

**BS 6811 :
Section 2.3 :
1992
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1985**

*(incorporating amendment 1 :
1988 and amendment 2 : 1992)*

Winding wires

Part 2. Methods of test

Section 2.3 Mechanical properties

Fils de bobinage
Partie 2. Méthodes d'essai
Section 2.3 Propriétés mécaniques

Wickeldrähte
Teil 2. Prüfung
Abschnitt 2.3 Mechanische Eigenschaften

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Committees responsible for this British Standard

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- British Cable Makers' Confederation
- British Non-ferrous Metals Federation
- British Railways Board
- Covered Conductors Association
- EEA (the Association of Electronics, Telecommunications and Business Equipment Industries)
- Electrical and Electronic Insulation Association
- Electronic Components Industry Federation
- Transmission and Distribution Association (BEAMA Ltd.)

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National foreword

This new edition of Section 2.3 of BS 6811 has been prepared under the direction of the Cables and Insulation Standards Policy Committee and is identical with IEC 851-3 : 1985 *Methods of test for winding wires Part 3 : Mechanical properties*, including amendment No. 1 1988 and amendment No. 2 1992, published by the International Electrotechnical Commission (IEC). This Section of BS 6811 supersedes BS 6811 : Section 2.3 : 1987 which is withdrawn.

Amendments to the text are indicated by a line in the margin.

NOTE. This Section should be read in conjunction with BS 6811 : Part 0 *General introduction and list of Parts*.

Cross-references

International standard	Corresponding British Standard
	BS 6811 <i>Winding wires</i> Part 2. <i>Methods of test</i>
IEC 851-1 : 1985	Section 2.1 : 1987 <i>General test conditions and schedule of tests</i> (Identical)
IEC 851-2 : 1985	Section 2.2 : 1987 <i>Determination of dimensions</i> (Identical)
IEC 851-5 : 1985	Section 2.5 : 1987 ¹⁾ <i>Electrical properties</i> (Identical)

The Technical Committee has reviewed the provisions of IEC 1033, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

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

¹⁾ BS 6811 : Section 2.5 : 1987 has been superseded by BS 6811 : Section 2.5 : 1992 which is identical with IEC 851-5 : 1988.

METHODS OF TEST FOR WINDING WIRES

Part 3: Mechanical properties

INTRODUCTION

The reader is referred to the General Introduction in I E C Publication 851-1: Methods of Test for Winding Wires, Part 1: General, which outlines the purpose of the new arrangement as indicated in the following table:

New arrangement without modification of the former texts

New clause	Former clause	Former publication
3	6	251-1
	6	251-3
	6	251-4
5.1.1	8.1	251-1
5.1.2	8.1	251-4
5.1.5	8.1	251-3
5.1.6	6	251-2
5.2	8.2	251-1
5.3	8.3	251-1
5.4	8.4	251-1
5.5.1	8.2.1	251-3
5.5.2	8.5	251-4

1. Scope

This standard relates to the following tests:

- Test 6: Elongation
- Test 7: Springiness
- Test 8: Flexibility and adherence
- Test 11: Resistance to abrasion
- Test 18: Heat and solvent bonding tests,

and groups the relevant texts previously laid down in the former I E C Publication 251.

2. Object

To standardize the mechanical properties of winding wires.

3. Test 6: Elongation

The elongation shall be measured with an elongation tester or a tensile test machine. The free measuring length shall be between 200 mm and 250 mm.

The wire shall be stretched at a rate of 5 mm/s $\pm$ 20%. The elongation shall be expressed as a percentage of the free measuring length.

Three measurements shall be made and the mean value taken as “elongation”.

4. Test 7: Springiness

4.1 Round wires with nominal conductor diameter up to and including 1.6 mm

– Nominal conductor diameter up to and including 1.6 mm

4.1.1 Method of test

A specimen of wire is wound five times round a mandrel with a diameter specified in the relevant specification sheet under the specified tension. The amount by which the end of the five turns recoils is measured.

4.1.2 Test apparatus

The general arrangement of the test apparatus is shown in Figure 1, page 24. The details of the mandrel are given in Table I and in Figure 2, page 24. (A helical groove, as indicated in Figure 2 may be used to facilitate winding, but the use of this groove is optional.)

The dial is marked with 72 equally spaced divisions so that the spring-back is read directly. The number read corresponds to the number of degrees each turn springs back.

4.1.3 Test procedure

The apparatus shall be mounted with the mandrel given in the relevant specification sheet locked in position with its axis horizontal, and so that the slot (or hole) for fastening the wire (and commencement of the helical groove, if used) correspond with “zero” of the dial.

The mandrel shall be dusted with powdered talc (french chalk) to prevent the wire clinging to the mandrel.

The specified load is attached to one end of the specimen of wire of about 1 m long. The handle is unlatched for free rotation. The other end of the wire is inserted into the slot or hole so that sufficient wire projects on the other side of the mandrel. The end is bent over to enable it to be held firmly to the mandrel. The weight shall be lowered carefully to apply tension to the wire. The wire is then hanging vertically below the mandrel with the dial zero and the slot or hole pointing vertically downward.

The free end of the wire being held securely, the mandrel shall be rotated counter-clockwise (looking at the face of the dial) by means of the handle, until five complete turns have been wound onto the mandrel (or into the groove, if used).

The mandrel shall be rotated further until the dial zero is vertically upwards and shall then be latched in this position. The wire shall be held in place on the mandrel, the load shall be removed and the wire shall be cut about 25 mm beyond the end of the fifth turn. This short piece of wire at the end of the fifth turn shall be bent into a vertical position in line with the dial zero to act as a pointer.

A pencil shall be placed to the left of the vertical piece of wire to prevent any sudden springback. The coil shall then be allowed to unwind slowly without jerking. If the wire springs back suddenly, erroneous results are obtained.

The mandrel and the dial are then unlatched and rotated to bring the pointer vertically upwards again. The bottom of the coil may be gently lifted once or twice with a finger to ensure that springback is complete.

The reading on the dial in line with the pointer indicates the springiness of the wire.

In the case of very springy wires, the pointer may recoil more than one complete revolution. It is then necessary to add 72 to the dial reading for each completed revolution of recoil.

TABLE I

Mandrel diameter (to bottom of groove) where used)	Dimension *				Depth of groove*	Width of groove*
	a	b	c	d	e	f
(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
3.0	6.0	6.0	30	0.25	0.04	0.15
5.0	6.0	7.5	32	0.25	0.08	0.30
7.0	6.0	9.0	34	0.40	0.12	0.50
10.0	6.0	9.0	34	0.60	0.16	0.70
12.5	6.0	9.0	40	0.80	0.20	0.80
19.0	10.0	11.0	45	1.20	0.30	1.20
25.0	12.5	12.5	45	2.00	0.15	0.75
37.5	12.5	14.5	47	2.40	0.25	1.25
50.0	12.5	17.5	50	2.80	0.40	2.00

* See Figure 2, page 24.

4.1.2 Nominal conductor diameter over 1.6 mm

Test under consideration.

4.2 Round wires with nominal conductor diameter over 1.6 mm and rectangular wires

4.2.1 Principle of test

The test consists of bending a specimen over a 30° angle, then removing the load and measuring the springback in degrees.

4.2.2 Specimen

The sample shall be at least 1 200 mm long and shall be removed from the spool with as little bending as possible. It shall be carefully straightened by hand and cut into 400 mm specimens. Work-hardening should be minimized. Elongation by machine should not be used for straightening.

4.2.3 Test apparatus

The springback is determined by means of the apparatus in figure 10 consisting essentially of two smooth jaws, one fixed (2), the other movable (1) and a sector graduated in degrees (5) with the 0° to 10° sector of the scale graduated in 0.5° increments.

The test apparatus shall be placed in a horizontal position on the test table. The graduated sector is an arc placed in a plane at 90° to the clamp faces. Its centre is located at the outer edge of the fixed jaw (3). The lever arm whose fulcrum is placed at the centre of the arc can move over the graduated sector in the horizontal plane. The lever arm shall have a sharp pointer or marker to measure clearly the springback. On the lever arm, which has approximately 305 mm length scaled off in millimetres, whose origin is at the fulcrum, there is a movable slider (4) with edged knife.

4.2.4 *Test procedure*

The test shall be made by bending the wire specimens in the same direction in which the wire was bent when wound on the spool. The bare wire thickness (or round wire diameter) shall be measured for determining the actual position of the slider. This thickness (or diameter) multiplied by 40 locates the slider to a specific dimension along the lever arm.

The specimen is moderately tightened between the jaws, sufficiently to prevent slipping with the direction of the former curvature *upwards*, or away from the operator to leave a free length of specimen extending approximately 12 mm beyond the slider knife edge.

By means of the lever arm, starting at the initial position (the 30° scale mark, position 1), the wire is gently bent 30° (to the 0° scale mark, position 2). The time of this bending shall be not less than 2 s, not more than 5 s.

The specimen is held at the 0° point (bent at 30°) for a maximum of 2 s.

The lever arm is gently returned in the reverse direction at the same angular rate at which it was initially moved until the slider knife edge moves away from the wire specimen. The lever arm is again raised until the slider knife edge again just contacts the wire specimen without moving it. The lever arm pointer will now indicate the springback in degrees.

4.2.5 *Value of springback*

The value of the springback (α) is read on the scale shown by the position of the lever arm on the graduated sector in position 3.

Three specimens shall be tested. The results of the three specimens shall not differ by more than 1° over a consecutive length of sample. The declared result shall be the average of the three specimens.

5. **Test 8: Flexibility and adherence**

5.1 *Mandrel winding test*

5.1.1 *Enamelled round wires*

A specimen of wire shall be wound for ten contiguous turns round a polished mandrel of the diameter given in the relevant specification sheet.

The mandrel shall be rotated between 1 rev/s and 3 rev/s, the tension of the wire being just sufficient to keep it in contact with the mandrel. Elongation or twisting of the wire shall be avoided.

If the relevant specification sheet calls for pre-stretching (before the wire is wound on the mandrel), a specimen of wire 200 mm to 250 mm long between grips shall be stretched to the specified percentage at a rate of 5 mm/s $\pm$ 20%.

After winding, the specimen shall be examined for cracks* under a magnification of:

- 10 to 15 times for nominal conductor diameters up to and including 0.04 mm;
- 6 to 10 times for nominal conductor diameters over 0.04 mm up to and including 0.5 mm;
- normal vision or up to six times for nominal conductor diameters over 0.5 mm.

Three tests shall be made.

* A "crack" is an opening in the insulation which exposes the bare conductor to view at the stated magnification.

5.1.2 *Fibre insulated round wires*

A specimen of wire shall be wound for ten contiguous turns round a polished metal mandrel of a diameter given in the relevant specification sheet.

The mandrel shall be rotated at between 1 rev/s and 3 rev/s, the tension of the wire being just sufficient to keep it in contact with the mandrel. Elongation or twisting of the wire shall be avoided.

The specimen shall be tested in accordance with Sub-clause 4.6.1 *a)* of I E C Publication 851-5: Methods of Test for Winding Wires, Part 5: Electrical Properties.

Five tests shall be made.

5.1.3 *Fibre covered enamelled round wires*

A specimen of wire shall be wound for ten contiguous turns round a polished metal mandrel of a diameter given in the relevant specification sheet leaving straight ends long enough for the electric strength test in accordance with Sub-clause 4.6.1 *b)* of I E C Publication 851-5.

The mandrel shall be rotated between 1 rev/s and 3 rev/s, the tension of the wire being just sufficient to keep it in contact with the mandrel. Elongation or twisting of the wire shall be avoided.

The specimen shall be examined for exposure of the bare conductor or underlying enamel with normal vision or magnification up to six times. If such exposure cannot be seen, the wire shall be tested in accordance with Sub-clause 4.6.1 *b)* of I E C Publication 851-5.

5.1.4 *Tape wrapped and bonded round wires*

A specimen of wire shall be wound for ten contiguous turns round a polished metal mandrel of a diameter given in the relevant specification sheet leaving straight ends long enough for the electric strength test in accordance with Sub-clause 4.6.1 *c)* of I E C Publication 851-5.

The mandrel shall be rotated between 1 rev/s and 3 rev/s, the tension of the wire being just sufficient to keep it in contact with the mandrel. Elongation or twisting of the wire shall be avoided.

The specimen shall be examined for cracks or delamination with normal vision or magnification up to six times.

If no crack* or delamination can be seen the specimen shall then be tested on break-down voltage in accordance with Sub-clause 4.6.1 *c)* of I E C Publication 851-5.

5.1.5 *Rectangular wires*

A specimen shall be bent through 180° round a mandrel of the diameter as given in the relevant specification sheet in two directions to form an elongated S-shape. The straight part between the U-shape bends shall be at least 150 mm.

Care should be taken to ensure that the specimen does not buckle or depart from a uniform bend. A suitable apparatus is shown in Figure 3, page 25.

The insulation shall be examined for cracks in the case of enamelled wires, and for openings in the case of fibre-insulated wires under a magnification of 6 to 10 times.

In the case of fibre-insulated wires only, if no opening can be seen, the specimen shall be subjected to the breakdown voltage test of Sub-clause 4.6.2 of I E C Publication 851-5.

Two specimens shall be bent, one flatwise (on the thickness), and one edgewise (on the width).

5.1.6 *Bunched wires (covering)*

The bunched wire shall be wound on a mandrel having a diameter as given in the specification sheet under a tension given in Sub-clause 3.2.1 c) of I E C Publication 851-2: Methods of Test for Winding Wires, Part 2: Determination of Dimensions.

In winding the bunched wire round the mandrel, care should be taken not to introduce a twist in the bunched wire for each revolution.

The winding then shall be examined by normal vision in diffused light to establish the required degree in the closeness of the covering.

One test shall be made.

5.2 *Stretching test (applicable to enamelled round wires)*

A specimen of wire having a length of 200 mm to 250 mm between grips shall be stretched to the specified percentage at a rate of 5 mm/s $\pm$ 20%.

After stretching, the specimen shall be examined for cracks or loss of adhesion under a magnification of:

- 10 to 15 times for nominal conductor diameters up to and including 0.04 mm;
- 6 to 10 times for nominal conductor diameters over 0.04 mm up to and including 0.5 mm;
- normal vision or up to six times for nominal conductor diameters over 0.5 mm.

Three tests shall be made.

5.3 *Jerk test (applicable to enamelled round wires)*

A specimen of wire having a length of 250 mm between the clamps of the testing apparatus, shown in Figure 4, page 26, shall be suddenly stretched to the breaking point or to an elongation given in the relevant specification sheet.

The specimen shall be examined for cracks or loss of adhesion under a magnification of:

- 10 to 15 times for nominal conductor diameters up to and including 0.04 mm;
- 6 to 10 times for nominal conductor diameters over 0.04 mm up to and including 0.5 mm;
- normal vision or up to six times for nominal conductor diameters over 0.5 mm.

The distance of 2 mm from the broken ends shall be disregarded.

Three tests shall be made.

5.4 *Peel test (applicable to enamelled round wires)*

A specimen of wire of about 600 mm length shall be placed in a test apparatus shown in Figure 5, page 27, consisting of two fixing devices 500 mm apart in the same axis. One of these is able to rotate. The other cannot rotate but can be displaced axially; the latter is loaded according to Table II to apply tension to the rotating wire.