BRITISH STANDARD

BS 5438:1989

Incorporating Amendment Nos. 1 and 2

Methods of test for

Flammability of textile fabrics when subjected to a small igniting flame applied to the face or bottom edge of vertically oriented specimens

UDC 677.014.27:614.841.411:536.468:543.874

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Textiles and Clothing Standards Policy Committee (TCM/-) to Technical Committee TCM/30, upon which the following bodies were represented:

Association of Heavy Textile Proofers of Great Britain
Bolton Institute of Higher Education
British Burn Association
British Carpet Manufacturers' Association Ltd.
British Clothing Industry Association
British Plastics Federation
British Steel Corporation
British Textile Employers' Association
Chemical Industries Association
Chief and Assistant Chief Fire Officers' Association
City of Bradford Conditioning House
Consumer Policy Committee of BSI
Department of the Environment (Building Research Establishment)
Department of the Environment (The Crown Suppliers)
Department of Trade and Industry (Consumer Safety Unit, CA Division)
Design Council
Home and Contract Furnishing Textiles Association
Home Office
International Wool Secretariat
Lambeg Industrial Research Association
London Scientific Services
Man-made Fibres Producers' Committee
Ministry of Defence
Soap and Detergent Industry Association
Society of Motor Manufacturers and Traders Ltd.
Textile Institute
Textile Research Council
Warrington Fire Research Centre

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Contents

Foreword

This British Standard has been prepared under the direction of the Textiles and Clothing Standards Policy Committee. It supersedes BS 5438:1976, which will be withdrawn when legislation which relates to BS 5438:1976 has been amended.

BS 5438 was introduced in 1976 and described three test methods for observing and measuring aspects of the flammability of textile fabrics when subjected to a small igniting flame applied to the face of a vertically oriented specimen. These test methods were subsequently specified in British Standard performance specifications for sleepwear, blankets, curtains and drapes, industrial protective clothing, tentage etc.

In some instances modifications to the original test procedures have been introduced in these performance specifications, notably reduced pinning. This reduced pinning has been found to give more realistic, although less reproducible results.

In 1994 BS 5438 was amended as a result of the publication of BS EN 26940 and BS EN 26941, which together partially superseded it. Tests 1A and 1B were deleted (superseded by the tests in clause **8** of BS EN 26940) as were tests 3A and 3B (superseded by the tests in clause **8** of BS EN 26941).

It should be noted that the procedure in clause **9** (test 2a), although retained for the time being, has been adopted in EN 532. In due course EN 26940, EN 26941 and EN 532 will be replaced by a new set of International/European Standards that will correspond to the six test methods in BS 5438:1989, which will then be withdrawn.

Advice on the choice of test method and acceptance criteria is given in Appendix C. Attention is also drawn to PD 2777:1994 which provides additional information on the development of BS 5438 and related standards.

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 16, 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.

Section 1. General

1 Scope

This British Standard describes methods of test for flammability of textile fabrics by observing and measuring the limited flame spread and of vertically oriented test specimens when subjected to a small igniting flame applied to the face or bottom edge. Test specimens can be of a single fabric or any combination of materials representative of the product in use, e.g. coated, multi-layered fabrics.

NOTE 1 Wherever practical, trimmings should be tested as part of the fabric assembly on which they are or will be used.
NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1
glowing

combustion of a material in the solid phase without flame but with emission of light from the combustion zone

(Extracted from BS ISO 4880.)

2.2
ignition

flaming of the test specimen for a period of 1 s or more after removal of the igniting flame, unless otherwise specified in performance requirements

2.3
flaming debris

material separating from the specimen during the test procedure and falling below the initial lower edge of the specimen and continuing to flame as it falls

2.4
hole

a break in the fabric at least 2 mm × 2 mm in size caused by melting, glowing or flaming. If the hole is crossed by any material it is described as discontinuous

NOTE This definition applies only to face ignition tests.

2.5
duration of flame

the length of time for which a material continues to flame, under specified test conditions, after the ignition source has been removed

(Extracted from BS ISO 4880.)

NOTE 1 Also called afterflame time.
NOTE 2 Flaming debris is not included in this definition.

2.6
afterglow time

the time for which a material continues to glow, under specified test conditions, after cessation of flaming or after removal of the ignition source, ignoring glowing debris

(Extracted from BS ISO 4880.)

NOTE Also called duration of afterglow.

2.7
flame application time

the time for which the igniting flame is applied to the test specimen

2.8
minimum ignition time

the minimum flame application time required to cause ignition (**2.2**) of the test specimen

2.9
flame spread time

the time taken by a flame on a burning material to travel a specified distance under specified test conditions, measured from when the igniting flame is applied

2.10
damaged length

the maximum extent of damaged material measured in a vertical or a horizontal direction, whichever is the greater, on each test specimen

NOTE Methods for measurement of damaged length are given in Appendix A.

2.11
surface flash

rapid spread of flame over the surface of a material without ignition of its basic structure

(Extracted from BS ISO 4880. See also BS 4569.)

3 Conditioning and testing atmospheres and location

3.1 Conditioning. Condition the test specimens for at least 24 h in an atmosphere having a temperature of 20 ± 5 °C and a relative humidity of 65 ± 5 %. If testing is not carried out immediately after conditioning place the conditioned test specimens in a sealed container. Begin testing each specimen within 2 min of removing it from either the conditioning atmosphere or the sealed container.

3.2 Testing atmosphere. Perform the tests in an atmosphere having a temperature of 15 °C to 30 °C, relative humidity of 55 ± 20 % and air movement which is less than 0.2 m/s at the commencement of the test and is not influenced further by mechanical devices operating during the test, and where the volume of air surrounding the test location is such that the test will be unaffected by any reduction of oxygen concentration. Where test 3 is to be performed in an open-fronted cabinet, make provision for mounting the specimen at least 300 mm from any wall.

NOTE 1 Draught shields may be required to restrict air movement in the region of the flame application.
NOTE 2 The testing location should be provided with means of removing smoke and fumes.

4 Health and safety of operators

There is a considerable risk with these tests and suitable precautions shall be taken.

NOTE Between tests, the atmosphere of the testing location, which should be of adequate dimensions to avoid endangering the health of operators, should be cleared of smoke and fumes by an extractor fan or other means of ventilation. It should be ensured that the required atmosphere and air movement for testing are restored (see **3.2**) after evacuation of smoke and fumes.

5 Apparatus

NOTE Since some products of combustion are corrosive, it is essential that the equipment should be constructed of material which will not be adversely affected by the fumes.

5.1 *Mounting frame* capable of holding the burner, test specimen holders and marker threads in the desired positions described in clause **6** and **11.4.2** [see Figure 1 and Figure 3(c)].

5.2 Gas burner[1)] having the dimensions given in Figure 2 and capable of being fixed vertically, horizontally or inclined at 30° to the vertical and capable of being moved quickly from stand-by positions, where the tip of the burner is at least 50 mm in front of the test specimen, to the operating positions described in **6.1.2** and **6.2.2** (see Figure 4).

NOTE Small differences in the design and dimensions of the burner can influence the configuration of the burner flame and so affect the results of the tests.

5.3 *A supply of commercial butane* complying with the requirements of BS 4250.

5.4 *Test specimen holders*

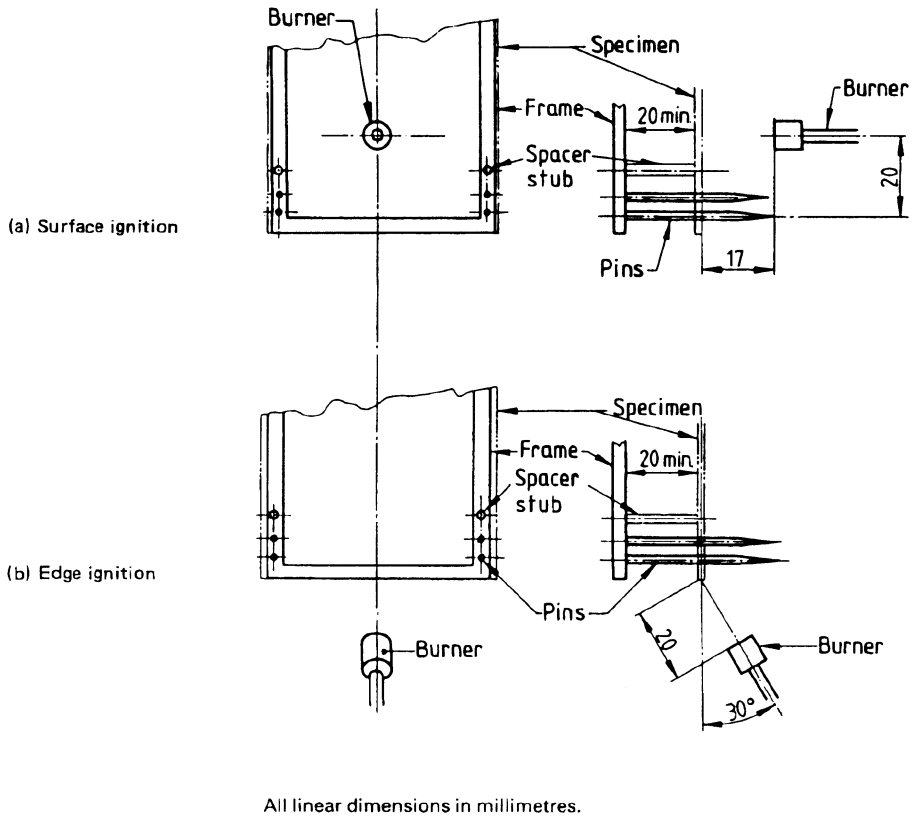
5.4.1 *Text deleted*

5.4.2 *Test specimen holder for tests 2A and 2B* consisting of a rectangular metal frame having a test specimen support pin of maximum diameter 2 mm and minimum length 27 mm at each corner of a rectangle of length 190 mm and width 150 mm. Spacer stubs of diameter 2 mm and minimum length 20 mm are provided adjacent to the test specimen support pins. The distance from the centre of a test specimen support pin to the edge of the frame is 5 mm and the distance from the centre of a test specimen support pin to the centre of the adjacent spacer stub is 6 mm [see Figure 3(b)].

NOTE The dimensions of the test specimen are given in **9.3** and **10.3**.

5.4.3 *Text deleted*

[1)] For information on the availability of such a burner apply to BSI Enquiries, Linford Wood, Milton Keynes, MK14 6LE.



All linear dimensions in millimetres.

Figure 1 — Test specimen holder and burner ignition location

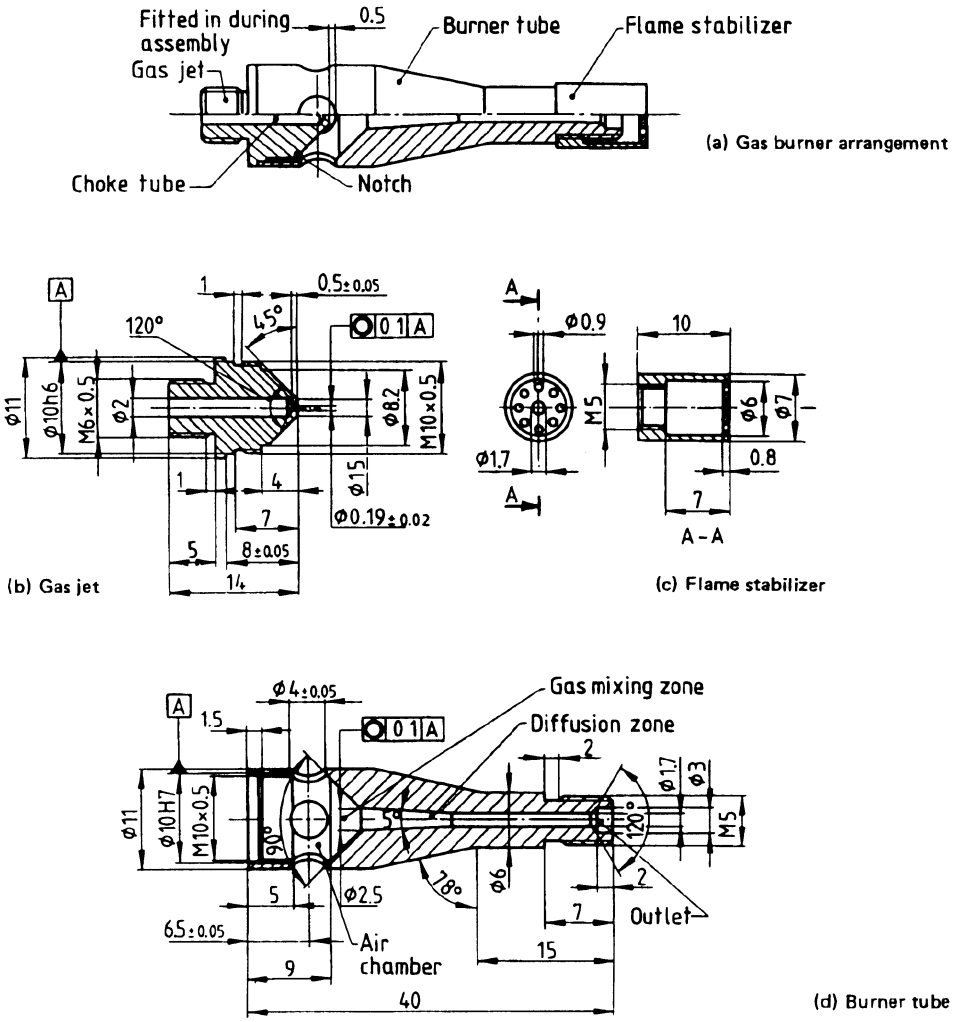
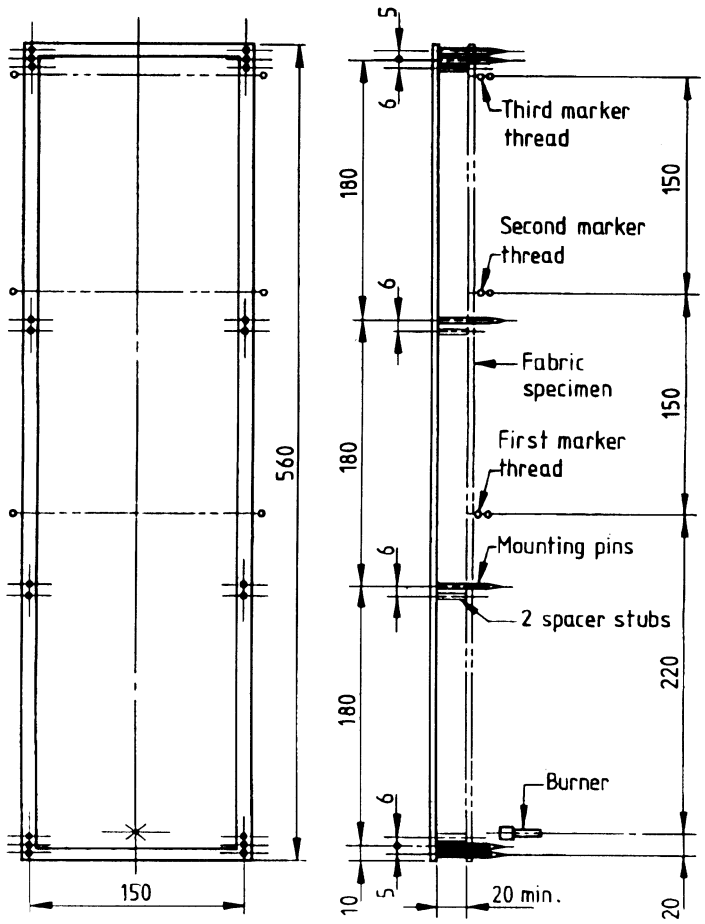


Figure 2 — Gas burner

(a) *Text deleted*

(b) *Text deleted*



(c) Test 3. Flame spread time

All dimensions in millimetres.

Figure 3 — Test specimen holders and location of test specimens

5.5 *Templates*

5.5.1 *Text deleted*

5.5.2 *A flat rigid template for tests 2A and 2B* of length 200 mm and width 160 mm having holes approximately 2 mm in diameter in each corner so positioned that centres of the holes correspond to the centres of the test specimen support pins on the test specimen holder for tests 2A and 2B (**5.4.2**), i.e. at each corner of a rectangle of length 190 mm and width 150 mm.

5.5.3 *Text deleted*

5.6 *Timing devices*

5.6.1 *A timing device* accurate to 0.2 s or better.

NOTE This is used in all tests to measure the flame application time.

5.6.2 *Timing devices* accurate to 0.2 s or better started automatically when the igniting flame is removed from the test specimen and capable of being stopped manually.

NOTE These devices are used in tests 1A, 1B, 2A and 2B to measure the afterflame and/or afterglow time. Their use is optional in tests 3A and 3B.

5.6.3 *Text deleted*

5.7 *A rule* graduated in millimetres.

NOTE This is required for tests 2A and 2B only.

5.8 *Text deleted*

6 Setting up the apparatus

6.1 Procedure A (face ignition)

6.1.1 *Mounting of test specimen*. Place the test specimen on the pins of the test specimen holder, making certain that the pins pass through the points marked off from the template and that the test specimen is at least 20 mm away from the rectangular metal frame of the test specimen holder. Fit the test specimen holder to the mounting frame with the specimen vertical.

6.1.2 *Operating position of burner*. Position the burner perpendicular to the surface of the test specimen such that the axis of the burner is 20 mm above the line of the lower pins and is aligned with the vertical centreline of the face of the test specimen [see Figure 4(a)]. Ensure that the tip of the burner is 17 mm from the face of the test specimen.

6.1.3 *Flame height adjustment*. Set the burner in the vertical stand-by position. Light the burner and preheat it for 2 min. Adjust the flame height to 40 ± 2 mm, measured as the distance between the tip of the burner tube and the top of the yellow part of the flame when the burner is vertically oriented and the flame is viewed in dim light [see Figure 4(c)].

6.1.4 *Flame check: horizontal reach*. Return the burner to the horizontal stand-by position and check that the horizontal reach of the flame is a minimum of 21 mm [see Figure 4(d)].

NOTE 1 It is essential that the horizontal reach of the flame obtained from the jet incorporated in the burner is at least this minimum length.

NOTE 2 If the apparatus does not have a horizontal stand-by position, the test specimen should be removed before carrying out this check.

6.1.5 *Flame position*. Move the burner from a stand-by position to the horizontal operating position (see **6.1.2**). Check that the flame impinges on the test specimen in the correct position [see Figure 4(a)].

6.1.6 *Adjustment of burner operating position*. Check the burner position and readjust if necessary for different fabrics.

NOTE The flame height and reach should be checked regularly.

6.2 Procedure B (bottom edge ignition)

6.2.1 *Mounting of test specimen*. Place the test specimen on the pins of the test specimen holder, making certain that the pins pass through the points marked off from the template and that the test specimen is at least 20 mm away from the rectangular metal frame of the test specimen holder. Fit the test specimen holder to the mounting frame with the specimen vertical.

6.2.2 *Operating position of burner*. Position the burner in front of, but below, the test specimen such that it lies in a plane passing through the vertical centreline of the test specimen and perpendicular to its face [see Figure 4(b)], with the longitudinal axis inclined upwards at 30° to the vertical towards the bottom edge of the test specimen. Ensure that the distance between the tip of the burner tube and the bottom edge of the test specimen is 20 mm.

NOTE It might not be possible to obtain consistent results with fabrics which exhibit sag or drape. Face ignition may be more appropriate for such fabrics.

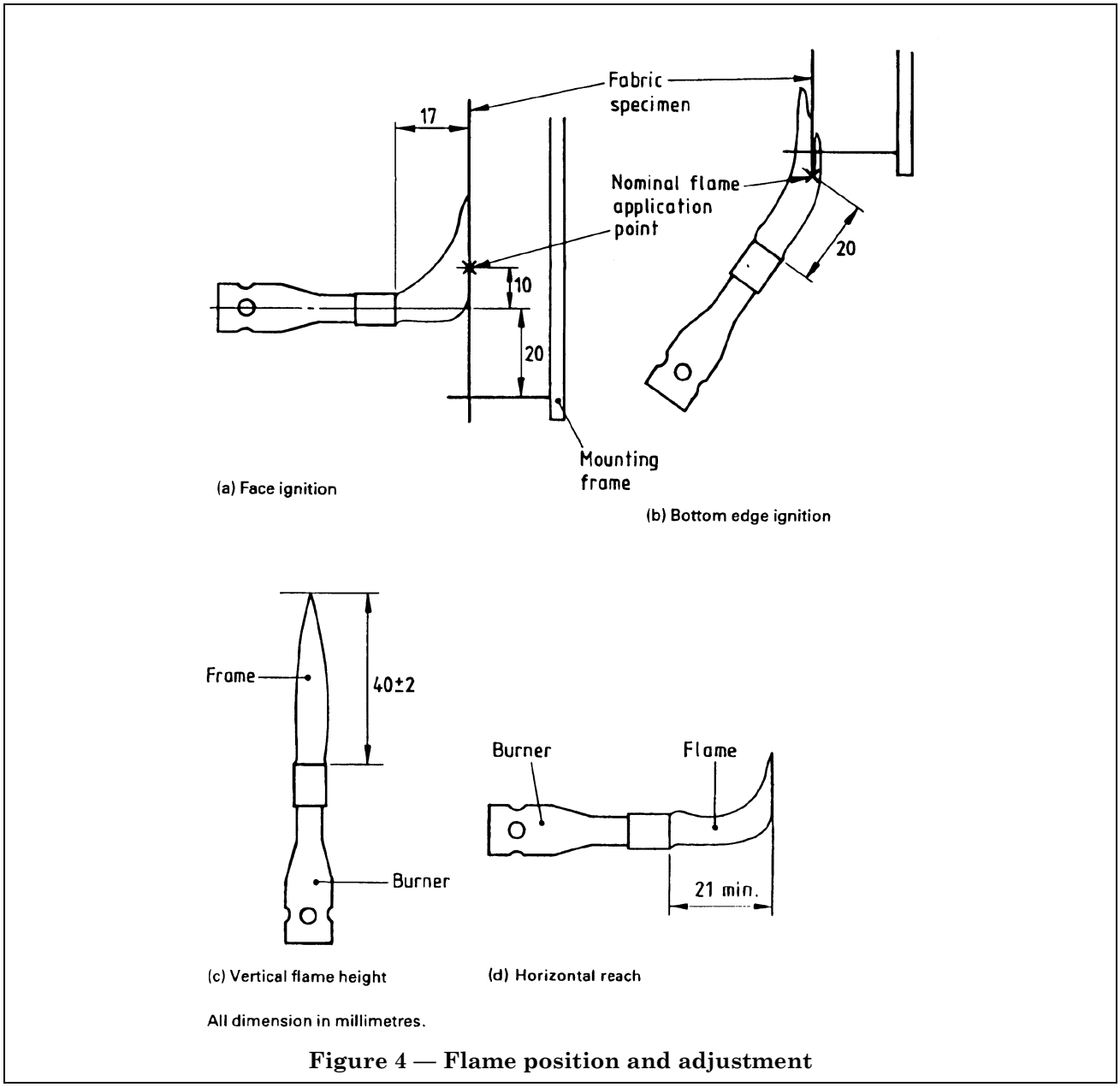


Figure 4 — Flame position and adjustment

6.2.3 *Flame height adjustment*. Set the burner in the vertical stand-by position. Light the burner and preheat it for 2 min. Adjust the flame height to 40 ± 2 mm, measured as the distance between the tip of the burner tube and the top of the yellow part of the flame when the burner is vertically oriented and the flame is viewed in dim light [see Figure 4(c)].

6.2.4 *Flame position*. Move the burner from a stand-by position to the inclined operating position (see **6.2.2**). Check that the edge of the test specimen bisects the flame [see Figure 4(b)].

6.2.5 *Adjustment of burner operating position*. Check the burner position and readjust if necessary for different fabrics.

NOTE The flame height should be checked regularly.

Section 2. Test procedures

7 *Text deleted*

8 *Text deleted*

9 Test 2A. Limited flame spread: face ignition

9.1 Principle

A small igniting flame is applied to a face of a vertical test specimen for a prescribed time and the duration of flaming, duration of afterglow and damaged length are measured. Spread of flame to the edge of the specimen, the formation of holes and the occurrence of flaming debris are noted.

9.2 Apparatus

Use the apparatus described in **5.1** to **5.3**, **5.4.2**, **5.5.2**, **5.6** and **5.7**.

9.3 Test specimens

Mark out a set of six test specimens 200 mm long × 160 mm wide, three with longer dimension in the length direction of the fabric or assembly and three with the longer dimension in the width direction. Use the template (**5.5.2**) to mark the position of the pins.

Condition the test specimens in accordance with **3.1**.

NOTE An extra test specimen is required for the setting up procedure (see clause **6** and **9.4.1**).

9.4 Test procedure

9.4.1 Set up the apparatus as described in **6.1**.

9.4.2 Position a test specimen on the specimen holder as described in **6.1.1**.

9.4.3 Apply the igniting flame for 10 s or for the flame application time given in the performance specification.

Observe and record the following information:

a) the duration of flaming;

b) the duration of afterglow;

c) the occurrence of any flaming debris;

d) whether, for any flame, any part of its lowest boundary reaches the upper edge or one of the vertical edges of the test specimen;

e) whether a hole develops which extends to the upper edge or one of the vertical edges of the specimen;

f) whether glowing reaches the upper edge or one of the vertical edges of the test specimen;

g) the maximum extent of any hole in the horizontal or vertical direction whichever is the greater;

h) the maximum damaged length measured in accordance with Appendix A;

i) which face of the fabric was subjected to the test flame.

9.4.4 Repeat **9.4.3** on the remaining five test specimens.

9.5 Test report (see **B.2**)

The test report shall include the following information:

a) a reference to this method of test, i.e. test 2A of BS 5438:1989;

b) the flame application time;

c) for each test specimen the following information:

1) the duration of flaming;

2) the duration of afterglow;

3) the occurrence of any flaming debris;

4) whether, for any flame, any part of its lowest boundary reaches the upper edge or one of the vertical edges of the test specimen;

5) whether a hole develops which extends to the upper edge or one of the vertical edges of the test specimen;

6) whether glowing reaches the upper edge or one of the vertical edges of the test specimen;

7) the maximum extent of any hole in the horizontal or vertical direction whichever is the greater;

8) the maximum damaged length measured in accordance with Appendix A;

9) which face of the fabric was subjected to the test flame.

10 Test 2B. Limited flame spread: bottom edge ignition

10.1 Principle

A small igniting flame is applied to the bottom edge of a vertical test specimen for a prescribed time and the duration of flaming, duration of afterglow and damaged length are measured. Spread of flame to the edge of the test specimen and the occurrence of flaming debris are noted.

10.2 Apparatus

Use the apparatus described in **5.1** to **5.3**, **5.4.2**, **5.5.2**, **5.6** and **5.7**.

10.3 Test specimens

Mark out a set of six test specimens 200 mm long × 160 mm wide, three with the longer dimension in the length direction of the fabric or assembly and three with the longer dimension in the width direction. Use the template (**5.5.2**) to mark the position of the pins.

Condition the test specimens in accordance with **3.1**.

NOTE An extra test specimen is required for the setting up procedure (see clause **6** and **10.4.1**).

10.4 Test procedure

10.4.1 Set up the apparatus as described in **6.2**.

10.4.2 Position a test specimen on the specimen holder as described in **6.2.1**.

10.4.3 Apply the igniting flame for 10 s or the flame application time given in the performance specification.

Observe and record the following information:

a) the duration of flaming;

b) the duration of afterglow;

c) the occurrence of any flaming debris;

d) whether, for any flame, any part of its lower boundary reaches the upper edge or one of the vertical edges of the test specimen;

e) whether glowing reaches the upper edge or one of the vertical edges of the test specimen;

f) the maximum damaged length measured in accordance with Appendix A.

10.4.4 Repeat **10.4.3** on each of the remaining five test specimens.

10.5 Test report (see **B.2**)

The test report shall include the following information:

a) a reference to this method of test, i.e. test 2B of BS 5438:1989;

b) the flame application time;

c) for each test specimen the following information:

1) the duration of flaming;

2) the duration of afterglow;

3) the occurrence of any flaming debris;

4) whether, for any flame, any part of its lowest boundary reaches the upper edge or one of the vertical edges of the test specimen;

5) whether glowing reaches the upper edge or one of the vertical edges of the test specimen;

6) the maximum damaged length measured in accordance with Appendix A;

7) a description of the bottom edge of the test specimen (i.e. raw, trimmed or hemmed);

8) which face of the fabric was towards the inclined burner.

11 *Text deleted*

12 *Text deleted*

Appendix A Measurement of damaged length

A.1 Principle

Measurement is made to assess the maximum extent of the total damage, ignoring any surface effects such as scorching or smoke deposition.

NOTE Damage resulting from application of an igniting flame to a test specimen may take the form of shrinkage, melting or charring. More than one type of damage may be observed and in some cases a hole may be formed.

A.2 Face ignition: procedure A

NOTE Some types of fabrics which melt or shrink may show more damage in the width direction than in the length direction. Such test specimens should be measured substituting width for length in the following instructions.

A.2.1 Remove the test specimen from the specimen holder and place it on a flat horizontal surface. Cut a slit from the bottom edge and parallel to the side of the test specimen as far as the lower boundary of the damaged area. If a ridge of resolidified material is formed around the perimeter of any hole it is necessary to cut through this ridge at the top and bottom of each hole.

A.2.2 Place a rule on top of the test specimen along the line of maximum damage and parallel with the side of the test specimen. Holding the rule down with one hand, gently raise the bottom edge of the free side of the test specimen until a definite resistance is felt.

A.2.3 Measure the length in millimetres from the lowest point of damage to the end of the resultant tear or hole.

A.3 Bottom edge ignition: procedure B

NOTE Some types of fabrics which melt or shrink may show more damage in the width direction than in the length direction. The tearing technique is not appropriate for such specimens.

A.3.1 Measure the length in millimetres of undamaged material remaining at each side of the test specimen along the line of maximum damage (normally the bottom edge of the test specimen) and subtract this from the original width of the test specimen.

A.3.2 Remove the test specimen from the specimen holder and place it on a flat horizontal surface.

A.3.3 Place a rule on top of the test specimen along the line of maximum damage and parallel with the side of the test specimen. Holding the rule down with one hand, gently raise the bottom edge of the free side of the test specimen until a definite resistance is felt.

A.3.4 Measure the length in millimetres from the top of the resultant tear or hole to the top of the test specimen and subtract this from the original length of the test specimen.

Appendix B Suggested test report formats

B.1 *Text deleted*

B.2 Limited flame spread

A suggested format for a report of minimum ignition time tests is as follows:

Test Laboratory.

Date.

Description of fabric sample including details of any pre-cleansing treatment.

Ref No.

These results were obtained using the specified test conditions and do not necessarily represent the behaviour of the test material under other conditions of test or use.

BS 5438:1989 Test 2A. Face ignition OR **BS 5438:1989 Test 2B. Bottom edge ignition**

Which face tested

Type of edge (raw, trimmed or hemmed)

Flame application time 10 s OR[a]

Flame application time 10 s OR[a]

	Orientation of test specimen					
	Length			**Width**		
	↑	↓	↑	→	←	→
Duration of flaming, (s)						
Duration of afterglow (s)						
Flaming debris (√ or ×)						
Flame to edge (√ or ×)						
Hole to edge (√ or ×)						
Glow to edge (√ or ×)						
Max. extent of hole, (mm)[b]						
Max. damaged length, (mm)						

Mean duration of flaming, (s)

Mean maximum damaged length, (mm)

Comments (deviation from standard procedure etc)

[a] Insert alternative.

[b] Test 2A only.

B.3 *Text deleted*

Appendix C Advice on the choice of test method and acceptance criteria

C.1 General

The test methods in this standard have been subjected to interlaboratory trials. Certain fabrics have been found to give variable results with specific test conditions.

Flame spread can be regarded as taking place in a series of steps. The procedure described in BS 5438:1976 attempted to measure fabric behaviour at each progressive step and to determine whether or not ignition took place, whether or not combustion continued and how quickly the fabric burned. Recent work has indicated that this approach is really only suitable for fabrics which do burn.

For fabrics which do not burn completely the flaming process may be extinguished at any one of several stages. The fabric may not ignite, it may ignite but extinguish before the igniting flame is removed giving zero afterflame, or it may extinguish shortly after removal of the igniting flame giving a short afterflame time. Flaming may persist for some time but without spreading or extensive damage may occur but with no afterflame. Flaming may spread in one direction only leaving extensive areas of the fabric undamaged. If flaming spreads sideways or downwards, e.g. by molten drips, it can extinguish without severing the marker threads in test 3. If, however, it spreads upwards with little or no sideways spread very short marker thread severance times can be recorded by a very small flame.

Some fabrics will only continue to support limited continuous flaming under very specific conditions. Such fabrics give widely different results between different specimens, but only under certain test conditions or in certain laboratories. In the past, this erratic behaviour has been ascribed to uneven application of flame retardant finish but it is just as likely to occur with fabrics which have not been treated with flame retardant finish. If a fabric ignites but burns with such difficulty that it eventually extinguishes, it may do so at any stage between zero afterflame, which cannot be distinguished from non-ignition, and burning to the edge, which is not distinguished from burning completely. Thus fabrics which burn with difficulty will tend to give erratic results if the test conditions are just sufficient to cause ignition.

C.2 Test 1. Minimum ignition time

The minimum ignition time is easy to determine on fabrics which continue to burn. It is normally related to the mass per unit area of the fabric and may vary depending on whether face or bottom edge ignition is used.

With flammable fabrics the minimum ignition time is an estimate of the shortest flame application which is likely to cause ignition. The minimum ignition time may not always cause ignition but longer flame application times almost certainly will. Except on very heavy fabrics, the 10 s flame application time specified in tests 2 and 3 will be sufficient to ignite all flammable fabrics.

Minimum ignition time is difficult to determine on fabrics which do not continue to burn. This standard specifies a larger specimen and a shorter afterflame time (1 s instead of 5 s) than the method described in ISO 6940 in an attempt to improve the detection of ignition of such fabrics. Problems still occur with fabrics which afterflame only for very short periods because they are recorded as not ignited with less than 1.0 s afterflame and ignited with 1.0 s afterflame or longer.

Some fabrics give a minimum and a maximum ignition time, i.e. there is a narrow critical range of flame application times which give rise to afterflame of more than 1 s. With shorter flame application times the fabric is not ignited, but with longer flame application times the fabric has ignited and any flaming has extinguished before the igniting flame is removed so that there is no afterflame.

With such fabrics that are difficult to ignite, afterflame is more likely to occur using short flame application times. This is why flame application times shorter than 10 s are specified in certain other flammability tests, e.g. ISO 6941. However a standard flame application time of 10 s is specified in tests 2 and 3 of this standard because it is considered that these tests ought to be carried out under standard conditions. The concept of using a flame application time based on the minimum ignition time found in test 1 was rejected in the preparation of BS 5438:1976 because of the lack of agreement in determining minimum ignition time. Work carried out during this revision of this standard indicated that 5 s flame application time is more severe on certain fabrics. It also gives more erratic results on these fabrics and fails to ignite some other fabrics which burn completely with a longer flame application time, e.g. a 15 s flame application fails to ignite some fabrics which ignite with 10 s flame application. In general 10 s flame application time is the most severe test on apparel fabrics. However, a longer flame application time may be more appropriate for very heavy fabrics.

C.3 Test 2. Limited flame spread

Test 2 was originally introduced as a means of reducing the amount of test specimen required for fabrics which do not burn sufficiently to sever the marker threads in test 3. No hole or flame to the edge in test 2 was accepted as being equivalent to no marker thread severance in test 3.

Some users of this standard did not consider that this performance standard was selective enough and they introduced additional requirements for afterflame and afterglow time, for hole size and for damaged length. However, recent interlaboratory trials indicate that these factors do not give consistent results. Some fabric/test combinations give very erratic results, whilst some laboratory/fabric combinations introduce a strong bias; they may be more or less likely to detect afterflame or they may give much lower or higher than normal damaged length results.

Fabrics which give limited flame spread may or may not afterflame. Any flame which persists is small and does not increase in intensity. It is liable to extinguish at any stage before the fabric is completely consumed and normally before the flame reaches the edge of the specimen. Thus, fabrics which give limited afterflame are liable to give extremely variable afterflame results on any given test and to give different behaviour on different tests or on the same test in different laboratories.

Various degrees of limited flame spread are detected by test 2 of this standard but the level attained is not completely dependent on fabric qualities. The conditions required to ensure continuation of afterflaming are so critical that minor differences between successive tests or between different laboratories can affect the results, as can the change from face to bottom edge ignition.

The problem is in specifying a combination of test conditions and performance specifications which will be certain to eliminate any unsafe fabrics but which will not reject safe fabrics because of laboratory or test variations. In order to solve this problem it is necessary to define what degree of safety is acceptable.

The generally accepted performance level for test 2 of this standard is for no hole or flame to reach the upper edge or either of the vertical edges of any of the six specimens. Cases sometimes occur in which just one specimen burns to the edge. This behaviour is unlikely to be detected on repeat testing and should be acceptable with or without repeat testing. Another anomaly occurs with some very lightweight fabrics where damage can reach the edge of the test specimen before the igniting flame is removed. This behaviour should also be acceptable provided that there is little or no afterflame. None of the specimens tested should burn completely. Under actual use conditions, fabrics tested to this performance level could be expected to give limited flame spread but with the extent of spread being highly dependent on the actual ignition conditions.

If a higher level of performance is sought, there is an increased probability that minor differences between laboratories or chance behaviour of certain specimens will influence the classification. The highest level of performance detected is when all six specimens tested give zero afterflame and no burning to an edge. This level is only achieved if the flame application time is long in relationship to the minimum ignition time of the fabric. If the flame application is within the critical range for the fabric (see **C.2**) afterflame times are extremely variable.

Specification of a very low afterflame time leads to differences between operators because of differences in response times. Some operators do not record afterflame times of below 1.0 s because such short times cannot be measured accurately; it takes something of the order of 0.5 s to observe that there is no afterflame and to stop the timer. Specification of a maximum afterflame time gives rise to rejection of a fabric which gives a long afterflame time on a single specimen. To allow for variability between test specimens it is preferable to specify a mean afterflame time. To allow for the limitation of the test method the value specified should be not less than 1.0 s, and to allow for variations between fabrics and laboratories a figure of 4.0 s is suggested. Fabrics which do not burn to the edge and have an average afterflame time of less than 4.0 s are unlikely to spread flame beyond the area affected by the igniting flame under actual use conditions.

The extent of flame spread may be evaluated by measurement of damaged length. This parameter is not as variable as afterflame time since most of the damage normally occurs during the flame application time. Heavy fabrics give short and reasonably consistent values for damaged length. They may afterflame for some time without increasing damaged length significantly. Lightweight fabrics give much higher values for damaged length. With very light fabrics damage may reach the edge of the test specimen within the flame application time. Thermoplastic fabrics give very erratic results for damaged length (hole formation) because of the erratic way in which they burn. With fabrics that char considerable differences can be recorded for damaged length between different laboratories. In these cases the differences appear to arise from differences in the measurement technique rather than in actual burning behaviour as it is possible to tear these fabrics well beyond the charred area.

The specification of damaged length requirements can lead to technical failures, i.e. fabrics which do not spread flame but fail to meet the values specified. This problem is particularly acute with lightweight fabrics which are also susceptible to considerable interlaboratory variations. The specification of a mean rather than a maximum damaged length (to avoid problems with outliers) may be appropriate for certain heavy fabric/test combinations but interlaboratory variations on lightweight fabrics are so great that damaged length cannot be regarded as a true measurement of fabric performance.

C.4 Test 3. Flame spread time

When BS 5438 was first issued in 1976 it was assumed that test 3 would be the standard test method and that marker thread severance times would be specified in performance standards. However, it was found that fabrics which satisfied the Nightdresses (Safety) Regulations 1967 gave a limited extent of burning rather that a limited rate of burning when tested using BS 5438:1976. The direction of flame spread varied with the nature of the fabric; charring fabrics tended to burn upwards whilst melting fabrics burned sideways. Some test specimens gave more, but still limited, flame spread than others. The specification for sleepwear introduced in BS 5722:1979 was based therefore on limited but variable flame spread rather than on restricted flame spread times. This specification has also been adopted for Curtains: Type A, in BS 5867-2:1980, and for Camping tests: Type F in BS 6341:1983.

BS 5722 was revised in 1984 to include dressing gown fabrics. Problems had been experienced with certain quilted constructions which gave limited but very erratic flame spread and would occasionally fail the requirements of BS 5722:1979. It was also desired to replace the previously used methods of test and performance standards for low flammability fabrics (BS 2963:1958 and BS 3121:1959). BS 5722:1984 therefore reverted to the specification of marker thread severance times. The times specified are equivalent to a constant flame spread rate of 12 mm/s and were selected to ensure that all sleepwear fabrics which burn completely will fail to comply with that standard. The Nightwear (Safety) Regulations 1985 specify flammability performance to BS 5722:1984 using BS 5438:1976.

The apparatus used in BS 5438:1976 has horizontal marker threads located 300 mm and 600 mm above the nominal flame application point and vertical marker threads located 75 mm either side of this point. The apparatus used in ISO 6941 has no vertical marker threads and the horizontal marker threads are 220, 370 and 520 mm above the burner location in test A (245, 395 and 545 mm above the bottom edge of the test specimen). The nominal flame application point is not specified in the International Standard but because of the different burner design and flame height it is approximately 10 mm above the burner axis in test A instead of 17 mm above the burner as is with the apparatus used in BS 5438:1976.

It would be possible therefore simply to specify marker thread severance times for the new method using the same maximum flame spread rate constant of 12 mm/s as used in BS 5722:1984. The comparative figures are given in Table 1.

However, fabrics do not normally burn at a constant rate. In particular, burning rates may be more rapid during the initial flame application time, giving low values for the time to the first marker thread. To avoid ambiguities between the new and old methods the first marker thread should not be used in comparing the two methods.

Anomalies between the old and new methods are still possible with certain fabrics because of the variable burning behaviour of the fabric. Failures to BS 5722:1984 can be obtained if only one specimen cuts one marker thread in less than the specified time, although other specimens may give no marker threads severed. Assessment of flammability based on the behaviour of the worst specimen tested ought not to be based on a single parameter, e.g. in the case of test 3 an upward burning rate, without taking into account whether burning is restricted in other respects, e.g. that it is unlikely to occur or does not spread sideways or increase in intensity.

C.5 Inconsistency between test 2 and test 3

The previous edition of this standard assumed that assessment would be made always by test 3 and that test 2 would be an acceptable alternative only if none of the specimens burned to an edge. However, it is sometimes possible for only one specimen to burn to the edge in test 2 and for no marker threads to be severed in test 3.

In this revision, test 2 is a separate test in its own right. If only some of the six specimens tested by test 2 burn to an edge, this fact can be recorded. The probability of limited flame spread can be evaluated against any relevant performance standard, which may possibly call for retesting of a further six specimens by test 2 if only one of the original specimens burns to an edge. Retesting by test 3 may be needed where performance levels based on test 3 are specified with test 2 given as an alternative using less fabric, but only if no specimens burn to the upper edges in test 2. Retesting by test 3 should not be necessary if any test 2 specimens burn to the vertical edges only.

Inconsistencies can still occur within test 3, with not all the marker threads being severed on some specimens and severance times being above or below the limits for different marker threads on different specimens. Performance standards for test 3 should allow for outliers and should not be based on the behaviour of the worst specimen.

Table 1 — Comparison of marker thread heights and marker thread severance times

Marker thread	BS 5438:1976		BS 5438:1989			
			Procedure 3A		Procedure 3B	
	Height of marker thread above nominal flame application point	Time to reach marker thread at constant 12 mm/s	Height of marker thread above nominal flame application point	Time to reach marker thread at constant 12 mm/s	Height of marker thread above nominal flame application point	Time to reach marker thread at constant 12 mm/s
	mm	s	mm	s	mm	s
1	150	Not used	210	(17.5)	245	(20.4)
2	300	25	360	30.0	395	32.9
3	600	50	510	42.5	545	45.4
Vertical		Not specified	Not fitted		Not fitted	

C.6 Choice of test procedure

Test 1 may be used to determine the minimum ignition time of fabrics which ignite and give sustained combustion. In the past it has been adapted and used to specify a class of "non-ignited" fabrics. However, most of these fabrics do ignite (see **C.2**) but give only transient combustion which may or may not be detected. Test 1 should not be used in this way, as the criterion for ignition is too short and the specimen size is too small.

Certain other British Standards determine the ignitability of composites involving textiles, e.g. BS 5852, BS 6807. In these standards ignition is defined as initiation of sustained combustion, i.e. combustion which persists beyond certain limits of time and distance. Composites which give transient combustion are classed as not-ignited in these tests, which are in fact tests for limited persistance of, or spread of, combustion when subjected to ignition sources of varying intensity. Test 2 should be used to identify materials which ignite but give limited spread of combustion.

Materials which burn completely can be classified according to their rates of flame spread as determined by test 3. However, many fabrics do not burn completely and in such cases the rate of flame spread by itself is not a true indication of the relative hazard. Test 3 could also be used as a test for limited extent of flame spread where this spread exceeds the limits of the test 2 specimen.

The choice of face or edge ignition will depend to a large extent on the end use and the likely method of ignition in use. Curtains, for example, are likely to be ignited on their bottom edge and test B could be specified, possibly with an appropriate hem along the bottom of the specimen to simulate actual use conditions. Ignition is usually quicker using bottom edge ignition and many materials burn more readily with bottom edge ignition. Bottom edge ignition is normally specified when it is desired to test under the most rigorous conditions. However, face ignition is more severe with certain fabrics.

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Publications referred to

BS 2963, *Methods of test for the flammability of fabrics.*

BS 3121, *Specification for performance requirements of fabrics described as of low flammability.*

BS 4250, *Liquified petroleum gas.*

BS 4250-1, *Specification for commercial butane and propane.*

BS 4569, *Method of test for the ignitability (surface flash) of pile fabrics and assemblies having pile on the surface.*

BS 5722, *Specification for flammability performance of fabrics and fabric assemblies used in sleepwear and dressing gowns.*

BS 5852, *Fire tests for furniture.*

BS 5852-1, *Methods of test for the ignitability by smokers' materials of upholstered composites for seating.*

BS 5852-2, *Methods of test for the ignitability of upholstered composites for seating by flaming sources.*

BS 5867, *Specification for fabrics for curtains and drapes.*

BS 5867-2, *Flammability requirements.*

BS 6341, *Specification for fabrics for camping tents.*

BS 6807, *Methods of test for the ignitability of mattresses with primary and secondary sources of ignition.*

PD 2777, *Fabric flammability and burning accidents.*

BS EN 26940, *Textile fabrics — Burning behaviour — Determination of ease of ignition of vertically oriented specimens.*

BS EN 26941, *Textile fabrics — Burning behaviour — Measurement of flame spread properties of vertically oriented specimens.*

BS ISO 4880, *Burning behaviour of textiles and textile products — Vocabulary.*

EN 532, *Clothing for protection against heat and flame — Method of test for limited flame spread.*

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