BS 4443 : Part 1 : 1988
UDC 678-405.8 : 678.074 : 620.1

British Standard Methods of test for

Flexible cellular materials

Part 1. Methods 1 to 6

Méthodes d'essai des matières alvéolaires souples
Partie 1. Méthodes 1 à 6

Verfahren zur Prüfung von Weichschaumstoffen
Teil 1. Verfahren 1 bis 6

British Standards Institution

Foreword

This Part of BS 4443 has been prepared under the direction of the Plastics Standards Committee and the Rubber Standards Committee as a revision of BS 4443 : Part 1 : 1979 which is withdrawn.

In this revision the methods of test have been realigned as far as possible with the methods agreed internationally and published by the International Organization for Standardization (ISO) (see appendix B).

Particular attention is drawn in this revision to the minimum time permitted after manufacture before testing and to changes in the conditioning procedures. Attention is also drawn to BS 4443 : Parts 2 and 3 which include methods for measuring indentation hardness, creep and dynamic cushioning characteristics.

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

Contents

Methods

1 Scope

This Part of BS 4443 describes the following six methods of test for flexible cellular materials of polymeric origin.

Methods 1A, 1B and 1C. Measurement of dimensions of test specimens

Method 2. Determination of apparent density

Methods 3A and 3B. Determination of tensile strength and elongation at break

Method 4. Measurement of cell count

Methods 5A and 5B. Determination of compression stress-strain characteristics

Methods 6A and 6B. Determination of compression set

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

2 Definitions

For the purposes of this Part of BS 4443, the following definitions apply.

2.1 apparent density. The mass per unit volume of the cellular material in air, at 23 ± 2 °C and 50 ± 5 % relative humidity.

2.2 tensile strength. The maximum force required to break the test specimen divided by its original cross-sectional area.

2.3 absolute elongation at break (E_a). The elongation at break as determined by method 3A of this standard.

2.4 comparative elongation at break (E_c). The change in distance between the reference lines of the test specimen at the time of break expressed as a percentage of the original distance and determined by method 3B of this standard.

2.5 derived elongation at break (E_d). The absolute elongation at break calculated from the comparative elongation at break using an experimentally determined relationship between these two quantities.

2.6 cell count. The number of cells per linear 25 mm in the flexible cellular material under specified conditions.

2.7 compression stress characteristics. The stresses, in kPa, required to produce compression strains of 25 ± 1 %, 40 ± 1 %, 50 ± 1 % and 65 ± 1 % of the initial test specimen thicknesses under the conditions specified; these stresses are designated CC_{25}, CC_{40}, CC_{50}, CC_{65}.

2.8 shape factor. The ratio of the area of one applied force-bearing face of the test specimen to the sum of the areas of the four perpendicular sides of the test specimen.

2.9 compression set (*CS*). The difference between the initial thickness and the final thickness of a test specimen of the flexible cellular material after compression for a given time and temperature and recovery time, expressed as a percentage of the initial thickness.

NOTE to clause 2. For the convenience of users of this standard, the definitions given above are repeated in the text where appropriate.

3 Methods 1A, 1B and 1C. Measurement of dimensions of test specimens

3.1 Introduction

Methods 1A, 1B and 1C specify procedures for the measurement of test specimen dimensions of cellular materials. An accurate measurement of the thickness is the basis for accurate values of various properties of cellular materials such as density, tensile strength, tear resistance and compression set.

Pressure from the measuring instrument has an influence on the measurement of the thickness of soft flexible materials. It is therefore necessary to specify the pressure for accurate comparative measurements in the laboratory as described in method 1A (see 3.2).

The selection of measuring tools and the best possible accuracy are dependent on the thickness of the cellular material and on the type of test specimen. The thicknesses occurring in practical work are covered in the three methods 1A, 1B and 1C.

NOTE. For control measurements in production and the comparative measurements between the customer and the supplier, the alternative methods 1B or 1C as applicable may be adopted by special agreement. In such cases this agreement should be stated in the pertinent test report.

Commercial measuring apparatus working with spring pressures does not necessarily comply with the conditions specified in method 1A. Such apparatus applying pressures of between 100 Pa and 500 Pa and having presser feet up to 20 cm^2 in area may be used only for materials obviously not influenced by the increased foot pressure.

When the circular foot overlaps the test area, vernier or dial calipers reading to an accuracy of 0.1 mm may be used; the procedure described in 3.3 shall be employed. The alternative is to measure, by means of the method described in 3.2, the thickness of the material in the area from which the test specimen is to be cut.

3.2 Method 1A

Measure the dimensions by means of a gauge having a flat circular foot of radius between 14.4 mm and 16.0 mm, and exerting a pressure of 100 ± 10 Pa.

It is desirable to mount the measuring device on a solid plane base plate. Ensure that the circular foot of the device does not extend over the edge of the test specimen area. Read the gauge to the nearest 0.02 mm and take the mean of three readings at different positions.

A suitable type of instrument and its method of operation are described in appendix A.

3.3 Method 1B. Alternative method for dimensions over 30 mm

Measure the dimensions by means of vernier or dial calipers reading to an accuracy of 0.25 mm. Take each measurement along a line perpendicular to the opposing faces of the test specimen. Present the caliper gauge to the test specimen, which is supported in such a way that the dimension to be measured is not-stressed. Set the measuring faces of the gauge to touch the surfaces of the test specimen without compressing it.

Take the mean of the three readings at different positions.

3.4 Method 1C. Alternative method for dimensions over 100 mm

Measure the dimensions by means of a rule graduated in millimetres and permitting a reading to an accuracy of 0.5 mm. Take each measurement along a line perpendicular to the opposing faces of the test specimen.

Take the mean of the three readings at different positions.

3.5 Test report

The report shall include the following:

(a) a description of the cellular material tested;

(b) the dimensions;

(c) the method used, i.e. method 1A, 1B or 1C of BS 4443 : Part 1 : 1988.

4 Method 2. Determination of apparent density

4.1 Introduction

This method describes a procedure for determining the apparent density of a flexible cellular material.

4.2 Definition

For the purposes of this method in this Part of BS 4443, the following definition applies.

apparent density. The mass per unit volume of the cellular material in air, at 23 ± 2 °C and 50 ± 5 % relative humidity.

4.3 Apparatus

4.3.1 *Balance,* capable of determining the mass of the test specimen to an accuracy of at least ± 0.5 %.

4.3.2 *Means of measuring* the dimensions of the test specimen as specified in method 1A, 1B or 1C as appropriate.

4.4 Test specimen

The test specimen shall be as large as practicable, of regular shape and not less than 100 cm^3 in volume.

4.5 Number of test specimens

A minimum of three test specimens shall be tested.

4.6 Conditioning

Material shall not be tested less than 72 h after manufacture, unless at either 16 h or 48 h after manufacture, it can be demonstrated that the values obtained do not differ by more than ± 10 % from those obtained after 72 h. Testing is permitted at either 16 h or 48 h if, at the selected time, the above criteria have been satisfied.

Prior to the test, the test specimens shall be stored for at least 16 h under the following standard conditions:

23 ± 2 °C, 50 ± 5 % relative humidity.

NOTE. This period can form the latter part of the period following manufacture.

4.7 Procedure

After conditioning as described in **4.6**, determine the mass of the test specimen to an accuracy of 0.5 %. Measure each dimension of the test specimen in accordance with method 1A, 1B or 1C as appropriate.

4.8 Calculation of results

Calculate the apparent density D (in kg/m^3) for each test specimen as follows:

$$D = \frac{10^6 M}{V}$$

where

M is the mass of test specimen (in g);

V is the volume (in mm^3).

Calculate the mean apparent density (in kg/m^3) for the material.

4.9 Test report

The test report shall include the following information:

(a) the description and identity of the cellular material;

(b) individual values of apparent density with details of test specimen dimensions, locations from which they were taken, and the presence or absence of skins;

(c) the mean value of apparent density of the material (in kg/m^3);

(d) any deviation from the procedure described in this method;

(e) the method used, i.e. method 2 of BS 4443 : Part 1 : 1988.

5 Methods 3A and 3B. Determination of tensile strength and elongation at break

5.1 Introduction

Methods 3A and 3B describe the procedures for determining the strength and deformation properties of flexible cellular material. Method 3A is an absolute method and method 3B is intended for comparative testing. Method 3B is a quicker method for establishing the elongation at break but it depends on the determination of an appropriate K value by a comparison of the elongation at break given by methods 3A and 3B for each material under consideration. No specific guidance on the accuracy of K is given since this will be determined largely by the accuracy which the application demands.

5.2 Definitions

For the purposes of these methods in this Part of BS 4443, the following definitions apply.

tensile strength (*T*). The maximum force required to break the test specimen divided by its original cross-sectional area.

absolute elongation at break (E_a). The elongation at break as determined by method 3A of this standard.

comparative elongation at break (E_c). The change in distance between the reference lines of the test specimen at the time of break expressed as a percentage of the original distance and determined by method 3B of this standard.

…ived elongation at break (E_d). The absolute elongation … eak calculated from the comparative elongation at break using an experimentally determined relationship *K* between these two quantities.

5.3 Apparatus

Tensile tests shall be made on a power-driven machine complying with the following requirements.

(a) The rate of travel of the power-actuated grip shall be 500 ± 50 mm/min and shall be uniform at all times.

(b) The machine shall comply with grade B of BS 5214 : Part 1.

(c) The machine shall be fitted with non-slip grips but, if only method 3A is to be carried out, self-tightening grips are acceptable.

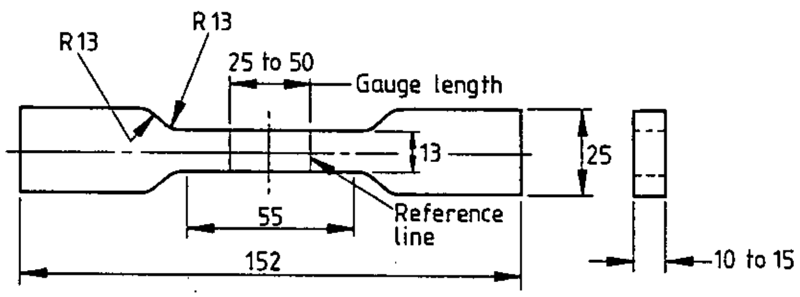
(d) For method 3B, the machine shall be fitted with an electronic force transducer, connected by a suitable circuit to an electronic null balance recorder having a chart speed of at least 500 mm/min. The magnification *Z* between the rate of movement of the power-actuated grip and the rate of movement of the chart shall be constant and known to ± 1 %.

5.4 Test specimen

5.4.1 *Shape and dimensions.* The test specimen shall be rectangular in cross section, without surface skin, and without visible defects.

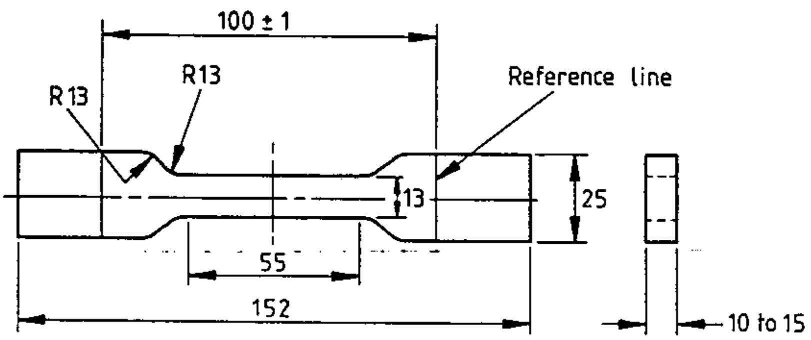
The test specimen shall be cut as shown in figures 1 and 2 and shall be 10 mm to 15 mm thick.

5.4.2 *Direction of sampling.* If the material reveals a predominant direction of the cellular structure (orientation of the cells), the test specimens for the tensile test shall be taken in such a way that their longitudinal axes lie at right



Dimensions are in millimetres.

Figure 1. Test specimen for method 3A



Dimensions are in millimetres.

Figure 2. Test specimen for method 3B

angles to this predominant direction. If this is not possible, the location of the longitudinal axis with respect to the predominant direction shall be stated in the test report.

5.4.3 *Number.* Five test specimens shall be tested.

5.5 Conditioning

Material shall not be tested less than 72 h after manufacture, unless, at either 16 h or 48 h after manufacture, it can be demonstrated that the tensile property values obtained do not differ by more than ± 10 % from those obtained after 72 h. Testing is permitted at either 16 h or 48 h if, at the selected time, the above criteria have been satisfied.

Prior to the test, the test specimens shall be stored for at least 16 h under the following standard conditions:

23 ± 2 °C, 50 ± 5 % relative humidity.

NOTE. This period can form the latter part of the period following manufacture.

5.6 Method 3A. Absolute method

5.6.1 *Procedure.* After conditioning as described in **5.5**, measure the thickness of the material in the area from which the test specimens are to be cut at five evenly distributed points. Alternatively make two measurements in the area from which each test specimen is to be cut. Measure these dimensions as described in clause **3**. The dimensions shall not vary by more than ± 2 %.

Cut the test specimens and mark their gauge length with two reference lines. The marker for these lines shall have two parallel marking edges, the inside limits of which shall be at least 25 mm and not more than 50 mm apart (see figure 1).

Place a test specimen in the grips of the testing machine specified in **5.3**, care being taken to adjust it symmetrically, so that the tension is distributed uniformly over the cross section. Start the machine and note the maximum force (measured to ± 1 %) and the distance between the inside edges of the two reference lines (measured to ± 1.0 mm) immediately prior to the rupture of the test specimen.

Reject test specimens that break outside the central region of uniform cross section and replace them by other test specimens. Test under the same temperature and humidity levels used for conditioning the material.

5.6.2 *Calculation of results*

5.6.2.1 *Tensile strength.* Calculate the mean thickness of the material and from this and the measured width of the gauge length of the test specimen cutter, calculate the mean cross-sectional area A of each of the test specimens.

Calculate the tensile strength T (in kPa) for each of the test specimens using the following equation:

$$T = 1000 \frac{F}{A}$$

where

F is the breaking force (in N);

A is the initial cross-sectional area (in mm^2).

The mean tensile strength of the test specimens shall be regarded as the tensile strength of the material.

5.6.2.2 *Absolute elongation at break.* Calculate the percentage elongation at break E_a using the following equation:

$$E_a = \frac{(L_t - L_o)}{L_o} \times 100$$

where

L_t is the gauge length at break (in mm);

L_o is the initial gauge length (in mm).

5.7 Method 3B. Comparative method

5.7.1 *Procedure.* After conditioning as described in **5.5**, measure the thickness of the material in the area from which the test specimens are to be cut at five evenly distributed points. Alternatively make two measurements in the area from which each test specimen is to be cut. Measure these dimensions as described in clause **3**. The dimensions shall not vary by more than ± 2 %.

Cut the test specimens and mark them with two reference lines such that the reference lines are approximately equidistant from the ends of the test specimens. Apply the reference lines with a marker having two parallel marking edges, the inside limits of which shall be 100 ± 1 mm apart (see figure 2).

Clamp a test specimen symmetrically in the non-slip grips of the testing machine so that the tension is distributed uniformly over the cross section, care being taken to ensure that the test specimen is clamped on the inner limits of the reference lines.

Start the chart recorder and testing machine and allow them to run until the test specimen breaks. Reject the test specimens that break outside the central region of uniform cross section and replace them by other test specimens.

Read the maximum force from the recorder chart. Measure the chart movement (to the nearest millimetre) between the first application of force, indicated by the trace leaving the elongation axis, and the point of failure of the test specimen, indicated by a rapid fall off in force.

5.7.2 *Calculation of results*

5.7.2.1 *Tensile strength.* Calculate the mean thickness of the material, and from this and the measured width of the gauge length of the test specimen cutter, calculate the mean cross-sectional area A of each of the test specimens.

Calculate the tensile strength T (in kPa) from the following equation:

$$T = 1000 \frac{F}{A}$$

where

F is the breaking force (in N);

A is the initial cross-sectional area (in mm^2).

The mean of the tensile strength of the test specimens shall be regarded as the tensile strength of the material.

5.7.2.2 *Comparative elongation at break.* Calculate the percentage comparative elongation at break E_c using the following equation:

$$E_c = \frac{ZL_c}{L_o} \times 100$$

where

$$Z = \frac{\text{the rate of movement of moving grip}}{\text{the rate of movement of recorded chart}};$$

L_c is the chart length between first application of force and the point of failure (in mm);

L_o is the initial separation of reference marks (in mm).

5.7.2.3 *Derived elongation at break.* Calculate the derived elongation at break E_d using the following equation:

$$E_d = K \times E_c$$

where

$$K = \frac{\text{the absolute elongation at break } E_a}{\text{the comparative elongation at break } E_c}.$$

NOTE. Experience has shown that, for any particular flexible cellular material, it is possible, under standardized conditions, to establish a factor K relating the comparative elongation at break with the absolute elongation at break as would be determined by method 3A of this standard.

Experiments using cellular materials derived from rubber latex, polyvinyl chloride, polyethylene and chloroprene rubber have shown K to have values between 1.00 and 1.35.

5.8 Test report

The report shall include the following:

(a) the nature of the cellular material;

(b) the location and direction of sampling (see 5.4.2) of test specimens in the product;

(c) the method used, i.e. method 3A or 3B of BS 4443 : Part 1 : 1988;

(d) the mean value of the tensile strength (in kPa);

(e) the mean value of the absolute or derived elongation at break expressed as a percentage.

6 Method 4. Measurement of cell count

6.1 Introduction

Method 4 specifies the procedure for measuring the cell count of flexible cellular material.

Because of the variation in individual cell size, even in uniform cell structures, it is more convenient to report the number of cells per unit length rather than the actual cell size.

6.2 Definition

For the purposes of this method of this Part of BS 4443, the following definition applies.

cell count. The number of cells per linear 25 mm of the flexible cellular material.

6.3 Apparatus

6.3.1 *Cloth counting glass*, 25 mm.

6.4 Test specimen

The test specimen shall consist of any material that is free of skin and has a plane surface large enough to accommodate the counting glass.

Surfaces revealing a marked elongation of the cellular structure or striations shall not be measured unless specifically required.

6.5 Conditioning

Material shall not be tested less than 72 h after manufacture, unless, at either 16 h or 48 h after manufacture, it can be demonstrated that the cell count values obtained do not differ by more than ± 10 % from those obtained after 72 h. Testing is permitted at either 16 h or 48 h if, at the selected time, the above criteria have been satisfied.

Prior to the test, the test specimens shall be stored for at least 16 h under the following standard conditions:

23 ± 2 °C, 50 ± 5 % relative humidity.

NOTE. This period can form the latter part of the period following manufacture.

6.6 Procedure

After conditioning as described in 6.5, lay the test specimen on a flat, horizontal surface without strain and count the actual number of cells against the counting edge of the glass.

Where cell counts along and across the test specimen are important, make a count in each direction.

6.7 Test report

The report shall include the following:

(a) a description of the cellular material;

(b) the directions in which cell counts were made;

(c) the cell count(s) (in number of cells per linear 25 mm);

(d) the method used, i.e. method 4 of BS 4443 : Part 1 : 1988.

7 Methods 5A and 5B. Determination of compression stress-strain characteristics

7.1 Introduction

The compression stress-strain characteristics are a measure of the load-bearing properties of the material. Two test methods are described, suitable for flexible cellular materials that may have different properties and require different procedures for determining the stress-strain characteristics.

The compression stress-strain characteristics differ from the indentation harness characteristics which are known to be influenced by:

(a) the thickness of the material under test;

(b) the tensile properties of the material under test;

(c) the shape of the indentor;

(d) the dimensions of the test specimen.

Method 5A is used for intercommunicating flexible specimen materials with densities not exceeding 250 kg/m^3.

Method 5B is a general method for testing denser (i.e. greater than 250 kg/m^3), non-intercommunicating, flexible cellular materials (i.e. expanded cellular rubbers). In method 5B measurements are made on at least two widely dispersed parts of the steeply rising part of the stress-strain curve. The shape factor of the test specimen is important and comparative test results can be obtained only on test specimens having the same shape factor. Method 5B may also be used to determine the strain at a specified compression stress.

7.2 Definitions

For the purposes of these methods in this Part of BS 4443, the following definitions apply.

compression stress characteristics. The stresses (in kPa) required to produce compression strains of 25 ± 1 %, 40 ± 1 %, 50 ± 1 % and 65 ± 1 % of the initial test specimen thicknesses under the conditions specified; these stresses are designated CC_{25}, CC_{40}, CC_{50}, CC_{65}.

shape factor. The ratio of the area of one applied force-bearing face of the test specimen to the sum of the areas of the four perpendicular sides of the test specimen.

7.3 Method 5A

7.3.1 *Apparatus.* The apparatus shall consist of a testing machine complying with grade B of BS 5214 : Part 1 and capable of compressing the test specimen by means of a compression plate moving at a uniform rate of 100 ± 10 mm/min.

The compression plate shall be maintained parallel to the base plate. The testing machine shall have a means of measuring, to an accuracy of ± 2 %, the force required to produce the specified compression, and of measuring the specimen thickness under load to an accuracy of ± 0.2 mm. It shall be capable of maintaining the specified degree of compression for the period specified by the procedure appropriate to the material under test.

The test specimens shall be supported on a smooth, flat and rigid surface, larger than the test specimens, which may be suitably vented with holes 6 mm in diameter and approximately 20 mm pitch to allow escape of air from the test specimen.

7.3.2 *Test specimen*

7.3.2.1 *Dimensions.* The test specimen shall be a right parallelepiped with a minimum width to thickness ratio of 2 : 1. The preferred test specimen shall be a right parallelepiped with square force-bearing surfaces of side 100 mm and with a thickness of 50 mm.

The area of the force-bearing surface of the test specimen shall be not less than 6400 mm^2 and it shall be such that at no point does it overlap the compression plate.

7.3.2.2 *Preparation.* The test specimen shall be without surface skins and without defects. If the test specimen contains moulded surfaces, this shall be noted in the test report. The thickness of the test specimen shall be not less than 10 mm, but thin sheets may be plied up to achieve this thickness provided that a minimum of 10 cell diameters are included in the thickness of one ply, sheets being cut to identical shapes and sizes.

7.3.2.3 *Number of test specimens.* Three test specimens shall be tested.

7.3.3 *Conditioning.* Material shall not be tested less than 72 h after manufacture, unless, at either 16 h or 48 h after manufacture, it can be demonstrated that the compression stress-strain characteristics obtained do not differ by more than ± 10 % from those obtained after 72 h. Testing is permitted at either 16 h or 48 h if, at the selected time, the above criteria have been satisfied.

Prior to the test, the test specimens shall be stored for at least 16 h under the following standard conditions:

23 ± 2 °C, 50 ± 5 % relative humidity.

NOTE. This period can form the latter part of the period following manufacture.

7.3.4 *Procedure.* Measure the dimensions of the test specimen using the appropriate procedure described in clause 3 and calculate the area to be compressed.

Insert the test specimen (**7.3.2**) in such a way that the force acts along the centre line of the test machine (**7.3.1**), and compress it at 100 ± 10 mm/min by means of the compression plate to produce a compression strain of 70 ± 2 % of the initial test specimen thickness. Then decompress the test specimen at the same rate until the separation between the compression plate and the base plate is equal to the initial test specimen thickness.

Immediately repeat this compression cycle three times and, on the fourth compression cycle, record the force required to produce 25 %, 40 %, 50 % and 65 % compression strain, referred to the initial thickness (see **7.2**). Determine the force either by simultaneous readings of the force and deflection at the required compression strains or preferably from an autographic record of the stress-strain curve.

If repeat tests on the same test specimen are required, allow a recovery period of not less than 16 h before retesting.

7.3.5 *Calculation of results.* Calculate the compression stress-strain characteristics *CC* (in kPa) at 25 %, 40 %, 50 % and 65 % compressions using the following equation:

$$CC = 1000\,\frac{F}{A}$$

where

F is the force (in N) at the appropriate compressions;

A is the area of the test specimen (in mm^2).

7.3.6 *Test report.* The report shall state the following:

(a) identity of the cellular material;

(b) description of the test specimen with reference to moulded surfaces;

(c) dimensions of the test specimen including the number of plies;

(d) compression stress-strain characteristic for individual test specimens and their mean;

(e) the method used, i.e. method 5A of BS 4443 : Part 1 : 1988.

7.4 Method 5B

7.4.1 *Apparatus.* The apparatus shall consist of a testing machine complying with grade B of BS 5214 : Part 1 and capable of compressing the test specimen by means of a compression plate moving at a uniform rate of 5 ± 1 mm/min.

The compression plate shall be maintained parallel to the base plate. The testing machine shall have means of measuring the specimen thickness under load to an accuracy of ± 0.025 mm. It shall be capable of maintaining the specified degree of compression for the period specified by the procedure appropriate to the material under test.

The test specimen shall be supported on a smooth, flat and rigid surface larger than the test specimen.

The compression plate may be of any convenient size or shape provided that it overlaps the test specimen in all directions. The surface of the compression plate shall be smooth but not polished.

7.4.2 *Test specimen*

7.4.2.1 *Dimensions.* The test specimen shall be a right parallelepiped with square load-bearing surfaces of side 40 mm minimum with a width to thickness ratio of 4 : 1.

The area of load-bearing surface of the test specimen shall be not less than 1600 mm^2 and shall be such that at no point does the test specimen overlap the compression plate.

7.4.2.2 *Preparation.* The opposing square faces shall contain the moulded surfaces. The edges of the test specimen shall be cleanly cut perpendicularly to the moulded surfaces and shall expose cell structure. The thickness of the test specimen shall be not less than 10 mm, but thin sheets may be plied up to achieve this thickness, such sheets being cut to identical shapes and sizes provided that a minimum of 10 cell diameters is included in the thickness of one ply.

7.4.2.3 *Number of test specimens.* Three test specimens shall be tested.

7.4.3 *Conditioning.* Material shall not be tested less than 72 h after manufacture, unless, at either 16 h or 48 h after manufacture, it can be demonstrated that the compression stress-strain characteristics obtained do not differ by more than ± 10 % from those obtained after 72 h. Testing is permitted at either 16 h or 48 h if, at the selected time, the above criteria have been satisfied.

Prior to the test, the test specimens shall be stored for at least 16 h under the following standard conditions:

23 ± 2 °C, 50 ± 5 % relative humidity.

NOTE. This period can form the latter part of the period following manufacture.

7.4.4 *Procedure.* Measure the dimensions of the test specimen using the appropriate procedure described in clause 3 and calculate the area to be compressed.

Insert the test specimen in such a way that the force acts along the centre line of the test machine (7.4.1) and compress it at 5 ± 1 mm/min by means of the compression plate until the compression strain applied equals that specified in the material specification. Then decompress the test specimen at the same rate until the separation between the compression plate and the base plate is equal to the initial test specimen thickness.

Immediately repeat this compression cycle three times and, on the fourth compression cycle, read the stress at the specified strain in kilopascals.

NOTE. Autographic recording of the stress-strain values is preferred.

Alternatively, if it is required to determine the strain at a specified compression stress, compress the test specimen until the compression stress equals that specified in the material specification and, on the fourth compression cycle, read the strain at the specified stress.

If repeat tests on the same test specimen are required, allow a recovery period of not less than 16 h before retesting.

7.4.5 *Calculation of results.* Express the result as the compression stress, *CC* (in kPa), at the specified strain using the following equation:

$$CC = 1000 \frac{F}{A}$$

where

F is the force at the specified strain (in N);

A is the area of test specimen (in mm^2).

7.4.6 *Test report.* The report shall state the following:

(a) identity of the cellular material;

(b) description of the test specimen with reference to moulded surfaces;

(c) dimensions of the test specimen including the number of plies;

(d) compression stress (in kPa) under specified strain, or the compression strain (as a percentage) under the specified stress;

(e) the method used, i.e. method 5B of BS 4443 : Part 1 : 1988.

8 Methods 6A and 6B. Determination of compression set

8.1 Introduction

Methods 6A and 6B consist of maintaining the test specimen under specified conditions of time, temperature and constant compressive strain and noting the effect on the thickness of the released test specimen. Method 6A is a more rapid method carried out at a temperature of 70 °C for 22 h. Method 6B is carried out by compressing the test specimen for 72 h at a temperature of 23 ± 2 °C.

8.2 Definition

For the purposes of these methods in this Part of BS 4443, the following definition applies.

compression set (*CS*). The difference between the initial thickness and the final thickness of a test specimen of the flexible cellular material after compression for a given time and temperature and recovery time, expressed as a percentage of the initial thickness.

8.3 Apparatus

8.3.1 *Compression device,* consisting of two flat plates larger in dimensions than the test specimens, with spacers and clamps such that the plates are held parallel to each other and the space between the plates is adjustable to the required compression of the test specimen.

8.3.2 *Measuring gauge,* such as the one described in appendix A.

8.3.3 *Air-circulating oven,* capable of maintaining the test specimens at a temperature of 70 ± 1 °C.

8.4 Test specimens

The test specimen shall be a right parallelepiped with square load-bearing surfaces of side 50 mm and width to thickness ratio of not less than 2:1. If skin is present, it shall be on the side in contact with the compression plate.

NOTE 1. When it is not possible to cut test specimens of the thickness specified, thinner sections of not less than 10 mm thickness may be used. The results so obtained may not be comparable with those obtained using the standard thickness.

When thin materials less than 10 mm in thickness are to be tested, sufficient test specimens 50 mm long x 50 mm wide shall be taken so that the sum of their thicknesses before compression is at least 25 mm. The test specimens shall be plied together and interleaved with photographic mounting slides, and the complete assembly shall be treated during the test as a single thick test specimen.

NOTE 2. When testing thin specimens of flexible cellular material of the order of 1 mm thick, the use of plied up test specimens results in a considerable interpenetration of the cell structures of adjacent layers. Since tests on thin sheets are often required, the use of glass slides is essential to remove this source of error.

8.5 Number of test specimens

Five test specimens or, in the case of thin material, five assemblies shall be tested.

8.6 Conditioning

Material shall not be tested less than 72 h after manufacture unless, at either 16 h or 48 h after manufacture, it can be demonstrated that the compression set values obtained do not differ by more than ± 10 % from those obtained after 72 h. Testing is permitted at either 16 h or 48 h if, at the selected time, the above criteria have been satisfied.

Prior to the test, the test specimens shall be stored for at least 16 h under the following standard conditions:

23 ± 2 °C, 50 ± 5 % relative humidity.

NOTE. This period can form the latter part of the period following manufacture.

In addition, for sponge rubber, the test specimen shall be conditioned for 1 h at a temperature of test of 70 ± 1 °C. It shall then be allowed to cool at 23 ± 2 °C for 30 ± 3 min immediately before the thickness is measured.

8.7 Procedure

8.7.1 *General.* Carry out the test by method 6A, method 6B or both. The result obtained by method 6A will not be the same as that obtained by method 6B.

After conditioning as described in **8.6**, measure the initial thickness of the test specimen as described in method 1A.

In the case of thin materials, avoid disturbance to the assemblies.

Calculate the thickness by deducting the aggregate thickness of the glass slides from the total measured thickness of the glass slides and flexible cellular material. Place the test specimen in the compression device (**8.3.1**), compress it by 75 % of its thickness and maintain it under this condition.

NOTE. In special cases a compression of 25 %, 50 % or 90 % may be agreed upon.

8.7.2 *Method 6A.* Within 15 min after compression, place the compressed test specimen in an oven (**8.3.3**) with air circulation at 70 ± 1 °C for 22 $^{+2}_{-0}$ h.

Remove the test apparatus from the oven and within 1 min remove the test specimen from the apparatus and place it on a wooden surface. Allow the test specimen to recover for 30 ± 5 min at the same temperature used for conditioning the test specimen (23 ± 2 °C) before remeasuring the thickness.

8.7.3 *Method 6B.* Maintain the test specimen for 72 h under compression at the same temperature as that used for conditioning the test specimen (23 ± 2 °C). Release the test specimen from compression and allow it to recover for 30 ± 5 min before remeasuring the thickness.

8.8 Calculation of results

Calculate the percentage compression set *CS* from the following equation:

$$CS = \frac{(T_o - T_r)}{T_o} \times 100$$

where

T_o is the original thickness of the material (in mm);

T_r is the thickness after recovery (in mm).

8.9 Test report

The test report shall include the following:

(a) a description of the cellular material;

(b) whether the test was done at a compression of 75 % or at a specially agreed compression of 25 %, 50 % or 90 %;

(c) the thickness and number of plies used, if other than as specified in 8.4;

(d) whether skin was present or absent;

(e) the mean value of compression set;

(f) the method used, i.e. method 6A or method 6B of BS 4443 : Part 1 : 1988.

Appendices

Appendix A. Apparatus to measure the thickness of small specimens of flexible cellular materials

A.1 Introduction

Figure 3 illustrates a suitable instrument for the method of measurement described in 3.2.

A.2 To zero the instrument

A.2.1 Lower the dial gauge foot by means of the spin wheel until the dial gauge reads zero.

A.2.2 Place the indentor on the base table and adjust, by means of the height adjustment, the height of the dial gauge (and, if necessary, the position of the cross beam) until contact is made between the foot and the indentor (shown by a light or a buzzer). Make the final adjustment to zero by rotating the bezel.

A.3 To measure

A.3.1 Place the flexible cellular material specimen on the table and the indentor on top of the specimen. Lower the foot by means of the spin wheel until contact is made.

A.3.2 Gently raise the foot by means of the spin wheel until contact is just broken. Read the thickness of the specimen directly from the dial.

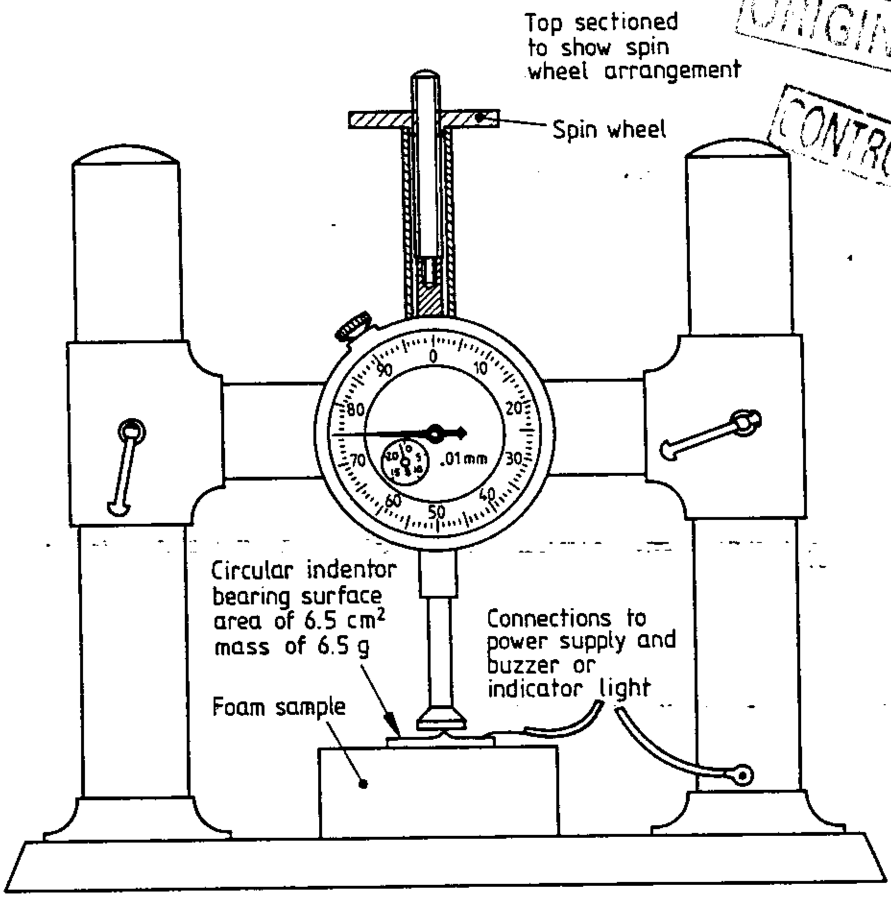


Figure 3. Apparatus to measure the thickness of small specimens of flexible cellular materials

Appendix B. Related ISO methods

Table 1. Related ISO methods

BS 4443 : Part 1 Method	Method number	ISO methods which are technically related
Measurement of dimensions of test specimens	1A	ISO 1923
	1B	ISO 1923
	1C	ISO 1923
Determination of apparent density	2	ISO 845
Determination of tensile strength and elongation at break	3A	ISO 1798
	3B	No equivalent
Measurement of cell count	4	No equivalent
Determination of compression stress-strain characteristics	5A	ISO 3386/1
	5B	ISO 3386/2
Determination of compression set	6A	ISO 1856 (Method A)
	6B	ISO 1856 (Method B)

Publications referred to

BS 4443	Methods of test for flexible cellular materials Part 2 Method 7 Indentation hardness tests Part 3 Method 8 Determination of creep Method 9 Determination of dynamic cushioning performance
BS 5214	Testing machines for rubbers and plastics Part 1 Constant rate traverse machines
ISO 845	Cellular plastics and rubbers — Determination of apparent density
ISO 1798	Polymeric materials, cellular flexible — Determination of tensile strength and elongation at break
ISO 1856	Polymeric materials, cellular flexible — Determination of compression set
ISO 1923	Cellular plastics and rubbers — Determination of linear dimensions
ISO 3386/1	Flexible cellular materials — Determination of compression stress/strain characteristic in compression Part 1 Low-density materials
ISO 3386/2	Polymeric materials, cellular flexible — Determination of stress-strain characteristic in compression Part 2 High density materials

This British Standard, having been prepared under the direction of the Plastics Standards Committee and the Rubber Standards Committee, was published under the authority of the Board of BSI and comes into effect on 29 February 1988.

First published May 1969
First revision March 1979
Second revision February 1988

ISBN 0 580 15989 2

The following BSI references relate to the work on this standard:
Committee reference PLM/RUM/10
Draft for comment 85/39268 DC

British Standards Institution. Incorporated by Royal Charter, BSI is the independent national body for the preparation of British Standards. It is the UK member of the International Organization for Standardization and UK sponsor of the British National Committee of the International Electrotechnical Commission.

In addition to the preparation and promulgation of standards, BSI offers specialist services including the provision of information through the BSI Library and Standardline Database; Technical Help to Exporters; and other services. Advice can be obtained from the Enquiry Section, BSI, Milton Keynes MK14 6LE, telephone 0908 221166, telex 825777.

Contract requirements. 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.

Revision of British Standards. British Standards are revised, when necessary, by the issue either of amendments or of revised editions. **It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.**

Automatic updating service. BSI provides an economic, individual and automatic standards updating service called **PLUS**. Details are available from BSI Enquiry Section at Milton Keynes, telephone 0908 221166, telex 825777.

Information on all BSI publications is in the *BSI Catalogue*, supplemented each month by *BSI News* which is available to subscribing members of BSI and gives details of new publications, revisions, amendments and withdrawn standards. Any person who, when making use of a British Standard, encounters an inaccuracy or ambiguity, is requested to notify BSI without delay in order that the matter may be investigated and appropriate action taken.

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Plastics Standards Committee (PLM/-) and the Rubber Standards Committee (RUM/-) to Technical Committee PLM/RUM/10, upon which the following bodies were represented:

British Plastics Federation
British Railways Board
British Rigid Urethane Foam Manufacturers' Association
British Rubber Manufacturers Association
Department of the Environment (Building Research Establishment)
Furniture Industry Research Association
Furniture, Timber and Allied Trades Union
Ministry of Defence
National Bedding Federation
Phenolic Foam Manufacturers Association
RAPRA Technology Ltd
Society of British Aerospace Companies Limited
Society of Motor Manufacturers and Traders Limited

Amendments issued since publication

Amd. No.	Date of issue	Text affected

British Standards Institution · 2 Park Street London W1A 2BS · Telephone 01-629 9000 · Telex 266933

8802-6-1.4k-B PLM/RUM/10

BS 4443 : Part 1 : 1988