BRITISH STANDARD SPECIFICATION

# FIRE TESTS
## ON BUILDING MATERIALS AND STRUCTURES

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BRITISH STANDARDS INSTITUTION

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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

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## CO-OPERATING ORGANIZATIONS

The Committee responsible for the preparation of this British Standard consists of representatives from the following Government departments and scientific and industrial organizations:—

British Constructional Steelwork Association
British Electrical and Allied Industries Research Association
British Fire Services' Association
Building Industries National Council
D.S.I.R.—Building Research Station
D.S.I.R.—Forest Products Research Laboratory
Federation of British Industries
Fire Offices Committee
Fire Offices Committee, Fire Protection Association
Institution of Fire Engineers
Institution of Municipal Engineers
Joint Fire Research Organization of the Department of Scientific and Industrial Research and Fire Offices Committee
London County Council
London Fire Brigade
Ministry of Works
National Federation of Building Trades Employers
Reinforced Concrete Association
Royal Institute of British Architects

BRITISH STANDARD SPECIFICATION FOR

# FIRE TESTS ON BUILDING MATERIALS AND STRUCTURES

## FOREWORD

The purpose of this British Standard is to specify a series of tests for determining those properties of building materials and structures which are relevant when considering the fire protection of buildings in which they are to be used, and by which such materials and structures may be accepted or rejected.

*Combustibility.*

*Surface spread of flame.* To require non-combustibility in all circumstances would be unreasonably severe and unnecessarily restrictive. It is often sufficient to require that materials should not be readily ignitable and, if ignited, that their tendency to spread flame be limited. The surface spread of flame test in Section Two may be used to classify combustible wall and ceiling lining materials according to the fire hazard they are likely to present in becoming ignited and spreading flame over their surfaces from one part of a building to another. This test may also be used to show the effectiveness of flame-retardant treatments in reducing the surface spread of flame on lining materials.

*Fire-resistance of structures.* Where a fire occurs in a compartment of a building, the structure of the compartment should be required to contain the fire by continuing to perform those of its normal functions which contribute to the integrity and insulation of the compartment. The fire-resistance test of Section Three grades elements of building structures in accordance with the time for which they are capable of fulfilling these functions while subjected to heating conditions representative of an actual fire in a compartment. Although the term ' fire-resistance ' has often been used indiscriminately in the past to denote the resistance of materials to ignition or spread of flame, the use of the term in this standard is restricted to the performance of complete elements of building structure without individual regard to the performance of the materials of which they are composed. Materials which perform well in the combustibility or surface spread of flame tests may not necessarily do so when built into an element of structure and subjected to the fire-resistance test.

Consideration is being given to the substitution of the term 'fire endurance' for the term 'fire resistance' as used in this British Standard, as it is felt in some quarters that the former term is more appropriate for the purposes of the tests.

*Alterations to the standard.* In the present revision of the standard some major alterations have been made, as follows:—

The non-inflammability test has been deleted. This test was sometimes found to give anomalous results. It was mostly applied to fabrics and decorative materials, for which purpose it was considered that a test similar to that given in B.S. 1547, 'Flameproof industrial clothing' would be more satisfactory.

The method of classification of materials in the surface spread of flame test has been amended. In the last edition of B.S. 476, the classification of a material rested on the mean spread of a certain number of specimens. While mean spread gives a measure of the general standard of performance of a material, it does not take account of the variability which is known to occur in the performance of different samples of most materials. The present method is intended to do this by classifying materials in such a way that not more than 1 per cent of a material is likely to have a performance below the standard of the class in which the material is placed, this proportion being chosen as acceptably small for safety reasons. The calculation of the performance of the material is such that credit is given to materials of uniform standard, since variability is penalized by requiring a correspondingly higher standard of general performance if any particular classification is to be attained. The values of the limits are derived from all available testing experience to date, and show an improved balance between 1½-minute and final or 10-minute values, the former having been made considerably more rigorous. The final limit of Class 2 is the equivalent of that used hitherto, while the 10-minute limit of Class 3 is more rigorous.

In the fire-resistance test it has been considered desirable to standardize the method of control of the furnace temperature for all types of specimen to that of the standard time-temperature curve (Fig. 1a), although the tolerance on the curve has had to be increased for conducting specimens in tests of longer than ½-hour duration.

For load-bearing structures, the loading has been reduced to the design load, as it has long been felt that the reasons advanced for imposing one and a half times the design load were not necessarily valid in every instance. It is also in keeping with American test practice. The water test has been deleted as it could not be applied to all types of structure nor

could it be applied during the heating period as is likely in practice. It was found to destroy much useful evidence of the behaviour of a structure and was rarely a deciding issue. The impact test has been deleted as, in general, it was not a satisfactory measure of the weakening effect of a fire. It has not yet been found possible to devise a satisfactory alternative.

An appendix has been added to the standard giving details of a test which may be used by those wishing to ascertain the probable spread of flame values of a material without the necessity for constructing the full size apparatus required for the surface spread of flame test specified in this British Standard. It is emphasized that this is not intended to be quoted in place of the standard test, and is purely for the purpose of obtaining in an economical manner an approximation of the values that will be obtained from the specified test.

## SPECIFICATION

### SCOPE

1. This British Standard specifies tests for determining those properties of building materials and structures relevant when considering the protection against fire of the buildings in which they are to be used.

## SECTION ONE: COMBUSTIBILITY TEST OF MATERIALS

### GENERAL

2. This test shall be applied to materials used in the construction or finishing of a building or structure, in order to determine whether they are combustible within the meaning of the definition.

### TEST PROCEDURE

3. *a. Size of specimen.* Materials for subjection to the combustibility test shall be made up into specimens each 2 in. × 1½ in. × 1½ in. (50·8 mm. × 38·1 mm. × 38·1 mm.). Specimens of materials which are normally less than 1½ in. thick shall be made of sufficient layers to achieve a final thickness as near as possible to but not exceeding 1½ in. (38·1 mm.). In no instance shall this thickness be exceeded.

*b. Number of specimens.* Six specimens shall be tested.

*c. Conditioning.* Three of the test specimens shall be dried by heating to a temperature of 100°C. (212°F.) for six hours, then allowed to cool to room temperature in a dry atmosphere. If these specimens are not tested immediately after conditioning, they shall be stored in a hermetically-sealed dry container until the time of test. The remaining three specimens shall be kept for a period of one week in a desiccator containing solid calcium chloride, before testing.

*d. Method of test.* The test for combustibility shall be carried out in the furnace detailed in Fig. 2. This furnace shall be heated by passing an electric current from a suitably regulated source through the nickel chrome resistance wire surrounding the heating tube. The temperature of the furnace shall be determined by a thermocouple situated at the level of the centre of the furnace and ⅜ in. (9·5 mm.) from the internal wall of the heating tube. The wires of this thermocouple shall not be thicker than 0·048 in. (18 S.W.G.) and bared for a length of 1 in. (25·4 mm.) from the junction. Throughout the test, and except while inserting specimens, the two-piece adjustable asbestos wood cover shall be arranged so that there is an aperture 1 sq. in. (6·45 sq. cm.) in area with its centre coinciding with the axis of the furnace heating tube. A pilot gas flame shall be located immediately above this aperture on the axis of the heating tube, and shall be between ⅝ in. (15·9 mm.) and ⅞ in. (22·2 mm.) in height.

In carrying out the test, the furnace temperature shall be raised to and stabilized at 750°C. (1382°F.) before insertion of the specimen. The specimen shall then be placed centrally in the tube, with its long axis vertical, not longer than 30 seconds being taken for this operation. The specimen shall be supported by a stirrup of nickel chrome wire which shall be hung through the aperture in the adjustable cover. If the specimen is likely to disintegrate or melt during the test, it shall be supported in a gauze or thin sheet-metal box respectively, having a base of 1⅝ in. (41·3 mm.) square and a height of 2 in. (50·8 mm.). The specimen shall be heated in this way for a period of 15 minutes.

### DEFINITION OF COMBUSTIBILITY

**4.** For the purposes of this British Standard a material shall be considered combustible if, during the test period, any one of the six specimens of the sample:

*a.* flames *or*

*b.* produces vapours which are ignited by the pilot flame *or*

*c.* causes the temperature of the furnace to be raised 50 Centigrade degrees (90 Fahrenheit degrees) or more above 750°C. (1382°F.).

## SECTION TWO:

### GENERAL

**5.** This test shall be applied to materials used as wall and ceiling linings so that they may be classified according to the tendency for flame to spread over their surfaces.

### TEST PROCEDURE

**6.** *a. Size and number of specimens.* A test sample of a material shall comprise six representative specimens, each 9 in. × 36 in. (228·6 mm. ×

914·4 mm.), and of their normal thickness. Laminar materials shall be tested in their normal condition.

*b. Preparation and conditioning of specimens.* Before test, the edges, together with a strip 1½ in. (38·1 mm.) wide from the edges on the unexposed face, shall be painted with sodium silicate composition, the ingredients of which are specified in Clause 8, after which the specimens shall be conditioned to a moisture content in equilibrium with air at 10–21°C. (50–70°F.) and 55–65 per cent relative humidity.

*c. Method of test.* The specimen shall be securely fixed to a wooden framework faced with asbestos millboard, being secured in such a way that the face of the specimen may burn without obstruction from the supports. It shall be mounted with its long axis horizontal and shall be brought, in not longer than five seconds, from a position at room temperature to a position where its test face is exposed to the radiated heat. The intensity of the heat radiated shall vary in such a way that the temperature of gold disk thermocouples, if placed in the same plane and along the length of the specimen, would be raised to the following values, within ± 3 per cent:—

| Distance from hotter end (in.) | 0 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C.) | 500 | 435 | 385 | 345 | 310 | 280 | 250 | 225 | 200 | 180 | 160 | 145 | 130 |

The gold disk thermocouple shall consist of a 0·0084 in. (35 S.W.G.) thick × 1 in. (25·4 mm.) diameter gold disk, to one face of which shall be silver soldered, flush with the surface and centrally disposed, a chromel-alumel thermocouple made from 0·018 in. diameter (26 S.W.G.) (0·46 mm.) wire. The disk shall be well blackened on the thermocouple side with platinum-black or lamp-black and this side shall be exposed to the heat radiation the intensity of which is to be measured.

Immediately the specimen is exposed to the radiated heat a vertical luminous gas flame shall be applied to its hotter end for one minute. This flame shall be 7 in. (177·8 mm.) long and shall issue from a ⅜ in. (9·53 mm.) diameter orifice placed not more than ¼ in. (6·35 mm.) in front of the surface of the specimen and at ¼ in. (6·35 mm.) above its lower edge.

The room in which the test is made shall be substantially free from draughts.

A typical application of the test is shown in Fig. 3.

*d. Observations during testing.* As soon as the igniting flame is in contact with the specimen, observations shall be made of the time of

spread of the flame front for measured distances along a line drawn parallel to the long axis, 3 in. (76·2 mm.) from the bottom edge of the specimen. Measurements shall be continued until the flames have died out or for 10 minutes, whichever is the longer time.

*e. Computation of results.* The following procedure shall be adopted for determining the effective spread of flame for a sample comprising six specimens:—

A curve shall be drawn for each specimen, showing the distance of spread of the flame front with time, along the horizontal marked line. From the fair curve shall be determined:

(i) the distance of spread during the first 1½ minutes
(ii) the distance of spread during the first 10 minutes
(iii) the final distance of spread of flame.

The qualifying criterion for any class shall be calculated from the following expression, and shall be called the 'effective spread of flame' of the material under test:—

Effective spread of flame

$$= x + 1{\cdot}04\sqrt{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 \ldots + (x_6 - \bar{x})^2}$$

where

$x_1$, $x_2$, $x_3$, $x_4$, $x_5$, $x_6$, are the individual spreads of flame for the six specimens, and $\bar{x}$ is the mean of these individual spreads, i.e.

$$\bar{x} = \frac{x_1 + x_2 + x_3 + x_4 + x_5 + x_6}{6}$$

## CLASSIFICATION OF SURFACE SPREAD OF FLAME

7. Surfaces shall be classified under one of the following headings, according to their observed behaviour under test. Where the faces of a material differ, both sides shall be tested and classified.

*Class* 1. *Surfaces of very low flame spread.* Those faces on which not more than 7·5 in. (19·0 cm.) effective spread of flame occurs.

*Class* 2. *Surfaces of low flame spread.* Those faces on which the effective spread of flame neither exceeds 12 in. (30·5 cm.) during the first 1½ minutes, nor exceeds a final value of 24 in. (60·7 cm.).

*Class* 3. *Surfaces of medium flame spread.* Those faces on which the effective spread of flame neither exceeds 12 in. (30·5 cm.) during the first 1½ minutes, nor exceeds 33 in. (83·9 cm.) after 10 minutes.

*Class* 4. *Surfaces of rapid flame spread.* Those faces on which the effective spread of flame either exceeds 12 in. (30·5 cm.) during the first 1½ minutes, or exceeds 33 in. (83·9 cm.) after 10 minutes.

INGREDIENTS OF SODIUM SILICATE COMPOSITION

8. The silicate composition shall conform to the following proportions:—

| | |
|---|---|
| Kaolin | 150 lb. (68 kg.) |
| Sodium silicate | 112 lb. (50·8 kg.) |
| Water | 100 lb. (45·4 kg.) |

The sodium silicate shall be of a 'neutral' grade in the form of an aqueous syrup in which the ratio of silica to soda is between $Na_2O$ : 3·2 $SiO_2$ and $Na_2O$ : 3·4 $SiO_2$ and which has a specific gravity between 1·41 and 1·43.

This flame retardant composition is not suitable for use as a permanent paint for fire protection purposes.

## SECTION THREE: FIRE-RESISTANCE TESTS OF STRUCTURES

### GENERAL

9. The following test is designed to grade elements of building structure according to their ability to resist fire while fulfilling their normal design functions. Examples of complete structures, the fire-resistance of whose elements may be determined by this test, are:—

Load-bearing and non-load-bearing walls and partitions
Glazing
Doors and shutters
Columns
Beams
Floors
Roofs

This list is not exhaustive, therefore where an element falls into none of these categories, it shall be tested by analogy with the most similar category.

### TEST PROCEDURE

10. *a. Size of test element of structure.* All test elements shall be full size wherever possible. Where the full dimensions exceed 10 ft. × 10 ft. (3·05 m. × 3·05 m.) for walls, floors, roofs, etc., or 10 ft. length (3·05 m.) for columns, beams, etc., the testing authority shall test a representative portion of the full size element having dimensions not less than 10 ft. × 10 ft. (3·05 m. × 3·05 m.), or being 10 ft. (3·05 m.) in length, as applicable.

*b. Construction and conditioning of test element.* The materials and standard of workmanship of the test element shall be representative of those applying in good practice, as defined by existing relevant codes and

standards. The test element shall be conditioned to reproduce the state in which the element is likely to be when in service in a building.

*c. Restraint and loading.* The restraint applied to the test element shall be similar to that applied to the element in service.

A load-bearing test element shall be subjected to a loading which produces the same maximum stress as would be produced in the full-size element when the latter is subjected to the maximum loading that it is designed to support. The applied loading shall be kept constant during the heating period, and shall be re-applied 48 hours after the end of the heating period, unless failure has already occurred.

Non-load-bearing test elements shall not be loaded during test.

*d. Method of test.* The test element shall be heated in a furnace the temperature of which shall be deemed to be the average of the readings of not less than 6 thermocouples disposed within the furnace so that they may fairly represent its average temperature. The hot junction of each thermocouple shall be placed 3 in. (76·2 mm.) from the nearest point of the specimen, and shall not be allowed to touch the surface, should any distortion of the latter occur during the test.

Free-standing columns shall be heated from all radial directions over their whole height. Structures whose function is to separate spaces shall be heated over the whole of one face only. Those which may be required to resist fire in one direction only shall be tested accordingly and the report of the testing authority shall be annotated to this effect. Those which may be required to resist fire in either direction shall normally be tested in the direction which, in the opinion of the testing authority, is likely to give the least resistance, and this performance shall be regarded as representative of the structure. For the purpose of special applications, a separating structure normally required to resist fire from either direction may, by prior agreement between the sponsor of the test and the testing authority, be tested from the side likely, in the opinion of the testing authority, to give the better performance, and the report of the testing authority shall be annotated to this effect. Structures such as walls containing flues, which are normally heated in service, shall be heated similarly during test.

The temperature of the furnace shall be controlled to follow, as closely as possible, the standard time-temperature curve shown in Fig. 1. Points on this curve which define its character are:—

| | | |
|---|---|---|
| 538°C. (1000°F.) | at 5 minutes | See Fig. 1 (b) |
| 704°C. (1300°F.) | at 10 minutes | |
| 843°C. (1550°F.) | at 30 minutes | |
| 927°C. (1700°F.) | at 1 hour | |
| 1010°C. (1850°F.) | at 2 hours | See Fig. 1 (a) |
| 1121°C. (2050°F.) | at 4 hours | |
| 1204°C. (2200°F.) | at 6 hours | |

The accuracy of the furnace control shall be such that:

(i) The furnace temperature does not exceed 871°C. (1600°F.) during the first 10 minutes of test.

(ii) The furnace temperature does not vary from that shown by the standard curve by more than ± 167 Centigrade degrees (± 300 Fahrenheit degrees) at any time after the first 10 minutes of test.

(iii) The area under the test furnace temperature-time curve does not differ from the area under the standard curve by more than the appropriate percentage of the latter area shown in the following Table 1.

TABLE 1. MAXIMUM TOLERANCE ON AREA UNDER STANDARD FURNACE TEMPERATURE-TIME CURVE

| Duration of test | Elements subject to requirements of Clause 11 *a*, *b*, *c* | Elements subject to requirements of Clause 11 *a*, *b* only |
|---|---|---|
| hr. | per cent | per cent |
| ½ | 15 | 15 |
| ½–1 | 10 | 15 |
| 1–2 | 10 | 15 |
| More than 2 | 5 | — |

*e. Observations during test.* In tests on elements with an unheated surface, other than those on such items as doors, shutters and glazing, against which combustible material would not be placed in service, the surface temperature of the unexposed face shall be measured at not less than five points, one approximately at the centre of the face, and one approximately at the centre of each quarter section. Any points of measurement additional to these five shall be disposed as uniformly as possible over the unexposed face of the element, provided that no point is closer than 12 in. (30·5 cm.) to the edge. The average temperature of the unexposed surface shall be deemed to be the average of the temperatures measured at these points. In addition, the temperature may be measured at the point that appears to be hottest at any time during the test. This temperature shall not be used in determining the average temperature but may be used in determining the maximum temperature.

These surface temperatures shall be measured by means of thermocouples, each attached to the face of a 1 in. (2·54 cm.) diameter copper disk which shall be secured to the surface of the element at the required position.

*f. Duration of test.* The test element shall normally be heated in the

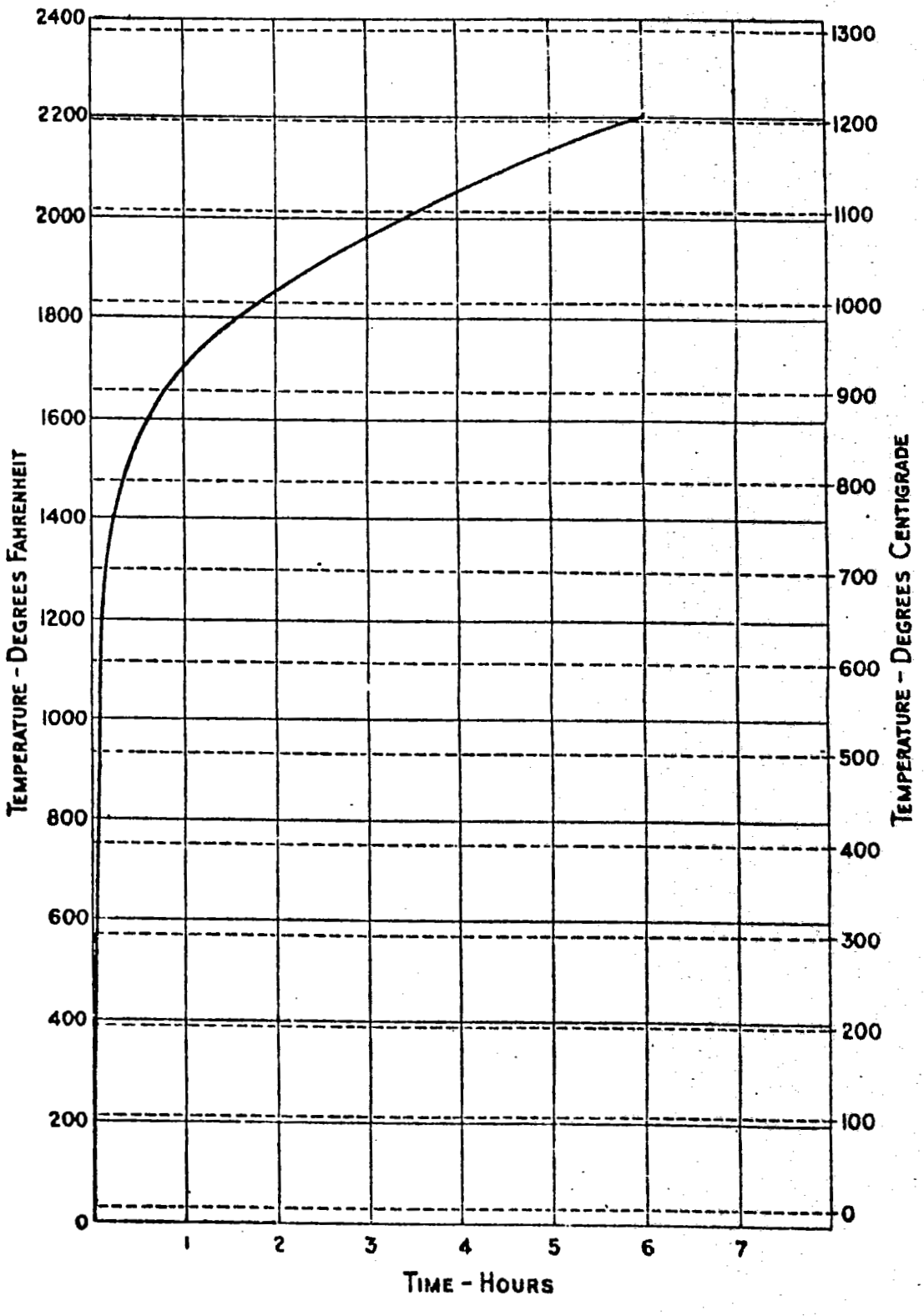



**Fig. 1 (a). Time-temperature curve**

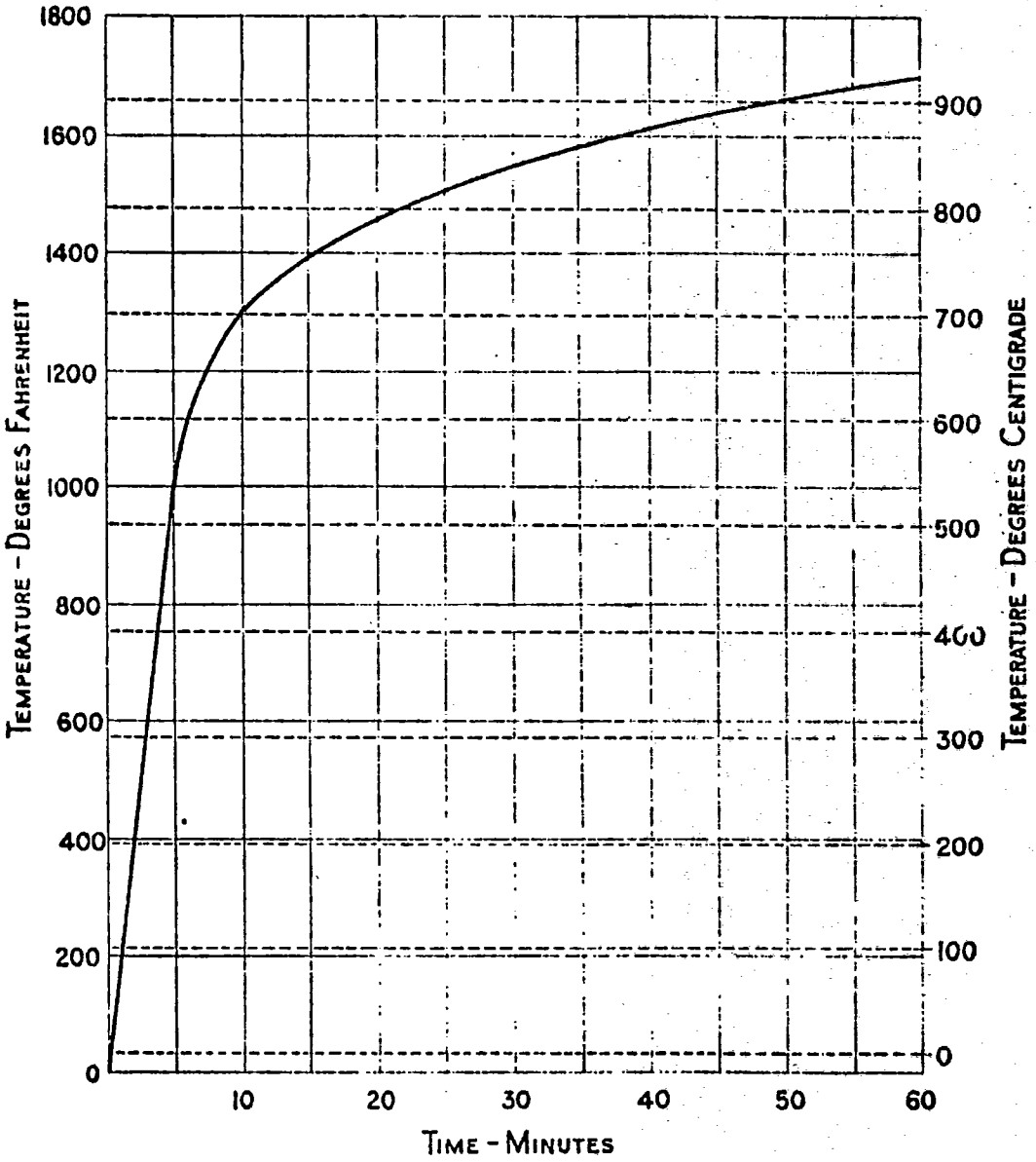



**Fig. 1 (b). Time-temperature curve (first hour)**

prescribed manner until failure has occurred under all the relevant test requirements of Clause 11, except that by agreement between the sponsor of the test and the testing authority the heating period may be concluded at any time after failure has occurred under at least one of the relevant test requirements. Alternatively, by prior agreement between the sponsor of the test and the testing authority, the heating period may be concluded after any one of the periods stated in Clause 12, if failure has not already occurred under the relevant test requirements.

### TEST RESULTS

**11.** The test result shall be stated in terms of the time, in hours and minutes, from the commencement of heating, for which the element of structure complies with those of the following three requirements which are relevant to it. Where a test is terminated by agreement, this shall be stated in the report.

*a. Collapse.* For all elements of structure, it is required that the element shall not collapse.

*b. Passage of flame.* For all elements of structure whose function is to separate spaces and hence to resist the passage of fire from one space to another, it is required that cracks, fissures or other orifices through which flame can pass shall not develop.

*c. Insulation.* For all elements of structure as in *b* above, it is required that the average temperature of the unexposed surface shall not increase by more than 139 Centigrade degrees (250 Fahrenheit degrees) above the initial temperature, and that the temperature of the unexposed face shall not increase at any point by more than 180 Centigrade degrees (325 Fahrenheit degrees), nor reach a value higher than 221°C. (430°F.), whichever is the lesser value. This requirement may be waived for elements such as doors, shutters and glazing, against which it is not intended that combustible material should be placed in service, provided that the statement of test result in the report of the testing authority is qualified by the statement that the insulation requirement was waived.

### DEFINITIONS OF FIRE-RESISTANCE

**12.** The fire-resistance of an element of structure shall be the grading period shown below which is most nearly equal to, but does not exceed, the test period for which the element fulfils all the relevant test requirements.

*Grading periods*

½ hour
1 hour
2 hours
3 hours
4 hours
6 hours

This principle shall also be followed where a test is terminated after an agreed period of heating.

### PARTICULAR APPLICATION

**13.** Where, for a particular application, a precepting authority waives either or both of the requirements of Clause 11 (*b*) and (*c*), if relevant, or requires their fulfilment only for some pre-determined period, the element may then be regarded *for the purposes of the particular application only*, as providing a fire-resistance equal to that grading period most nearly equal to, but not exceeding, the test period for which the remaining test requirement or requirements are fulfilled.

## APPENDIX

## APPARATUS FOR PRELIMINARY SURFACE SPREAD OF FLAME TEST

This appendix describes apparatus for making a preliminary surface spread of flame test which it is hoped will prove to be useful for manufacturers or groups of manufacturers to install and operate. It also describes how the apparatus should be calibrated and the test conducted to give the same classification of surfaces as does the full-scale standard test. Details are given in Fig. 4.

It is emphasized that it is not intended that this test should replace the test specified in Section Two of this standard, since its development is not yet sufficiently advanced to permit it to be considered as a standard test, although it is sufficient to warrant its use as a preliminary test in the development of a product.

**1.** General. The preliminary surface spread of flame test can be applied in all circumstances where the standard test could also be applied.

The preliminary test enables surfaces to be classified within the four classes defined in the standard test.

**2.** Test procedure. *a. Size and number of specimens.* The test sample of a material should normally comprise six specimens each 3¾ in. × 12 in. (9·53 cm. × 30·5 cm.) and of the normal thickness. For surfaces of materials which are likely to vary in character, e.g. painted surfaces on which the thickness of application may be non-uniform, a total of up to twelve specimens may be tested.

*b. Conditioning of specimens.* Before test, the specimens should be conditioned to a moisture content in equilibrium with air at 10–21°C. (50–70°F.) and 55–65 per cent relative humidity.

*c. Description of apparatus.* The apparatus for the preliminary surface spread of flame test is one-third the linear size of the apparatus shown in Fig. 3. In the original apparatus as designed by the Joint Fire Research Organization, a proprietary type of gas-fired surface combustion heater, 1 ft. square, formed the radiant panel, and was mounted as shown in Fig. 4 within a surround of refractory concrete cast from a 1 : 2 mix of high alumina cement * and crushed firebrick.

The specimen holder is constructed of asbestos wood ¼ in. (6·35 mm.) or ½ in. (12·7 mm.) thick, and is hinged centrally to a vertical side of the refractory concrete frame, so that in the test position it is perpendicular to the radiant panel. The face of the specimen under test, when the specimen is placed in the holder and the holder is swung into test position, is flush with the inner surface of the refractory surround. The width of the specimen exposed to the furnace is 3 in. (7·6 cm.). The specimen is retained in position by a suitable backing board of asbestos wood, which presses the specimen firmly against the inner face of the holder. The backing board itself, which is not shown in the diagram, may be clamped by wedges or by retaining screws.

The radiant panel is supplied with gas from a ½ in. (12·7 mm.) main, controlled by a sensitive ½ in. (12·7 mm.) gas cock. A supply of air from a blower driven by an electric motor is mixed with the gas in a mixing chamber immediately behind the radiant panel, and the gas or mixture is burnt at the porous fire-brick surface of the panel heating the latter to the required temperature.

The electrically driven blower used by the Joint Fire Research Organization was driven by a motor of 360 watts, but it is recommended that a half horsepower motor be used.

During the casting of the refractory surround, provision is made for fixing a $\frac{1}{16}$ in. (1·59 mm.) bore gas pipe along the lower edge of the surround and vertically up to the lower edge of the specimen. This pipe supplies gas for the pilot flame.

The radiant panel is ignited and the gas supply is adjusted so that the radiant intensity to which the surface of the specimen is subjected in its test position has the same value at comparable distances from the end of the specimen nearest the panel as it has in the standard test. Thus the temperature on the surface of the small-scale specimen, as measured by a gold-disk thermocouple as described in B.S. 476, would be:

| Distance from hotter end (in.) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C.) | 500 | 435 | 385 | 345 | 310 | 280 | 250 | 225 | 200 | 180 | 160 | 145 | 130 |

* B.S. 915, 'High alumina cement.'

*d. Calibration of apparatus.* The temperature of the radiation panel corresponding to the setting of the furnace can be measured in one of two ways, so that the furnace may be reset when required without the necessity for calibration with the gold disk thermocouples.

In the first method, a total radiation pyrometer is used and should be placed at such a distance from the panel, dependent upon the constants of the instrument, that the 1 ft. (30·5 cm.) square radiant panel fills the cone of vision of the receiving tube but does not include any of the surround.

In the second method, the pyrometer is replaced by a 26 S.W.G. chromel-constantan thermocouple, silver soldered to a 28 S.W.G. × 1 in. (2·54 cm.) diameter copper disk to the faces of which asbestos paper, 0·01 in. thick, is secured with sodium silicate of the same composition as stated in Clause 8. The copper disk should be supported between two steel rods by stretching the thermocouple wires between them, the rods being fixed rigidly to a suitable support. The refractory surround can be used for this purpose. The disk is then brought into position facing the plane of the radiant panel and 5 in. (12·7 cm.) from it at a point 3 in. (7·6 cm.) above its lower edge and on its vertical centre line. The gas supply to the furnace having been adjusted to give the required radiant intensities along the face of the specimen, the disk is allowed to achieve its equilibrium temperature and its e.m.f. is then recorded. A dead-beat instrument is desirable for this measurement as there may be rapid fluctuations in the temperature of the disk about its mean value, due to turbulent draughts from the hot face of the panel. The method of construction of the asbestos-faced copper disk thermocouple is shown in Fig. 5.

The setting of the radiant panel used by the Joint Fire Research Organization was such that its temperature was about 875°C. (1607°F.). An e.m.f. of about 30 millivolts was obtained from the asbestos-faced copper disk thermocouple after it had attained its equilibrium temperature within 10 minutes.

*e. Method of test.* With the furnace adjusted as described in (*d*) above, the test specimen in its holder is swung from its position at room temperature into a position with its long axis horizontal and its face vertical and perpendicular to the surface of the radiant panel. Immediately on exposure of the specimen to the heat radiation, a vertical luminous gas flame is applied to the hotter end for one minute. This flame is 2 in. (5 cm.) long and issues from the $\frac{1}{16}$ in. (1·59 mm.) orifice shown in Fig. 4. The room in which the test is made must be substantially free from draughts.

*f. Observations during testing.* As soon as the igniting flame is in contact with the specimen, observations should be made of the time of spread of the flame front for measured distances along the longitudinal centre-line of the specimen, either until the flames die out or for 10 minutes whichever is the longer.

**3. Computation of results.** The following procedure should be adopted for determining the mean distance of spread of flame. A curve should be drawn for each specimen showing the distance of spread of flame with time along the longitudinal centre-line of the specimen. From the curves of the individual specimens, a mean curve should be constructed for the whole sample. If flaming ceases on a specimen or specimens after a certain time, while the remaining specimens continue to flame, the final distance of spread on this specimen or specimens should be used in determining the mean spread of the whole sample at subsequent times, i.e. in effect the curve of the specimen should be continued as a line parallel to the time ordinate.

**4. Classification.** Surfaces should be preliminarily classified in accordance with the test results and with the following class definitions, which correspond to those of the standard test:—

*Class* 1. *Surfaces of very low flame spread.* Those surfaces on which not more than 3 in. (7·6 cm.) effective spread of flame occurs.

*Class* 2. *Surfaces of low flame spread.* Those surfaces on which the effective spread of flame neither exceeds 4 in. (10·1 cm.) during the first minute nor exceeds a final value of 6¾ in. (17·1 cm.).

*Class* 3. *Surfaces of medium flame spread.* Those surfaces on which the effective spread of flame neither exceeds 4 in. (10·1 cm.) during the first minute nor exceeds 8⅔ in. (22 cm.) during the first 3¼ minutes.

*Class* 4. *Surfaces of rapid flame spread.* Those surfaces on which the effective spread of flame exceeds 4 in. (10·1 cm.) during the first minute or exceeds 8⅔ in. (22 cm.) during the first 3¼ minutes.

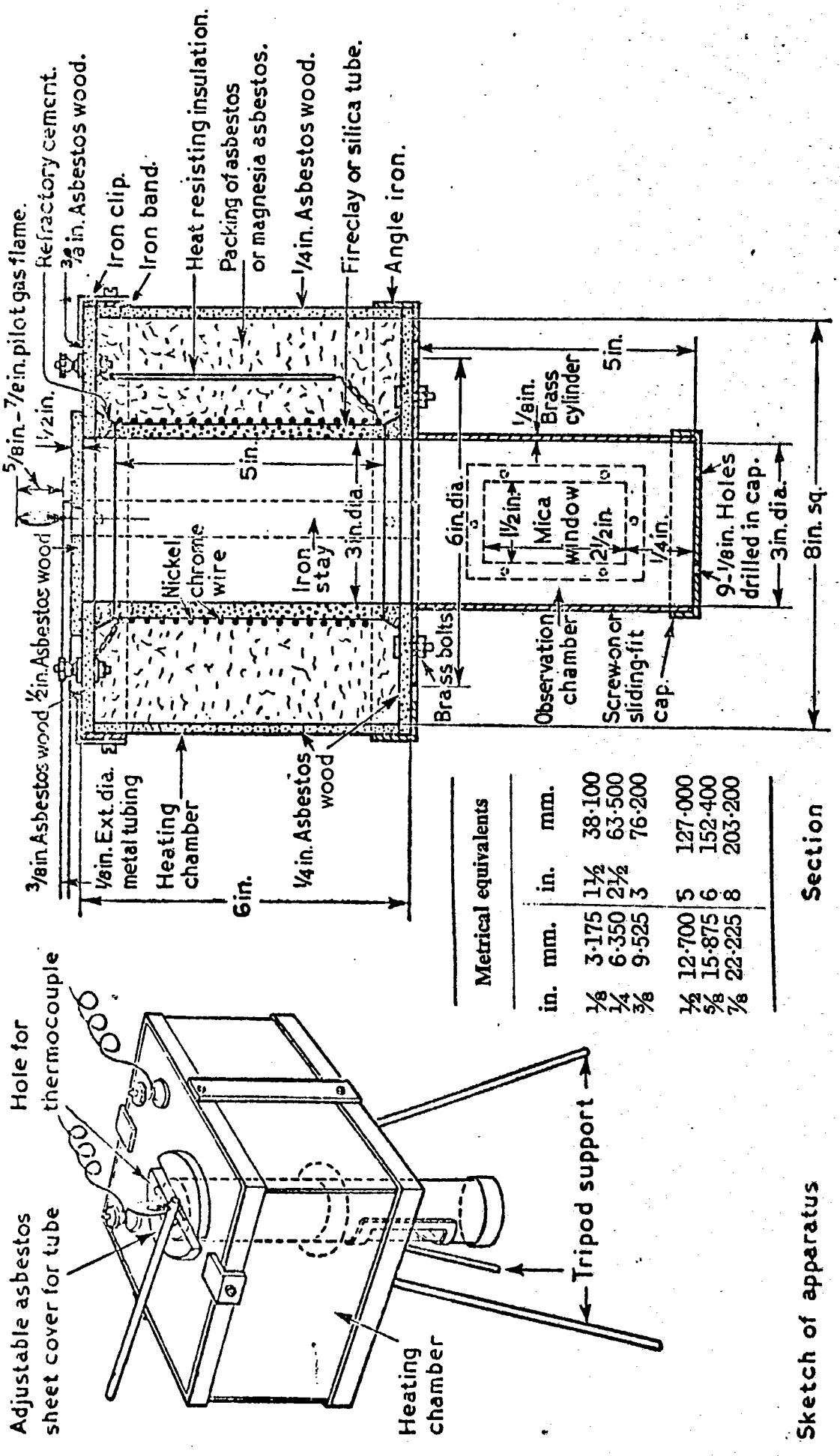
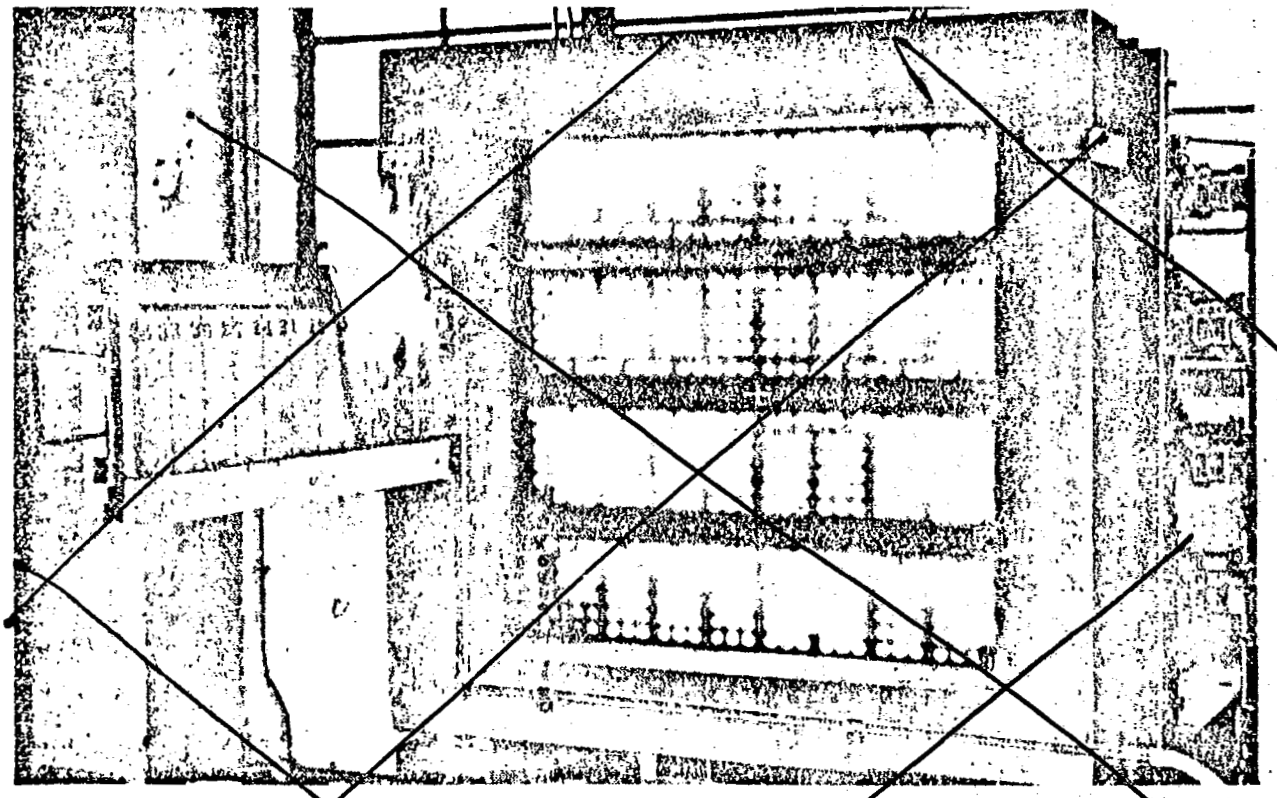



Fig. 2. Apparatus for combustibility test



*By permission of H.M. Stationery Office*

**Fig. 3 (a). Arrangement of the spread of flame test apparatus at the Joint Fire Research Laboratory, Elstree, showing specimen in position**

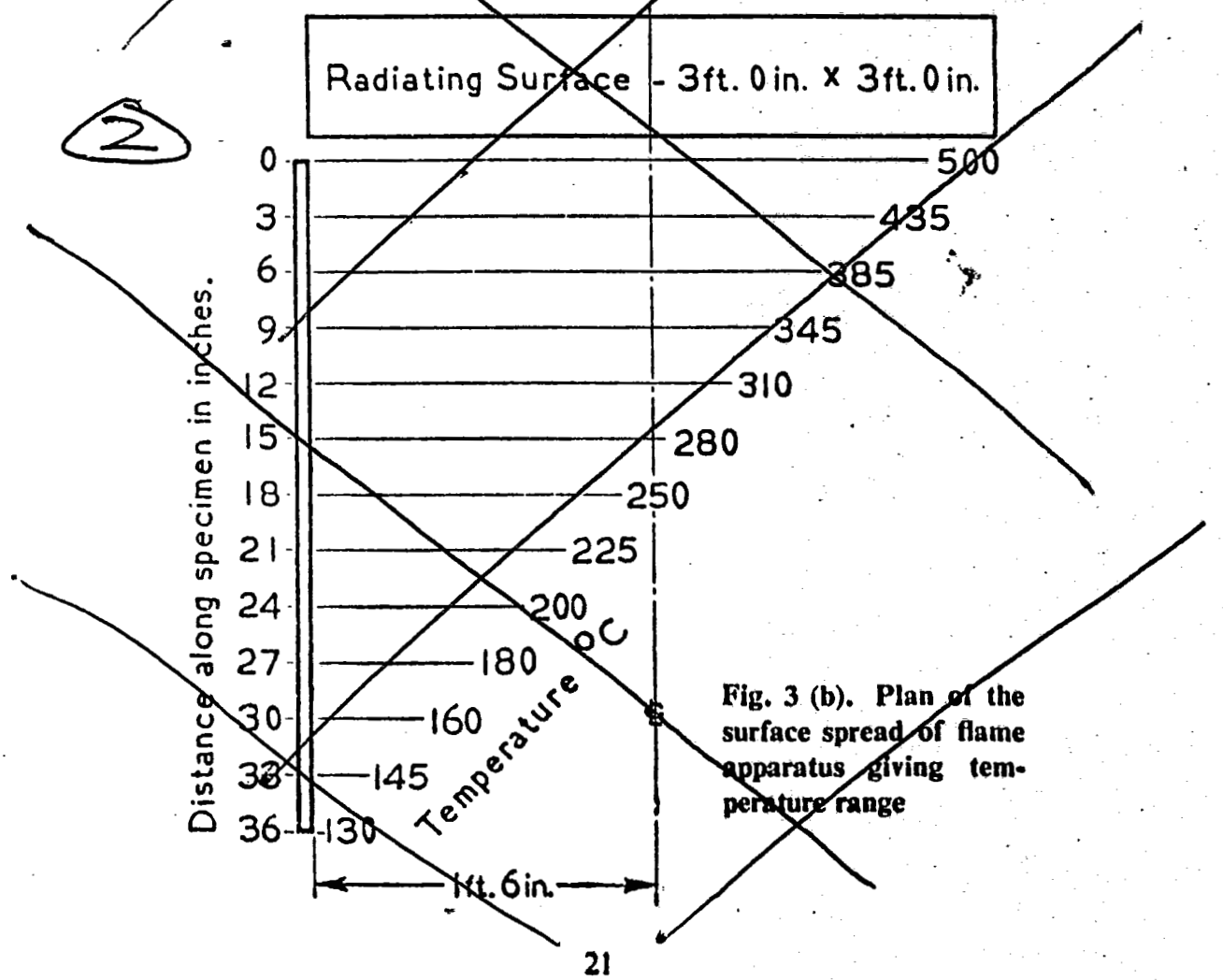
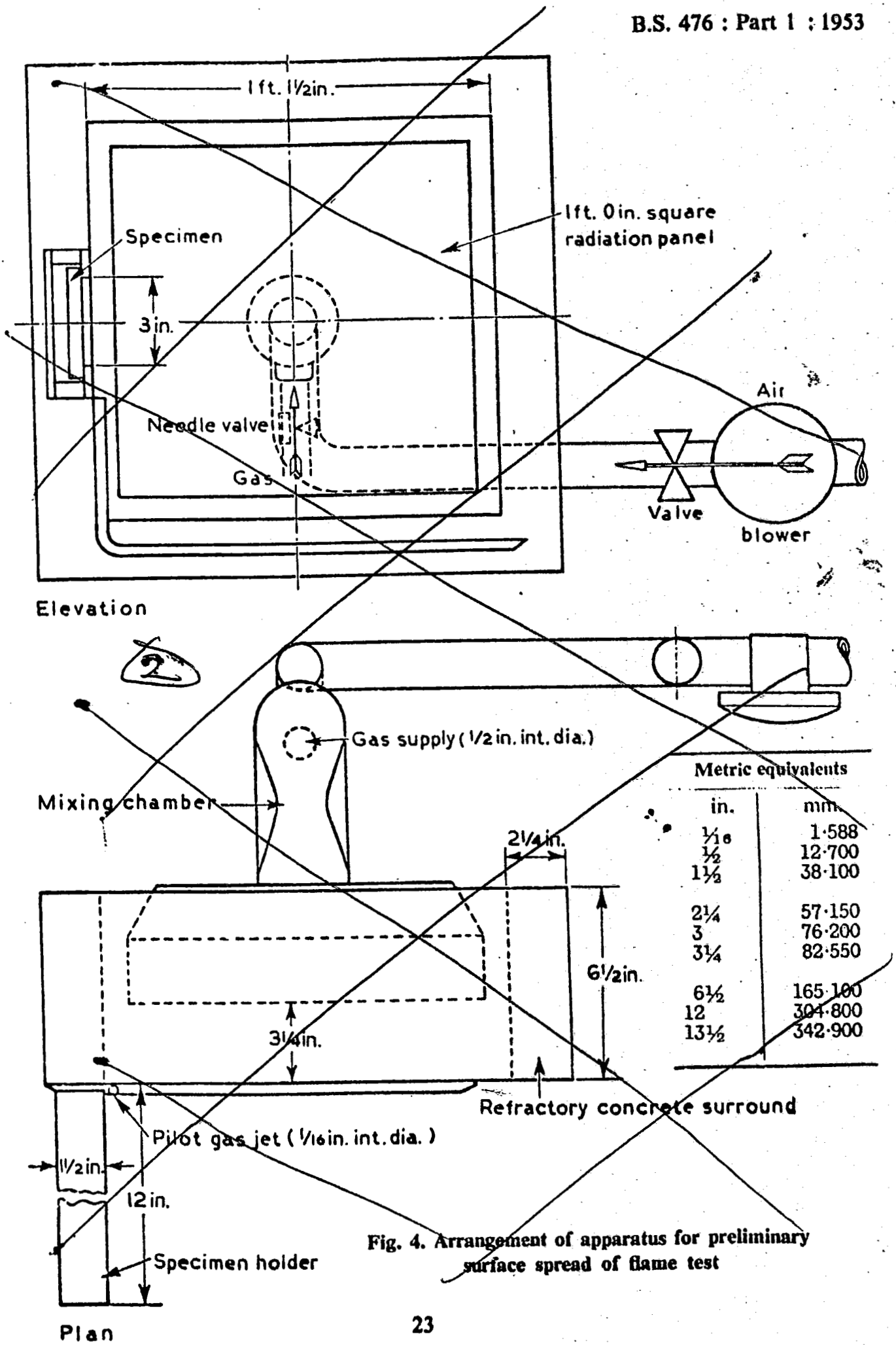


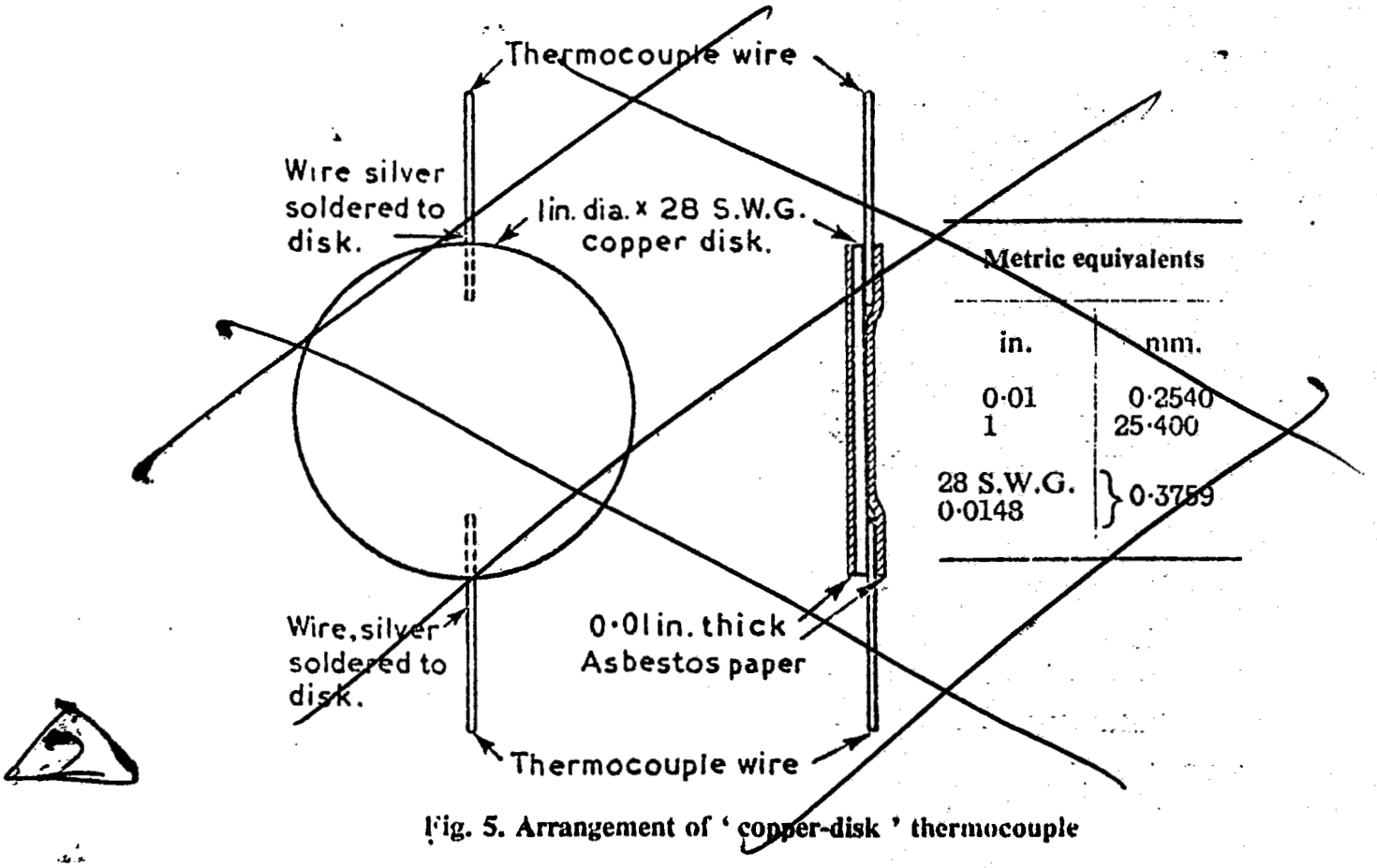

**Fig. 3 (b). Plan of the surface spread of flame apparatus giving temperature range**




**Metric equivalents**

| in. | mm |
|---|---|
| 1/16 | 1·588 |
| ½ | 12·700 |
| 1½ | 38·100 |
| 2¼ | 57·150 |
| 3 | 76·200 |
| 3¼ | 82·550 |
| 6½ | 165·100 |
| 12 | 304·800 |
| 13½ | 342·900 |

**Fig. 4. Arrangement of apparatus for preliminary surface spread of flame test**




Metric equivalents

| in. | mm. |
|---|---|
| 0·01 | 0·2540 |
| 1 | 25·400 |
| 28 S.W.G. 0·0148 | 0·3759 |

Fig. 5. Arrangement of ' copper-disk ' thermocouple

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AMD 409

# Amendment Slip No. 1, published 26 January, 1970

to B.S. 476 : Part 1 : 1953

Fire tests on building materials and structures

NOTE. B.S. 476, 'Fire tests on building materials and structures', Part 4, 'Non-combustibility test for materials', now published, supersedes some of the material in this standard. This Amendment deletes that material.

## Deletion

**Foreword**

**Combustibility.** Delete this clause.

**Alterations to the standard.** Delete the third paragraph of this clause, from 'In the combustibility test,' to 'the pilot flame.'.

**Section One. Combustibility test of materials**

**Clauses 2, 3 and 4.** Delete these clauses.

**Fig. 2. Apparatus for combustibility test.** Delete this figure.

AMD 686

# Amendment Slip No. 2, published 18 February, 1971

## to B.S. 476 : Part 1 : 1953

## Fire tests on building materials and structures

NOTE. B.S. 476, 'Fire tests on building materials and structures', Part 7, 'Surface spread of flame tests for materials', now published, supersedes some of the material in this standard. This Amendment deletes that material.

## Deletion

**Foreword** (as amended by Amendment No.1)

*Surface spread of flame.* Delete this paragraph.

*Alterations to the standard.* Delete the fourth and seventh paragraphs.

**Section two. Surface spread of flame test for materials**

Delete the section heading.

**Clauses 5, 6, 7 and 8.** Delete these clauses.

**Appendix. Apparatus for preliminary surface spread of flame test**

Delete this Appendix.

**Figs. 3, 4 and 5.** Delete these figures.