BS 5131 : Section 5.7 : 1978
[Fatigue, rigid units]
UDC 685.31 : 620.1 : 539.431

British Standard Methods of test for

Footwear and footwear materials

Part 5. Testing of complete footwear

Section 5.7 Fatigue test for rigid units and shoe bottoms

Méthodes d'essai des chaussures et des matériaux entrant dans leur confection
Partie 5. Essai de la chaussure complète
Section 5.7 Essais de fatigue des unités rigides et du fond de la chaussure

Prüfverfahren für Fussbekleidung und Fussbekleidungswerkstoffe
Teil 5. Prüfen der fertigen Fussbekleidung
Abschnitt 5.7 Ermündungsprüfungen für steife Einheiten und Schuhunterseiten

NOTE. It is recommended that this Section should be read in conjunction with the information in the General introduction to BS 5131, published separately.

1. Scope

This Section describes a test that reproduces the effect of the repeated forces applied to the unit in normal walking, which may eventually produce cracking or complete fracture. The magnitude and direction of the forces used in the test are based on measurements made in wear on shoes containing rigid units. This test is applicable to rigid through bottom units (often called clog units or through platform units) made from rigid plastics, rigid polyurethane, or wood, and to complete shoe bottoms containing these units, i.e. with the insole and outsole left on. It is also suitable for testing complete bottoms containing cork or semi-rigid PVC units, but not for testing these units on their own. It is not applicable to more flexible units because they bend too much to allow the full fatigue force to be applied. For these more flexible units the test described in Section 5.8 of this standard is recommended.

NOTE. Section 5.7 is based on SATRA* Physical test method PM87.

2. Reference

This Section refers to the following standards publication:

BS 5131 Methods of test for footwear and footwear materials
Section 5.8 Durability in flexing, shoe bottoms (in course of preparation)

3. Principle

The unit is clamped across the forepart and forces are applied to the heel end alternately up and down, as in wear. The lines of clamping and application of the force are so defined that the moment length is always 52 % of the length of the unit, irrespective of size. For testing units from women's shoes under normal conditions the maximum force in each direction is 49 N and, for units from men's shoes, 118 N. These forces produce the same deformations of the units as, on average, occur in wear. In addition, an accelerated test can be carried out on the most rigid units from women's shoes using a force of 98 N.
The number of flexes required to produce failure is recorded, together with the type and position of the damage. If no failure is obtained, the number of flexes at the end of the test is noted.

4. Apparatus and materials

The following apparatus and materials are required.

4.1 *A suitable fatigue tester* (see figure 5.7/1). The forepart of the bottom unit is held in clamp unit S so that the bottom unit is vertical with the heel end uppermost. The clamp faces need to be at least 50 mm deep from top to bottom. The heel is at the centre of a frame, T, which oscillates from left to right and back in a horizontal plane. The magnitude of the oscillation of frame T needs to be adjustable and the maximum throw obtainable should be at least 75 mm. This oscillation compresses two springs, U, alternately, which apply the desired forces to the heel and deform it a little. When the frame, T, moves to the left, the right-hand spring is compressed and this applies an 'upward' force to the underside of the unit.

Similarly, when the frame moves to the right, the left-hand spring is compressed and the force is applied to the insole surface and 'downwards'. The compression characteristics of the two springs should be known to an accuracy of at

*Shoe and Allied Trades Research Association.

least 2 % up to a force of 120 N and should lie in the range 50 N to 60 N per centimetre of compression.

The deformation forces are applied to the unit via two horizontal rollers, V, of diameter approximately 25 mm. These are fixed to two frames, W, which slide freely on bearing surfaces on the main frame, T. The compression springs are attached to the ends of frame T with adjustable fixings, Z, so that they can be advanced towards each other or retracted. In order to accommodate units of all possible heel heights it is desirable that the range of adjustment of each spring should be about 75 mm. The other end of each spring presses against its roller frame during the compression half of each flexing cycle, but is not attached to it.

It is recommended that during the test the rollers should be held in contact with the heel of the unit by two light springs, X, attached to the roller frames and of a suitable length for the unit. (If not, each roller will bang against the unit at the start of its compression half cycle.)

The machine should flex the units at 125 ± 10 flexes per minute. It should be fitted with a counter and two cut off switches, Y, one on each side of the unit being flexed. If either of these is operated by a large deformation of the unit, resulting from a crack or bend, the machine is stopped automatically and the test is finished.

NOTE. The SATRA Fatigue Tester for rigid units, STM 413, shown diagrammatically in figure 5.7/1, is suitable.

4.2 *A curing resin filler* which is fairly fast setting, but does not generate too much heat when doing so.

NOTE. David's P38 is a suitable commercial product.

4.3 *A silicone release agent.*

5. Preparation of units for test

5.1 If the bottom of a complete shoe is to be tested, cut away the upper level with the surface of the insole.

5.2 The positions for clamping the unit and applying the deforming forces are determined below. The procedure is illustrated by figure 5.7/2.

5.2.1 On the upper surface of the unit or the insole, mark the extreme toe and heel points A and B, respectively. Draw in the line AB lightly and measure its length along the surface of the insole using a flexible steel rule or tape. Mark on the line AB two points C and D such that CB = 2/3 AB and DB = 0.15 AB. Lightly draw a line EF through C at right angles to AB and mark its centre point I. Do the same for point D to obtain point J. Join points I and J with a heavier line and also draw lines KIL and MJN at right angles to IJ. During the test the unit will be clamped along the line KL.

5.2.2 Place the unit on a flat surface and draw lines LO and NP on the edge of the unit, as shown in figure 5.7/3, so that they are at right angles to the surface. Mark points O and P. Obtain and mark similar points Q and R on the other side of the unit. Draw lines OQ and PR on the underside of the unit. During the test the deforming forces will be applied at the lines MN and PR in directions NP and PN respectively.

5.2.3 Occasionally it happens that because of the design of the unit, points P and R do not fall on the heel or are very close to the front edge. In such a case move P and R backwards until they do fall on the heel and are at least 5 mm from this edge. Move O and Q the same distance to keep OP constant. Redraw the perpendicular lines OL and QK to obtain the new positions of K and L, and the lines PN and MR to obtain the new positions of M and N.

5.3 In order to clamp the unit accurately and vertically in the fatigue tester between the flat parallel faces of the clamp unit S, a pair of blocks are produced, moulded to the shape of the upper and lower surfaces of the unit in the forepart. These blocks should be moulded from a curing resin filler system, as specified in **4.2.** A base mould is required, as illustrated in figure 5.7/4, that has across it a flat-bottomed trough 50 mm wide and 5 mm deep, and a rectangular top mould, 50 mm wide and longer than the width of the forepart.

5.4 Spray the base mould, top mould and the surfaces of the forepart of the unit with silicone release agent. Mix sufficient resin, following the maker's instructions. Fill the trough in the base mould with resin so that the amount filled is a little wider than the forepart of the unit. Place the unit in the base mould as shown in figure 5.7/4 so that the line OQ on the underside of the unit coincides with the rear edge of the trough. Press the unit down to exude excess resin until the unit rests on this rear edge. Remove most of the excess resin. Apply a band of resin to the top surface of the unit about 50 mm wide so that its rear edge overlaps the line KL on that surface. Place the top mould on the resin so that it is horizontal and its edges are vertically above the edges of the trough in the base mould. Press the top mould down gently to exude resin until the minimum thickness of resin is about 5 mm.

5.5 Leave the resin to harden. If the compound used is fairly fast curing it may be found better to dismantle the moulds as soon as the resin is firm, to avoid the possibility that the heat generated during the rest of the curing process might damage the unit. When the resin blocks are fully hardened, grind off excess material along their rear edges so that they fit accurately along the lines KL and OQ on the unit.

6. Procedure

6.1 Turn the motor by hand until the frame, T, is at the centre of its oscillation. Unhook the two light springs, X, at one end. Retract the springs, U, and roller frames, W, by approximately equal amounts until the gap between the two rollers, V, is a little more than the height of the heel of the unit to be tested.

6.2 Separate the two clamping plates of the forepart clamping unit, S, until the distance between them is a little greater than the thickness of the forepart of the unit plus its filler blocks. Also move the two clamping plates sideways until the face of one of them is vertically underneath the inner side of the corresponding roller, V, as judged by eye. (The right-hand side plate and roller have been aligned in figure 5.7/1.)

6.3 Insert the unit, heel end uppermost between the rollers, V, and the clamping plates so that its underside is adjacent to the roller and plate which have been aligned vertically. Position and clamp the forepart of the unit so that the top (rear) edges of the filler blocks are aligned with the top edges of the clamping plates of unit S, and the centre line of the unit (IJ in figure 5.7/2) is vertical and aligned with the centre line of the clamping plates. (The centre line of the heel should then align with the centre line of the flexing frame, T, in plan view.) Raise or lower clamping unit S until the lines MN and PR on the upper and lower surfaces of the heel of the unit are at the same level as the centres of the two rollers. If it is then apparent that the heel of the unit is much nearer one roller than the other, move clamp S sideways until the heel is approximately central.

6.4 The bottom unit is now correctly clamped. The springs, U, should now be set so that they apply the required deforming forces to the unit.

6.4.1 Advance the two springs, U, using adjustments, Z, until the two rollers, V, just touch the heel of the unit without compressing it. Reattach the two light springs, X. Set the flexing mechanism to give about half its maximum throw. Turn the motor by hand until one of the two springs, U, is compressed the maximum amount. Measure its compressed length and subtract this from its original length to obtain the amount of compression. Turn the motor further to compress the second spring fully and measure the amount it has been compressed. Average the two values of compression. Readjust the throw of the machine until the average compression of the two springs is within 1 mm of the value needed to provide the deformation force required for the test. The precise amount of compression required will depend on the compression characteristics of the springs used but, for guidance, approximate values are given in table 5.7/1.

Table 5.7/1. Approximate values of spring compression to produce the standard forces

	Force	Approximate spring compression
	N	mm
Men's normal conditions	118	21
Women's normal conditions	49	9
Women's accelerated test	98	18

6.4.2 If it is found that, with the throw at its maximum possible value, the desired compression of the spring still cannot be obtained, this shows that the unit is too flexible to be tested. Many units from women's shoes that are too flexible for the accelerated test can, however, be tested under normal conditions.

6.4.3 When the average force produced by the two springs is correct, adjust them individually, if necessary, by rotating the appropriate screw head (or heads), Z, until each spring compression is within 0.5 mm of the specified value.

Lock the spring adjustment mechanism so that it cannot move during the test.

Position the automatic cut off switches, Y, so that the movement of the roller frames, W, needed to operate them, beyond that required to deform the unit the maximum amount at the start of the test, is as given in table 5.7/2.

Table 5.7/2. Setting positions for the automatic cut-off switches

	mm
Men's normal conditions	12
Women's normal conditions	5
Women's accelerated test	10

6.4.4 Switch on the machine and allow it to run for a few seconds. Switch off and recheck the compressed lengths of the two springs. If they have changed appreciably (by more than a millimetre), check for any movement of the bottom unit in the clamping plates and reset the compressed length of the springs by resetting the flexing frame, T; also re-position the automatic cut-off switches, if necessary.

6.5 Set the cycle counter to zero and start the machine. If the bottom unit does not break, run it for at least the following number of cycles.

Men's and women's normal conditions: 500 000 cycles (approximately 65 h)

Women's accelerated test: 100 000 cycles (approximately 13 h)

Where time permits, however, run the test for twice these minimum periods.

If the bottom unit breaks, or bends to an appreciable extent, the cut-off switches will stop the machine automatically and this is the end of the test.

6.6 Record the number of cycles shown by the counter.

7. Expression of results

7.1 If the unit has failed during the test, record the number of cycles required to produce failure, and the type and position of the damage. A break in the forepart along the clamping line is accepted as a valid type of failure.

7.2 If the unit has not failed during the test, record the number of cycles at which the test was stopped, and the type and position of damage if there is any. If there is no damage, record the result as 'no damage'.

8. Test report

Include the following items in the test report:

(a) the results, expressed in accordance with clause 7;

(b) test conditions, i.e. whether 'men's' or 'women's' and whether 'normal' or 'accelerated';

(c) the nature and full identification of the sample;

(d) reference to the method of test (i.e. BS 5131 : Section 5.7);

(e) the date of testing.

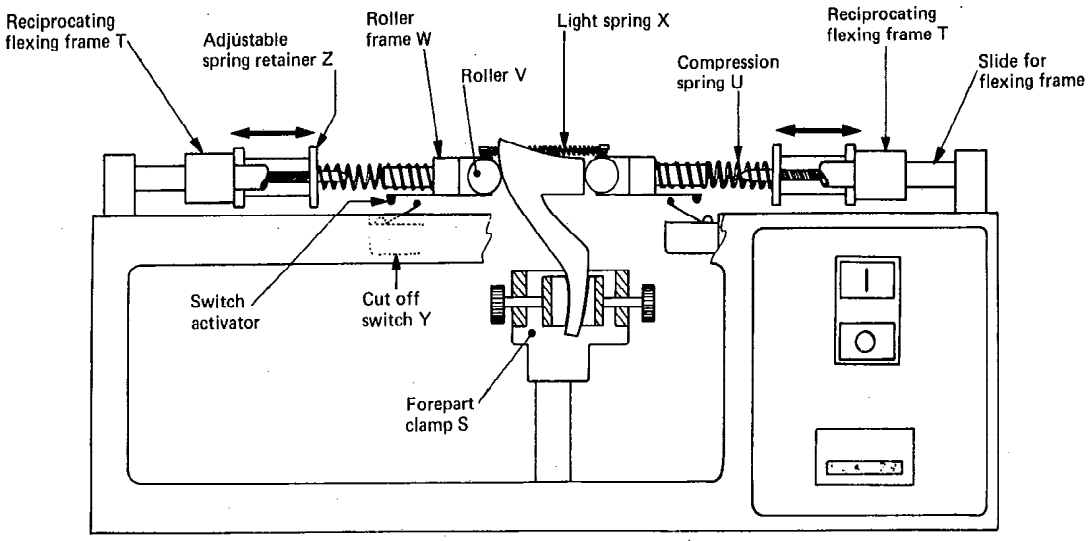

Figure 5.7/1. Fatigue tester

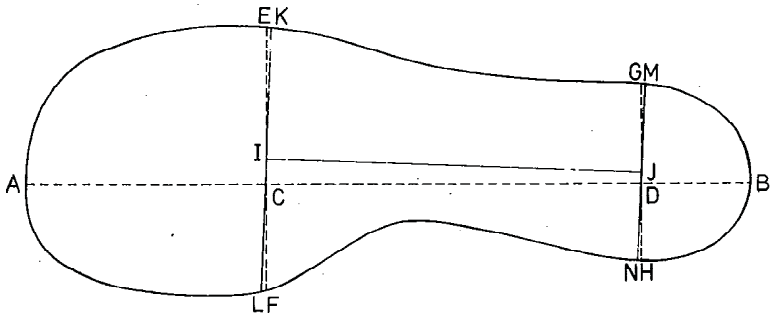

Figure 5.7/2. Determination of clamping positions

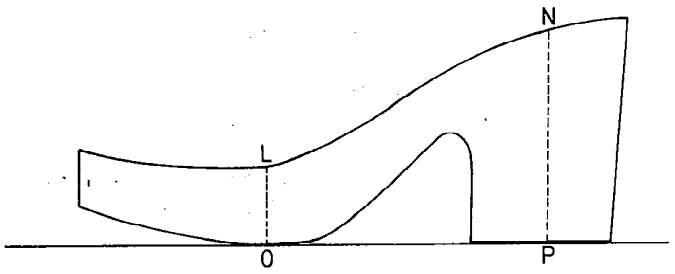

Figure 5.7/3. Determination of positions for applying deforming force

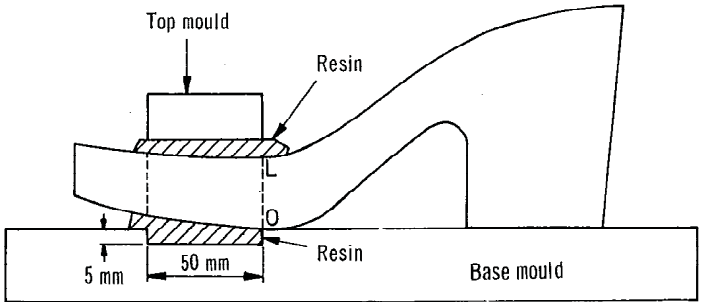

Figure 5.7/4. Position of unit in the base mould

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