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Full document details: BS 480-2:1954

Superseded by 480: 1960
+ 6 amendments

BRITISH STANDARD 480 : PART 2 : 1954

IMPREGNATED PAPER-INSULATED CABLES

FOR ELECTRICITY SUPPLY

Part 2 : Aluminium sheathed cables for working voltages up to and including 22kV

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IMPREGNATED PAPER-INSULATED CABLES FOR ELECTRICITY SUPPLY

Part 2. Aluminium sheathed cables for working voltages up to and including 22kV

B.S. 480 : Part 2 : 1954

Price ~~3/-~~ 6/- net

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THIS BRITISH STANDARD, having been approved by the Electrical Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on 23rd July, 1954.

First published : March, 1933.
First revision : May, 1942.
Second revision : July, 1954

The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

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 2000, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook, price 12s. 6d.

This standard makes reference to the following British Standards :—

B.S. 77. Voltages for a.c. transmission and distribution systems of authorized undertakers.
B.S. 84. Screw threads of Whitworth form.
B.S. 205. Glossary of terms used in electrical engineering.
B.S. 350. Conversion factors and tables.
B.S. 443. The Testing of the zinc coating on galvanized wires.
B.S. 801. Lead and lead-alloys ~~for cable sheathing~~. Sheaths of electric cable.
B.S. 1442. Galvanized mild steel wire for armouring cables.
B.S. 1471. Wrought Aluminium and aluminium alloys. Tubes.

Amd. 2.

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 B.S.I. references relate to the work on this Standard :—
Committee reference ELE/3/10 Draft for comment CR(ELE) 501

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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 :—

*Admiralty
*Air Ministry
*Association of Consulting Engineers (Incorporated)
*Association of Supervising Electrical Engineers
*British Electrical and Allied Industries Research Association
British Electrical and Allied Manufacturers' Association
British Electrical Development Association
*British Electricity Authority and Area Boards
*British Railways. The British Transport Commission
*Cable Makers' Association
*Crown Agents for Oversea Governments and Administrations
Electric Lamp Manufacturers' Association
Electric Light Fittings Association
*Electrical Contractors' Association (Incorporated)
Electrical Contractors' Association of Scotland
Engineering Equipment Users' Association
*General Post Office
*Institution of Electrical Engineers
*Ministry of Fuel and Power
Ministry of Labour and National Service (Factory Dept.)
*Ministry of Supply
*Ministry of Works
*National Physical Laboratory
*North of Scotland Hydro Electric Board
Oil Companies Materials Committee
Public Transport Association (Incorporated)
Radio Industry Council
War Office

The Government departments 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 the standard :—

British Plastics Federation
British Steel Wire Industries Association
Engineering Standards Co-ordinating Committee, Cables and Wires Panel
Independent Cable Makers' Association
London Transport Executive
Municipal Passenger Transport Association
National Coal Board

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BRITISH STANDARD SPECIFICATION FOR

IMPREGNATED PAPER-INSULATED CABLES FOR ELECTRICITY SUPPLY

Part 2. Aluminium sheathed cables for working voltages up to and including 22kV

FOREWORD

This revision of B.S. 480 includes the requirements for lead or lead-alloy sheathed cables, and aluminium sheathed cables, which are dealt with in separate, self-contained parts as follows :—

Part 1. Lead or lead-alloy sheathed cables for working voltages up to and including 33 kV.

Part 2. Aluminium sheathed cables for working voltages up to and including 22 kV.

This British Standard now contains ' quality ' clauses dealing with the composition of the various components of the cable.

Part 2 of the standard is similar to Part 1 except with regard to those requirements relating to the aluminium sheath and protective covering. It is published separately from Part 1 as it is expected that an early revision will be necessary after further experience in the manufacture of aluminium sheathed cable. This part applies only to cables with swaged seamless aluminium sheath for working voltages up to and including 22 kV. Such cables, owing to the comparative hardness of the sheath, are not generally required to be armoured as are lead sheathed cables, but for special conditions, where armouring is considered necessary, dimensions are specified.

It will also be noted that the bending test only requires two cycles of operations compared with three in Part 1 for lead sheathed cables, and is related to the diameter over the sheath. This is due to the physical characteristics of the aluminium sheath.

The practice introduced into Part 1 of specifying nominal diameters has been followed.

Cables which comply with the requirements for minimum insulation and sheath thickness will have the stated nominal diameters, which allow reasonable manufacturing tolerances.

When cable is to be installed in vertical (or steeply inclined) situations, and/or where compliance with the requirements of Clause 26*b* is required, this should be stated when asking for a quotation or placing an order.

For details of current ratings and maximum permissible operating conductor temperatures, reference should be made to the Regulations for the Electrical Equipment of Buildings issued by the Institution of Electrical Engineers, where applicable, and otherwise to Electrical Research Association Report F/T 183.*

See Amdt No. 1

SPECIFICATION

SECTION ONE : GENERAL

SCOPE

1. Part 2 of this British Standard relates to impregnated paper-insulated swaged seamless aluminium sheathed cables for operating voltages up to and including 22 kV.

The operating voltage mentioned at the head of Tables 8–15 and Table 17 is the system voltage, as defined in B.S. 77**, for which the cables are designed and it refers to :—

a. the voltage between phases, in three-phase systems ;

b. the voltage between outer conductors, in three-wire a.c. or d.c. systems ;

c. the voltage between conductors, in two-wire a.c. or d.c. systems.

For the purpose of this standard a system may be considered to be an earthed system if :—

(i) the neutral point is earthed in such a manner that the maximum voltage which can occur between any conductor and earth does not exceed 80 per cent. of the system voltage, *or*

(ii) a device is installed which automatically and instantly cuts out any part of the system which becomes accidentally earthed, *or*

(iii) the neutral point is earthed through an arc suppression coil with arrangements for isolation within an hour of the occurrence of a fault. For cables for 11kV and over, excluding belted cables, this period may be increased to eight hours per operation provided that the total period in any year does not exceed 125 hours.

DEFINITIONS

2. For the purposes of this British Standard the definitions relating to electric cables, in B.S. 205, ' Glossary of terms used in electrical engineering ', shall apply, with the addition of the following :—

S.A. cable. A three-core cable in which each core is individually aluminium sheathed.

* This report supersedes E.R.A. Report F/T 128.

** B.S. 77, ' Voltages for a.c. transmission and distribution systems of authorized undertakers '.

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Amdt No. 6

INTERNATIONAL STANDARDS OF RESISTANCE FOR COPPER

3. The following values adopted by the International Electrotechnical Commission* for 'standard annealed copper' have been taken as standard for annealed high-conductivity copper :—

a. At a temperature of 20°C. the volume resistivity of standard annealed copper is 1/58 = 0·017 241 . . . ohm square millimetre per metre, $\left(\frac{\text{ohm mm}^2}{\text{m}}\right)$. Copper which has this resistivity is said to have a conductivity of 100 per cent.

b. At a temperature of 20°C., the density of standard annealed copper is 8·89 grammes per cubic centimetre, $\left(\frac{\text{g}}{\text{cm}^3}\right)$

c. At a temperature of 20°C., the coefficient of linear expansion of standard annealed copper is 0·000 017 per degree Centigrade.

NOTE. The above value of the coefficient of linear expansion may be applied to annealed copper over a temperature range from 0°C. to 150°C.

d. At a temperature of 20°C., the coefficient of variation of the resistance with temperature of standard annealed copper, measured between two potential points rigidly fixed to the wire, the metal being allowed to expand freely, is :—

$$0{\cdot}003\,93 = \frac{1}{254{\cdot}45\ldots} \text{ per degree Centigrade.}$$

e. As a consequence, it follows from *a* and *b* that at a temperature of 20°C. the mass resistivity of standard annealed copper is 1/58 × 8·89 = 0·153 28 . . . ohm gramme per metre per metre.

NOTE. For the purpose of calculating the tables, the decimal equivalent of 1/58 has been extended to 0·017 241 379 . . . .

RESISTANCE OF A SOLID CONDUCTOR AT 20°C.

4. For the purpose of calculating the tables, the resistance of a solid conductor of standard annealed copper at 20°C., 1000 yards in length, and of a uniform cross-sectional area of one square inch, has been taken as 0·024 436 6 ohm.

TABLES FOR CONVERTING VALUES FROM BRITISH TO METRIC MEASURE

5. The metric equivalent of the dimensions given in this specification may be obtained from B.S. 350, 'Conversion factors and tables'.

DIMENSIONS, WEIGHTS AND RESISTANCES OF STANDARD COPPER WIRES AND STRANDED CONDUCTORS

6. The dimensions, nominal weights, and resistances of standard circular copper wires used for circular conductors shall be in accordance with the values specified in Table 5.

* I.E.C. Publication No. 28.

The dimensions, nominal weights and resistances of standard circular stranded conductors shall be in accordance with the values specified in Table 6.

The standard resistances of shaped conductors shall be in accordance with the values specified in Table 6. In the formation of shaped conductors containing less than 19 wires the same number of wires shall be used as for a circular conductor of equivalent area. For conductors having 19 wires or more the number of wires shall be the same as in a circular conductor of equivalent area, subject to a maximum permissible variation of plus or minus one wire. All the wires in any given shaped conductor shall be of the same nominal size.

In Table 6 the areas and resistances of the stranded conductors have been calculated by multiplying the corresponding values for one of the single wires of which the stranded conductor is composed, by the constants specified in Table 1, which allows for an increase of 2 per cent in the length of each wire, except the centre wire.

TABLE 1. CONSTANTS FOR THE CALCULATION OF CROSS-SECTIONAL AREAS AND RESISTANCES OF STRANDED CONDUCTORS

Number of wires stranded	Constant	
	Area	Resistance
7	6·882 35	0·145 299
19	18·647 1	0·053 627 8
37	36·294 1	0·027 552 7
61	59·823 5	0·016 715 8
91	89·235 3	0·011 206 3
127	124·529	0·008 030 23

Amdt No. 6.

TOLERANCES ON THE STANDARD RESISTANCE OF WIRE AND STRANDED CONDUCTORS

7. The tolerances on the standard resistance of wires and stranded conductors shall be as specified in Table 2.

TABLE 2. TOLERANCES ON RESISTANCE OF WIRES AND STRANDED CONDUCTORS

Conductors	Tolerance on resistance
	per cent
Circular wires	+3
Stranded conductors	+2

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The values corresponding to the tolerances shown above are specified in Tables 5 and 6. In Table 6 an additional 2 per cent increase in resistance is allowed for twin and multicore cables, to take into account the increase in length due to the laying up of the cores.

Amdt No. 6

FORM OF CONDUCTORS

8. Unless otherwise specified in the tables the conductors of all twin and multicore cables are shaped.

VARIATION OF RESISTANCE WITH TEMPERATURE

9. The constants for converting the resistance of annealed copper at a temperature T°C. to the standard temperature 20°C. shall be as specified in Columns 2 and 5 of Table 7, and the reciprocals for converting the resistance at 20°C. to the resistance of T°C. shall be as specified in Columns 3 and 6 of Table 7.

SECTION TWO : CONSTRUCTION

Amdt 4.

CONDUCTORS See Amdt No. 6.

Page 8

10. *a. Materials.* The conductor shall be composed of plain annealed copper wire, which, before stranding, shall be approximately circular in section, smooth, uniform in quality, free from scale, inequalities, spills, splits and other defects.

The term 'annealed' signifies that the wire before stranding is capable of at least 15 per cent elongation without fracture, the test piece being not less than 6 in. and not more than 12 in. long.

The stranded conductor shall be clean and reasonably uniform in size and shape and its surface shall be free from sharp edges.

b. Jointing. Not more than two joints shall be allowed in any one of the single wires forming every complete length of conductor, and no joint shall be within 12 in. of any other joint in the same layer. Joints shall be brazed, silver soldered or electrically welded. No joint shall be made in the conductor after it has been stranded.

INSULATION

11. *a. Paper.* All paper used for cable insulation shall be uniform in texture, long fibred and free from dark spots, imperfectly pulped materials, woody matter, lime spots, metallic particles ~~or~~ and other deleterious substances. It shall contain no mechanical wood pulp or esparto.

The paper shall be free from chemical impurities, acids, alkalis and salts to the extent that not more than 1 per cent by weight is soluble in

water. Chemicals used in pulping, bleaching or other process of manufacture shall be removed. The paper shall be free from loading materials and from gelatine, albumen and resin size. The ash from a moisture free sample shall not exceed 1·5 per cent by weight.

The paper shall be applied in the form of tapes laid helically, successive layers when applied in the same direction breaking joint so as to form a reasonably smooth and compact covering of uniform thickness.

Samples of crease-free impregnated paper tapes shall be taken from completed cables when requested and, when tested by the following method, the breaking strength of the test strips specified shall be not less than 4 lb. per mil of thickness and the elongation at break shall be not less than 1·5 per cent.

Method. Cut the impregnated paper tapes into strips ⅝ in. wide and not less than 9 in. long and condition them for 24 hours at a relative humidity of 65 per cent and a temperature of 17-~~20~~ 21°C. After removing surplus compound, measure the thickness of the conditioned impregnated paper tapes to the nearest 0·1 mil (0·0001 in.), and then test the tapes in a tensile testing machine having a distance of approximately 7 in. between grips. Amdt No. 1 Page 23

b. Core identification. All 1100 volt twin and multicore cables shall have the cores identified by numbers printed on the outer layer (or layers) of paper at frequent intervals as shown below. The numbers 1, 2 and 3 indicate live conductors and 0 the neutral.

Twin { 0, 1

3-core { 0-1, 2, 3

4-core { 0, 1, 2, 3

5-core { 0, 1, 2, 3, 4 (special-purpose conductor)

The sequence of laying up of the cores shall be as shown above. All 3-core cables for voltages of 3300 volts and above shall have the cores identified by numbers as follows :—

1 2 3

The printing shall preferably be in white on a dark background.

The core identification tapes shall comply with the requirements of Sub-clause *a*. The dyes used shall not fade unduly, shall be chemically neutral, and shall have no injurious effect on the fibres of the paper.

c. Screening. For cables described in the tables as screened cables, the screening applied over each individual core shall consist of either

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