

**SPECIFICATION FOR
ENAMELLED
COPPER CONDUCTORS
TEMPERATURE INDEX 155
(Modified polyester base)**

Part 2. Rectangular conductors

BS 4720 : Part 2 : 1971

BRITISH STANDARDS INSTITUTION

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THIS BRITISH STANDARD, having been approved by the Electrical Industry Standards Committee, was published under the authority of the Executive Board on 17 March, 1971.

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SBN: 580 06478 6

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In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 5000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook, price £1.50. The BS Yearbook may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

- BS 1036. Electrolytic tough pitch high conductivity copper.
- BS 2045. Preferred numbers.
- BS 2565. Drums for covered winding wires and strips for electrical purposes for use in the United Kingdom.
- BS 3239. Determination of resistivity of metallic electrical conductor materials.

British Standards are revised, when necessary, by the issue either of amendment slips 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.

The following BSI references relate to the work on this standard:
Committee reference ELE/36 Draft for comment 69/29908

Printed in England by Gaylard & Son Ltd, London, S.E.14

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CO-OPERATING ORGANIZATIONS

The Electrical Industry Standards Committee under whose supervision this British Standard was prepared consists of representatives from the following Government departments and scientific and industrial organizations:

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- Association of Mining, Electrical and Mechanical Engineers
- Association of Supervisory and Executive Engineers
- *British Electrical and Allied Manufacturers' Association
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- *Electronic Engineering Association
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- Lighting Industry Federation Limited
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- *Post Office
- Public Transport Association (Incorporated)
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The Government department and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

- Association of Manufacturers of Domestic Electrical Appliances
- British Fractional Horsepower Electric Motor Manufacturers' Association
- British Non-Ferrous Metals Federation High Conductivity Copper Group
- Copper Development Association
- Covered Conductors Association
- Radio and Electronic Component Manufacturers' Federation
- Society of Motor Manufacturers and Traders Limited
- Telecommunication Engineering and Manufacturing Association
- Telephone Manufacturers' Technical Development Committee

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FOREWORD

In accordance with the practice of publishing British Standards which are as nearly as possible in line with internationally agreed recommendations, this standard closely follows the dimensions given in IEC Publication . . .*, the requirements given in IEC Publication . . .* and methods of test given in IEC Publication . . .*.

Unlike the IEC Recommendation for enamelled rectangular wire with up-graded thermal endurance properties, the scope of this British Standard has been limited to a modified polyester enamel.

A test for thermal endurance has been introduced. The test procedure is in accordance with IEC Publication 172†, except that the median value has been adopted to shorten the duration of the test. The test may also be used for the assessment of the comparative thermal endurance of enamelled wires in conjunction with varnishes but, because the manufacturer of the enamelled wire does not control the varnish used in treating windings, it must not be assumed that the stated life will be appropriate for varnished wires.

The schedule of preferred sizes of conductors includes only some of the sizes in the R' series‡ in general use for transformer windings.

An alternative method of test for breakdown voltage, which is at present in use in some other countries and is described in the methods of test given in IEC Publication . . .*, is being examined for possible inclusion at a later date.

SI units are used in preference to 'metric technical units'. The relationship between the units of force in the two systems is $1 \text{ N} = 0.102 \text{ kgf}$.

SPECIFICATION

1. SCOPE

1.1 General. This Part of BS 4720 gives requirements and dimensions for solid copper conductors of rectangular section, covered with a modified polyester enamel having a temperature index of 155, e.g. polyester imide enamel.

* In course of preparation.

† IEC Publication 172, 'Test procedure for the evaluation of the thermal endurance of enamelled wire by the lowering of the electric strength between twisted wires'.

‡ See BS 2045, 'Preferred numbers'.

1.2 Sizes. The requirements of the standard are applicable to conductors having thicknesses from 0.80 mm up to 5.60 mm, and widths of 2.0 mm to 16.0 mm.

A schedule of preferred sizes is given in Appendix A and Table 7.

1.3 Thickness of covering. Two thicknesses of covering, Grade 1 and Grade 2, are specified.

2. DEFINITIONS

For the purposes of this Part of this British Standard, the following definitions apply:

(1) *Wire.* The insulated material as received.

(2) *Conductor.* The bare metal after removal of the enamel.

(3) *Increase in dimensions due to the covering.* The difference between the width or thickness over the enamel and the corresponding dimension of the conductor.

(4) *Tolerance.* The permissible divergence of an actual magnitude from that prescribed.

(5) *Crack.* Any discontinuity in the enamel which penetrates significantly below the surface and which is visible at the stated magnification.

(6) *Temperature index.* The Celsius temperature corresponding to an extrapolated life of 20 000 h on an Arrhenius plot.

NOTE. The plot uses the straight line of best fit to the measured lives of groups of specimens aged at not less than three elevated temperatures in accordance with IEC Publication 172*.

3. GENERAL REQUIREMENTS AND TEST CONDITIONS

3.1 Unless otherwise specified, all tests shall be carried out within a temperature range of 15°C to 35°C and a relative humidity range of 45 % to 75 %. Before measurements are made, the specimens shall be preconditioned under these atmospheric conditions for a time sufficient to allow the specimens to reach stability.

3.2 The wire to be tested shall be removed from the packaging in such a way that the wire will not be subjected to tension or unnecessary bends. Before each test, sufficient wire shall be discarded to ensure that no damaged wire is included in the test specimens.

3.3 When no specific range of sizes is given for a test, the test is applicable to all sizes.

* IEC Publication 172, 'Test procedure for the evaluation of the thermal endurance of enamelled wire by the lowering of the electric strength between twisted wires'.

4. CONDUCTOR

4.1 Materials. The high conductivity copper used in manufacturing the wire shall comply with the requirements of BS 1036*.

4.2 Tolerance on conductor dimensions. The conductor dimensions shall not differ from the nominal values by more than the tolerances given in Table 1.

TABLE 1. TOLERANCES ON DIMENSIONS

Width or thickness		Tolerance ±
Over	Up to and including	
mm	mm	mm
—	3.15	0.030
3.15	6.30	0.050
6.30	12.50	0.070
12.50	16.00	0.100

4.2.1 Radius on corners. The radius on the corners of the bare conductor shall be maintained within 25 % of the values given in Table 2. They shall merge smoothly into the flat, and the conductor shall be free from sharp, rough and projecting edges.

TABLE 2. RADIUS ON CORNERS

Nominal thickness of conductor		Corner radius
Over	Up to and including	
mm	mm	mm
—	1.00	Semicircular
1.00	1.60	0.50†
1.60	2.24	0.65‡
2.24	3.55	0.80
3.55		1.00

* BS 1036, 'Electrolytic tough pitch high conductivity copper'.

† Or semicircular for wires with widths greater than 4.75 mm when so agreed between the purchaser and the manufacturer.

‡ Or 0.80 mm for wires with widths greater than 4.75 mm when so agreed between the purchaser and the manufacturer.

4.3 Resistance of conductor. The resistance of the wire shall be expressed as the d.c. resistance at 20 °C. The method used shall provide an accuracy of not worse than 0.5 % and is described in BS 3239*.

One measurement shall be made.

If the resistance is measured at a temperature t other than 20 °C (R_t), the resistance R_{20} at 20 °C shall be calculated by means of the formula:

$$R_{20} = \frac{R_t}{1 + \alpha(t - 20)}$$

where: t is the actual temperature in degrees Celsius during the measurement,
and

α is the temperature coefficient (for the particular case of copper,
 $\alpha = 0.00393$).

The measured value of resistance shall be not greater than the value calculated from the measured dimensions of the conductor and a resistivity of $1/57.5$ (0.01739) $\Omega \text{ mm}^2 \text{ m}^{-1}$.

5. ENAMEL COVERING

5.1 General. The conductor shall be completely and uniformly covered with a durable, flexible, synthetic enamel based on a modified polyester resin, e.g. polyester-imide. The enamel shall have a smooth surface, free from embedded particles of dust and other deleterious material.

5.2 Increase in dimensions due to the enamel. The dimensions of the conductor and the enamelled wire shall be determined by the method described in Appendix B. The increase in width and thickness shall be not less than the minimum value given in Table 3. The overall width and thickness shall be not greater than the sum of the maximum conductor width or thickness, as specified in 4.2, and the maximum increase in dimensions given in Table 3.

TABLE 3. INCREASE IN DIMENSIONS DUE TO THE ENAMEL

Grade	Increase in dimension	
	Min.	Max.†
	mm	mm
1	0.060	0.110
2	0.110	0.160

* BS 3239, 'Determination of resistivity of metallic electrical conductor materials'.

† The maximum increase may be exceeded provided that the maximum overall dimension does not exceed the maximum permitted dimension of the bare conductor plus the maximum increase given above.