



© British Standards Institution. No part of this publication may be photocopied or otherwise reproduced without the prior permission in writing of BSI

British Standard

Decorative, high pressure laminates (HPL) based on thermosetting resins

Part 2. Methods of determination of properties

Stratifiés décoratifs "haute pression" à base de résines thermodurcissables
Partie 2. Méthode de détermination des propriétés

Dekorative Hochdruckschichtpreßstoffe auf Basis härtpbarer Harze
Teil 2. Prüfung

Foreword

This Part of BS 3794, prepared under the direction of the Plastics Standards Committee, supersedes BS 3794 : Part 2 : 1982 which is withdrawn.

BS 3794 was first published in 1946 as BS 1323. In 1964 it was completely revised and the standard was reissued as BS 3794. In 1973 the standard was revised again to adopt metric units but with no other significant change from the 1964 edition.

In 1982 the standard was published as BS 3794 : Parts 1 and 2 which were, respectively, technically equivalent to and identical with ISO 4586/1 and ISO 4586/2 published by the International Organization for Standardization (ISO). Part 1 then became the specification and Part 2 contained the test methods.

BS 3794 : Part 2 : 1982 described a number of alternative methods for demonstrating compliance with certain properties. In the new edition of this Part, the alternative test methods for resistance to colour change in enclosed

carbon arc light and for resistance to cigarette burns (simulated with an electric heater) have been withdrawn, since these are not used in the UK. Experience has shown that the methods for evaluating colour fastness and resistance to cigarette burns described in clauses 16 and 17 are adequate.

Additional tests for flatness, edge straightness, squareness, steam resistance, two methods for blistering resistance, and a method for crazing resistance of thick laminates have been introduced. Accordingly, this Part is no longer dual numbered since some of these new tests are not included in the related ISO standard. The relationship between the two editions is summarized in table 1.

Attention is drawn to the revision of BS 3794 : Part 1 published simultaneously.

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

Table 1. Summary of changes

Property	Clause reference	
	BS 3794 : 1986	BS 3794 : 1982
Appearance	3	5
Thickness	4	4
Flatness	5	Not included
Surface wear	6	6
Boiling water immersion	7	7
Dry heat	8	8
Dimensional stability at elevated temperature	9	9
Dimensional stability at 20 °C	10	10
Impact resistance (small ball)	11	11
Impact resistance (large ball)	12	12
Cracking, thin laminates	13	13
Scratching	14	14
Staining	15	15
Colour change (Xenon lamp)	16	16
Colour change (Carbon arc)	Withdrawn	17
Cigarette burns (actual)	17	18
Cigarette burns (simulated)	Withdrawn	19
Formability, Method A	18	20
Formability, Method B	19	21
Blistering, Method A	20	Not included
Blistering, Method B	21	Not included
Steam resistance	22	Not included
Fire characteristics	Being considered	22
Crazing, thick laminates	23	Not included
Edge straightness	24	Not included
Squareness	25	Not included

Contents

	Page		Page
Foreword		Inside front cover	
Committees responsible		Back cover	
Methods		Figures	
1 Scope	2	1 Example of equipment for measuring flatness	22
2 Definition	2	2 Type of apparatus for measuring abrasive resistance	23
3 Appearance	2	3 Typical holding jig for determination of dimensional change	24
4 Thickness	2	4 Impact tester (shown with spring compressed)	25
5 Flatness	3	5 Support fixture for impact tester	25
6 Resistance to surface wear	3	6 Example of calibration graph relating actual force to scale value	26
7 Resistance to immersion in boiling water	4	7 Example of evaluation diagram for assessing the effect of impact blows with an impact tester	26
8 Resistance to dry heat	5	8 Free-fall ball impact test apparatus for large diameter ball impacts	27
9 Dimensional stability at elevated temperatures	6	9 Clamping jig for free-fall ball impact test apparatus for large diameter ball impacts	28
10 Dimensional stability at 20 °C	7	10 Steel clamping device for testing resistance to cracking	29
11 Resistance to impact by small diameter ball	8	11 Type of apparatus for measuring the resistance to scratching	30
12 Resistance to impact by large diameter ball	9	12 Scratching point	31
13 Resistance to cracking (thin laminates)	10	13 Example of suitable viewing enclosure	32
14 Resistance to scratching	11	14 Example of scratching test	32
15 Resistance to staining	12	15 Limit curves for the standardization of diamond points	33
16 Resistance to colour change in xenon arc light	15	16 Specimen for resistance to scratching test	33
17 Resistance to cigarette burns	15	17 Forming apparatus (method A)	34
18 Formability (method A)	16	18 Forming apparatus (method B)	35
19 Formability (method B)	17	19 Blistering apparatus (method B)	37
20 Resistance to blistering (method A)	18	20 Resistance to steam: test arrangement	38
21 Resistance to blistering (method B)	19	21 Edge straightness measurement	39
22 Resistance to steam	19	22 Squareness measurement	39
23 Resistance to crazing (thick laminates)	20		
24 Edge straightness	20		
25 Squareness	21		
Tables			
1 Summary of changes		Inside front cover	
2 Group 1 staining agents		13	
3 Group 2 staining agents		13	
4 Groups 3 and 4 staining agents		14	

Methods

1 Scope

This Part of BS 3794 describes methods of test for determination of the properties of decorative, high pressure laminates (HPL).

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definition

For the purposes of this Part of BS 3794, the following definition applies.

decorative, high pressure laminate (HPL). A sheet consisting of layers of fibrous sheet material (for example paper) impregnated with phenolic and/or aminoplastic thermosetting resins, assembled and bonded together by means of heat and a pressure of not less than 5 MPa*, the outer layer or layers on one or both sides having decorative colours or designs.

3 Appearance

3.1 Principle

Sheets are inspected for surface appearance and defects under standardized conditions of lighting and viewing.

3.2 Apparatus

3.2.1 Horizontal inspection table, of height approximately 700 mm and large enough to accommodate the largest sheets to be inspected.

3.2.2 Overhead white fluorescent lights, of colour temperature approximately 5000 K and giving an intensity of 800 lx to 1000 lx over the whole area of the largest sheets to be inspected.

NOTE. A convenient distance of the lights from the inspection table is approximately 1.5 m.

3.3 Test specimen

The test specimen shall be the sheet under test, as received.

3.4 Procedure

Place the sheet, decorative face uppermost, on the inspection table. Wipe it free of any loose contamination, if necessary, with a soft cloth. Inspect it from the distance specified in BS 3794 : Part 1 for defects such as smudges, smears, finger-prints, scratches, foreign particles, damage or any other form of blemish evident within the decorative surface.

Carry out the inspection using normal vision, corrected if necessary. A magnifying glass shall not be used for viewing the sheet.

3.5 Test report

The test report shall contain the following:

- (a) the identity of the product;
- (b) the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;
- (c) the method of test;
- (d) the date of test;
- (e) the viewing distance;
- (f) the defects observed.

4 Thickness

4.1 Principle

The thickness of the laminate is measured using a special gauge.

4.2 Apparatus

4.2.1 Thickness gauge (ratchet-type micrometer or dial indicator), having two flat parallel measuring surfaces of diameter at least 6 mm and capable of being read to 0.01 mm. When the thickness of a decorative laminated sheet is being measured the two surfaces shall exert a pressure of 10 kPa to 100 kPa upon each other.

4.3 Test specimen

The specimen shall be the sheet under test, as received.

4.4 Procedure

Check the gauge for accuracy and then determine the thickness of the sheet to the nearest 0.01 mm.

NOTE. It is recommended that the thickness should be measured at a minimum of four points and a distance of at least 20 mm from the edge of the sheet.

4.5 Test report

The test report shall contain the following:

- (a) the identity of the product;
- (b) the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;
- (c) the method of test;
- (d) the date of test;
- (e) all the thickness values measured;
- (f) the location of the points at which the thickness measurements were made.

*1 MPa = 1 MN/m².

5 Flatness

5.1 Principle

The maximum bow of the sheet is measured using a flatness gauge.

5.2 Apparatus

5.2.1 Flatness gauge, with dial indicator as shown in figure 1.

5.3 Test specimen

The test specimen shall be the sheet under test, as received, stored in accordance with the manufacturer's recommendations.

5.4 Procedure

Place the flatness gauge on a suitable flat surface and note the reading on the dial indicator h_1 (in mm).

Place the sheet under test, concave side uppermost, on a flat surface. Bring the flatness gauge (5.2.1) lightly into contact with the sheet at the position of maximum curvature, so that the two outer feet and the dial indicator foot are all in contact with the laminate surface, taking care not to disturb the natural curvature of the sheet.

Note the reading on the dial indicator h_2 (in mm).

Calculate the maximum bow h (in mm) from $|h_2 - h_1|$.

If the curvature of the sheet is greater than the maximum range of the flatness gauge use a straightedge (see 24.2.1) and a steel rule (see 24.2.2) to measure the bow.

5.5 Test report

The test report shall contain the following:

- (a) the identity of the product;
- (b) the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;
- (c) the method of test;
- (d) the date of test;
- (e) the maximum bow h (in mm).

6 Resistance to surface wear

6.1 Principle

The ability of the decorative surface of the sheet under test to resist abrasive wear through to the sublayer is determined. Abrasion is achieved by rotating a specimen in contact with a pair of loaded cylindrical wheels covered with abrasive paper. The wheels are positioned so that their cylindrical faces are equidistant from the specimen's axis of rotation, but not tangential to it. As they are turned by the rotating specimen, they abrade an annular track on the specimen's surface. The number of revolutions of the specimen required to cause a defined degree of abrasion is used as a measure of resistance to surface wear.

6.2 Apparatus and materials (see figure 2)

6.2.1 Calibration plates, of rolled zinc sheet, having a thickness of 0.8 ± 0.1 mm and a Brinell hardness of 48 ± 2 when tested in accordance with BS 240 : Part 1 using a ball of diameter 5 mm and a load of 360 N.

6.2.2 Abrasive paper strips (1), of width 12 mm and length approximately 160 mm, having the following composition:

- (a) paper of grammage 70 g/m² to 100 g/m²;
- (b) powdered aluminium oxide having a particle size such that it will pass through a sieve of aperture size 100 μ m and remain on a sieve having an aperture size of 63 μ m;
- (c) adhesive backing (optional).

6.2.3 Double-sided adhesive tape, only required if the adhesive paper used has no adhesive backing.

6.2.4 Testing machine.

6.2.4.1 Specimen holder, in the form of a disc (7) which rotates in a horizontal plane at 58 r/min to 62 r/min and to which the test specimen (6) can be clamped flat (4 and 5).

6.2.4.2 Abrasive wheels (3), two cylindrical rubber-covered wheels of width 12 mm and diameter 50 mm, which rotate freely about a common axis. The curved surface of the wheels, to a depth of 6 mm, shall be of rubber (2) of hardness 50 IRHD to 55 IRHD when tested in accordance with BS 903 : Part A26. The inside faces of the wheels shall be 50 mm to 55 mm apart, and their common axis shall be 20 mm from the vertical axis of the specimen holder. The wheels shall be positioned symmetrically in a plane containing the axis of the specimen holder.

6.2.4.3 Holding and lifting device (8), for the abrasive wheels, so constructed that each wheel exerts a force (F) of 5.4 ± 0.2 N on the test specimen.

6.2.4.4 Revolution counter.

6.2.4.5 Suction device, so fitted that two nozzles are over the abraded section of the specimen under test. One nozzle shall be situated between the wheels, the other diametrically opposite. The centres of the nozzles shall be 77 mm apart and 1 mm to 2 mm from the surface of the test specimen. When the nozzles are closed, there shall be a vacuum of 1.5 kPa to 1.6 kPa.

6.2.5 Conditioning chamber, with a standard atmosphere of 23 ± 2 °C and 50 ± 5 % relative humidity.

6.3 Test specimens

The test specimen shall be a piece of the sheet under test, shaped to fit the type of clamping device used.

NOTE. It will usually be a disc of diameter about 130 mm, or a square of about 120 mm with its corners rounded to give a diagonal of about 130 mm, and it will usually have a hole of diameter 6 mm in its centre.

Three specimens shall be prepared.

6.4 Preparation of test specimens and abrasive paper

Clean the surface of the test specimens with an organic solvent that is immiscible with water, for example 1,1,1-trichloroethane. Pre-condition the test specimen and the abrasive strips for at least 72 h in the conditioning atmosphere (6.2.5) before testing.

6.5 Procedure

6.5.1 Preparation of abrasive wheels. Bond a strip of pre-conditioned abrasive paper (6.2.2) to each of the rubber-covered wheels using either the adhesive backing, if present, or the double-sided adhesive tape (6.2.3), in such a way that the cylindrical surface is completely covered, but without any overlapping of the abrasive paper.

6.5.2 Calibration of abrasive paper. Prepare two abrasive wheels with previously unused strips of adhesive paper from the batch to be used for testing (see 6.5.1).

Determine the mass of a zinc plate (6.2.1) to the nearest 0.001 g and clamp it in the specimen holder (6.2.4.1). Lower the abrasive wheels on to the zinc plate and operate the suction device (6.2.4.5). Allow the zinc plate to rotate for 500 revolutions and then redetermine its mass to the nearest 0.001 g. Ensure that its loss in mass is 0.130 ± 0.020 g.

Do not use any batch of abrasive paper that causes a loss in mass of the zinc plate outside the permitted limits.

6.5.3 Abrasion of test specimen. Perform the test immediately after removal of the test specimen and calibrated abrasive paper from the pre-conditioning atmosphere (see 6.4).

Prepare sufficient abrasive wheels for the test using previously unused abrasive paper. Fit two wheels to the machine and set the revolution counter (6.2.4.4) to zero.

Clamp the specimen in the holder, ensuring that its surface is flat. Lower the abrasive wheels on to the specimen, operate the suction device and allow the specimen to rotate. Examine the specimen for wear after each 25 revolutions and examine the abrasive paper for clogging with abraded particles. Replace the abrasive paper if it becomes clogged, or after 500 revolutions, whichever occurs first.

Continue the test in this way until the initial wear point (I_p) is reached. Record the number of revolutions and resume the test until the final wear point (F_p) is reached. Record the number of revolutions again.

The initial wear point (I_p) is that point at which the first clearly recognized wear-through of the print, pattern, plain colour coating or solid colour paper appears and the sub-layer becomes exposed in each of four quadrants.

The sub-layer for printed papers is the background on which the pattern is printed; for plain colours it is the first sub-layer of different colour.

The final wear point (F_p) occurs in the case of a patterned laminate when about 95 % of the pattern is removed in the abraded area, and in the case of a plain colour laminate when an underlayer of a different colour is exposed over about 95 % of the abraded area.

Carry out the test on each of three test specimens.

6.6 Expression of results

Calculate the wear resistance of the product under test as the average of the values obtained from the three test specimens, rounded to the nearest 50 revolutions.

The wear resistance, expressed in revolutions, for each specimen, is given by the formula

$$\frac{I_p + F_p}{2}$$

6.7 Test report

The test report shall contain the following:

- (a) the identity of the product;
- (b) the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;
- (c) the method of test;
- (d) the date of test;
- (e) the wear resistance of the product (in revolutions).

7 Resistance to immersion in boiling water

7.1 Principle

The resistance to immersion in boiling water is determined by the increase in mass and thickness of a test specimen and examination for a change in appearance, blistering or delamination after immersion for 2 h.

NOTE. The test is related to ISO 62.

7.2 Apparatus

7.2.1 Balance, accurate to 0.001 g.

7.2.2 Oven, capable of being maintained at 50 ± 2 °C.

7.2.3 Vessel, containing boiling distilled water.

7.2.4 Vessel, containing distilled water at 23 ± 2 °C.

7.2.5 Desiccator.

7.2.6 Micrometer thickness gauge.

7.2.7 Suitable heating apparatus, e.g. an electric hot-plate.

7.2.8 Specimen holder, to hold specimens vertically during immersion and to prevent contact with other specimens and the vessel.

7.3 Test specimens

The test specimen shall be 50 ± 1 mm square; the thickness of the sheet shall be as received and cut in such a way that no appreciable heat is generated and the edges are free from cracks. Cut edges shall be smooth. Three specimens shall be used.

7.4 Procedure

Dry the three test specimens for 24 ± 1 h in the oven (7.2.2), maintained at 50 ± 2 °C. Allow to cool in the desiccator (7.2.5) to 23 ± 2 °C and determine the mass of each specimen to the nearest 0.001 g (mass m_1).

Measure the thickness of each specimen as specified in clause 4, in each case at the centre of its four edges (d_1 , d_2 , d_3 and d_4) and with the external edge of the micrometer

anvil approximately 5 mm from each side edge. Mark the measuring points so that subsequent measurements can be made in the same places.

Place the specimens in the vessel (7.2.3) containing boiling distilled water. Take care to prevent the specimens from making contact over any substantial area with one another or with the vessel.

After $2 \text{ h} \pm 5 \text{ min}$, remove the specimens from the boiling water and allow to cool for $15 \pm 5 \text{ min}$ in the vessel (7.2.4) containing distilled water maintained at $23 \pm 2^\circ\text{C}$. Take the specimens out of the water and remove all surface water with a clean dry cloth or with filter paper. Determine the masses of the specimens again to the nearest 0.001 g (mass m_2) within 1 min of taking them out of the water. Determine the thickness of each test specimen to the nearest 0.01 mm at the same points as before (d_5, d_6, d_7 and d_8).

Examine each test specimen visually for any change in appearance, blistering or delamination.

7.5 Expression of results

Express the change of appearance of the specimens in accordance with the following rating scale.

5. No visible change.
4. Slight change of gloss and/or colour.
3. Moderate change of gloss and/or colour.
2. Severe change of gloss and/or colour.
1. Blistering and delamination present.

The boiling water absorbed by each test specimen, expressed as a percentage by mass, is given by the formula

$$\frac{m_2 - m_1}{m_1} \times 100$$

where

m_1 is the mass of the specimen before immersion;

m_2 is the mass of the specimen after immersion.

The percentage increase in thickness at the measuring points of each test specimen is given by the formulae

$$\frac{d_5 - d_1}{d_1} \times 100$$

$$\frac{d_6 - d_2}{d_2} \times 100, \text{ etc.}$$

where

d_1, d_2, d_3 and d_4 are the thicknesses measured before immersion;

d_5, d_6, d_7 and d_8 are the corresponding thicknesses measured after immersion.

Calculate the percentage (by mass) of boiling water absorbed by the product under test as the average of the values obtained from the three test specimens.

Calculate the percentage increase in thickness of the product under test as the average of the 12 values obtained at the four measuring points on all three specimens.

7.6 Test report

The test report shall contain the following:

- (a) the identity of the product;
- (b) the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;
- (c) the method of test;
- (d) the date of the test;
- (e) the percentage increase in mass of the product;
- (f) the percentage increase in thickness;
- (g) the rating corresponding to the appearance change found for the product (see 7.5).

8 Resistance to dry heat

8.1 Principle

A specimen taken from the product under test is bonded to wood chipboard to simulate service conditions, and then subjected to dry heat by contact with a vessel of defined heat capacity, initially at 180°C but cooling during the 20 min of contact. The resistance to the test conditions is assessed by visual examination.

The test is intended to determine the suitability of decorative, high pressure laminates for use in kitchens where contact with moderately hot cooking utensils is to be expected.

8.2 Apparatus and materials

8.2.1 Glycerol tristearate (or other suitable material).

The same glycerol tristearate (or other material) shall be used for at least twenty tests, but if it has been heated to a temperature above 200°C , or in case of dispute, fresh material shall be used.

NOTE. The use of any material of similar specific heat which will produce the same result is permitted, e.g. a metal block that can minimize the health and safety risks.

8.2.2 Fine-faced wood chipboard, $230 \pm 5 \text{ mm}$ square, $19 \pm 1.3 \text{ mm}$ thick, of density $675 \pm 25 \text{ kg/m}^3$ and a moisture content of $9 \pm 2\%$ (m/m).

8.2.3 Urea-formaldehyde adhesive, containing approximately 15 % (m/m) of filler, or an adhesive with equivalent performance.

8.2.4 Cast cylindrical aluminium or aluminium alloy vessel, without a lid, the bottom of which has been machined flat. It shall have an external diameter of $100 \pm 1.5 \text{ mm}$ and an overall height of $70 \pm 1.5 \text{ mm}$. The wall thickness shall be $2.5 \pm 0.5 \text{ mm}$ and the base thickness $2.5^{+0.5}_{-0} \text{ mm}$.

8.2.5 Heat source, to heat the vessel (8.2.4) uniformly.

8.2.6 Inorganic heat-insulating board, of thickness about 2.5 mm and 150 mm square. Asbestos cement shall not be used.

8.2.7 Thermometer, of range -5°C to $+250^{\circ}\text{C}$.

8.2.8 Fixing frame, to hold the test specimen flat.

8.2.9 Stirrer.

8.3 Test specimen

The test specimen shall be prepared by uniformly bonding a piece of the sheet under test to the wood chipboard (8.2.2) using the specified adhesive (8.2.3). One specimen 230 ± 5 mm square shall be used. The bonded specimen shall be pre-conditioned for at least 7 days at $23 \pm 2^{\circ}\text{C}$ and $50 \pm 5\%$ relative humidity before testing.

For materials of thickness greater than 2 mm, the effect of bonding the specimen is insignificant and the test can be conducted with the specimen resting in close contact with the chipboard. This technique is also acceptable for routine quality control testing of laminates less than 2 mm thick; however, in case of dispute, laminates less than 2 mm shall be bonded to chipboard.

8.4 Procedure

Fill the vessel (8.2.4) with glycerol tristearate (or other material) (8.2.1). Fix the thermometer (8.2.7) centrally in the vessel with its bulb about 6 mm from the bottom. Raise the temperature of the material to approximately 185°C , stirring from time to time. Transfer the vessel to the heat-insulating board (8.2.6) and allow the temperature to fall to $180 \pm 1^{\circ}\text{C}$, stirring continuously; or if a metal block is used ensure that the temperature is $180 \pm 1^{\circ}\text{C}$.

Immediately place the vessel containing the hot material or metal block on the surface of the test specimen and allow to stand for 20 min without further stirring.

At the end of this period, remove the vessel or metal block and allow the specimen to cool for a period of 45 min. Examine the specimen for surface disturbance, for example blistering, crazing, discoloration or loss in gloss visible to the naked eye, allowing the light to fall on the specimen at various angles of incidence.

8.5 Expression of results

Express the change of appearance of the specimen in accordance with the following rating scale.

5. No visible change.
4. Slight change of gloss and/or colour only visible at certain viewing angles.
3. Moderate change of gloss and/or colour.
2. Severe change of gloss and/or colour.
1. Surface damage and/or blistering.

8.6 Test report

The test report shall contain the following:

- (a) the identity of the product;
- (b) the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;

(c) the method of test;

(d) the date of test;

(e) the rating corresponding to the appearance change found for the product (see 8.5).

9 Dimensional stability at elevated temperatures

9.1 Principle

The lateral dimensional changes of specimens taken from the sheet under test are assessed over an extreme range of relative humidities at elevated temperatures.

9.2 Apparatus

9.2.1 Oven, capable of being maintained at $70 \pm 2^{\circ}\text{C}$.

9.2.2 Conditioning chamber, with an atmosphere of $40 \pm 2^{\circ}\text{C}$ and 90 % to 95 % relative humidity.

NOTE. This relative humidity occurs at a temperature of 40°C in equilibrium above a saturated solution of sodium tartrate $(\text{CHOH-COONa})_2 \cdot 2\text{H}_2\text{O}$.

9.2.3 Conditioning chamber, with a standard atmosphere of $23 \pm 2^{\circ}\text{C}$ and $50 \pm 5\%$ relative humidity.

9.2.4 Bedplate and mounted dial gauge, or other apparatus capable of measuring to an accuracy of 0.02 mm.

9.2.5 Rigid jig, for holding the specimen straight during measurement.

NOTE. A typical jig is shown in figure 3.

9.2.6 Desiccator, of suitable size.

9.3 Test specimens

The test specimen shall be 140 ± 0.8 mm long, 12.7 ± 0.4 mm wide and of the thickness of the sheet under test. The edges shall be free from cracks and shall be made smooth with fine abrasive paper or cloth. Machining and abrading operations shall be slow enough to avoid appreciably heating the material.

Twelve test specimens shall be tested, six of them with their major axes parallel to the machine direction of the paper from which the sheet has been made, and six with their major axes at right angles to the machine direction*. Three specimens from each direction shall be used for the low humidity test and three for the high humidity test.

If the machine direction is not known, carry out flexural strength tests at various angles. The test specimen which gives the highest value shall be assumed to have been cut parallel to the machine direction.

The specimens shall be pre-conditioned for 4 days at $23 \pm 2^{\circ}\text{C}$ and $50 \pm 5\%$ relative humidity before testing.

*Known as the 'cross-machine direction'.

9.4 Procedure

9.4.1 General. Make all measurements of length to the nearest 0.02 mm with the test specimen vertical in the jig (9.2.5), the lower end in contact with the bedplate and the upper end in contact with the foot of the dial gauge (see 9.2.4). When any test specimen is measured for the second time, take care to ensure that it is located in the jig in the same relative position as it was in when first measured. Make all measurements within 5 min after removal from the conditioning atmosphere.

9.4.2 Dry heat test. Measure the length of each of the six specimens and then place them in the oven (9.2.1), maintained at $70 \pm 2^\circ\text{C}$. After 24 h, remove them and allow them to cool to ambient temperature in the desiccator (9.2.6) for 1 h. Again measure the length of each specimen.

9.4.3 High humidity test. Measure the length of each of the six specimens and then place them in the conditioning chamber (9.2.2). After 96 ± 4 h, remove each specimen, wipe it free of surface water, with a cloth, and again measure its length.

9.5 Expression of results

Calculate the change as a percentage of the initial length for each specimen.

Calculate the mean percentage change for each of the four sets of three test specimens, to the nearest 0.05 %.

Calculate the combined dimensional change for each direction of the sheet as the sum of the average absolute dimensional changes in each of the low and high humidity tests if the movements are in opposite directions; but if they are in the same direction, take the larger of the two average changes as the combined dimensional change.

Example (using test specimens in one direction only).

Dry heat test

Test specimen	1	2	3	Mean to nearest 0.05 %
Initial length (mm)	139.77	139.85	139.83	
Final length (mm)	139.26	139.22	139.24	
Change in length (mm)	-0.51	-0.63	-0.59	
Change (%)	-0.36	-0.45	-0.42	-0.4

High humidity test

Test specimen	4	5	6	Mean
Initial length (mm)	139.88	139.80	139.83	
Final length (mm)	140.33	140.21	140.31	
Change in length (mm)	+0.45	+0.41	+0.48	
Change (%)	+0.32	+0.29	+0.34	+0.3

The movements in the two tests are in opposite directions, therefore the combined dimensional change = $0.3\% + 0.4\% = 0.7\%$.

9.6 Test report

The test report shall contain the following:

- the identity of the product;
- the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;
- the method of test;
- the date of test;
- the combined dimensional change for the machine direction;
- the combined dimensional change for the cross-machine direction.

10 Dimensional stability at 20°C

10.1 Principle

The lateral dimensional changes of specimens taken from the sheet under test due to changes of humidity at 20°C are measured.

10.2 Apparatus

10.2.1 Conditioning chambers, maintained at the following three atmospheres:

- $20 \pm 2^\circ\text{C}$ and $32 \pm 3\%$ relative humidity;
- $20 \pm 2^\circ\text{C}$ and $90 \pm 3\%$ relative humidity;
- $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity.

10.2.2 Means for measuring lengths of 200 mm to the nearest 0.05 mm.

10.3 Test specimens

Four test specimens, approximately 250 mm x 50 mm, shall be cut from the sheet under test in both the machine and cross-machine directions of the papers from which the sheet was manufactured. If these directions are not known, they shall be determined in accordance with 9.3. Measuring marks shall be made on the decorative face of the specimens approximately 200 mm apart and 25 mm from each end.

The specimens shall be pre-conditioned for 7 days at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity before testing.

10.4 Procedure

Measure the distance between the marks on all eight specimens to the nearest 0.05 mm with the specimens laid out flat.

Keep four specimens, two cut in the machine and two cut in the cross-machine directions, for 7 days at $20 \pm 2^\circ\text{C}$ and $32 \pm 3\%$ relative humidity.

Keep the remaining four specimens for 7 days at $20 \pm 2^\circ\text{C}$ and $90 \pm 3\%$ relative humidity.

Remeasure the distance between the marks as before within 1 min after removal from the conditioning atmosphere.

10.5 Expression of results

Calculate the change in measured length of each specimen as a percentage of the initial measured length.

Calculate the mean percentage change in measured length for each of the four pairs of specimens, to the nearest 0.05 %.

Calculate the combined dimensional change for each direction of the sheet as the sum of the mean absolute percentage changes in each of the low and high humidity tests.

10.6 Test report

The test report shall contain the following:

- the identity of the product;
- the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;
- the method of test;
- the date of test;
- the combined dimensional change for the machine direction;
- the combined dimensional change for the cross-machine direction.

11 Resistance to impact by small diameter ball

11.1 Principle

The decorative surface of a test specimen, taken from the sheet under test and bonded to wood chipboard to simulate service conditions, is subjected to the impact of a 5 mm diameter steel ball mounted at one end of a spring-loaded bolt. The minimum spring force needed to cause visible damage is measured, which is taken as a measure of resistance to impact.

11.2 Apparatus and materials

11.2.1 Fine-faced wood chipboard, 19 ± 1.3 mm thick, of density $675 \pm 25 \text{ kg/m}^3$ and a moisture content of $9 \pm 2\%$ (m/m).

NOTE. Where the specimen is bonded to chipboard, the test actually measures the impact resistance of the whole composite material, i.e. laminate, adhesive and substrate. The correct choice of chipboard quality is therefore very important in achieving good reproducibility with this test. In case of dispute, the same test should be carried out on chipboards from three different suppliers.

11.2.2 Urea-formaldehyde adhesive, containing approximately 15 % (m/m) filler, or an adhesive with equivalent performance, e.g. based on polyvinyl acetate.

11.2.3 Solution of dye in alcohol, graphite or talcum powder, to contrast with the colour of the sheet under test (optional).

11.2.4 Impact tester (see figure 4), consisting of an impact bolt with a 5 mm diameter steel ball mounted at one end, which is projected once against the surface under test by the release of a compression spring. The spring compression force before release can be adjusted continuously from 0 to 90 N by means of a force-setting barrel (housing).

The compression spring is 100 mm long when released and has a constant of $1962 \pm 50 \text{ N/m}$. It is compressed by drawing back the impact bolt and is held in the loaded position by a retainer which engages in the bolt. It is released to deliver the impact blow by a release unit which withdraws the retainer.

11.2.5 Arrangement (for example a scale pan and weights), capable of being suspended from the impact bolt to exert a compression force on the spring.

11.2.6 Support fixture (see figure 5), which clamps to the shaft of the impact tester and provides a convenient mounting of sufficient mass for the tester to be held at right angles to the surface of the test specimen and to avoid recoil following the release of the impact bolt.

11.2.7 Steel plate, approximately 300 mm x 300 mm x 50 mm.

11.2.8 Hand lens, with approximately x6 magnification (optional).

11.3 Test specimens

The test specimens shall be prepared by uniformly bonding a piece of the sheet under test to the wood chipboard (11.2.1) using the specified adhesive (11.2.2). Ten specimens, each 200 ± 5 mm square, shall be prepared. The bonded test specimens shall be pre-conditioned for at least 7 days at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity before testing.

11.4 Calibration of the impact tester

Suspend the tester with the impact bolt pointing upwards so that its longitudinal axis is free to hang vertically.

Set the force-setting barrel, which serves to vary the impact force, to zero on the scale. Compress the spring by a force P_0 (calibration force) using a suitable arrangement (11.2.5) suspended from the knob used to draw back the impact bolt, ensuring that the bolt is clear of the retainer of the release unit.



Turn the force-setting barrel until the retainer of the release unit is just in contact with the impact bolt. This position can be determined by increasing or decreasing the compressing force very slightly to observe whether the retainer is just in contact. Record the indicated force P_x on the scale of the instrument corresponding to the calibration force P_e .

Repeat this calibration procedure for various values of P_e in the range required and draw a graph relating values of the scale reading P_x to values of the calibration force P_e (see figure 6 for an example).

NOTE. The graph will be an approximately straight line which will not pass through the origin, because a constant but undetermined force is exerted during the calibration procedure by the mass of the impact bolt and any suspension arrangement (11.2.5).

Draw a second line passing through the origin and parallel to the first line. The second line is the calibration graph for the instrument. Use the graph to correct every indicated force P_x employed in testing.

Prepare a new calibration graph after every 500 tests.

11.5 Procedure

Carry out the test in the laboratory atmosphere. In cases of dispute carry out the test at $23 \pm 2^\circ\text{C}$.

Place the steel plate on a convenient rigid horizontal surface and locate the test specimen on it with its decorative surface uppermost. Fix the impact tester in its support fixture, load the tester, place the assembly on the test specimen and release the impact bolt. Start preliminary tests with a spring force of 10 N and increase by 5 N on each occasion to determine the minimum spring force at which the surface of the specimen shows damage due to impact stress.

Test at least five additional specimens for the final determination of the maximum force at which no damage occurs. For this purpose, start with the spring force determined in the preliminary test and reduce it in suitable stages, e.g. 1 N, after every five tests.

NOTE. To make the damage more easily visible, the surface of the specimen may be rubbed after the test with a solution of dye in alcohol, graphite or talcum powder (depending on the colour of the decorative surface). A magnifier with X6 magnification may also be used.

Ensure that the distance between points of impact is at least 20 mm and the distance between points of impact and the edge of the test specimen is at least 30 mm.

Examine the specimen for damage at the points of impact. For the purpose of this test, damage is defined by the presence of fine hairline cracks (which are frequently concentric), continuous cracks or flaking of the decorative surface. Indentations without cracks do not count as damage.

Alternatively if the test is only conducted to determine whether the impact strength of a material exceeds a limiting value, the test specimen shall sustain no damage after ten successive individual impact blows with the spring force set to the limiting value.

11.6 Expression of results

Enter the results of the series of tests on to an evaluation diagram (see figure 7 for an example), in which they are subdivided into 'test specimens not damaged' and 'test

specimens damaged', for each value of spring force used. This results in a transition range in which some specimens are damaged and some undamaged. The impact strength of the material is the maximum value of the spring force, in newtons, for which no damage occurs in a series of five tests.

11.7 Test report

The test report shall contain the following:

- (a) the identity of the product;
- (b) the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;
- (c) the method of test;
- (d) the date of test;
- (e) the impact strength (in N).

12 Resistance to impact by large diameter ball

12.1 Principle

The maximum drop height, which can be achieved without incurring visible surface cracking or producing an imprint greater than the specified maximum diameter, is determined by dropping a steel ball of specified diameter on to the product (bonded to chipboard if specified).

12.2 Apparatus and materials

12.2.1 High quality fine-faced wood chipboard, 19 ± 1.3 mm thick, of density $675 \pm 25 \text{ kg/m}^3$ and a moisture content of $9 \pm 2\%$.

NOTE. Where the specimen is bonded to chipboard, the test actually measures the impact resistance of the whole composite material, i.e. laminate, adhesive and substrate. The correct choice of chipboard quality is therefore very important, in achieving good reproducibility with this test. In cases of dispute, the same test should be carried out on chipboards from three different suppliers.

12.2.2 Urea-formaldehyde adhesive, containing approximately 15 % filler, or one of equivalent performance, e.g. based on polyvinyl acetate.

12.2.3 Free-fall ball impact test apparatus, as shown in figure 8, or equivalent apparatus that will produce the same results.

12.2.4 Polished steel ball, weighing 324 ± 0.5 g and measuring 42.8 ± 0.2 mm diameter, having no damaged or flattened surface.

12.2.5 Specimen clamping jig, as shown in figure 9.

12.3 Test specimens

The test specimens shall be 230 ± 5 mm square. For laminates less than 2.0 mm thick, the specimens shall be prepared by uniformly bonding a piece of the sheet under test to the wood chipboard (12.2.1) using the specified adhesive (12.2.2). The bonded specimens shall be pre-conditioned for at least 7 days at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity before testing.

For laminates not less than 2.0 mm but less than 5.0 mm thick, the effect of bonding the specimen is insignificant and testing shall be carried out with the laminate clamped in the frame in contact with the chipboard.

For laminates equal to or greater than 5.0 mm thick testing shall be carried out with the specimens clamped in the frame without the chipboard support.

12.4 Procedure

Carry out the test in the laboratory atmosphere. In cases of dispute carry out the test at $23 \pm 2^\circ\text{C}$.

Clamp the test specimen in the clamping frame and place the assembly on the solid base of the free-fall ball impact test apparatus. Cover the specimen with a sheet of carbon paper with its coated face in contact with the decorative surface. Adjust the height scale so that its base is touching the face of the test specimen.

Position the electromagnet at any arbitrary height (the minimum height specified in Part 1 of the standard for the material under test is a useful starting point).

Place the steel ball on the energized electromagnet. Operate the release mechanism so that the ball falls on the specimen, catching the ball on the first rebound so that multiple impacts do not occur.

Examine the impact spot. If cracking is evident or the carbon imprint is greater than the specified diameter, lower the electromagnet and repeat the test. If no cracking is evident and the imprint is smaller than the specified diameter, raise the electromagnet and repeat the test. Ensure that the distance between points of impact, and between points of impact and the edge of the test specimen, is at least 50 mm. For reference purposes, make only one impact per test specimen.

Repeat the above procedure as necessary to determine the impact resistance which is defined as the maximum height for which no visible surface cracking, or imprint greater than the specified diameter, occurs in five successive impacts.

12.5 Test report

The test report shall contain the following:

- (a) the identity of the product;
- (b) the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;
- (c) the method of test;
- (d) the date of test;
- (e) the indentation diameter;
- (f) the impact resistance (in mm).

13 Resistance to cracking (thin laminates)

13.1 Principle

A test specimen taken from the sheet under test is rigidly clamped in a steel fixture under slight curvature with the decorative face in tension. The specimen is subjected to additional stress by heating at 80°C for 20 h, and then the resistance to cracking is assessed by visual examination.

13.2 Apparatus

13.2.1 Steel clamping device; as shown in figure 10, manufactured from steel with a linear coefficient of thermal expansion of $11 \times 10^{-6}^\circ\text{C}^{-1}$.

13.2.2 Conditioning chamber, with a standard atmosphere of $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity.

13.2.3 Electrically heated oven, provided with air circulation and capable of being maintained at $80 \pm 2^\circ\text{C}$.

13.2.4 Hand lens, with approximately 6x magnification.

13.2.5 Lighting, of intensity 800 lx to 1000 lx.

13.3 Test specimens

The test specimens shall be $120 \pm 2\text{ mm} \times 50 \pm 2\text{ mm}$ and of the thickness of the sheet under test. The lengthwise direction of the test specimens shall coincide with the direction of greatest change in dimensions as determined in accordance with clauses 9 or 10. Two test specimens shall be used.

The test specimens shall be pre-conditioned for 48 h at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity before testing.

13.4 Procedure

Clamp the test specimen at $23 \pm 2^\circ\text{C}$ with the decorative side uppermost (i.e. in tension) in the clamping device (13.2.1). It is essential that the test specimen does not slip in the clamp during the test.

Transfer the clamped test specimen to the oven (13.2.3), maintained at $80 \pm 2^\circ\text{C}$, and leave for $20 \pm 1\text{ h}$.

After removal from the oven and cooling to ambient temperature with the test specimen still clamped in position, examine the surface with the naked eye and under 6x magnification (13.2.4) for the presence and extent of any cracking. The light intensity during the examination is 800 lx to 1000 lx.

Carry out the test on both test specimens.

13.5 Expression of results

Express the change of appearance of the test specimens in accordance with the following rating scale.

5. Decorative surface unchanged from as received condition; no hairline cracks.
4. Hairline cracks only visible under x6 magnification, irregularly distributed across the surface.
3. In addition to grade 4 faults, cracks visible to the naked eye (normally parallel to the short edge of the specimen).
2. A gaping crack which may extend right across the specimen.
1. Specimen broken into separate parts.

13.6 Test report

The test report shall contain the following:

- (a) the identity of the product;
- (b) the number and date of this British Standard, i.e. BS 3794 : Part 2 : 1986;
- (c) the method of test;
- (d) the date of test;
- (e) the lower test rating of the two specimens (see 13.5).

14 Resistance to scratching

14.1 Principle

The minimum force applied to a diamond scratching point of defined geometry, which produces a continuous surface mark visible to the naked eye, on the decorative laminate under test is determined.

This minimum force is determined by applying successively decreasing forces to the diamond point and examining the marks produced.

14.2 Apparatus

14.2.1 Scratch testing apparatus (see figure 11).

14.2.1.1 Stand with a device to indicate the horizontal position, e.g. a spirit level.

14.2.1.2 Freely rotating supporting turntable (A). This shall rotate about a vertical axis without play and is preferably motor driven. The speed of rotation shall be 5 ± 1 r/min.

NOTE. Rotation by hand, within the speed range is permissible, but uniform speed is essential.

14.2.1.3 Arm (B) carrying the holder for the diamond, mounted on a ball bearing, with a horizontal axis. The height of this axis shall be adjustable so that the arm is exactly horizontal when the scratching point rests on the test specimen.

14.2.1.4 Means of applying a known force with an accuracy of ± 0.01 N to the scratching point with weights (C and D).

14.2.1.5 Hemispherical diamond scratching-point (E) with a point radius of 0.09 ± 0.003 mm and an included angle of $90 \pm 1^\circ$ (see figure 12). The diamond shall be mounted in the arm with the flat part on the leading side of the shank facing the working direction.

NOTE. Because of the need for diamond points to conform accurately to the above requirements it is advisable to use a supplier prepared to give a certificate of conformation. For information on recommended diamond point suppliers apply to the Enquiry Section, BSI, Linford Wood, Milton Keynes MK14 6LE.

Diamonds for use shall be standardized before use as described in 14.3.

14.2.1.6 Clamping disc (F) to keep the test specimen flat.

14.2.2 Viewing enclosure, having a matt black interior and a light source located at the top. Its dimensions shall be such that the test specimen is located vertically below the light source and at a distance of 600 mm. An aperture in the front shall allow inspection of the test specimen at various angles from a distance of 400 ± 10 mm.

NOTE. A suitable enclosure is shown in figure 13.

The light source consists of a 100 W frosted bulb, mounted in a white reflector having an aperture of approximately

140 mm diameter and producing an illumination of 800 lx to 1000 lx at the specimen surface.

14.2.3 Conditioning chamber, with a standard atmosphere of $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity.

14.2.4 Viewing mask (see figure 14) made from thin flat opaque sheet material, such as thin metal sheet or plastics card.

14.3 Standardization of the diamond point

14.3.1 General. Carry out the standardization using a disc cut from polymethyl methacrylate cast sheet of minimum thickness 3 mm (4 mm preferred). Fasten this disc to the supporting table instead of the laminate. Apply forces of 1.5 N to 5 N in steps of 0.5 N in turn and rotate the disc at 5 ± 1 r/min.

Use polymethyl methacrylate sheet with a Vicat softening temperature of at least 112°C when measured in accordance with BS 2782 : Method 120A.

NOTE. To reach the Vicat softening temperature, polymethyl methacrylate sheet normally has to be vacuum dried for 24 h at 80°C .

14.3.2 Calibration. Complete one revolution for each force. Measure the depth of penetration with a suitable measuring apparatus at four points spaced 90° apart on the same scratch and calculate the arithmetical mean depth for each force.

Diamonds that give a penetration depth of $4\text{ }\mu\text{m}$ or more for a force of 4.0 N shall be deemed unsatisfactory. Only diamonds which give penetration values as defined by the limit curves shown in figure 15 shall be used to test decorative laminates.

Any irregularity in the curvature of the diamond point shall cause it to be rejected and all diamond points used shall be rechecked after each 1000 tests.

14.4 Test specimen

One test specimen of the shape and dimensions shown in figure 16 shall be cut from the sheet under test.

The test specimen shall be pre-conditioned for 4 days at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity before testing.

14.5 Procedure

Wipe the test specimen surface using a solvent such as acetone, and cotton fabric. It is important that once cleaned the surface is not fingered in the test area.

Ensure that the stand of the test apparatus (see figure 11) lies horizontally.

Adjust the height of the arm (B) so that it is horizontal when the diamond point rests on the test specimen.

Start the test with a force of 5 N. Place the arm (B) in a vertical position. Fix the test specimen with the locking disc (F) and secure it correctly to avoid any slipping.

Lower the arm (B) and place the diamond point in contact with the test specimen taking care to avoid any impact.



Start rotating the turntable anticlockwise for a complete revolution at a uniform speed of 5 ± 1 r/min.

Stop the turntable and inspect the specimen.

If a continuous mark is visible with a force of 5 N, continue the test using other tracks on the test specimen concentric with the first and spaced at least 2 mm apart, decreasing the force in steps of 0.5 N units down to a force of 2 N.

If a continuous mark is visible with a force of 2 N, continue testing by reducing the force in 0.25 N increments.

For forces below 1 N, continue testing by reducing the force in 0.10 N increments.

If no continuous mark is visible at a force of 5 N, add a fixed force of 5 N to the arm (B) and continue testing by adjusting the moveable force to increase the total force in steps of 0.5 N.

If a large number of tracks is required to determine the end point it may be necessary to continue the test on a second test specimen taken from the same sheet.

Place the scratched samples in a standard atmosphere of $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity for 24 h before final inspection.

Clean the surface of the test specimen. With the mask in place on the surface of the specimen, place specimen and mask on the viewing point in the enclosure with one aperture of the mask in the 12 o'clock position. Tilt the specimen at any angle without rotating the specimen or mask, whilst viewing each aperture in turn with the naked eye, corrected if necessary.

NOTE. In judging the lowest force producing a continuous mark, care is needed to ensure that the mark selected as the end point is truly continuous in all eight apertures in the viewing mask. The operator has to guard against mentally bridging gaps in the marks.

14.6 Expression of results

Record the minimum force (in N) giving a continuous mark visible after 24 h in the standard atmosphere. An example of a test result of 2.5 N is shown in figure 14.

In cases of dispute three observers shall view the test specimen and report their results independently. The final result will be the average of the three reported values.

14.7 Test report

The test report shall contain the following:

- (a) the identity of the product;
- (b) the number and date of this British Standard; i.e. BS 3794 : Part 2 : 1986;
- (c) the method of test;
- (d) the date of test;
- (e) the scratch resistance (in N).

15 Resistance to staining

15.1 Principle

The test specimens taken from the sheet under test are left in contact with a series of liquid stains and solvents that are likely to be encountered in everyday use. Resistance to the liquids is assessed by the presence of any marks produced.

15.2 General

All products shall be tested with each of the six staining agents marked with an asterisk in tables 2, 3 and 4.

NOTE. The other staining agents are included for information only. In the case of a specific complaint, the staining agent in question (selected from group 1, 2 or 3) should be used to verify the quality of the laminate.

15.3 Staining agents

Suitable staining agents are given in tables 2, 3 and 4.