Methods for test for

Determination of properties of cushioning materials for package design purposes

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Packaging and Freight Containers Standards Policy Committee (PKM/-) to Technical Committee PKM/22, upon which the following bodies were represented:

British Paper and Board Industry Federation

British Rubber Manufacturers Association Ltd.

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Contents

Foreword

This British Standard has been prepared under the direction of the Packaging and Freight Containers Standards Policy Committee to provide a standard listing methods of test for the determination of those properties of cushioning materials which are particularly relevant for purposes of package design.

Certain methods are based closely on methods of test given in BS 4443 but these have been modified to make them more specific to package design and the basic cushion design guidance given in BS 1133-12.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

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

Section 1. General

0 Introduction

A packaged article, depending on its nature, may require the package to provide protection against shocks occurring during transit. Such shocks may be of high or medium intensity but intermittent, caused by drops or other impacts or, more usually, of lower intensity but repeated, due to vehicle vibration.

One method of protecting the article is to cushion it against anticipated shocks using materials which deflect on impact. Such cushioning materials reduce the level of shock from impacts by allowing controlled movement of the packaged article within the package at the instant of impact, so reducing the deceleration and the resulting force transmitted to the article. Cushioning materials can also be used to reduce the transmission of vibration to the article when this is likely to be a problem.

In order to design a package providing adequate protection, various properties of the available cushioning materials need to be considered. The methods described in this standard are particularly appropriate for measuring those properties relevant to package design.

Design data obtained by these methods, while essential for rational design of the cushion, provide only an estimate of package performance, which is influenced by many other factors including:

a) the type of container and the material from which it is constructed;

b) the orientation of the package on impact;

c) the nature of the surface on which it falls;

d) the ratio of overall cushion volume to internal air volume (open cell materials only);

e) friction between the packaged article and any side cushions.

Instrumented tests on a prototype package are always advisable to check that the required level of protection has been achieved.

BS 1133-12 gives information on the various types of cushioning materials and outlines a basic cushion design procedure.

1 Scope

This British Standard describes methods for the determination of those properties of sheet or block cushioning materials particularly relevant for package design purposes; dynamic cushioning performance, creep strain and residual compression set.

The standard also includes methods for the determination of relevant properties of loose fill materials and for the measurement of fungal growth of both cushioning and loose fill materials.

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 British Standard the following definitions apply.

2.1
static stress

the force exerted by the drop hammer of the test apparatus (method 1) or the test block (method 3) when at rest, divided by the original area of the test piece (method 1) or the base area of the block (method 3), expressed in kPa

2.2
peak deceleration

the maximum deceleration of the drop hammer during the impact on the test piece (method 1) or the maximum deceleration of the test block during the test drop (method 3)

2.3
corrected value of peak deceleration G_c

the value of the measured peak deceleration (G_m) after correction for any small deviation of the original thickness of the test piece from the standard reference thickness at which it was intended to test. This is obtained by multiplying the measured peak deceleration by the original thickness divided by the standard reference thickness

2.4
standard gravitational acceleration g_n

the acceleration due to the effect of the earth's gravitational pull. Although this value varies slightly from place to place, it is usually considered to be a constant with the value of 9.81 m/s^2

2.5
nominal drop height h_n

the height specified for drop testing the package under free fall conditions

NOTE In order to achieve the same impact velocity on the drop test machine (method 1) a slightly greater actual drop height h_c is required because of friction effects (see **4.1.2**).

2.6
residual compression set

the percentage loss in thickness of the test piece after impact or after a selected period under static stress and a short period of recovery

2.7
creep strain

the percentage change in strain exhibited by a test piece under static stress as determined by measurements after 15 min and a selected period after loading

2.8
compression stress

the static force per unit area of the original cross section of the test piece

Section 2. Method 1. Determination of dynamic cushioning performance of sheet or block material

3 General

This method describes the procedure for determining the dynamic cushioning performance of sheet or block material by measuring the peak deceleration of a mass when it is dropped onto a test piece of the material. It is based on method 9 of BS 4443-3 which is intended primarily for quality assurance purposes for packaging applications.

4 Apparatus

4.1 *Drop test machine,* in accordance with **4.1.1** to **4.1.3**.

4.1.1 The apparatus is a guided vertical drop tester comprising a drop hammer with a flat base, with an impacting area greater than that of the impacted test piece, and an anvil whose face is parallel to the base of the drop hammer. The mass of the drop hammer shall be adjustable in the range of static stresses required; alternatively a range of hammers can be used. The mass of the anvil and the base to which it is attached shall be at least 100 times that of the hammer to prevent undesirable vibrations which may conceal or modify the true shape of the deceleration time curve. The natural frequency of vibration of the hammer should be as high as practicable, preferably above 1 000 Hz.

It is essential that the drop hammer mechanism is such that the safety of the operator is assured when the test pieces are being placed on the anvil; some form of safety interlock is recommended.

4.1.2 Due to contact with the guides the drop hammer will lose energy during the fall, and the actual drop height (h_c) has to be greater than the theoretical drop height to ensure that at impact the velocity of the hammer is the same as would be achieved under free fall conditions from the selected nominal drop height (h_n).

The impact velocity under free fall conditions for any drop height is calculated using the following equation:

$$V = \sqrt{(2\, g_n\, h_n)}$$

where

V is the impact velocity (in m/s);

g_n is the acceleration due to gravity (9.81 m/s^2);

h_n is the nominal drop height (in m).

4.1.3 The instrumentation for measuring, recording and storing the deceleration on impact shall be capable of an accuracy to within ± 5 %.

5 Test pieces

5.1 Number of test pieces

Three test pieces shall be tested at each of, as a minimum, five values of static stress for each combination of drop height and thickness. For the minimum test sequence 45 test pieces are required.

5.2 Dimensions of test pieces

Each test piece shall be a right parallelepiped with the following dimensions:

Length and width (to be equal):	either 150 ± 5 mm or 250 ± 5 mm;
Thickness:	within the range 25 mm to 150 mm.

NOTE For commercial purposes this test can also be used for thinner pieces.

The difference in the mean thickness between the test pieces in a set of 10 shall be not greater than 2 mm. Measure the dimensions in accordance with Appendix A.

5.3 Preparation of test pieces

Test pieces of thickness 25 mm and more can, where necessary, be obtained by plying up two sheets without the use of adhesive. Cut such sheets to identical shapes and sizes and ensure that they are of the same orientation with respect to any known direction of anisotropy.

Cut the test piece by any suitable means which does not alter the dynamic cushioning characteristics, for example a band saw or a sharp knife. Hot wire cutting shall not be used.

NOTE The presence of skin in the test piece may affect the test result. Where skin will form an integral part of the article in use, the preparation of the test piece should be a matter for agreement between the purchaser and the supplier.

The presence of skin on the test piece shall be noted in the test report.

6 Conditioning and test conditions

Materials shall not be tested less than 72 h after manufacture. Prior to testing, condition the test pieces for at least 16 h under the following standard conditions:

23 ± 2 °C, 50 ± 5 % r.h.

NOTE The conditioning period may form the latter part of the 72 h following manufacture.

Carry out the test at the same conditions unless design data are required on performance under other specific conditions.

7 Procedure

7.1 General

7.1.1 Measure the original thickness, T_o, of the test piece in accordance with either method 1A or 1B of Appendix A. Having ensured that the drop hammer is in the safe position, place the test piece on the anvil of the apparatus. Prepare the drop hammer to impact the test piece.

7.1.2 For tests in conditions other than 23 ± 2 °C and 50 ± 5 % r.h., condition the test piece at the specified test conditions for a period of at least 16 h following the measurement of the original thickness T_o.

7.1.3 Impact the test piece using the actual drop height h_c as calculated in **4.1.2** and the static stress as described in **7.3**. Measure and record the peak deceleration, G_m, of the drop hammer on impact. Each test piece is to be used for only one combination of static stress and impact velocity.

NOTE For certain commercial purposes the test may be carried out by impacting the test piece three times at intervals of 60 ± 15 s, with the peak deceleration, G_m, measured and recorded on the first and third impacts.

After the first or third impact, as appropriate, remove the test piece, allow it to recover for 5 ± 1 min and measure its thickness, T_v in accordance with either method 1A or 1B of Appendix A.

7.2 Drop height

Carry out tests from either three drop heights, preferably those equivalent to nominal drop heights of 300 mm, 600 mm and 900 mm (see **4.1.2**) or five drop heights, the additional nominal drop heights being 750 mm and 1 350 mm.

NOTE Tests at five drop heights are necessary for Ministry of Defence type approval purposes.

7.3 Static stress

At each drop height, use a minimum of five different levels of static stress, such that one gives approximately the minimum peak deceleration on impact, the remainder being equally distributed above and below this level, corresponding approximately to a 10 % and 20 % increase in peak deceleration.

8 Calculation

8.1 Residual compression set

Calculate the residual compression set after impact and recovery as follows.

$$\text{Residual compression set} = \frac{T_o - T_v}{T_o} \times 100\ \%$$

where

T_o is the original thickness of the test piece (in mm);

T_v is the thickness of the test piece after impact and recovery (in mm).

8.2 Peak deceleration

Calculate the corrected value of the peak deceleration G_c (in m/s^2) as follows:

$$G_c = G_m \frac{T_o}{T_s}$$

where

G_m is the measured value of the peak deceleration (in units of standard gravitational acceleration);

T_o is the original thickness (in mm);

T_s is the standard reference thickness (in mm).

9 Test report

The test report shall include the following:

a) a description of the material (including nominal density);

b) the conditioning and test conditions, if other than as described in clause **6**, with a brief indication of the drop testing machine used;

c) the method of measurement used for recording test piece size, i.e. method 1A, 1B or 1C;

d) a set of dynamic performance curves constructed by plotting the corrected values of peak deceleration (G_c) against the appropriate values of static stress, in kilopascals, for each combination of a standard reference thickness (T_s) and nominal drop height (h_n);

NOTE First and third drop curves should be shown on the same graph where appropriate.

e) the residual compression set after impact and recovery for each test piece;

f) whether or not the test pieces were plied and the location of skin, if present;

g) the method used, i.e. method 1 of BS 7539:1992.

Section 3. Method 2. Measurement of creep strain and compression set of sheet or block cushioning material

10 General

During storage and distribution the force exerted by the packaged item tends to compress the cushion underneath the item. This results in space within the package, possible loss of location of the item and less effective protection against impact due to reduction in cushion thickness.

This section of BS 7539 describes a method for determining such creep of a cushioning material when compressed by a static force, for package design purposes. It is based on method 8 of BS 4443-3, which is intended primarily for quality assurance purposes for packaging applications.

In packaging applications the maximum allowable static stress for the envisaged life is often the important parameter, rather than the amount of creep. For such purposes isochronous curves, as described in BS 4618-1.1, may be more suitable.

11 Apparatus

11.1 *Two flat plates,* at least one of which is self aligning, so arranged that they compress the test piece in a vertical direction. The plates shall be capable of being loaded so that during the period of test the static stress does not change by more than ± 1 % and the separation of the plates shall be capable of being measured to within 0.1 mm. The compression stress required varies with the material, but is usually not more than 10 kPa. The apparatus shall be placed on a substantial support to minimize the effects of vibration.

12 Test pieces

12.1 Number of test pieces

Normally two test pieces shall be tested for each of five selected compression stresses covering the dynamic operating range in practice. Where test variability is high, however, it may be necessary to test a larger number, in which case it is recommended that the choice is made after preliminary tests.

NOTE Attention is drawn to the fact that cushioning materials tend to be variable in all their properties. For critical applications therefore, testing programmes should be designed to assess the source of variability, both within and between batches.

12.2 Dimensions of test pieces

Each test piece shall be a right parallelepiped with the following dimensions:

Length:	150 ± 2 mm;
Width:	150 ± 2 mm;
Mean thickness:	50 ± 1 mm.

The thickness of the test piece shall be subject to a tolerance of ± 1 mm about the selected mean value. Measure the dimensions in accordance with method 1C of Appendix A.

12.3 Preparation of test pieces

The thickness of the test piece can, where necessary, be achieved by plying up, without the use of adhesive, sheets each not less than 10 mm thick, provided that, for cellular materials, a minimum of 10 cell diameters are included in any one ply. Cut such sheets to identical shapes and sizes and ensure that they are of the same orientation with respect to any known direction of anisotropy.

Cut the test piece by any suitable means which does not alter the compression characteristics, for example a band saw or a sharp knife. Hot wire shall not be used for cutting test pieces.

NOTE The presence of skin on the test piece may affect the test result.

Where horizontal skin will form an integral part of the article in use, such skin shall be included in the test piece and a note included in the test report. Skin shall not be present on the vertical sides of the test piece.

13 Conditioning and test conditions

13.1 Standard conditions

Samples shall not be tested less than 72 h after manufacture. Prior to testing, condition the test pieces for at least 16 h in the following standard conditions:

23 ± 2 °C, 50 ± 5 % r.h.

NOTE The conditioning period may form the latter part of the 72 h following manufacture.

13.2 Special conditions

For specific design purposes it may be necessary to carry out tests at points within the range – 40 °C to + 55 °C, for example where exposure to tropical conditions is envisaged, the suggested test conditions are 40 ± 2 °C and 90 ± 5 % r.h.

NOTE For certain materials extended conditioning may be necessary to ensure uniform distribution conditions within the test piece.

14 Procedure

Measure the original thickness T_o of the test piece in accordance with method 1A of Appendix A.

For tests at other than 23 ± 2 °C and 50 ± 5 % r.h., condition the test piece at the specified test conditions for a period of at least 16 h following the measurement of the original thickness T_o.

Place the test piece in the apparatus and apply to the test piece the appropriate compression stress in such a manner as to avoid impact.

Measure the thickness T_1 of the test piece after 15 ± 1 min without removing the compression stress and repeat the measurement T_2 after the selected period(s), again without removing the compression stress. At the end of the test, remove the compression stress and remeasure the thickness T_R after the test piece has been allowed to recover for 30 ± 2 min at the relevant test conditions using the same measuring equipment as when measuring T_o.

15 Calculation of results

15.1 Creep strain

Calculate the percentage creep strain as follows:

$$\text{Percentage creep strain} = \frac{(T_1 - T_2)}{T_1} \times 100$$

where

T_1 is the thickness under compression stress after 15 min (in mm);

T_2 is the thickness under compression stress after each selected period (in mm).

NOTE Plotting creep strain against the logarithm of time of test gives an approximately straight line and an estimate of the amount of creep over longer periods is possible. A test time of 100 days is recommended and suitable measurement intervals are 0.01, 0.1, 1, 3, 10 and 100 days. From the plot of the first four points a reasonable estimate can be obtained.

15.2 Residual compression set

Calculate the residual compression set as follows:

$$\text{Residual compression set} = \frac{(T_o - T_R)}{T_o} \times 100\ \%$$

where

T_o is the original thickness (in mm);

T_R is the thickness after recovery on test completion (in mm).

16 Test report

The test report shall include the following:

a) a description of the material;

b) the conditioning and test conditions if other than as described in **13.1**;

c) the duration of test;

d) the compression stress used, in kilopascals;

e) the individual values for creep strain after each selected period;

f) the individual values for compression set on test completion;

g) whether or not the samples were plied and the location of skin, if present;

h) the method used, i.e. method 2 of BS 7539:1992.

Section 4. Methods 3A, 3B and 3C. Determination of the cushioning properties of loose fill materials

17 General

Loose fill materials such as wood wool, expanded polystyrene shapes, vermiculite, are used extensively in the packaging of non-critical items. Their main use is to position an item within a container so that the item is held away from the container surfaces. The majority of loose fill materials also offer a degree of protection against impact.

In relation to these listed uses this section describes methods for determining the following:

a) the expected compression of loose fill material under load and the overfill required to compensate;

b) the maximum static stress the material can support under repeated low level impacts;

c) the effectiveness of the material at positioning an item securely under vibration.

18 Apparatus

18.1 *Vibration table,* of sufficient size, rigidity and mass carrying capacity supported on a mechanism that will maintain the surface horizontal during vibration. The differences in surface level between the table extremities shall not exceed 10 mm.

18.2 *Bounce test equipment,* having the following characteristics.

a) The motion is vertical, sinusoidal with a peak to peak displacement of 25 ± 1 mm at each of two points not less than 600 mm and not greater than 1 700 mm apart. The frequency at one of the points is between 4.66 Hz and 4.83 Hz and at the other point 0.9 ± 0.3 times that at the first point.

b) The test surface consists of a horizontal flat table and side barrier assembly faced with a low resistance material, such as 25 mm plywood. The two points at which the required motion is to be achieved are on the centre line of the table.

Figure 1 illustrates the basic drive mechanism of suitable bounce test equipment.

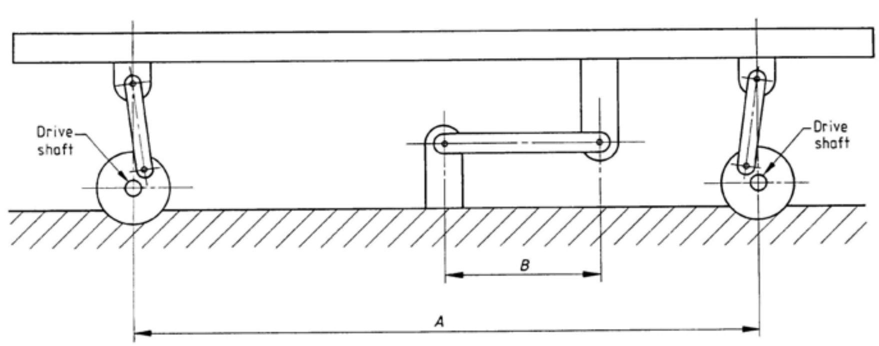
18.3 *Test box,* of battened plywood construction having internal
dimensions 350 mm × 350 mm × 400 mm and constructed as shown in Figure 2.

18.4 *Compression tray,* of 10 mm plywood as shown in Figure 3 dimensioned to be a free-sliding fit inside the test box and suitably weighted to give the required static stress (typically between 1 kPa and 4 kPa).

18.5 *Test blocks,* giving known static stresses over the range 0.5 kPa to 6.0 kPa in suitable increments. The block size is 200 mm × 200 mm × 200 mm. One face of the block shall be designated the base. The opposite face to the base is fitted with an accelerometer which should not protrude above the surface of the block.

18.6 *Instrumentation,* comprising accelerometers and data display or storage devices to measure input and response accelerations as described in clause **21**. The instrumentation system shall have a response accurate to within ± 5 % over the frequency range specified for the test.

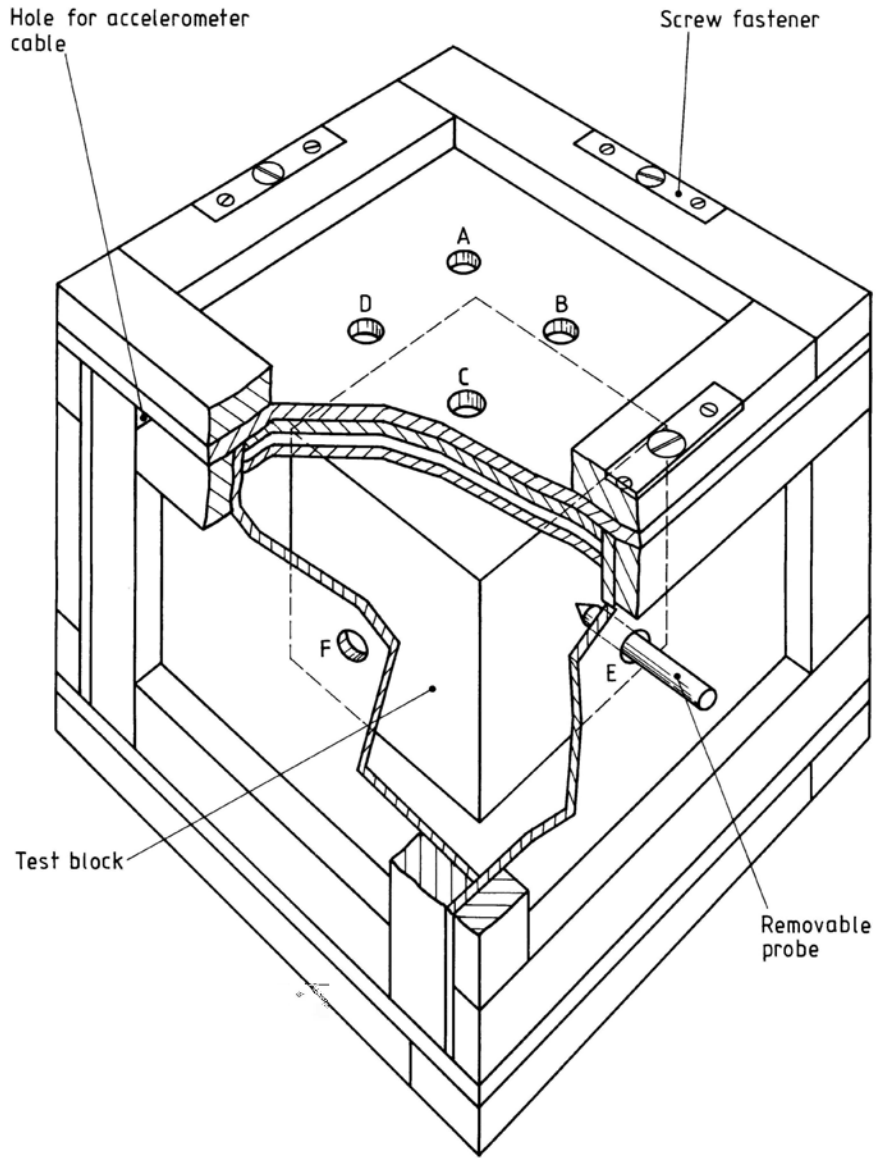
18.7 *Steel probe,* 3 mm in diameter and 450 mm long.



Dimension: *A* not less than 600 mm and not greater than 1700 mm;
B greater than 250 mm.

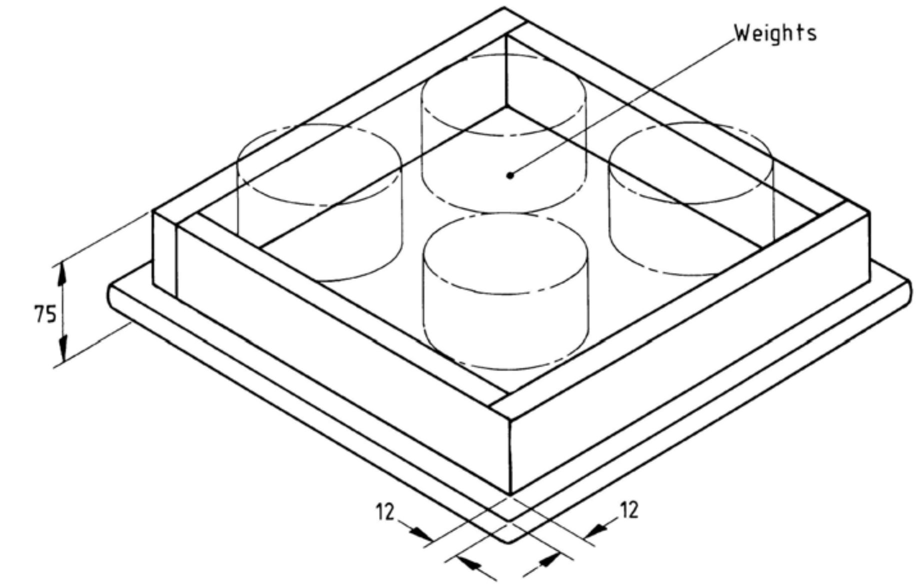
NOTE Both drive shafts to rotate in the same direction.

Figure 1 — Bounce machine, basic drive mechanism



(See also Figure 4.)

Figure 2 — Construction of test box used in methods 3A, 3B and 3C



Dimensions are in millimetres.

Figure 3 — Compression tray

19 Conditioning and test conditions

Sample material shall not be tested less than 72 h after manufacture. Prior to testing, condition the material for at least 16 h in the following standard conditions:

23 ± 2 °C, 50 ± 2 % r.h.

NOTE The conditioning period may form the latter part of the 72 h following manufacture.

Carry out the test at the same conditions unless design data are required on performance under other specific conditions.

20 Method 3A. Determination of compression under load and required overfill

20.1 Procedure

20.1.1 Load the test box with the sample material to a depth of 150 mm, tapping the box continually to initially settle the contents.

20.1.2 Position the compression tray, suitably weighted to give the appropriate static stress, upon the sample material and leave for 5 min.

20.1.3 Secure the test box base down to the vibration equipment and vibrate at 7 Hz for 2 min at an amplitude of ± 3 mm.

20.1.4 Leave in position for 5 min and then measure the depth of material under the tray t_f in millimetres.

20.2 Calculation

20.2.1 ***Compression and percentage compression***

Calculate the compression (in mm), given that 150 mm is the original depth of sample material, as follows:

$$\text{Compression} = 150 - t_f$$

where

t_f is the final depth after compression (in mm).

Calculate the percentage compression c as follows:

$$c = \frac{100(150 - t_f)}{t_f}$$

where

t_f is the final depth after compression (in mm).

20.2.2 *Required initial depth*

Calculate the initial depth of sample material (t_i) (in mm) needed to give a required depth t beneath the packaged item under operating conditions as follows:

$$t_i = \frac{100\ t}{100 - c}$$

where

t is the required depth (in mm);

c is the percentage compression calculated in accordance with **20.2.1**.

20.2.3 *Required overfill*

Calculate the thickness of overfill t_o (in mm) required to accommodate compression throughout the package as follows:

$$t_o = 2\ (t_i - t)$$

where

t_i is the required inital depth of sample material (in mm);

t is the required depth (in mm).

20.3 Test report

The test report shall include the following:

a) a description of the material (including nominal density);

b) the conditioning and test conditions if other than as described in clause **19**;

c) the amount of compression in mm and percentage compression;

d) thickness of overfill;

e) the method used, i.e. method 3A of BS 7539:1992.

21 Method 3B. Determination of the maximum static stress the material can support under repeated low-level impacts

21.1 General

The following procedure is carried out at not less than five values of static stress covering the anticipated useful range of the sample material.

21.2 Procedure

21.2.1 Load the test box (**18.3**) with the sample material to a test depth t_d (in mm) of

$$\frac{100 \times 75}{100 - c}$$

where

c is the percentage compression calculated in accordance with **20.2.1**.

Tap the box continually to settle the contents.

21.2.2 Place a selected test block (**18.5**) fitted with an accelerometer, centrally and base down, on the sample material.

21.2.3 Add sample material around and above the block, tamping down gently to settle the contents without disturbing the test block, to give a total depth of material of 200 + 2 t_d mm. Place the lid in position, press down to close, and secure.

21.2.4 Drop the test box from a height of 750 mm flat on to its base and record the peak deceleration.

21.2.5 Carry out three replicate sets of determinations at each static stress using fresh sample material at every impact.

21.3 Calculation

Use these figures to produce a peak deceleration static stress curve and determine the optimum static stress.

21.4 Test report

The test report shall include the following:

a) a description of the material;

b) the conditioning and test conditions if other than as described in clause **19**;

c) optimum static stress, in kilopascals;

d) mean peak deceleration at optimum static stress;

e) the peak deceleration static stress curve;

f) number of the method used, i.e. method 3B of BS 7539:1992.

22 Method 3C. Determination of effectiveness of positioning an article under vibration

22.1 Procedure

22.1.1 Follow the procedure in **21.2.1** to **21.2.3** using a test block giving the optimum static stress.

22.1.2 Using a steel probe 3 mm diameter by 450 mm long, determine the position of the test block relative to the test box using the four holes in the lid and the single hole in each of the sides of the test box (see Figure 2 and Figure 4). Record all measurements made.

22.1.3 Place the test box, on its base, centrally between the centre lines of the drive shafts of the bounce test equipment described in **18.2**. Restrict the movement of the test box with a rectangular retaining barrier attached to the table frame. Ensure that there is an all round clearance of 50 mm to 75 mm between the barrier and the vertical surfaces of the test box and that the top of the barrier is 50 ± 25 mm below the top of the test box. Operate the equipment for 15 min. Record the position of the test block as described in **22.1.2**.

22.2 Calculation

From the measurements described in **22.1.2** and **22.1.3** determine the maximum movement of the test block.

22.3 Test report

The test report shall include the following:

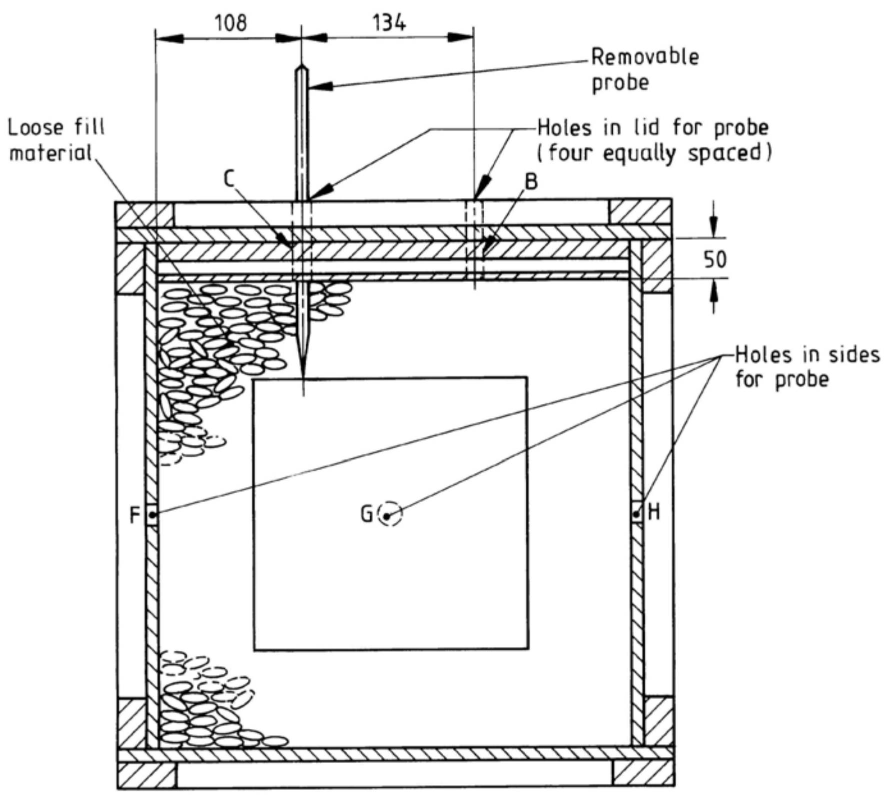
a) a description of the material;

b) the conditioning and test conditions if other than as described in clause **19**;

c) the value of optimum static stress used;

d) maximum movement recorded;

e) the method used, i.e. method 3C of BS 7539:1992.



Section through box

Dimensions are in millimetres.

Figure 4 — Determination of test block position (method 3C)

Section 5. Method 4. Measurement of fungal growth of sheet or block cushioning material

23 Test specimens

Select four representative test specimens approximately 125 mm × 75 mm in size from different parts of the sample.

24 Procedure

Use the method described in test J of BS 2011-2.1J with a 28 day exposure period unless otherwise specified and assess the extent of growth on the basis of the scale included.

25 Test report

The test report shall include the following:

a) full description of the test specimens together with details of any pretreatment employed;

b) duration of test;

c) the extent of any growth expressed on the scale 0 to 3 (in accordance with BS 2011-2.1J).

Appendix A Measurement of dimensions of test pieces (based on BS 4443-1)

A.1 Introduction

These methods describe procedures for the measurement of test piece 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 **A.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 piece. The thicknesses occurring in practical work are covered in the three methods 1A, 1B and 1C.

For control measurements in production and for comparative measurements between the customer and the supplier, the alternative methods 1B and 1C, as applicable, can be adopted by special agreement, and this has to be stated in the test report.

Commercial measuring apparatus working with spring pressures does not necessarily satisfy the conditions specified in method 1A. Such apparatus applying foot pressures of between 100 Pa and 500 Pa and having pressure feet up to 20 cm^2 in area can 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 can be used, employing the procedure described in **A.4**. The alternative is to measure, by means of the method described in **A.2**, the thickness of the material in the area from which the test piece is to be cut.

A.2 Method 1A

A.2.1 *Apparatus*

A.2.1.1 *Measuring instrument.* (A suitable type of instrument is illustrated in Figure 5.) To zero the instrument first lower the dial gauge foot by means of the spin wheel until the dial gauge reads zero then 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 buzzer). Make the final adjustment to zero by rotating the bezel.

To measure, place the test piece on the table and the indentor on top of the test piece. Lower the foot by means of the spin wheel until contact is made. Gently raise the foot by means of the spin wheel until contact is just broken. The thickness of the test piece is read directly from the dial.

A.2.2 *Procedure*

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 piece area. Read the gauge to the nearest 0.02 mm and take the mean of three readings at different positions.

A.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 piece. Present the caliper gauge to the test piece, 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 piece without compressing it.

Take the mean of three readings at different positions.

A.4 Method 1C. Alternative method for dimensions over 100 mm

Measure the dimension 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 piece.

Take the mean of three readings at different positions.

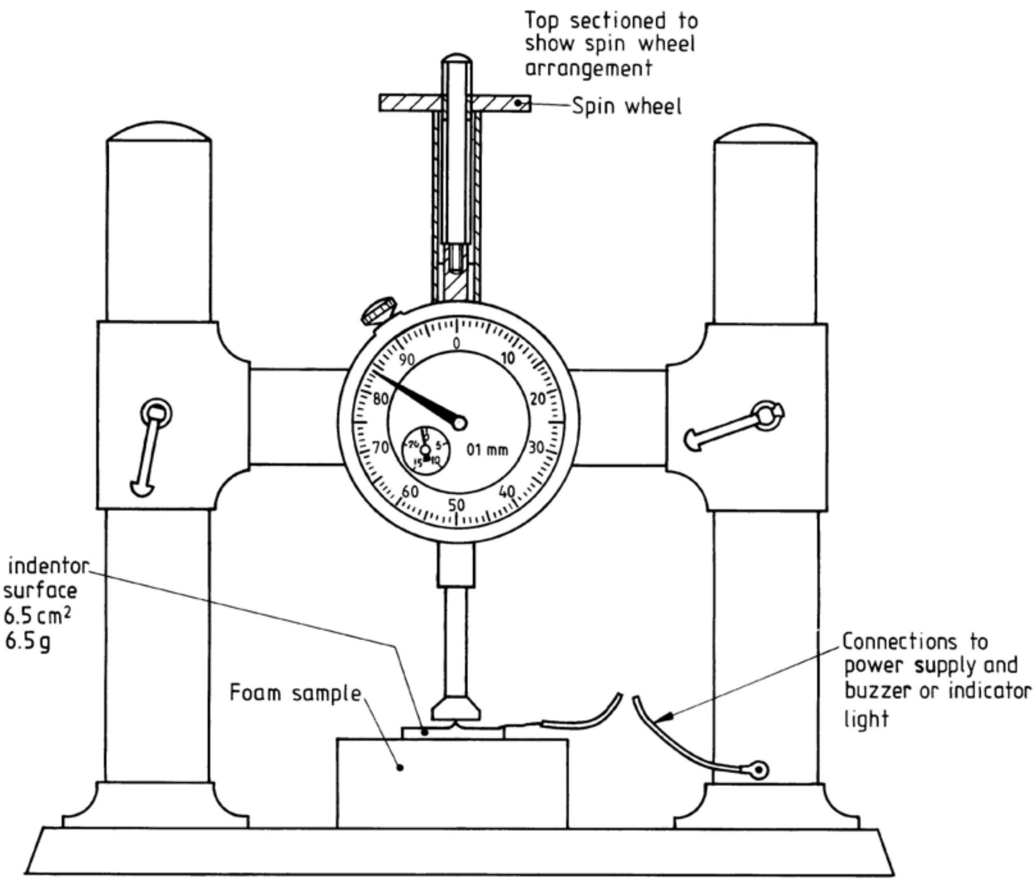


Figure 5 — Apparatus for measurement in accordance with method 1A

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Publication(s) referred to

BS 1133, *Packaging code*.
BS 1133-12, *Methods of protection against shock (excluding cushioning devices)*.
BS 2011, *Basic environmental test procedures*.
BS 2011-2.1J, *Test J and guidance. Mould growth*.
BS 4443, *Methods of test for flexible cellular materials*.
BS 4443-1:Methods 1 to 6
BS 4443-3:Method 8, *Determination of creep*.
BS 4443:Method 9, *Determination of dynamic cushioning performance*.
BS 4618, *Recommendations for the presentation of plastics design data*.
BS 4618-1.1, *Creep*.

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