

Specification for

Impregnated paper-insulated lead or lead alloy sheathed electric cables of rated voltages up to and including 33 000 V

ICS 29.060.20

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the General Electrotechnical Engineering Standards Committee (GEL/-) to Technical Committee GEL/3, upon which the following bodies were represented:

Aluminium Federation
 Association of Consulting Engineers
 Association of Manufacturers of Domestic Electrical Appliances
 British Approvals Service for Electric Cables
 British Cable Makers' Confederation
 British Plastics Federation
 British Railways Board
 British Shipbuilders
 British Telecommunications plc
 Department of Energy (Electricity Division)
 Department of the Environment (Property Services Agency)
 Department of Trade and Industry (Consumer Safety Unit, CA Division)
 ERA Technology Ltd.
 Electricity Supply Industry in England and Wales
 Engineering Equipment and Materials Users' Association
 Institution of Electrical Engineers
 London Regional Transport
 Ministry of Defence

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Association of Supervisory and Executive Engineers
 British Cable Makers' Confederation (Supertension Cables Group)
 British Gas plc

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Foreword

This British Standard has been prepared under the direction of the General Electrotechnical Engineering Standards Committee.

This reprinted edition incorporates Amendments Nos. 1, 2 and 3.

BS 6480, as amended by Amendment No. 1:1995, Amendment No. 2:1997 and Amendment No. 3:2006, includes the technical content of HD 621 S1:1996, sections 3-J1, 3-J2, 4-J1 and 4-J2.

NOTE BS 7894 implements HD 621 S1:1996, section 4-J3.

Attention is drawn to the recommendations for the selection and operation of cables, and installation, which are given in Appendix A and Appendix B.

The contents of this British Standard cover subject matter similar to that covered by IEC 60055-1 and IEC 60055-2. The dimensional requirements for the cables specified in the British Standard are, however, at variance with those quoted in the IEC publication. This is due to the fact that because of different installation conditions in the UK, it has not been possible to adopt the IEC publication as a national standard, although it is recognized that IEC 60055 was approved as being the best agreement, from a world-wide point of view, possible at present.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 58, an inside back cover and a back cover.

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1 Scope

This British Standard specifies requirements for construction and dimensions and describes methods of test for impregnated paper-insulated lead or lead alloy sheathed cables for operation in systems of nominal voltages up to and including 33 000 V between phases. It applies to mass-impregnated non-draining cables of the categories stated below, for continuous operation at conductor temperatures not exceeding the values given.

600/1 000 V: single-core, two-core, three-core, four-core and five-core (80 °C max.).

1 900/3 300 V and 3 800/6 600 V: single-core and three-core belted (80 °C max.).

3 300/3 300 V and 6 600/6 600 V: three-core belted (80 °C max.).

6 350/11 000 V and 8 700/11 000 V: three-core belted (65 °C max.).

6 350/11 000 V and 8 700/15 000 V: single-core and three-core screened (70 °C max.).

12 700/22 000 V and 19 000/33 000 V: single-core and three-core screened, and three-core lead or lead alloy sheathed (SL) (65 °C max.).

NOTE 1 The titles of the publications referred to in this standard are listed on the inside back cover.

NOTE 2 Attention is drawn to Appendix F which lists information to be supplied with the enquiry or order.

2 Definitions

For the purposes of this British Standard the definitions given in BS 4727-2:Group 08 apply, together with the following.

2.1

rated voltage, U_o

the nominal power-frequency voltage between conductor(s) and earth for which the cable is suitable

2.2

rated voltage, U

the nominal power-frequency voltage between phase conductors for which the cable is suitable

2.3

maximum voltage, U_m

the maximum sustained power-frequency voltage between phase conductors for which the cable is suitable

2.4

nominal value

the value by which a quantity is designated and which is often used in tables

NOTE Usually, in this standard, nominal values give rise to values to be checked by measurements taking into account specified tolerances.

2.5

approximate value

a value which is only indicative

NOTE In this standard, values described as “approximate” do not constitute requirements to be checked by measurements.

3 Voltage designation

The cables shall be designated by the rated voltages U_o and U , expressed in the form U_o/U .

In addition, in the heading of each of the Table 11 to Table 38 the value of U_m is shown in parentheses.

NOTE Guidance on the selection of cables of appropriate voltage designations for particular systems is given in Appendix A.

4 Conductors

The conductors shall be either plain annealed copper conductors or aluminium conductors complying with BS 6360.

The type of conductor, i.e. whether circular or shaped solid (class 1), circular, circular compacted or shaped stranded (class 2), sectoral circular (class 1) or Milliken circular (class 2) shall be as indicated for the type and rated voltage of the cable in Table 11 to Table 38.

Conductors shall have a regular profile.

5 Conductor screening

Cables having a nominal rated voltage U of 11 000 V and above shall have a screen on each conductor consisting of two layers of semi-conducting carbon paper tape having a total approximate thickness of 0.2 mm. The two layers shall be applied helically in the same direction and breaking joint.

6 Insulation

6.1 General

The conductors, after screening if required by Clause 5, shall be insulated with layers of paper tapes.

For belted cables further layers of paper tapes shall be applied over the laid-up cores in accordance with 9.2.

6.2 Material

6.2.1 The paper used for cable insulation shall be uniform in texture and long fibred. It shall be free from dark spots, and shall contain no imperfectly pulped materials, woody material, lime spots, metallic particles and other deleterious substances and shall comply with 6.2.2, 6.2.3, 6.2.4 and 6.2.5.

6.2.2 The paper shall be free from chemical impurities, acids, alkalis and salts to such an extent that not more than 1 % by mass is soluble in water when tested in accordance with E.8.

6.2.3 The conductivity of the aqueous extract shall not exceed 6 mS/m when determined in accordance with BS 5626-2.

6.2.4 The pH value of the aqueous extract shall be not less than 6.0 and not more than 8.0 when determined in accordance with BS 5626-2.

6.2.5 The ash content of the paper shall not exceed 1.5 % on a moisture free (oven-dry) basis, when determined in accordance with BS 5626-2.

6.3 Method of application

The paper shall be applied in the form of tapes laid helically. When applied in the same direction successive layers shall break joint so as to form a reasonably smooth and compact covering of uniform thickness. The registration shall be generally between 60/40 and 80/20. However in cables having voltage ratings of 3 800/6 600 V and above, it is permissible to have a group of three coincident gaps in adjacent tapes but there shall be not more than two such groups in the insulation thickness.

6.4 Thickness of paper

The thickness of the individual paper tapes of the core and belt insulation shall be not greater than 0.15 mm and 0.2 mm respectively.

6.5 Thickness of insulation

The thickness of insulation excluding all screening tapes, determined in accordance with E.1 shall be not less than that specified in Table 11 to Table 38.

7 Identification of cores

Multicore belted cables shall have the core identified by numbers as shown below printed in white on the outer layer (or layers) of insulating paper.

Multicore screened cables shall have the cores identified by numbers as shown below printed in white either on the outer layer (or layers) of insulating paper or, at the manufacturer's discretion, on the paper tape intercalated with the metal tape.

The height of the figures shall be not less than 4.5 mm and they shall be sufficiently closely spaced to provide complete and ready identification of all cores in any 25 mm of cable. Any dyes used shall not fade unduly, shall be chemically neutral and shall have no injurious effects on the fibres of the paper.

Number of cores	Numbers
Two-core	0, 1
Three-core	1, 2, 3
Four-core	0, 1, 2, 3
Five-core	0, 1, 2, 3, 4

NOTE The numbers "1", "2" and "3" are intended to indicate phase conductors and "0" the neutral. In a five-core cable, the number "4" indicates the special purpose conductor.

Compliance shall be verified by visual examination and measurement.

Compliance of durability shall be checked by rubbing the core 10 times with a piece of cotton wool or cloth soaked in water.

8 Insulation screening

The cores of the following cables shall be screened:

- single-core cables having a rated voltage of 6 350/11 000 V and above;
- three-core cables having a rated voltage of 8 700/15 000 V and above;
- three-core cables having a rated voltage of 6 350/11 000 V if screened type is required;
- three-core SL cables having rated voltage of 12 700/22 000 V and 19 000/33 000 V.

In screened cables, a complete screen shall be applied over each individual core and at the manufacturer's discretion shall consist of either:

- perforated metallized paper which incorporates a layer of aluminium approximately 0.013 mm thick or for 19 000/33 000 V cables only, a layer of semi-conducting carbon paper tape or tapes followed by a perforated metallized paper which is intercalated with a semi-conducting paper; or

- one of the following, as appropriate.

- For cables up to and including 12 700/22 000 V, a non-ferrous metal tape approximately 0.075 mm thick intercalated or not with an insulating or semi-conducting carbon paper tape; the application of an overlapped metal tape without intercalation is not permitted. Additionally, the application of semi-conducting carbon paper or papers under the non-ferrous metal tape is permitted at the discretion of the manufacturer but shall be applied when the non-ferrous metal tape is applied with a gap.

- For 19 000/33 000 V cables, two semi-conducting carbon paper tapes followed by a non-ferrous metal tape approximately 0.075 mm thick applied with a gap or intercalated with an insulating or semi-conducting carbon paper tape. Application of an overlapped metal tape without intercalation is not permitted.

For 6 350/11 000 V single-core cables only, a screen consisting of a layer of semi-conducting carbon paper is permitted at the discretion of the manufacturer. This semi-conducting carbon paper tape shall have an approximate thickness of 0.1 mm and shall be applied with an overlap over the insulation.

Single-core screened cables having conductor sizes of 500 mm² and larger shall have a fabric tape incorporating interwoven copper wires applied over the screen.

9 Laying-up

9.1 General

The cores of cables shall be laid-up in the sequence of the core numbers specified in Clause 7.

9.2 Belted cables

In multicore belted cables, the cores shall be laid-up together with paper or jute fillers to form a compact and circular cable, and covered with further layers of paper to provide the belt insulation. The interstices between the cores shall be adequately filled to prevent excessive longitudinal creasing of the belt papers.

6 350/11 000 V and 8 700/11 000 V belted cables shall have a screen consisting of a semi-conducting carbon paper tape of approximate thickness 0.1 mm applied with an overlap over the belt insulation.

9.3 Screened cables

In three-core screened cables, the screened cores shall be laid-up together with paper or jute fillers to form a compact and circular cable, and shall be lapped with a binder of fabric tape incorporating interwoven copper wires.

9.4 Screened SL cables

In screened SL cables the sheathed cores, each protected in the manner specified in 13.1, shall be laid-up together, filled with compounded jute or other suitable material, and shall have a binder of compounded hessian or other suitable tape applied over the laid-up cores.

9.5 Direction of lay

The direction of lay of the cores of multicore cables shall be right-hand.

10 Impregnation

10.1 General

Before lead or lead alloy sheathing, drying and mass impregnation with an insulating compound shall be carried out so that the cable, in its sheathed state, complies with 10.2 and 10.3.

10.2 Drainage test

10.2.1 Requirement. The sheathed cable shall be tested in accordance with 10.2.2 and the maximum drainage of compound into the space provided shall be documented.

NOTE Unless specified at the time of ordering (see Appendix F), cables should not exceed the maximum drainage values given in Table 1.

10.2.2 Method. Carry out the test on a sample not less than 900 mm long, cut from a selected length of cable in its sheathed state. Seal the test sample at both ends, and leave a space at one end for the collection of any compound which may drain out of the cable during the test. Suspend the sample vertically, with the drainage space at the lower end, in a heated chamber for 7 days, at not less than the appropriate temperature given in Table 1. Measure the amount of compound which has drained into the space provided at the end of this period.

10.3 Breaking load and elongation at break of impregnated paper

When tested in accordance with E.7, the paper, after removal from an impregnated core, shall comply with the following:

- a) the breaking load of the test strip shall be not less than 650 N/mm of thickness;
- b) the elongation at break of the test strip shall be not less than 1.5 %.

Table 1 — Maximum drainage

1 Voltage designation V	2 Type	3 Test temperature °C	4 Maximum drainage ^a %
Up to and including 6 600/6 600	All types	80	3.0
6 350/11 000	Screened single-core and three-core	70	2.5
6 350/11 000 and 8 700/11 000	Belted three-core	65	2.5
8 700/15 000	All types	70	2.5
12 700/22 000	All types	65	2.5
19 000/33 000	All types	65	2.5

^a Percentage drainage based on volume of interior of sheath of sample.

11 Identification of manufacturer

A tape printed at intervals of not greater than 300 mm with the manufacturer's name and year of manufacture shall be provided throughout the length of the cable under the lead or lead alloy sheath.

12 Lead or lead alloy sheath

12.1 A lead or lead alloy sheath shall be extruded over the impregnated cable.

12.2 The composition of the lead or lead alloy sheath, (see **A.3**), shall be in accordance with BS 801.

12.3 The lead or lead alloy sheath shall be impervious to moisture, reasonably close-fitting and free from defects.

12.4 The minimum thickness of the lead or lead alloy sheath measured in accordance with **E.2** shall not fall below the appropriate value given in Table 11 to Table 38 by an amount more than (5 % plus 0.1 mm), (0.05 mm rounded upwards).

NOTE Minimum thickness, evaluated according to this requirement, is given in Table 39.

13 Bedding

13.1 Lapped bedding

Lapped bedding under the armour shall have an approximate thickness of 1.5 mm after application of the armour.

Lapped bedding, except in screened SL cables, shall consist of two compounded paper tapes applied immediately over the previously compounded lead or lead alloy sheath, followed by one or more layers of suitable compounded fibrous materials applied either with or without additional compound (see Clause 16).

NOTE The additional compound will not be applied in the case of bright wire armoured cables or armoured cables having a PVC oversheath, unless requested by the purchaser at the time of enquiry or order (see Appendix F).

In screened SL cables one compounded paper tape and one compounded cotton or synthetic fibre tape shall be applied over each of the previously compounded metallic sheathed cores, followed, over the laid-up cores by one or more layers of suitable compounded fibrous materials applied with additional compound (see Clause 16).

13.2 Extruded bedding

The bedding shall consist of an extruded layer of TM 1 PVC compound complying with BS 7655-4.1 applied over the metallic sheath. It is permissible to apply a layer of compound over the metallic sheath before application of the extruded bedding.

The minimum thickness of extruded bedding, measured in accordance with **E.3**, shall not fall below the appropriate value given in Table 11 to Table 38 by more than (15 % plus 0.1 mm), (0.05 mm rounded upwards). When tested in accordance with BS 5099, the extruded bedding shall not break down.

NOTE Minimum thickness, evaluated according to this requirement, is given in Table 39.

14 Armour

14.1 General

When armouring of multicore cables is required, the armour for cables having a nominal diameter over the lead or lead alloy sheath exceeding 12 mm shall consist of either:

- a) two layers of steel tape applied over the bedding; or
- b) one layer of galvanized steel wire (single-wire armour) applied over the bedding; or
- c) two layers of galvanized steel wire (double-wire armour) applied over the bedding.

For cables having a nominal diameter over the metallic sheath not exceeding 12 mm, the armour shall consist of wires and not tapes.

NOTE 1 Armoured cables will be supplied with an armouring as specified in a) or b) unless method c) is requested by the purchaser at the time of enquiry or order (see Appendix F).

NOTE 2 In the relevant tables, STA denotes steel tape armour and SWA denotes steel wire armour single layer.

NOTE 3 At the manufacturer's discretion it is permissible to apply a synthetic or suitable compounded fibrous tape over the SWA when an oversheath is applied.

14.2 Steel tape armour

The steel tape shall have a tensile strength in the range of 300 MN/m² to 475 MN/m². The thickness of the steel tape shall be in accordance with the appropriate table with a tolerance of $\pm 10\%$.

The tape shall be coated on both sides with a preservative compound.

NOTE At the manufacturer's discretion the steel tape may be galvanized in lieu of preservative compound.

The layers shall be laid on helically with a left-hand lay so that the outer tape is approximately central over the gap of the inner tape. The gap between adjacent turns of each tape shall not exceed 50 % of the width of the tape. The outer tape shall overlap the inner tape on both sides by not less than 15 % of the tape width. Joints in steel tape shall be welded and surface irregularities removed to give a smooth finish.

14.3 Single-wire armour

Single-wire armour shall consist of one layer of wires of the appropriate size specified in Table 11 to Table 38 and the armour shall be applied helically with a left-hand lay.

The armour wire shall comply with the following.

- a) When determined in accordance with E.4, the diameter of the armour wire shall not fall below its nominal value given in the appropriate table by more than 5 %.
- b) When determined in accordance with E.5, the mass of zinc coating of galvanized steel armour wire shall be not less than that given in Table 2.

Table 2 — Mass of zinc coating

Nominal diameter of armour wire (in mm)	1.25	1.6	2.0	2.5	3.15
Minimum mass of zinc coating per square metre (in g)	150	172	180	195	206

Joints in armour wire shall be brazed or welded and any surface irregularity shall be removed. A joint shall be not less than 1 m from the nearest joint in any other armour wire in the completed cable.

14.4 Double-wire armour

Double-wire armour shall consist of two layers of wires. The nominal diameter of wire for both layers shall be the same as that for the appropriate single-wire armoured cable specified in Table 11 to Table 38. The requirements of 14.3 as to quality and joints in each separate layer shall apply.

The direction of lay of the inner layer of armour shall be left-hand.

The direction of lay of the outer layer of armour shall be either left-hand or right-hand.

NOTE Cables will be supplied with the direction of lay of the outer layer of armour right-hand unless a left-hand direction is requested by the purchaser at the time of enquiry or order (see Appendix F).

There shall be a separator consisting of a layer of suitable compounded fibrous material between the two layers of wire.

15 Serving and oversheath

15.1 Oversheath for unarmoured cables

The oversheath for unarmoured cables shall be an extruded layer of either TM1 PVC compound complying with BS 7655-4.1 or of TS2 MDPE compound complying with BS 7655-10.1.

Where a graphite coating is required the oversheath shall be black.

NOTE 1 Cables will be supplied without a layer of compound applied to the lead or lead alloy sheath before application of the oversheath unless requested by the purchaser at the time of enquiry or order (see Appendix F).

NOTE 2 Oversheaths are normally black but colours other than black may be provided by agreement between the manufacturer and purchaser, subject to their suitability for the particular exposure conditions under which the cables are to be used.

The thickness of the oversheath, determined by taking the average of a number of measurements in accordance with E.3, shall be not less than the appropriate value given in Table 11 to Table 38 and the smallest of the measured values shall not fall below the value in the appropriate table by an amount more than (15 % plus 0.1 mm), (0.05 mm rounded upwards).

NOTE 3 Minimum thickness, evaluated according to this requirement, is given in Table 39.

When spark tested in accordance with BS 5099, the extruded oversheath shall not break down.

NOTE 4 Cables will be spark tested unless a d.c. voltage test is requested by the purchaser at the time of enquiry or order (see Appendix F).

If a d.c. voltage test (see 21.5) is to be carried out (see A.4.4), a coating of graphite shall be applied over the surface of the oversheath. For 19 000/33 000 V cables, the thicknesses of oversheath having a graphite coating are given in the appropriate columns of Table 36 and Table 37. For cables of lower voltage ratings, the manufacturer shall be consulted to determine an appropriate thickness for these conditions, increased beyond the values for standard cables given in the tables.

15.2 Serving for armoured cables

For armoured and served cables, the serving of the armour shall consist of one or more layers of suitable compounded fibrous materials applied with additional compound and having an approximate radial thickness of 2.0 mm.

In order to prevent adhesion, a coating of whitewash or other suitable material shall be applied to the outside of the cable.

15.3 Oversheath for armoured cables

The oversheath for armoured cables shall be an extruded layer of either TM1 PVC compound complying with BS 7655-4.1 or of TS2 MDPE compound complying with BS 7655-10.1.

Where graphite coating is required the oversheath shall be black.

NOTE 1 Cables will be supplied without a layer of compound applied to the armour before application of the oversheath unless requested by the purchaser at the time of enquiry or order (see Appendix F).

NOTE 2 Oversheaths are normally black but colours other than black may be provided by agreement between the manufacturer and purchaser, subject to their suitability for the particular exposure conditions under which the cables are to be used.

When the thickness of the oversheath is determined in accordance with E.3, the smallest of the measured values shall not fall below the appropriate value specified in Table 11 to Table 38 by an amount more than (20 % plus 0.2 mm), (0.05 mm rounded upwards).

NOTE 3 Minimum thickness, evaluated according to this requirement, is given in Table 39.

When spark tested in accordance with BS 5099, the extruded oversheath shall not break down.

NOTE 4 Cables will be spark tested unless a d.c. voltage test is requested by the purchaser at the time of enquiry or order (see Appendix F).

If a d.c. voltage test (see 21.5) is to be carried out (see A.4.4), a coating of graphite shall be applied over the surface of the oversheath. For 19 000/33 000 V cables, the thickness of the oversheath having a graphite coating are given in the appropriate columns of Table 36, Table 37 and Table 38. For cables of lower voltage ratings, the manufacturer shall be consulted to determine an appropriate thickness for these conditions, increased beyond the values for standard cables given in the tables.

16 Compounds for lapped bedding and serving

Compounds used in the protective bedding and serving shall be of such a nature that in the finished cable they do not crack or run at the temperatures likely to be attained in transit to the site or on the site, during installation or when the cables are in operation.

The compound shall adhere to the armour and lead or lead alloy sheath so that if the coverings are unwrapped it shall be evident that the metal surfaces were completely covered by the closely adherent compound before the removal of the wrapping. Care shall be taken to ensure that the amount of compound applied is retained evenly around the cable. The compounds used shall have no deleterious effect on the metallic sheath, armour or protective coverings. They shall be derived from bitumen and shall be free from the distillation products of coal or wood.

NOTE 1 The suitable fibrous materials referred to in 9.4, 13.1, 14.4 and 15.2 include crepe paper (other than for the outer layer of serving), jute yarn, hessian tapes and tapes made from natural or synthetic fibres.

NOTE 2 Where galvanized steel tape is used it will be recognized that the under tape will not be bitumen coated where overlapped by the top tape.

17 Cable markings

17.1 General

The cable shall be marked in accordance with 17.2, 17.3 and 17.4.

17.2 Marking of oversheathed cables

17.2.1 External marking

Where the cable is provided with an extruded oversheath, the external surface shall be legibly marked with the following.

a) The wording	“ELECTRIC CABLE”
b) Voltage designation:	
600/1 000	600/1 000 V;
1 900/3 300 and 3 300/3 300	3 300 V;
3 800/6 600 and 6 600/6 600	6 600 V;
6 350/11 000 and 8 700/11 000	11 000 V;
8 700/15 000	15 000 V;
12 700/22 000	22 000 V;
19 000/33 000	33 000 V;
c) British Standard number	BS 6480 ^a
d) Manufacturer's identification	XYZ
e) Number of cores, type and nominal area of phase/neutral/special purpose conductors, where applicable	
(1) Copper conductor cables	4 × 50
NOTE 4 × 50 indicates a 4-core cable with 50 mm ² copper conductors.	
(2) Copper conductor cables with reduced neutral and a special purpose conductor	3 × 300/150/16
NOTE 3 × 300/150/16 indicates a 5-core cable with three 300 mm ² copper phase conductors, one 150 mm ² copper neutral conductor and one 16 mm ² copper special purpose conductor.	
(3) Aluminium conductor cables	4 × 50 AL
NOTE 4 × 50 AL indicates a 4-core cable with 50 mm ² aluminium conductors.	

The marking of items a) to d) shall be by embossing or indenting on the oversheath.

^a Marking BS 6480 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

For cables with tabulated approximate overall diameters above 15 mm, items a), b) and c) shall appear, in any sequence that neither confuses nor conflicts, on two or more primary lines along the axis of the cable, approximately equally spaced around the circumference of the cable. Items d) and e) shall appear on at least one line, which may be one of the primary lines, or a secondary line or lines. They may appear in any sequence that neither confuses nor conflicts, and need not be on the same line.

For cables with tabulated approximate overall diameters of 15 mm or smaller, the elements of marking shall be disposed as for cables above 15 mm except that the marking for items a) to d) shall appear on one or more primary lines.

The letters and figures shall consist of upright block characters. The characters shall have a minimum height of 3 mm. The distance between the end of one element of marking and the beginning of the next identical element of marking shall be not greater than 550 mm, for items a), b) and c), and not greater than 1 100 mm for items d) and e).

Compliance shall be checked by visual examination and measurement.

17.2.2 Identification of year of manufacture

A means of identifying the year of manufacture of the cable shall be provided throughout the length of the cable internally in accordance with Clause 11.

Where additional marking is provided on the surface of the cable, it shall comply with the requirements given for items d) and e) of 17.2.1 in respect of maximum distance between marks.

17.2.3 Mark of an approval organization

If the mark of an approval organization is used it shall be provided throughout the length of the cable.

If the mark is applied to the cable it shall be on the surface in the form of the symbol(s) specified by the approval organization, and shall comply with requirements given for items d) and e) of 17.2.1 in respect of maximum distance between marks.

NOTE As an alternative to the mark of the approval organization, an identification thread may be incorporated into the cable, as specified by the approval organization.

17.2.4 Additional marking

The use of additional marking is permitted. Where such marking is made it shall be throughout the length of the cable, and may be on the external surface of the cable, or by means of a tape or thread within the cable, or by combination of these methods. If the additional marking is applied to the surface of the cable it shall not render illegible the marking specified in 17.2.1, 17.2.2 and 17.2.3.

The additional marking, however made, shall be repeated at intervals not exceeding 1 100 mm.

17.3 Identification of 600/1 000 V cables

In order to distinguish between 600/1 000 V cables and cables of higher voltage rating, 600/1 000 V cables shall be identified by a varnished yellow paper, cellulose acetate or similar tape bearing the letters "LV" at intervals not greater than 100 mm. The "LV" tape shall be applied longitudinally over the two compounded paper tapes on the lead or lead alloy sheath, when the protective covering includes these tapes. If the protective covering does not include the two compounded tapes, the "LV" tape shall be applied immediately over the lead or lead alloy sheath.

NOTE This "LV" tape is not required for cables having an extruded oversheath.

For the purpose of inspection at the factory, compliance shall be checked by visual examination at the ends of the cable.

When a perforated yellow paper tape is used, it shall be approximately 0.13 mm thick and 16 mm wide. The letters shall be approximately 6.5 mm high and shall be formed by perforating the tape with 0.8 mm (approximately) diameter holes spaced 0.8 mm (approximately) apart.

When yellow cellulose acetate or similar tape is used, it shall be not less than 6 mm wide and legibly printed in black. The printing shall be readily decipherable, after removing any adhering compound.

17.4 End markings

The ends of each drum length of cable having three, four or five cores shall be marked "A" and "Z", "A" being the end at which the sequence of the core numbers (see Clauses 7 and 9) is clockwise and "Z" the end at which the sequence is anti-clockwise.

18 Sealing and drumming

Before despatch, the cable manufacturer shall cap the ends of all cable in order to form a seal to prevent the ingress of water during transportation and storage.

For multicore unarmoured cables rated at 19 000/33 000 V, conductor pulling eyes shall be fitted to the leading end of the cable, and a plumbed seal made between the pulling eye and the lead alloy sheath. Any lead alloy sheath exposed between the pulling eye and the polyethylene oversheath shall be reinforced, for example, by the application of a heat shrink sleeve.

Cable drums shall be lagged so as to protect the cable from damage, and the end of the cable projecting from the drum shall also be protected from mechanical damage.

Each drum shall be durably marked with a distinguishing number on the outside of the flange and particulars of the cable, i.e. voltage, length, conductor size and cable type. The gross mass shall be shown and the direction for rolling shall be indicated by an arrow.

19 Schedule of tests

Table 3 lists the complete range of tests applicable to the cables covered by this standard and refers to the relevant clauses of the standard specifying the requirements and test methods. The last column shows the category of each test, i.e. R, RS, SS and T.

The categories and corresponding designations are as follows.

- a) *Routine tests (R)*: tests made at the manufacturer's works on all cables in the finished state or, as appropriate (e.g. spark test) during manufacture.
- b) *Regular sample tests (RS)*: tests made at the manufacturer's works on representative samples selected regularly by the manufacturer, or as specified by the purchaser at the time of ordering.
- c) *Special sample tests (SS)*: tests made on samples if specified by the purchaser at the time of ordering at a frequency agreed between the purchaser and the manufacturer provided that the quantity ordered exceeds 10 km.
- d) *Type tests (T)*: tests made on cable as produced by a specific manufacturer to demonstrate the manufacturer's ability to satisfactorily produce a range of cables designed to comply with this standard. These tests, after they have been successfully completed, need not be repeated unless changes are made which might affect compliance with the test requirements. (See Appendix C and Clause 24.)

Table 3 — Schedule of tests

1	2	3	4
Test	Requirement (clause reference)	Test procedure	Category
<i>Tests on components</i>			
Conductor construction	4	BS 6360	RS
Insulation and screening:			
(a) material	6.2 and 8	E.8 and BS 5626-2	SS
(b) application	6.3	Visual examination	RS
(c) thickness of individual paper (if required)	6.4	Measurement	SS
(d) total thickness	6.5	E.1	RS
(e) tensile strength and elongation at break	10.3	E.7	SS
Core identification	7	7	RS
Laid-up cores	9	Visual examination	RS
Lead or lead alloy sheath:			
(a) material	12.3	BS 801	RS
(b) thickness of sheath	12.4	E.2	RS
Bedding:			
(a) lapped	13.1	Visual examination	RS
(b) extruded			
(1) material	13.2	BS EN 60811-1-1	T
(2) thickness	13.2	E.3	RS
(3) spark test	13.2	BS 5099	R
Armour:			
(a) steel tape armour:			
(1) material	14.2	14.2	SS
(2) application	14.2	Visual examination and measurement	SS
(b) wire armour:			
(1) diameter	14.3 and 14.4	E.4	SS
(2) mass of zinc coating	14.3 and 14.4	E.5	SS
Oversheath			
(a) material	15.1 and 15.3	BS EN 60811-1-1	T
(b) thickness, unarmoured cable	15.1	E.3	RS
(c) thickness, armoured cable	15.3	E.3	RS
Spark test	15.1 and 15.3	BS 5099	R
<i>Test on complete cables</i>			
Cable markings	17	Visual examination and measurement	R
Conductor resistance test	21.2	BS 6360	R
Tan δ measurement test for 19 000/33 000 V cables	21.3	21.3	R
Voltage test on complete cable	21.4	21.4	R
Bending test	23.2	E.6	SS
Drainage test	10.2	10.2	SS
D.C. voltage test on oversheath (optional, see Clause 15 and Appendix A)	21.5	21.5	R
Type tests for 19 000/33 000 V cables	24.2	Appendix C	T

20 Test conditions

20.1 Ambient temperature

Tests shall be made at an ambient temperature of 20 ± 15 °C, unless otherwise specified in the details for the particular test.

20.2 Frequency and waveform of power-frequency test voltages

Unless otherwise specified in the particular test, a.c. test voltages shall have a frequency between 49 Hz and 61 Hz. The waveform shall be substantially sinusoidal.

21 Routine tests

21.1 General

Routine tests shall be as given in Table 4.

Table 4 — Routine tests

1	2	3
Test	Requirement given in clause	Test method
Conductor resistance	21.2	BS 6360
Tan δ (19 000/33 000 V cables)	21.3	21.3
Voltage test on complete cable	21.4	21.4
D.C. voltage test on oversheath (optional)	21.5	21.5
Spark test	15.1, 15.3	BS 5099

21.2 Conductor resistance

The d.c. resistance of each conductor shall comply with BS 6360 when measured and corrected to 20 °C in accordance with that standard.

21.3 Power factor, tan

21.3.1 Requirement. When cables rated at 19 000/33 000 V are tested as described in **21.3.2** the value of tan δ determined by the test at $0.5 U_0$ shall not exceed the appropriate value specified in column 1 of Table 5. The difference in tan δ between $0.5 U_0$ and $1.25 U_0$, and between $1.25 U_0$ and $2.0 U_0$ shall not exceed the appropriate value specified respectively in columns 2 and 3 of Table 5.

The tan δ of the insulation shall be measured at ambient temperature and the test shall be made before the voltage test described in **21.4**.

21.3.2 Method. The sequence of testing shall be at $0.5 U_0$, $1.25 U_0$ and $2.0 U_0$, i.e. 9.5 kV, 24 kV and 38 kV. Apply the test voltage between each conductor and the lead or lead alloy sheath, the other conductors connected to the lead or lead alloy sheath when three-core cable is tested.

Make the measurement with a suitable bridge, using a loss free capacitor as standard. Correct any measurements made at temperatures below 20 °C either by subtracting from the measured value 2 % of this value per degree Celsius of the difference between the test temperature and 20 °C, or by the use of a correction curve appropriate to the insulant if agreement on such a curve has been reached between the purchaser and the manufacturer. Make no correction for a test temperature of 20 °C or greater.

Table 5 — Power factor, tan δ , of 19 000/33 000 V cables

1	2	3
Maximum tan δ at 0.5 times U_0 at 20 °C	Maximum difference in tan δ between	
	0.5 and 1.25 times U_0	1.25 and 2.0 times U_0
30×10^{-4}	20×10^{-4}	40×10^{-4}

21.4 Voltage test on complete cable

21.4.1 Requirement. When tested as described in either method A (21.4.2) or method B (21.4.3) there shall be no breakdown of insulation.

NOTE Cables will be tested in accordance with method A unless the manufacturer requests permission to carry out the test in accordance with method B.

21.4.2 Method A. Make the test with a power-frequency voltage using either three-phase or single-phase or a combination of both at the discretion of the manufacturer. When using three-phase on a belted cable, connect the neutral point of the transformer to the lead or lead alloy sheath, thus applying a voltage between the conductor and the lead or lead alloy sheath equal to the value in column 2 of Table 6 divided by $\sqrt{3}$. This is equivalent to the value in column 3 except for cables rated 600/1 000 V, 3 300/3 300 V, 6 600/6 600 V and 8 700/11 000 V for which an additional test is required. Make this additional test by applying a single-phase voltage between the conductors connected together and the lead or lead alloy sheath.

In all cases the test voltage shall be increased gradually to the appropriate values specified in Table 6 and maintained constant for 5 min.

21.4.3 Method B. Carry out the test as described in 21.4.2, except that the voltage test shall be made with direct current, the applied voltage being equal to 2.4 times the appropriate alternating test voltage and the duration of each application being 5 min.

21.5 D.C. voltage test on oversheath

NOTE This is an optional routine test requirement, and needs to be specified by the purchaser in the enquiry or order (see Clause 15) and Appendix F).

21.5.1 Requirement. The oversheath shall not break down on the application of a test voltage as described in 21.5.2.

21.5.2 Method. The d.c. test voltage shall be applied between the underlying metal layer at negative polarity and the outer conducting layer for a period of 1 min.

Table 6 — Test voltage on completed cable at works

1	2	3	4
Voltage designation	Alternating test voltage (r.m.s.)		
	Belted cables		Single-core and screened cables
	Between conductors	Between any conductor and lead or lead alloy sheath	Between any conductor and lead or lead alloy sheath
V	V	V	V
600/1 000	3 500	3 500	3 500
1 900/3 300	10 000	5 800	6 000
3 300/3 300	10 000	10 000	—
3 800/6 600	17 000	9 800	10 000
6 600/6 600	17 000	17 000	—
6 350/11 000	25 000	14 400	15 000
8 700/11 000	25 000	22 000	—
8 700/15 000	—	—	22 000
12 700/22 000	—	—	30 000
19 000/33 000	—	—	45 000

The voltage applied shall be equal to 8 kV per millimetre of specified thickness of oversheath subject to a maximum of 25 kV.

22 Regular sample tests

Regular sample tests shall be as given in Table 7.

Table 7 — Regular sample tests

1	2	3
Test	Requirement given in clause	Test method
Insulation thickness	6.5	E.1
Lead or lead alloy sheath thickness	12.4	E.2
Extruded bedding thickness	13.2	E.3
Oversheath thickness:		
unarmoured	15.1	E.3
armoured	15.3	E.3

23 Special sample tests

23.1 General

Special sample tests shall be as given in Table 8.

Table 8 — Special sample tests

1	2	3
Test	Requirement given in clause	Test method
Thickness of individual insulating papers	6.4	Micrometer
Wire armour diameter	14.3, 14.4	E.4
Mass of zinc coating	14.3, 14.4	E.5
Bending test	23.2	E.6
Drainage test	10.2	10.2
Tensile strength and elongation at break of impregnated paper	10.3	E.7
Material tests on insulating papers	6.2	E.8 and BS 5626-2

23.2 Bending test

After being subjected to the bending test as specified in **E.6**, the sample shall comply with the following.

- The sample shall withstand a voltage test in accordance with **21.4**, but with the test voltage increased by 50 %.
- After the voltage test, a 300 mm length cut from the middle of the sample shall be stripped and examined. The serving or oversheath shall be free from splits, the armour shall not be noticeably displaced and the lead or lead alloy sheath shall be free from splits and cracks.
- The number of papers in the 300 mm length that contain longitudinal or edge tears exceeding in length 6 mm or 50 % of the paper width, whichever is the smaller, shall not exceed the amount given in Table 9.

At no point throughout the insulation of cables having voltage ratings of 3 800/6 600 V and above shall there be more than three coincidental tears of any length in adjacent papers.