area density, kg/m^2: .....
Mass of conditioned specimen,
excluding baseboard and foil wrapping (mean): .....
Face subjected to test: .....
Other information: .....
Form in which specimen was tested: .....

Test results

	Time, in seconds, of sustained surface ignition at specified irradiance				
	1 W/cm^2	2 W/cm^2	3 W/cm^2	4 W/cm^2	5 W/cm^2
Specimen (1)					
(2)					
(3)					
(4)					
(5)					

Observations:

The test results relate only to the behaviour of the test specimens of a product under the particular conditions of the test; they are not intended to be the sole criterion for assessing the potential fire hazard of the product in use.

NOTE Complete test details can be obtained from the full test report available from the sponsor.

Annex C Application and limitations of test

The test method specified in this International Standard is concerned with essentially flat building products (materials, composites or assemblies) which may be exposed to fire and whose ignition and subsequent burning may affect fire growth and spread. The test examines the ability of products to become ignited when irradiated from a primary fire in the presence of means for piloting the ignition. In practice this might be by flame contact, continuous or intermittent, or by embers, sparks or by burning material falling down.

It is one of a series of tests for the reaction to fire being developed by ISO, the results of all of which will usually need to be considered together in order to assess the effect of such products on fire behaviour and hence to enable requirements for building control to be specified.

The test is intended to provide information which can be used in the evaluation of wall and ceiling linings, flooring systems, external claddings, and duct insulation materials. In some well-defined circumstances the exposure to fire of such products is capable of precise specification and the result of the test may be directly related to the performance expected in practice. In other cases a much less precise specification will be possible. However, the test may be made use of to distinguish products which are more easily ignited from those which are less easily ignited; this will often contribute to a difference in hazard between the materials.

The method may also be applicable to non-building products.

Evidence is accumulating for a correlation between the ignitability test specified in International Standards and flame spread tests, at least for the higher flux levels. It is possible that the results of the ignitability test could provide a good measure of fire growth.

The present test does not consider the ability to ignite by flame contact alone, without additional impressed radiation.

The test employs a horizontal specimen but this is rather to permit the testing of thermoplastics than to represent products

which in practice are used in a horizontal orientation. In any case the representation of the ignition of realistic exposed areas of vertically-orientated products is not necessarily achieved simply by a test with a small vertical specimen. The orientation will affect other variables which in turn can modifiy time to ignition, for example the absorption of radiation in the volatiles being generated by the specimen and the modification of the air flow past the specimen by the heater. Orientation and specimen size may well interact.

The test will have particular relevance for fire spread and growth situations where, a fire having grown to a certain point, a new phase of spread or growth is possible if ignition by radiation can bring fuel hitherto uninvolved into play. For example, a relatively small fire near a wall in a compartment may be expected to grow rapidly if it succeeds in igniting a flammable wall lining; ignition of a lining material in a corridor heated by strong radiation passing through a door opening from a well-developed fire in a room may initiate a phase of fire spread in the corridor.

Ignition by radiation is clearly an important consideration where protection against fire spread is being sought by spatial separation — for example spread of fire between buildings can be prevented by spacing them sufficiently apart. The ignition performance of modern materials is a factor of especial importance here since existing building control for space separation has as an underlying basis the critical irradiance for pilot ignition essentially of cellulosic materials.

One feature of the test is that the specimens are heated almost entirely by radiation. The ignition performance of a specimen with a shiny metallic finish might be much better in this test than it would be in practice in a situation where, by contact with the flame or combustion gases, the absorptance of the finish may be markedly increased by soot deposition or condensation of moisture. It should be realized that the visual appearance of a surface is not always a guide to its absorptance for thermal radiation. White surfaces, with low absorptance for white light may have high absorptance for thermal radiation from sources at fire temperatures.

Annex D Variability in time to sustained surface ignition

An interlaboratory trial has been carried out in which replicate batches of a number of materials were tested by a number of laboratories according to a test procedure closely similar to that given in this International Standard. The main difference — and the only one likely to affect the results — was that in the interlaboratory trial the power input to the heater was maintained constant, rather than the temperature of the heater. These two methods were compared in an experiment carried out by the Experimental Building Station of Australia, employing six different materials. Full details of the experiment were supplied to the ISO Working Group responsible for developing this test, but the results have not otherwise been published.

No significant differences in ignition time, or in the variability of ignition time between the two methods were found and accordingly it was felt that the data on variability given in the table would be representative of the test method specified in this International Standard. The interlaboratory trial showed that the sustained surface ignition times of some materials were relatively more variable than those of others. Furthermore for some materials the relative variability increased with decreasing irradiance. It is therefore not meaningful to quote a single value for the variation of the test.

No significant differences in the variability of the time to sustained surface ignition were found between the participating laboratories, but ignition time is sensitive to irradiance and it became clear during the trial that careful attention must be paid to the measurement of irradiance. The table gives the coefficients of variation of the time to sustained surface ignition for seven materials obtained within and between nine laboratories whose measurements of irradiance were shown to be accurate

by circulation among them of a calibrated heat-flux meter. Another material tested in the interlaboratory trial (a thin coating of PVC on glass fibre mat) gave mainly transient ignitions and has not been included in the analysis.

The values given in the table were calculated entirely from complete data sets where sustained ignition had occurred in all five replicate cases. In cases where any laboratory obtained one or more non-ignitions at a particular irradiance, then no calculation was made of the coefficient of variation for this irradiance.

The table also gives the repeatabilities and reproducibilities for single values of time to sustained surface ignition, derived from the coefficients of variation within and between laboratories and defined in accordance with ISO 5725.

Repeatability (r) is the value below which the difference between two ignition times obtained with the same method on identical test material, under the same conditions (same laboratory, same apparatus, same operator, and a short interval of time), may be expected to lie with a specified probability (in this case taken as 95 %).

Reproducibility (R) is the value below which the difference between two ignition times obtained with the same method on identical test material, under "different" conditions (different laboratories, different operators, different apparatuses and/or different times), may be expected to lie with a specified probability (in this case taken as 95 %).

The values in the table suggest that for some products there is relatively greater variation at the lowest irradiance.

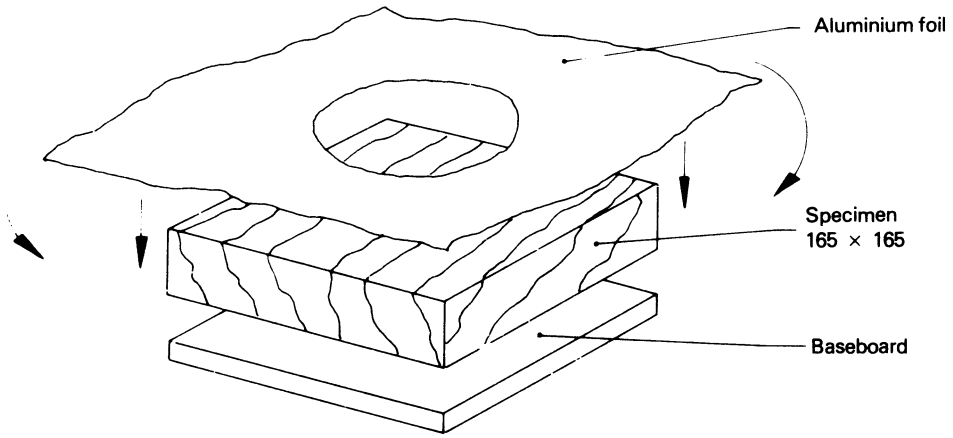
Table — Coefficients of variation, repeatabilities and reproducibilities of time to sustained surface ignition

Product	Approximate thickness mm	Irradiance W/cm^2	Overall mean time to ignition[a] s	Coefficient of variation of time to sustained surface ignition % of mean time		Difference between single values of time to ignition	
				Within laboratories	Between laboratories	Repeatability (within laboratories) % of mean	Reproducibility (between laboratories) % of mean
Chipboard (fire retardant grade)	13	5	28,7	10	13	29	47
		4	49,1	8	12	21	41
		3	103,2	8	9	23	33
		2	315,1	7	16	20	49
Plasterboard	13	5	42,5	13	19	36	64
		4	89,5	14	16	40	60
Nylon carpet on foam backing	7	5	32,4	6	9	19	30
		4	48,7	5	13	14	38
		3	85,1	10	22	27	67
Hardboard (untreated)	3	5	43,1	8	8	22	31
		4	64,3	9	8	25	34
		3	112,9	5	13	15	39
		2	234,8	7	18	19	54
Glass-reinforced polyester	1	5	22,7	7	9	19	31
		4	32,9	13	14	37	55
		3	53,4	11	21	32	67
		2	199,2	28	67	80	206
Expanded polystyrene (fire retardant grade)	30	5	28,0	14	13	39	54
		4	47,4	17	26	48	88
		3	164,1	20	29	58	101
Polyvinyl chloride (rigid)	1,7	5	33,0	6	6	18	26
		4	53,8	22	19	63	82
		3	92,0	13	12	37	51
		2	339,1	28	17	79	92

[a] The overall mean times to ignition given here apply to the batches of the products actually tested and do not necessarily represent the performance of the material in general.

Dimensions in millimetres

Wrapping of specimen and baseboard



Wrapped specimen

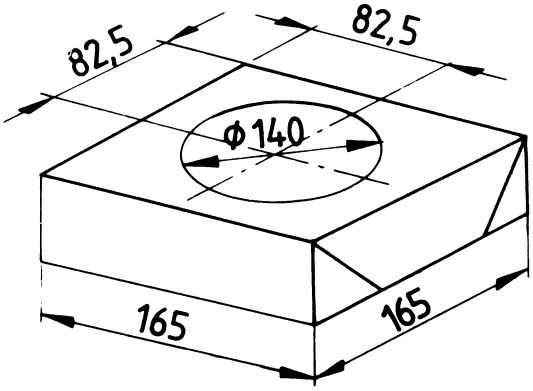


Figure 1 — Wrapping of the specimen

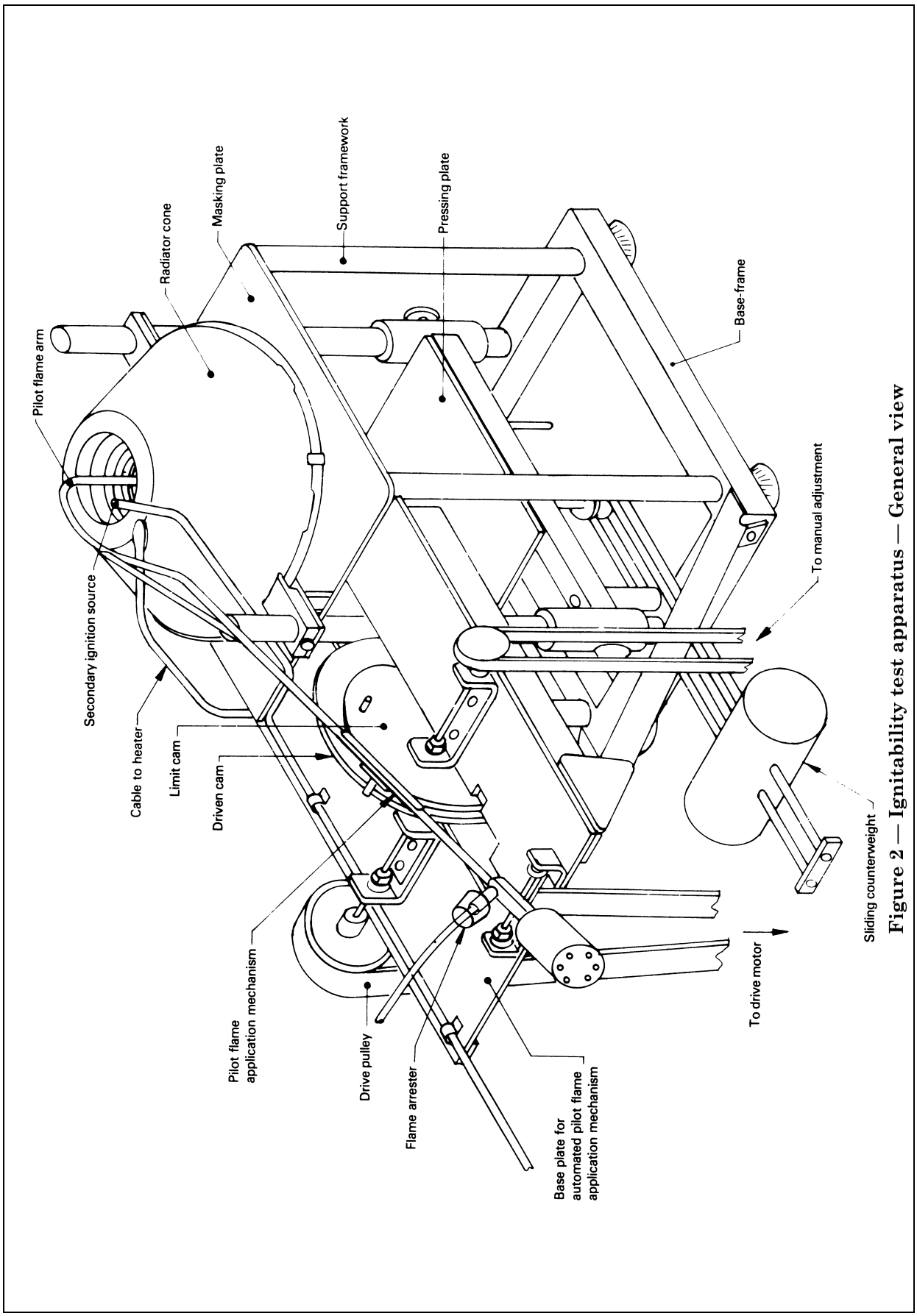


Figure 2 — Ignitability test apparatus — General view

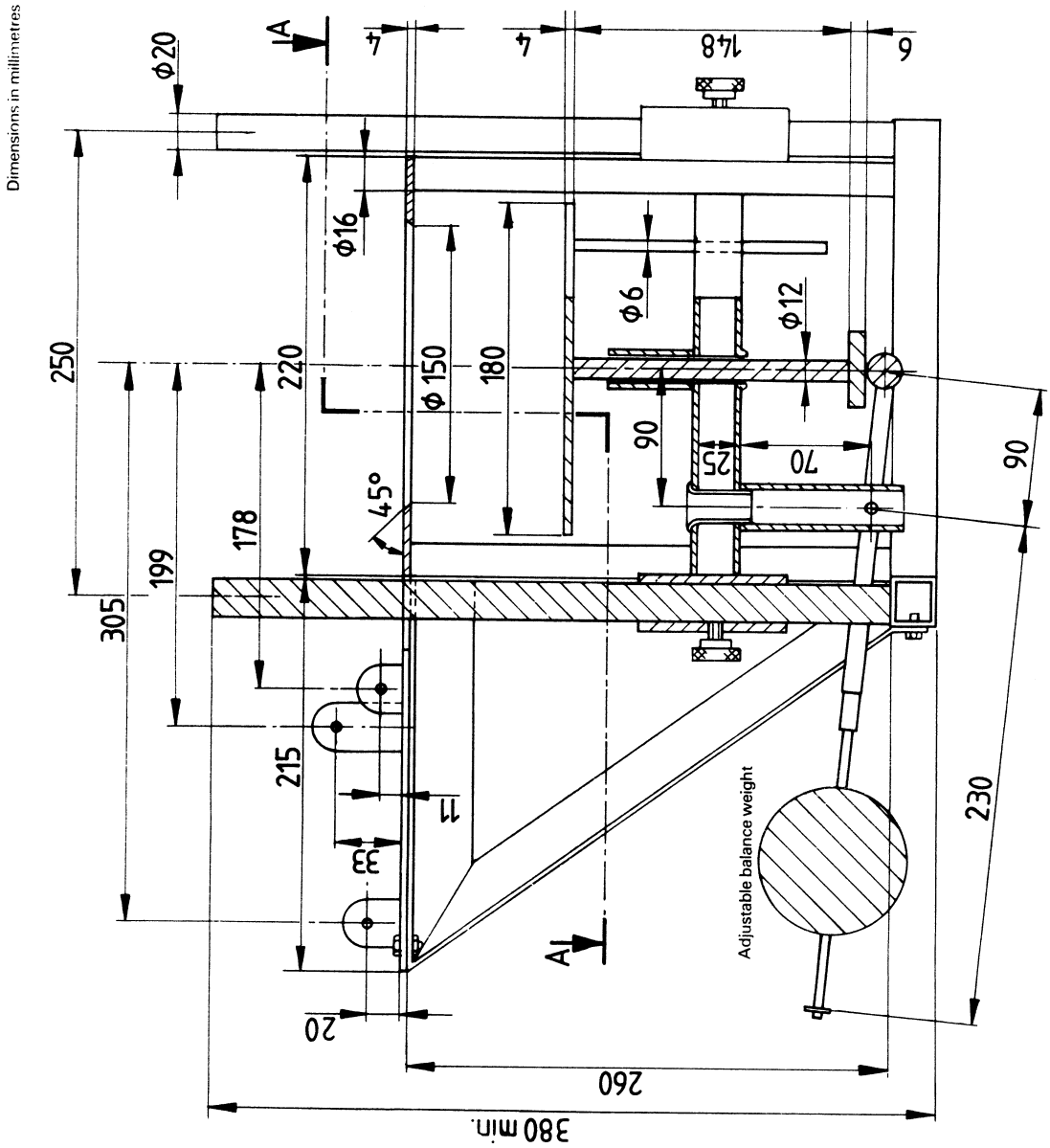


Figure 3a) — Specimen support framework — Part sectional elevation along B-B [Figure 3b)]

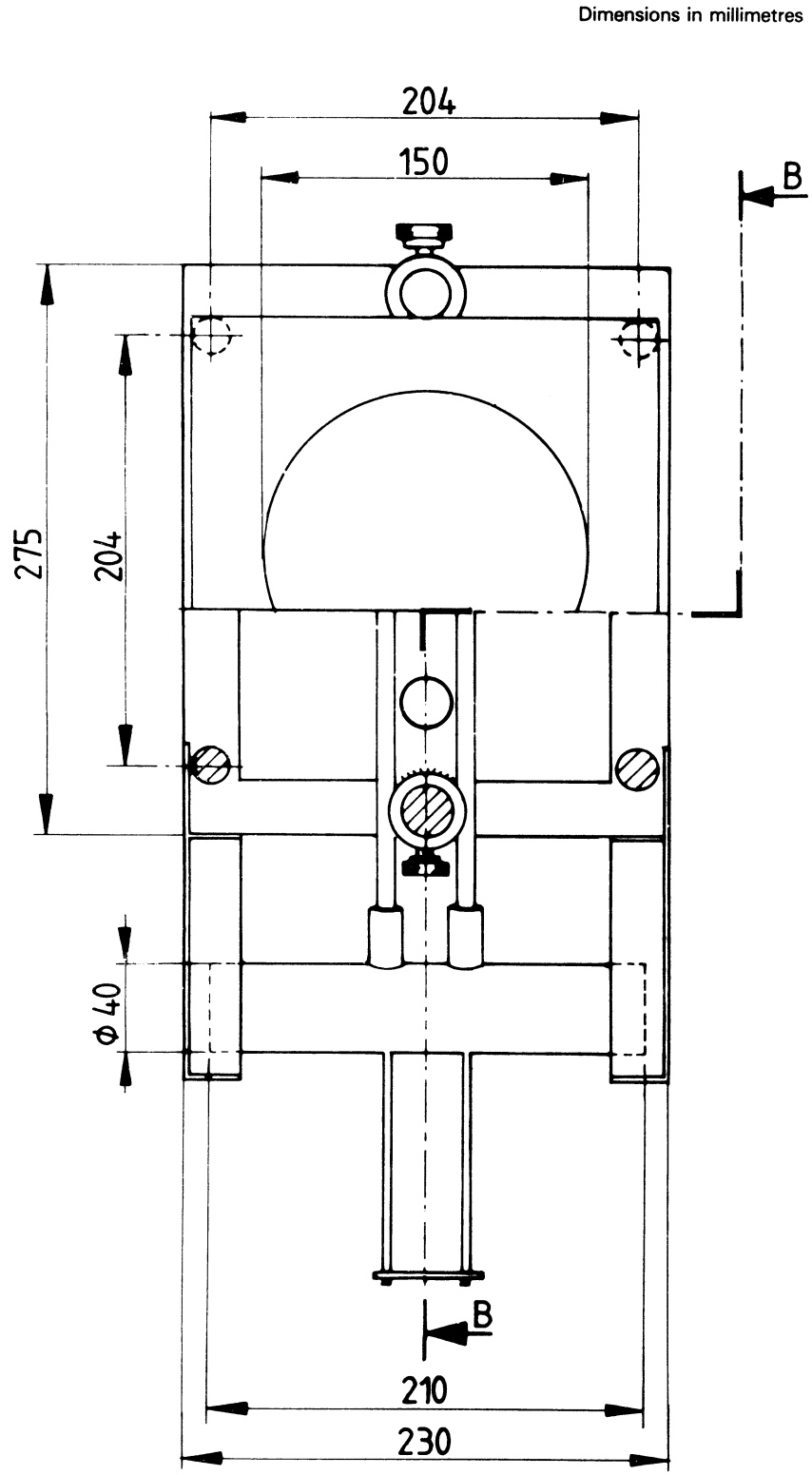


Figure 3b) — Specimen support framework — Part sectional plan along A-A [Figure 3a)]

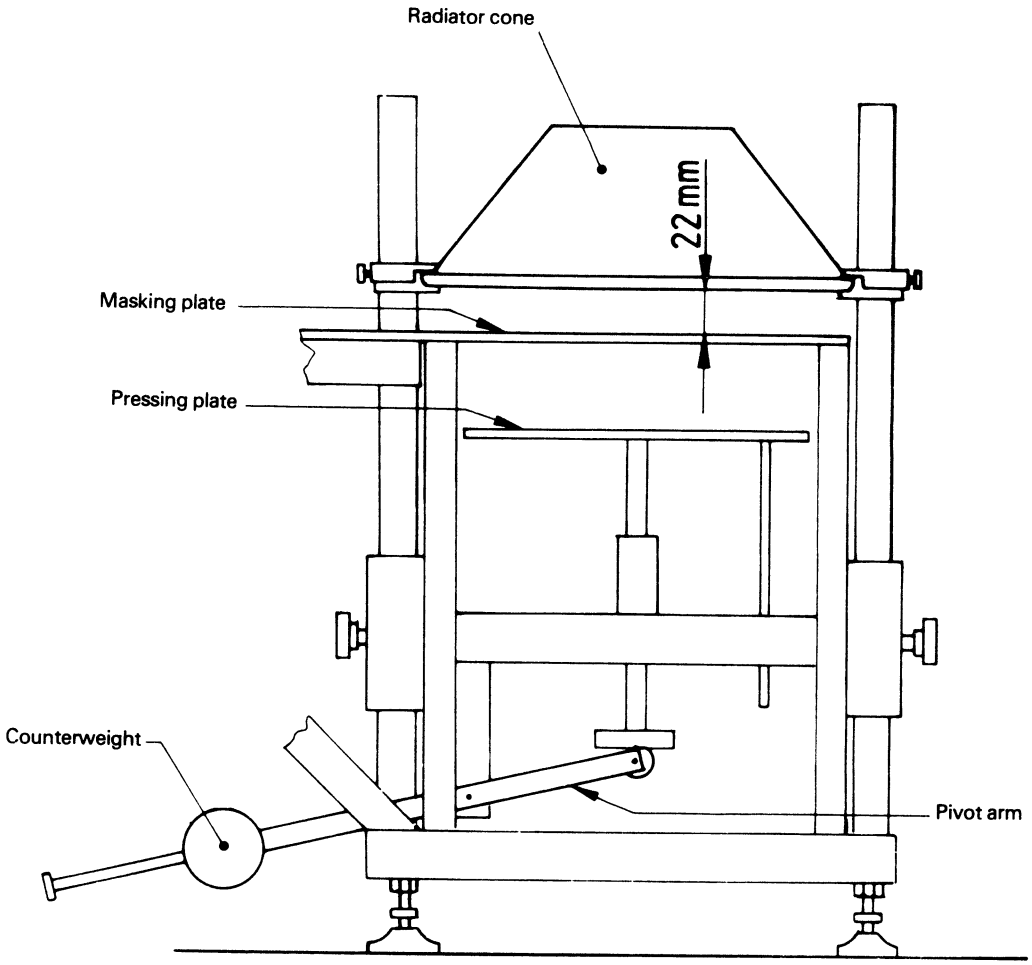


Figure 4a) — Specimen support framework and radiator cone

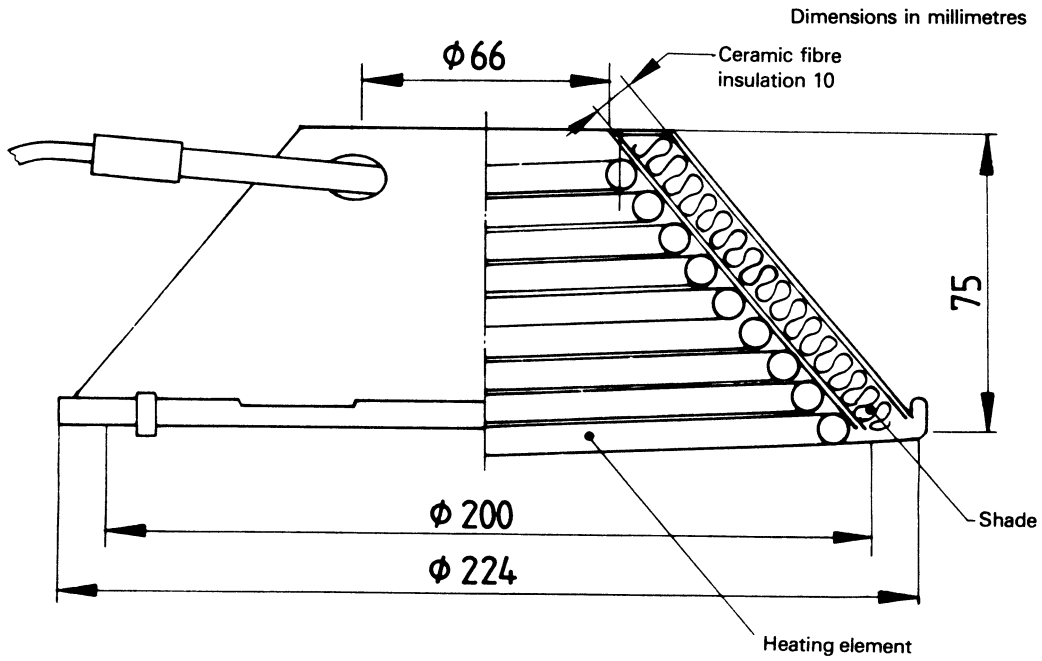


Figure 4b) — Radiator cone

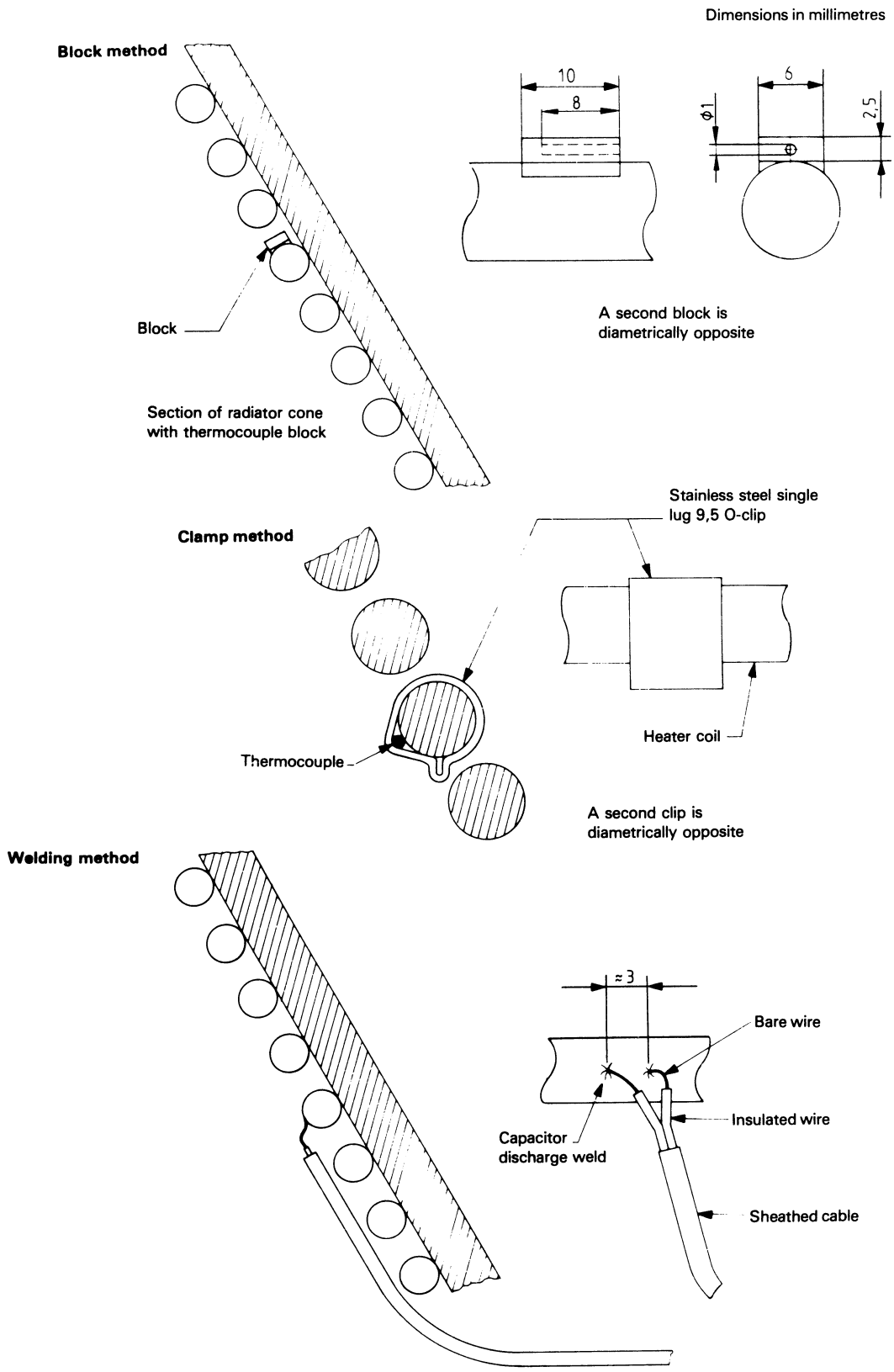


Figure 4c) — Methods for attachment of thermocouples to heater coil

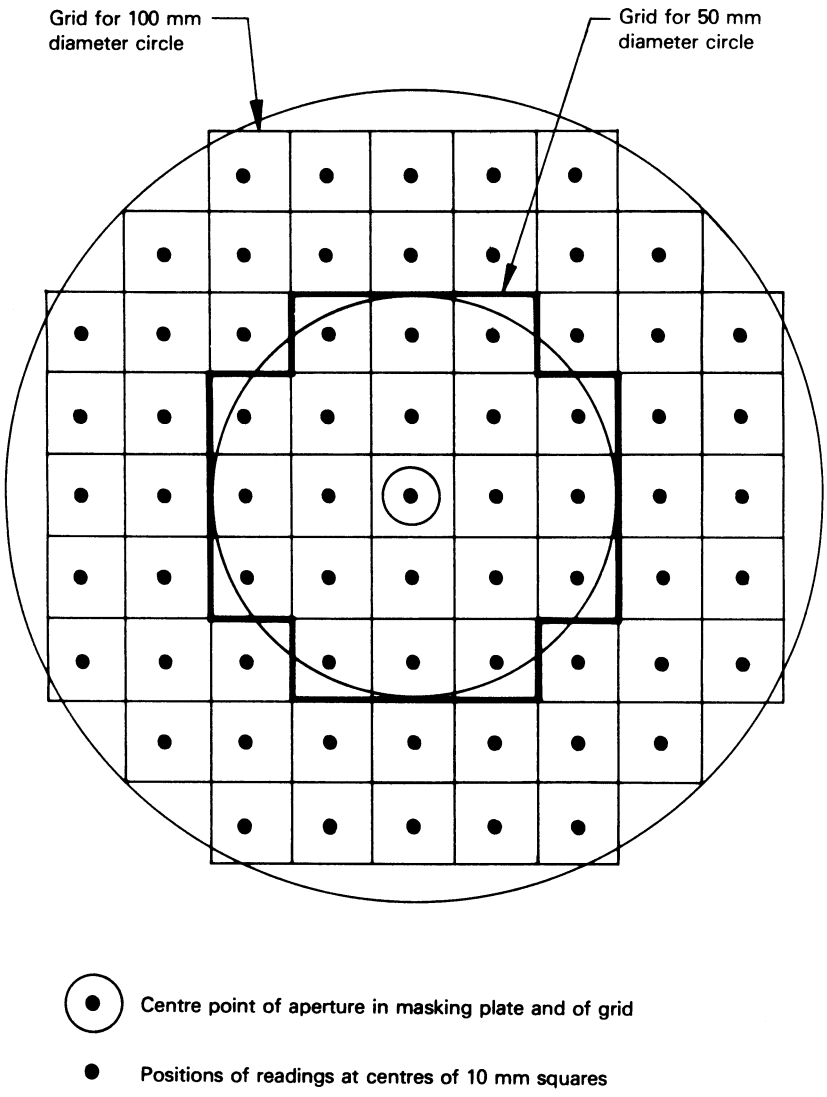


Figure 4d) — Grids of readings for irradiance distribution

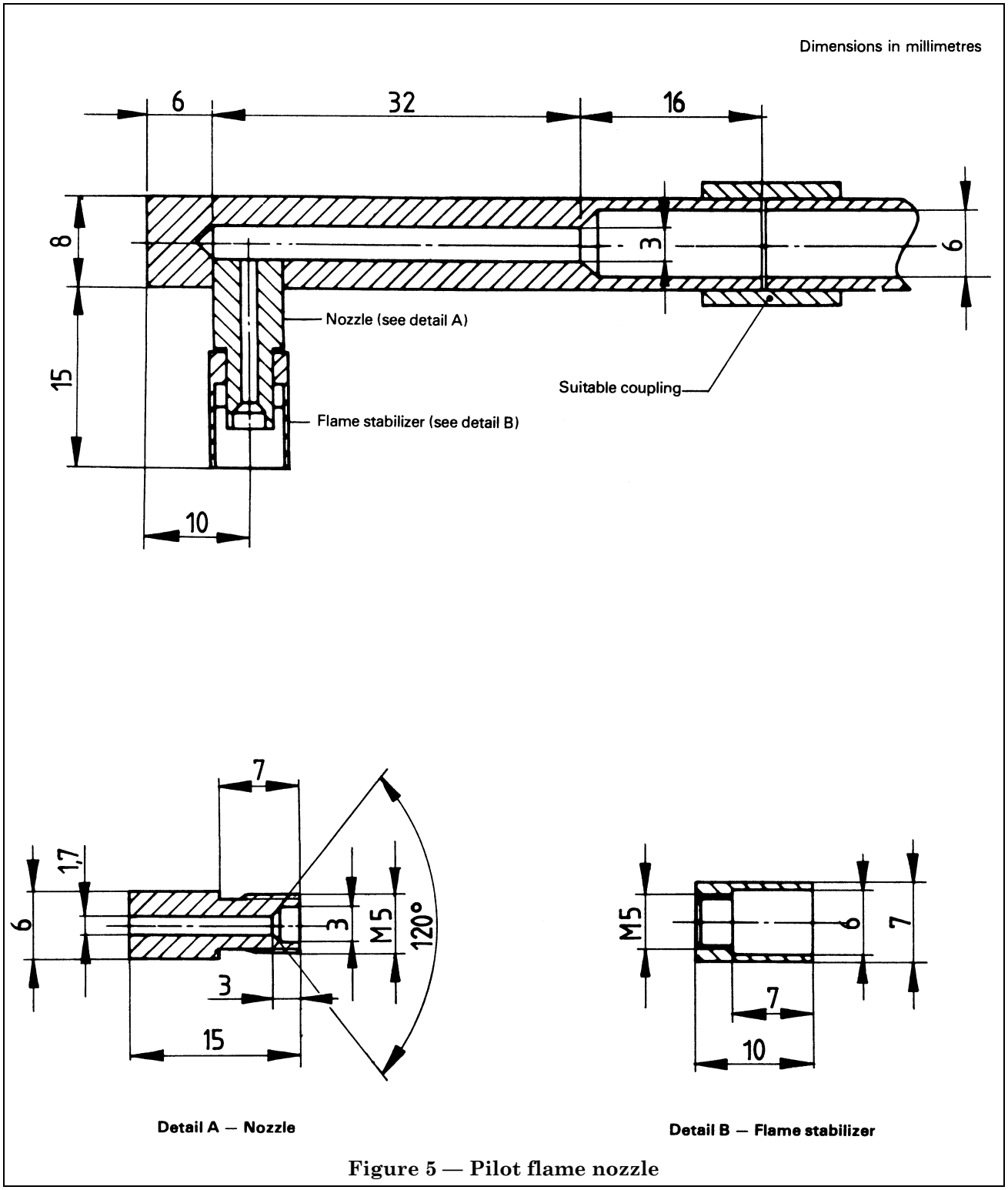


Figure 5 — Pilot flame nozzle

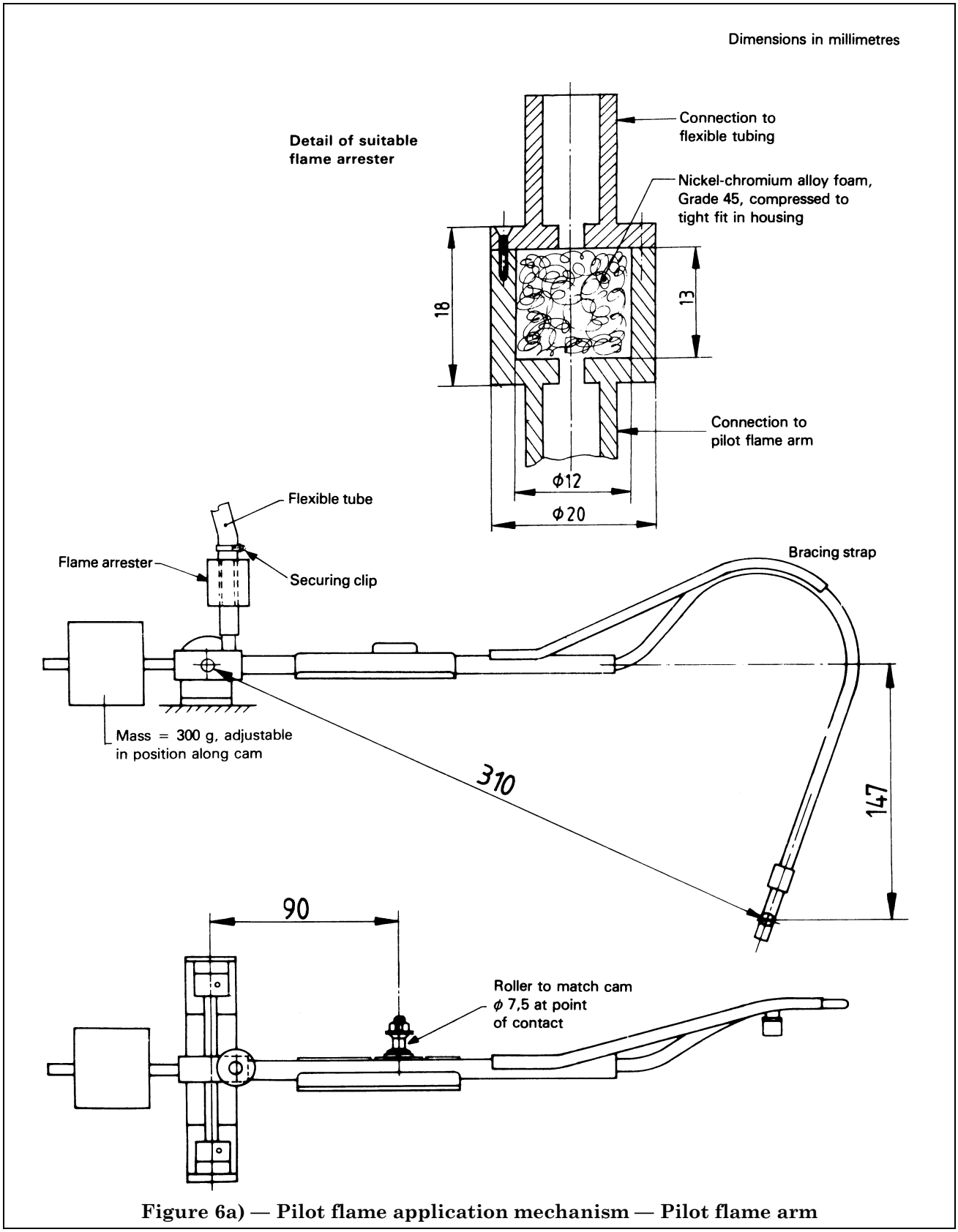


Figure 6a) — Pilot flame application mechanism — Pilot flame arm

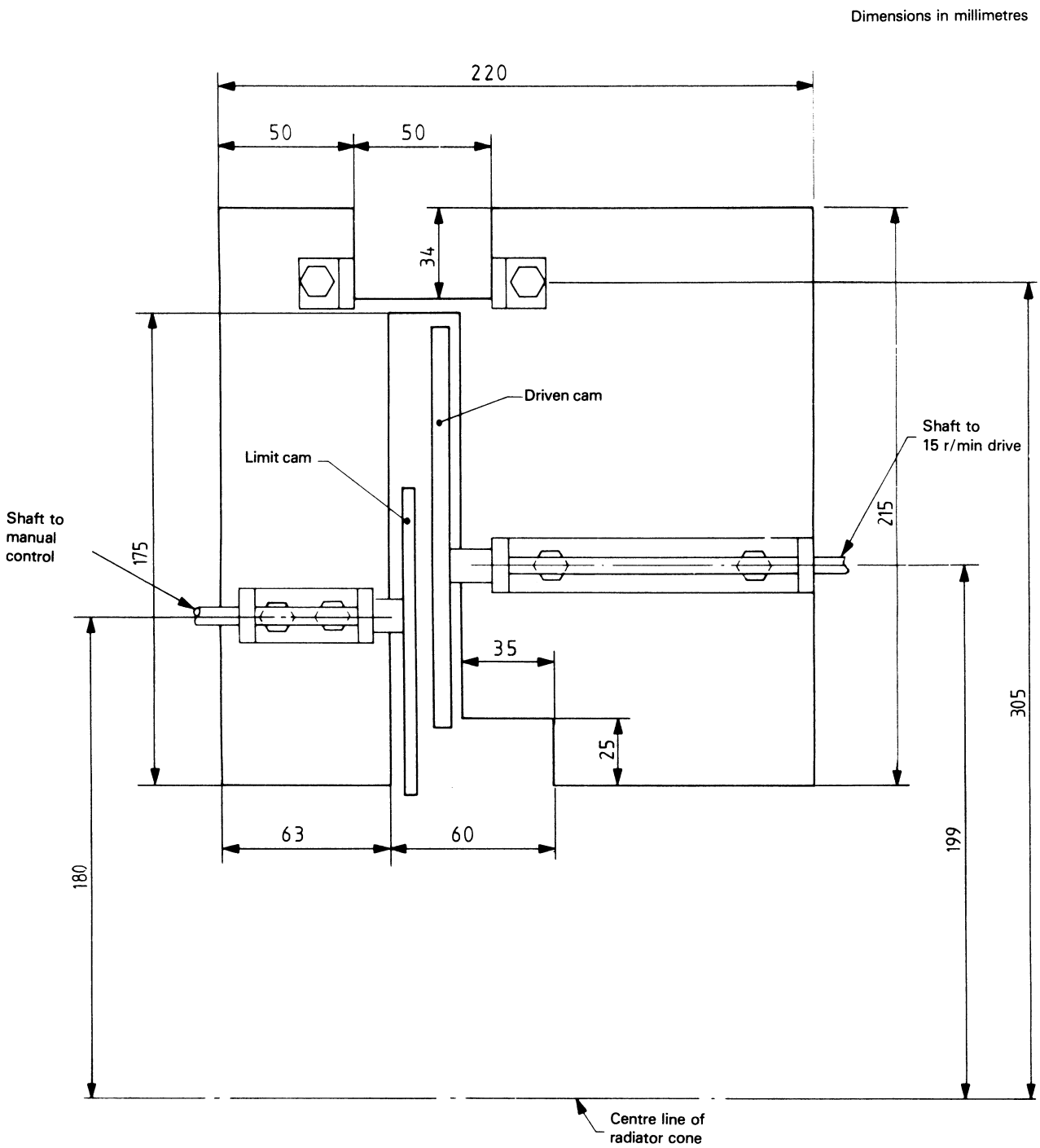


Figure 6b) — Pilot flame application mechanism — Base plate (plan view)

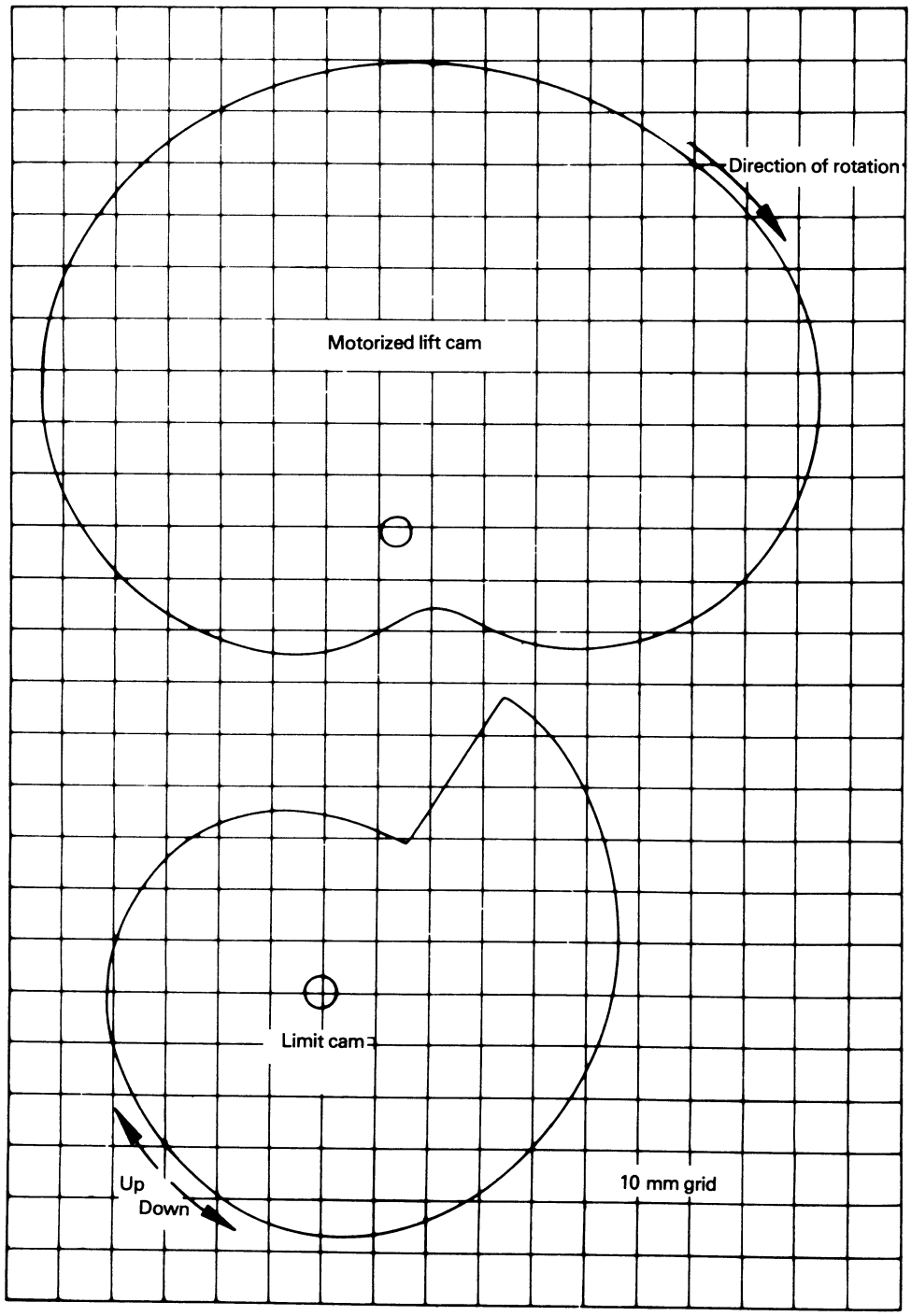


Figure 6c) — Pilot flame application mechanism — Cam geometry

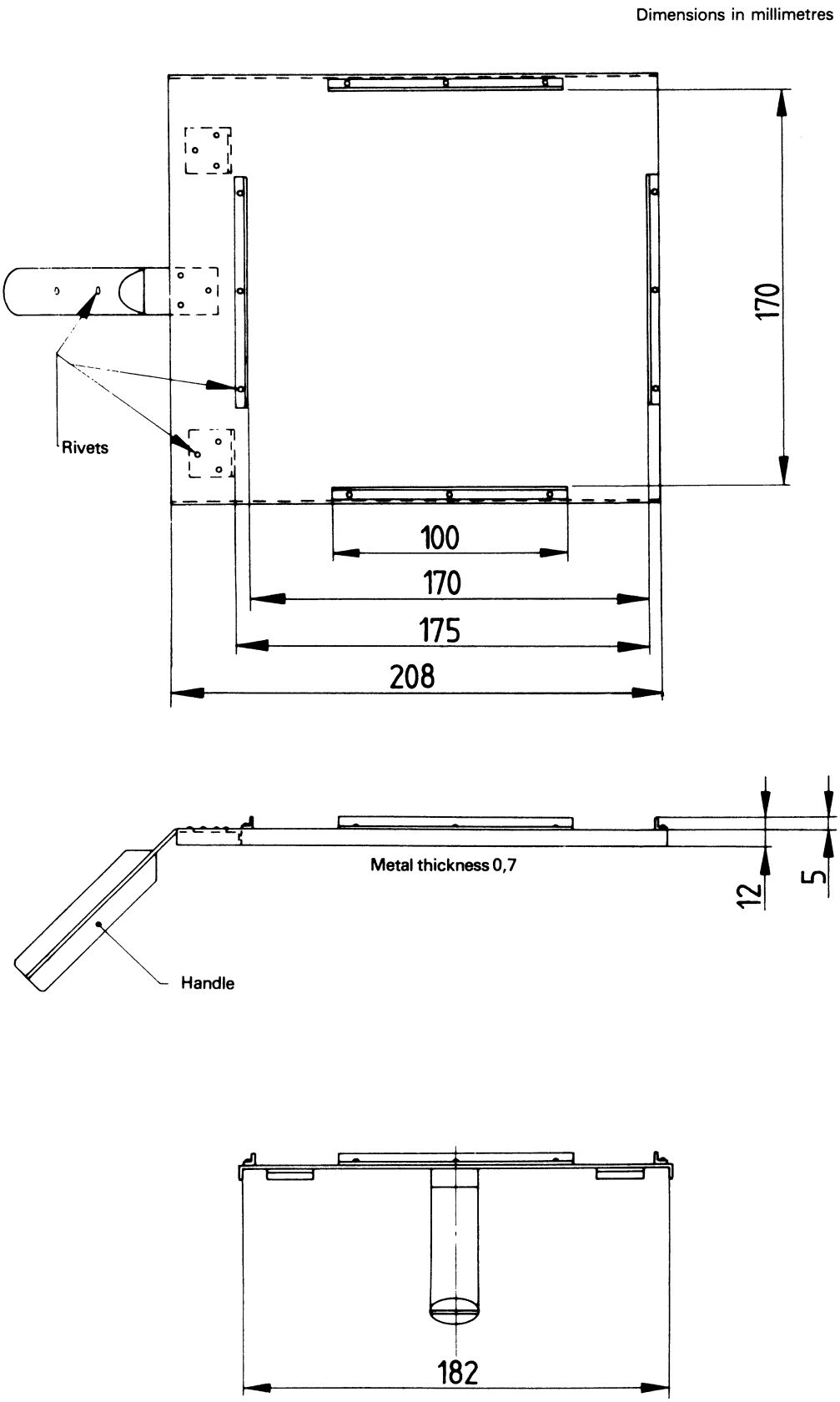


Figure 7 — Specimen insertion and location tray

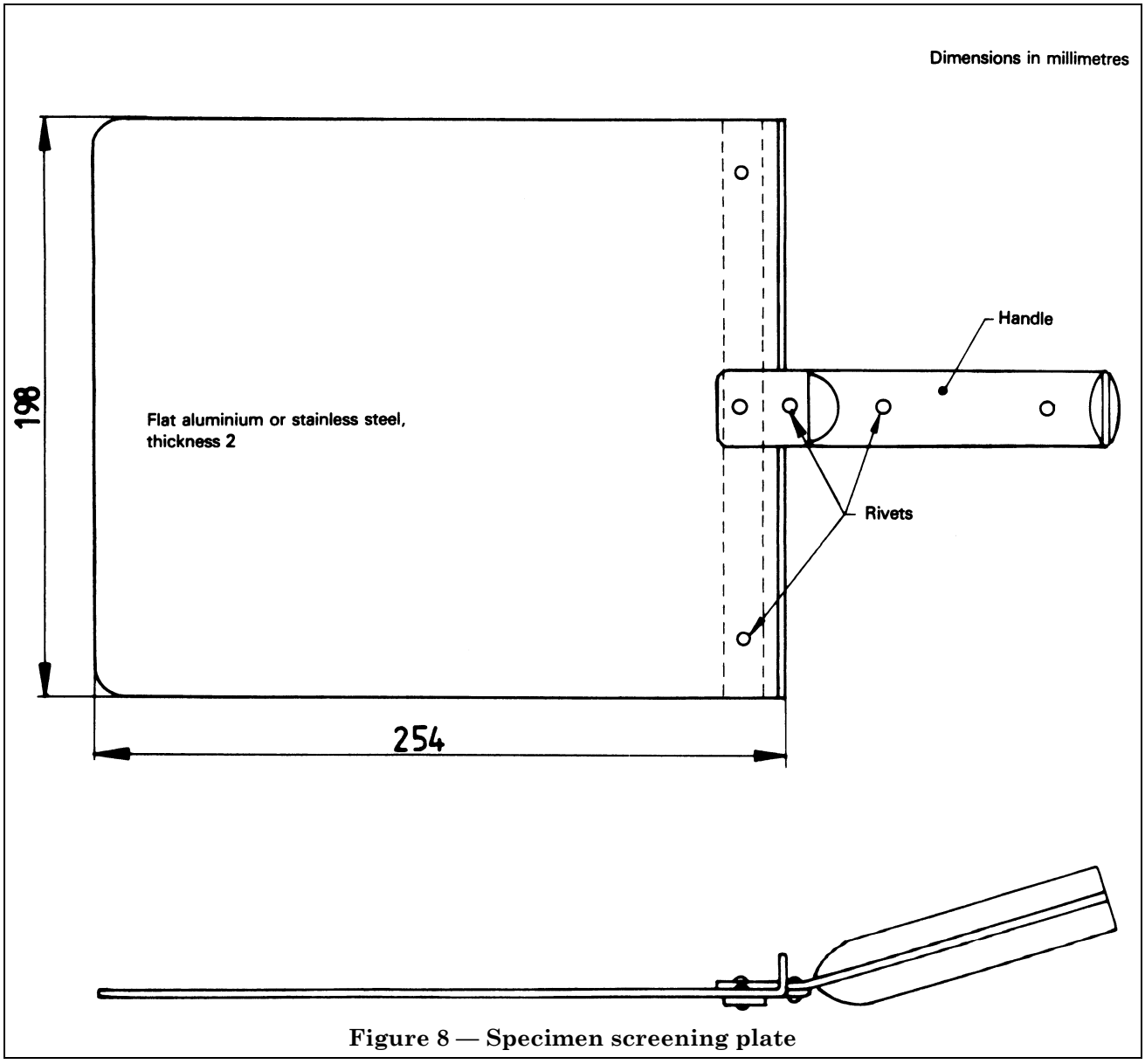


Figure 8 — Specimen screening plate

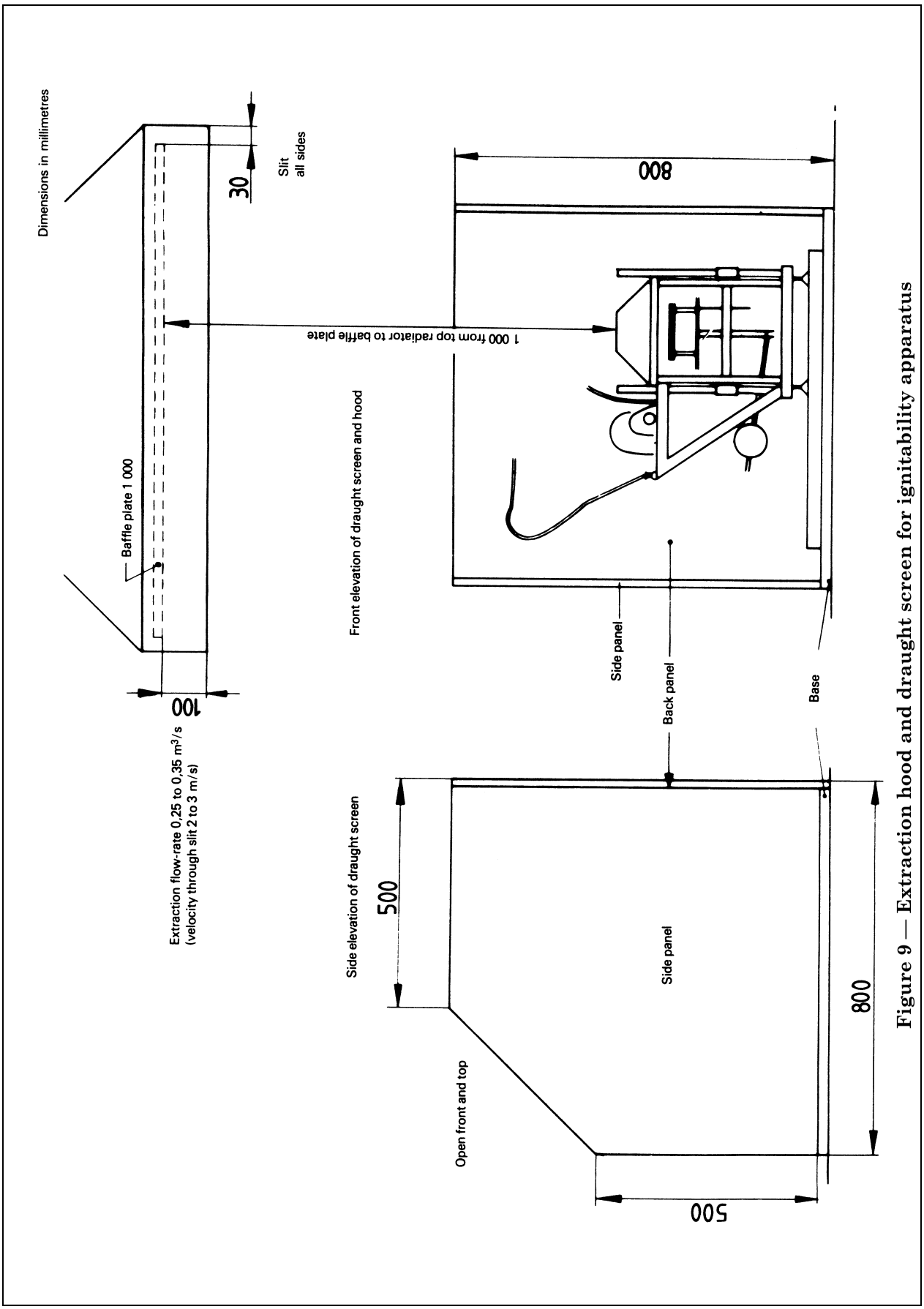


Figure 9 — Extraction hood and draught screen for ignitability apparatus

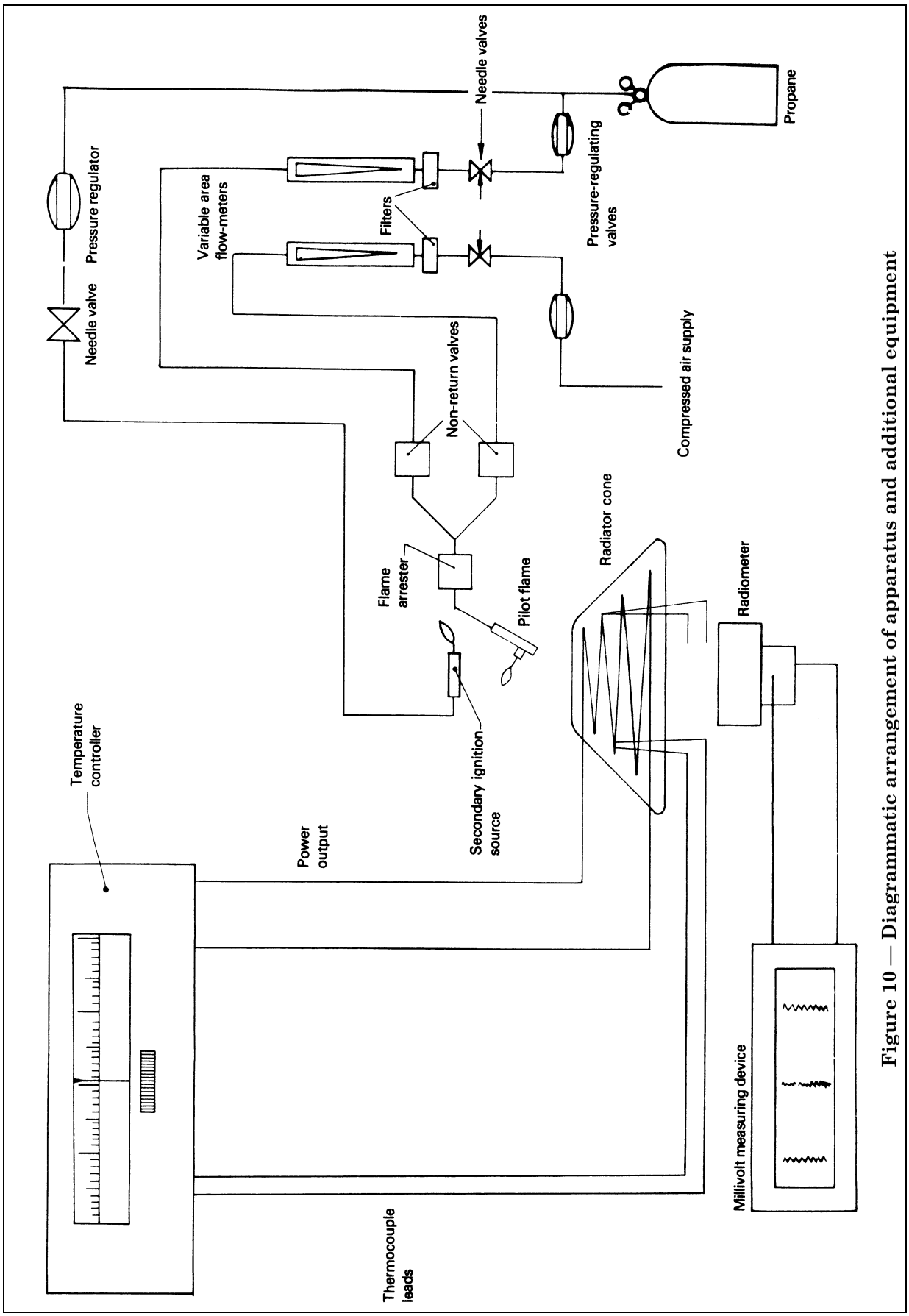


Figure 10 — Diagrammatic arrangement of apparatus and additional equipment

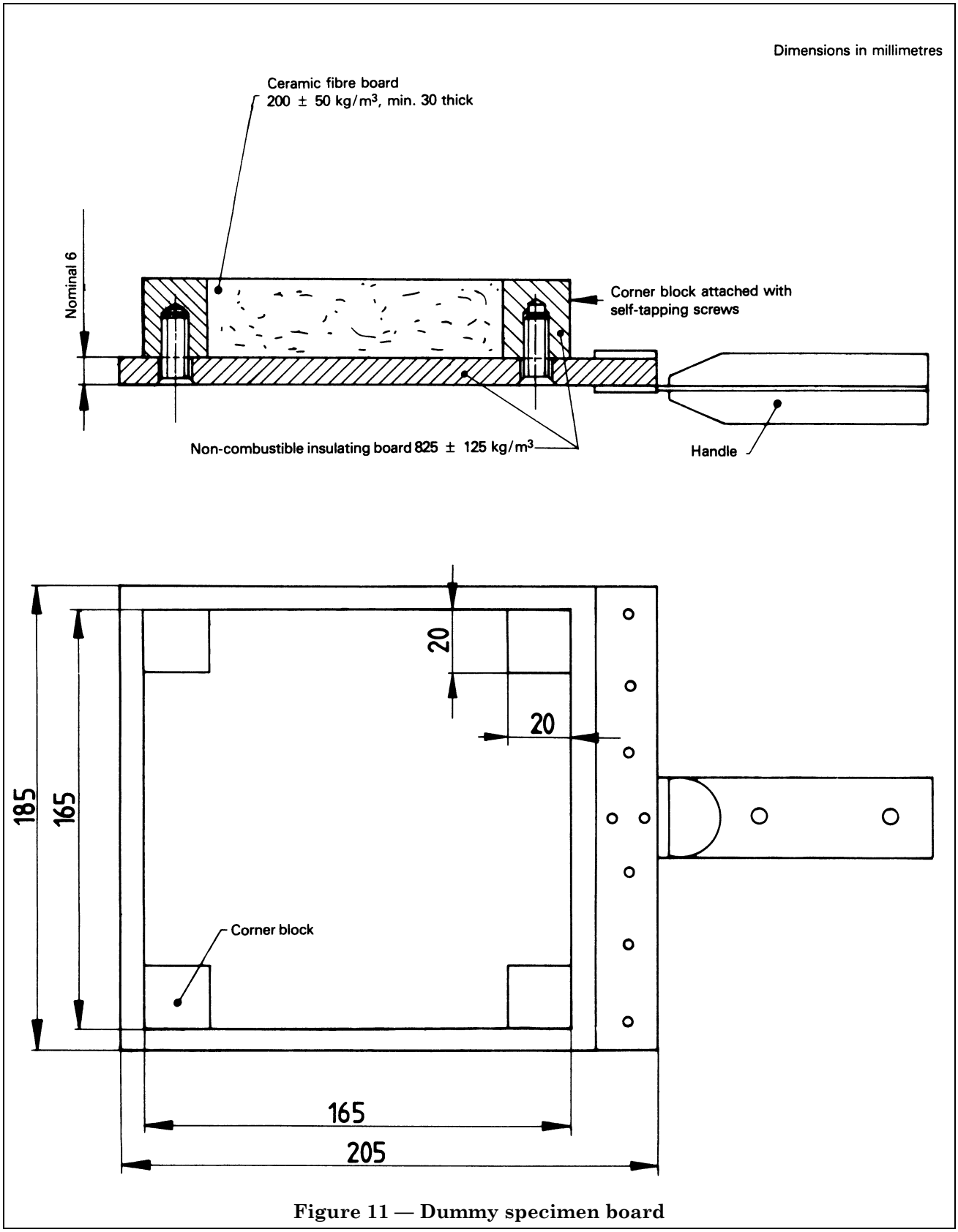


Figure 11 — Dummy specimen board

Publications referred to

See national foreword.

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