BRITISH STANDARD

BS : 7870 :
Section 3.1 :
1996

LV and MV polymeric insulated cables for use by distribution and generation utilities

Part 3. Specification for distribution cables of rated voltage 0.6/1 kV

Section 3.1 PVC and XLPE insulated combined neutral and earth copper wire concentric cables with copper or aluminium conductors

(Implementation of HD 603)

ICS 29.060.20

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee GEL/20, Electric cables, to subcommittee GEL/20/2, Mains cables 1kV and above, upon which the following bodies were represented:

Association of Consulting Engineers
British Approvals Service for Cables
British Cable Makers Confederation
British Iron and Steel Producers' Association
British Plastics Federation
ERA Technology Ltd.
Electricity Association
Engineering Equipment and Materials Users' Association
Institution of Incorporated Executive Engineers
London Underground Ltd.
British Railways Board
British Steel Industry

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Contents

Foreword

BS 7870 was prepared by Technical Committee GEL/20. It implements the nationally applicable parts of Harmonization Documents HD 603, 604, 605, 620, 622, 626 and 627 published by the European Committee for Electrotechnical Standardization (CENELEC) in accordance with the decision of the CENELEC Technical Board.

BS 7870 applies to cables for fixed installations having a rated voltage U_o/U up to and including 19/33kV, and is published as a series of separate Parts and Sections, as listed in the table in the Foreword of Part 1.

Part 3 : Section 3.1 of BS 7870 implements part of HD 603 : Part 3N and all of HD 603 : Part 5S, and is to be read in conjunction with BS 7870 : Parts 1 and 2.

The cable types included in this Section are as follows:

(a) single-core PVC insulated stranded copper phase conductor with concentric copper wire neutral/earth (Type 3N1);

(b) single-core PVC insulated solid aluminium phase conductor with concentric copper wire neutral/earth (Type 3N2);

(c) three-core PVC insulated stranded copper phase conductors with concentric copper wire neutral/earth (type 3N4);

(d) three-core PVC insulated solid aluminium phase conductors with concentric copper wire neutral/earth (type 3N5);

(e) single-core XLPE insulated stranded copper phase conductor with concentric copper wire neutral/earth (type 5S1);

(f) single-core XLPE insulated solid aluminium phase conductor with concentric copper wire neutral/earth (type 5S2);

(g) three-core XLPE insulated stranded copper phase conductors with concentric copper wire neutral/earth (type 5S3);

(h) three-core XLPE insulated solid aluminium phase conductors with concentric copper wire neutral/earth (type 5S4).

A guide to use for these types of cable is under consideration.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

WARNING. The methods of test described in this British Standard do not detail all precautions necessary to meet the requirements of the Health and Safety at Work, etc, Act 1974. Attention should be paid to any appropriate safety precautions and the tests should only be carried by authorized personnel.

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

Specification

1 Scope

This Section of BS 7870 specifies requirements and dimensions for PVC and XLPE insulated, combined neutral/earth (CNE), single-and three-phase, concentric type service cables, having an extruded PVC oversheath for use on concentric neutral/earth systems.

For PVC and XLPE insulated cables, the maximum conductor temperature in normal operating conditions is 70 °C .

The maximum conductor temperature in short-circuit conditions is 160 °C for PVC insulated, and 250 °C for XLPE insulated cables.

2 References

2.1 Normative references

Section 3.1 of BS 7870 incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate place in the text and the publications are listed on the inside back page. For a dated reference, only the cited edition applies: any subsequent amendments to or revisions of the publication apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, any amendment to, or the latest edition of, the cited publication applies.

2.2 Informative references

Section 3.1 of BS 7870 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of the standard are listed on the inside back page, but reference should be made to the latest editions.

3 Voltage designation

Cables shall be designated by the voltages U_0, U and U_m, expressed in the form U_0/U (U_m).

The voltage designation of cables in this standard is:

0.6/1 (1.2) kV.

In an a.c. system, the rated voltage of the cable shall be at least equal to the nominal voltage of the system for which it is intended. If used in d.c. systems, the cables specified in this standard shall have a maximum voltage against earth not exceeding 1.5 kV.

4 Phase conductors

The phase conductors shall be either stranded (class 2) plain annealed copper or solid (class 1) aluminium conductors in accordance with BS 6360. The d.c. resistance shall conform to the values given in tables 2 to 9.

Copper conductors in single phase cables shall be circular or compacted circular. Copper conductors for three-phase cables shall be circular or compacted circular for the 16 mm^2 size and circular or compacted circular or shaped for the 25 mm^2 size.

Aluminium conductors for both single- and three-phase cables shall be circular for all sizes.

5 Insulation

The insulation shall be either PVC compound type TI 1 conforming to the requirements of BS 7655 : Section 3.1, or XLPE compound type GP 8 conforming to the requirements of BS 7655: Section 1.3.

Insulation shall be applied by the extrusion process and shall form a compact homogeneous body.

The thickness shall be in accordance with the values specified in tables 2 to 9.

The cores of all cables shall be identifiable by colours, as follows:

a) single-core: red

b) three-core: red, yellow and blue

The colours shall either be on the external surface or extend throughout the insulation. The colours shall be durable such that when tested in accordance with **2.5.4** of BS 7870 : Part 2 : 1996, they shall not be effaced.

6 Assembly of cores

The cores of three-phase cables shall be laid up with a right hand lay and minimum lay length of 550 mm. Where necessary, fillers of suitable synthetic material may be used.

7 Bedding for three phase cables

Unless otherwise agreed, a tape bedding, having an approximate total thickness of 0.5 mm, shall be applied over the laid up cores of three-phase cables. Unless otherwise agreed, the bedding shall be PVC.

NOTE 1. A polyester separation tape may be applied between the laid up cores and the PVC tape as part of the bedding, at the discretion of the manufacturer.

NOTE 2. By agreement between the manufacturer and the purchaser, extruded PVC bedding may be supplied.

8 Neutral/earth concentric conductor

The neutral/earth conductor shall consist of a single layer of plain annealed copper wires applied with either a right or left hand direction of lay or an alternating right and left hand lay. The number and diameter of the wires before cabling, the minimum and maximum lay length and the d.c. resistance shall conform to the values given in tables 2 to 9.

The maximum gap between adjacent wires shall not exceed 4 mm.

Conformity shall be checked by visual examination and measurement.

NOTE. One or more overlapped synthetic binder tapes may be applied immediately over the concentric layer.

9 Oversheath

The oversheath shall be an extruded layer of black PVC type TM 1 conforming to the requirements of BS 7655 : Part 4.1

The thickness of the oversheath shall conform to the values specified in tables 2 to 9.

10 Cable markings

10.1 External marking

The external surface of all cables conforming to this British Standard shall be legibly marked with the following elements.

Element	*Example of marking*
a) Electric cable:	ELECTRIC CABLE
b) Voltage designation:	600/1000V
c) British Standard number:	BS 7870/3/1
d) Manufacturer's identification:	XYZ

e) Number of cores and nominal area of phase/neutral/earth conductors, e.g.

1) 3 × 25 AL/CU shall indicate a three-core cable with 25 mm^2 aluminium phase conductors having a copper concentric neutral/earth conductor

2) 1 × 25 CU/CU shall indicate a single-core cable with 25 mm^2 copper phase conductor having a copper concentric neutral/earth conductor

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

For cables with tabulated approximate overall diameters greater than 15 mm, items a), b) and c) shall appear, in any sequence that is deemed neither to confuse nor conflict, 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, together or separately, in any sequence that is deemed neither to confuse nor conflict, on either one of the primary lines, or on a secondary line or lines.

For cables with tabulated approximate overall diameters of 15 mm or less, the items shall be disposed as for cables of greater than 15 mm diameter, except that the marking for items a), b) and c) 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 shall be not greater than 550 mm for items a), b) and c), and not greater than 1100 mm for items d) and e).

Conformity shall be checked by visual examination and measurement.

10.2 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, either internally or by marking on the surface of the cable.

If the identification mark is internal, the distance between the end of one mark and the beginning of the next mark shall be not greater than 550 mm.

NOTE. An identification thread may be used as an alternative internal marking.

If the identification is by marking on the surface it shall conform to **10.1** d) and e) in respect of the maximum distance between marks.

10.3 The mark of an approval organization

If the mark of an approval organization is used, it shall be provided throughout the length of the cable, either as a mark on the surface of the cable, or as an identification thread, as specified by the approval organization.

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 conform to **10.1** d) and e) in respect of the maximum distance between marks.

10.4 Additional marking

Where additional marking is made, it shall be throughout the length of the cable, and on the external surface of the cable, or by means of a tape or thread within the cable, or by a 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 **10.1** to **10.3**.

The additional marking, however made, shall be repeated at intervals not exceeding 1100 mm.

10.5 End markings

The end of each drum length of three-phase cable at which the sequence of core colours is clockwise shall be marked red. The other end shall be marked green.

11 Tests

Conformity shall be checked by inspection and by the tests specified in table 1.

12 Additional requirements

12.1 Sampling for thickness measurement

On a sample taken from one end of each drum length of cable selected for the test, and having discarded any portion which may have suffered damage, make the measurements of thickness of insulation and oversheath listed in table 1.

If any of the thicknesses measured does not conform to tables 2 to 9, two further samples shall be checked for the non-conforming factors. If both the samples meet the specified requirements, the cable shall be deemed to conform, but if either does not meet the requirements, the cable shall be deemed not to conform.

12.2 Voltage test on complete cable

When the voltage test is carried out in accordance with **3.2.1** of BS : 7870 : Part 2 : 1996, using a test voltage of 3.5 kV a.c. for a duration of 5 min, the insulation shall not break down.

12.3 Insulation resistance test (PVC insulated cables only)

After completion of the voltage test and after the application of 500 V d.c. for 1 min, the insulation resistance measured between each phase conductor and between the phase conductors and all the wires in the concentric layer shall not be less than that given below:

Size (mm^2)	MΩ/km at 20 °C
4	8
10	7
16	6
≥25	5

12.4 Spark test

When spark testing is carried out in accordance with **3.6.1** of BS 7870 : Part 2 : 1996, the following voltages shall be used.

a) Spark test on phase cores at the core stage of manufacture:

4 to 16 mm^2 6 kV a.c. or 9 kV d.c.

25 to 35 mm^2 10 kV a.c. or 15 kV d.c.

b) Spark test on oversheath:

Single-core cables (all sizes) 8.5 kV a.c. or 13 kV d.c.

Three-core cables (all sizes) 11 kV a.c. or 16.5 kV d.c.

12.5 Compatibility

When tested in accordance with **8.1.4** of BS EN 60811-1-2 : 1995 for 7 days at (80 ± 2) °C, the materials shall conform to table 10 of this standard.

13 Sealing and drumming

After completion of the manufacturer's tests, both ends of every length of cable shall be sealed to prevent the ingress of moisture during transportation and storage. The seal shall be effected either by using close fitting plastics caps fitted over the ends of the cable enclosing the oversheath and firmly secured to it by plastics adhesive tapes, or other approved means.

NOTE. The cap should be sufficiently robust to withstand the effects of installing the cable but the possibility of damage to moisture seals during handling and installation of the cable should be borne in mind. Where such damage may have occurred, the seals should be inspected and remade if necessary.

Each drum shall bear a distinguishing number on the outside of one flange. Particulars of the cable, i.e. voltage, length, conductor size, 'Copper' or 'Al' (as appropriate), 'PVC' or 'XLPE' (as appropriate), 'single-phase' or 'three-phase' (as appropriate), 'CNE', length number, gross and net weights, shall be clearly shown on one flange of the drum. The words 'Running End Red' or 'Running End Green', as appropriate, shall be marked on the flange and the direction of rolling shall be indicated by an arrow.

Table 1. Schedule of tests

Test	Requirements given in clause:	Test method described in:
Routine tests		
Phase conductor resistance	tables 2 to 9	Part 2 : 1996, **3.1.1**
Concentric neutral/earth resistance	tables 2 to 9	Part 2 : 1996, **3.1.1**
Voltage test on complete cable	**12.2**	Part 2 : 1996, **3.2.1**
Insulation resistance	**12.3**	**12.3**
Spark test:		
a) insulation	**12.4**a	Part 2 : 1996, **3.6.1**
b) oversheath	**12.4**b	Part 2 : 1996, **3.6.1**
Cable markings	**10**	visual
Sample tests		
Phase conductor material and construction	**4**	BS 6360
Concentric neutral/earth material and construction	**8**	visual
Insulation:		
a) application	**5**	visual
b) thickness	tables 2 to 9	Part 2 : 1996, **2.1.1**
c) colour	**5**	visual
d) durability of colour	**5**	Part 2 : 1996, **2.5.4**
Oversheath:		
a) application	**9**	visual
b) thickness	tables 2 to 9	Part 2 : 1996, **2.1.2**
Type tests		
Insulation	**5**	BS EN 60811
Oversheath	**9**	BS EN 60811
Compatibility	table 10	**12.5**

Table 2. PVC insulated single-core copper phase plus helical concentric copper neutral/earth conductor

Description	Nominal cross-sectional area of phase conductor (mm^2)		
	4	16	25
Form of phase conductor	circular or compacted circular stranded		
Minimum average thickness of insulation (mm)	0.8	1.0	1.2
Minimum thickness of insulation at any point (mm)	0.66	0.85	1.04
Concentric neutral conductor:			
number of wires	15	19	25
approximate diameter of wires (mm)	0.67	1.04	1.13
minimum length of lay (mm)	55	100	120
maximum length of lay (mm)	80	135	165
Minimum average thickness of PVC oversheath (mm)	1.4	1.4	1.4
Minimum thickness of PVC oversheath at any point (mm)	1.09	1.09	1.09
Approximate overall diameter (mm)	8.7	12.5	14.4
Maximum d.c. resistance per km of cable at 20°C:			
a) phase (Ω)	4.61	1.15	0.727
b) concentric neutral (Ω)	4.8	1.2	0.76

Table 3. PVC insulated single-core aluminium phase plus helical concentric copper neutral/earth conductor

Description	Nominal cross-sectional area of phase conductor (mm^2)		
	10	25	35
Form of phase conductor	Circular solid		
Minimum average thickness of insulation (mm)	1.0	1.2	1.2
Minimum thickness of insulation at any point (mm)	0.85	1.04	1.04
Concentric neutral conductor:			
number of wires	21	27	25
approximate diameter of wires (mm)	0.67	0.85	1.04
minimum length of lay (mm)	75	105	120
maximum length of lay (mm)	105	145	165
Minimum average thickness of PVC oversheath (mm)	1.4	1.4	1.4
Minimum thickness of PVC oversheath at any point (mm)	1.09	1.09	1.09
Approximate overall diameter (mm)	10.2	13.0	14.4
Maximum d.c. resistance per km of cable at 20 °C:			
a) phase (Ω)	3.08	1.2	0.868
b) concentric neutral (Ω)	3.2	1.3	0.91

Table 4. PVC insulated three-phase copper plus helical concentric copper neutral/earth conductor

Description	Nominal cross-sectional area of phase conductor (mm^2)		
	16	25	25
Form of phase conductor	Circular or compacted circular stranded		Shaped stranded
Minimum average thickness of insulation (mm)	1.0	1.2	1.2
Minimum thickness of insulation at any point (mm)	0.85	1.04	1.04
Radial thickness PVC tape bedding (mm)	0.5	0.5	0.5
Concentric neutral conductor:			
number of wires	48	56	56
approximate diameter of wires (mm)	0.67	0.75	0.75
minimum length of lay (mm)	205	255	215
maximum length of lay (mm)	280	345	290
Minimum average thickness of PVC oversheath (mm)	1.8	1.8	1.8
Minimum thickness of PVC oversheath at any point (mm)	1.43	1.43	1.43
Approximate overall diameter (mm)	22.1	26.0	22.9
Maximum d.c. resistance per km of cable at 20 °C:			
a) phase (Ω)	1.15	0.727	0.727
b) concentric neutral (Ω)	1.2	0.76	0.76

Table 5. PVC insulated three-phase aluminium plus helical concentric copper neutral/earth conductor

Description	Nominal cross-sectional area of phase conductor (mm^2)	
	25	35
Form of phase conductor	Circular solid	
Minimum average thickness of insulation (mm)	1.2	1.2
Minimum thickness of insulation at any point (mm)	1.04	1.04
Radial thickness PVC tape bedding	0.5	0.5
Concentric neutral conductor:		
number of wires	45	61
approximate diameter of wires (mm)	0.67	0.67
minimum length of lay (mm)	230	255
maximum length of lay (mm)	310	345
Minimum average thickness of PVC oversheath (mm)	1.8	1.8
Minimum thickness of PVC oversheath at any point (mm)	1.43	1.43
Approximate overall diameter (mm)	24.1	26.2
Maximum d.c. resistance per km of cable at 20 °C:		
a) phase (Ω)	1.2	0.868
b) concentric neutral (Ω)	1.3	0.91

Table 6. XLPE insulated single-core copper phase plus helical concentric copper neutral/earth conductor

Description	Nominal cross-sectional area of phase conductor (mm^2)	
	16	25
Form of phase conductor	Circular or compacted circular stranded	
Minimum average thickness of insulation (mm)	0.7	0.9
Minimum thickness of insulation at any point (mm)	0.53	0.71
Concentric neutral conductor:		
number of wires	19	45
approximate diameter of wires (mm)	1.04	1.13
minimum length of lay (mm)	90	110
maximum length of lay (mm)	125	155
Minimum average thickness of PVC oversheath (mm)	1.4	1.4
Minimum thickness of PVC oversheath at any point (mm)	1.09	1.09
Approximate overall diameter (mm)	11.8	13.7
Maximum d.c. resistance per km of cable at 20 °C:		
a) phase (Ω)	1.15	0.727
b) concentric neutral (Ω)	1.2	0.76

Table 7. XLPE insulated single-core aluminium phase plus helical concentric copper neutral/earth conductor

Description	Nominal cross-sectional area of phase conductor (mm^2)	
	25	35
Form of phase conductor	Circular solid	
Minimum average thickness of insulation (mm)	0.9	0.9
Minimum thickness of insulation at any point (mm)	0.71	0.71
Concentric neutral conductor:		
number of wires	27	25
approximate diameter of wires (mm)	0.84	1.04
minimum length of lay (mm)	100	115
maximum length of lay (mm)	135	155
Minimum average thickness of PVC oversheath (mm)	1.4	1.4
Minimum thickness of PVC oversheath at any point (mm)	1.09	1.09
Approximate overall diameter (mm)	12.3	13.7
Maximum d.c. resistance per km of cable at 20 °C:		
a) phase (Ω)	1.2	0.868
b) concentric neutral (Ω)	1.3	0.91

Table 8. XLPE insulated three-phase copper conductors plus helical concentric copper neutral/earth conductor

Description	Nominal cross-sectional area of phase conductor (mm^2)		
	16	25	25
Form of phase conductor	Circular or compacted circular stranded		Shaped stranded
Minimum average thickness of insulation (mm)	0.7	0.9	0.9
Minimum thickness of insulation at any point (mm)	0.53	0.71	0.71
Radial thickness PVC tape bedding (mm)	0.5	0.5	0.5
Concentric neutral conductor:			
number of wires	48	56	56
approximate diameter of wires (mm)	0.67	0.75	0.75
minimum length of lay (mm)	190	235	200
maximum length of lay (mm)	260	315	270
Minimum average thickness of PVC oversheath (mm)	1.8	1.8	1.8
Minimum thickness of PVC oversheath at any point (mm)	1.43	1.43	1.43
Approximate overall diameter (mm)	20.6	24.6	21.5
Maximum d.c. resistance per km of cable at 20 °C:			
a) phase (Ω)	1.15	0.727	0.727
b) concentric neutral (Ω)	1.2	0.76	0.76

Table 9. XLPE insulated three-phase aluminium conductors plus helical concentric copper neutral/earth conductor

Description	Nominal cross-sectional area of phase conductor (mm^2)	
	25	35
Form of phase conductor	Circular solid	
Minimum average thickness of insulation (mm)	0.9	0.9
Minimum thickness of insulation at any point (mm)	0.71	0.71
Radial thickness PVC tape bedding	0.5	0.5
Concentric neutral conductor:		
number of wires	45	61
approximate diameter of wires (mm)	0.67	0.67
minimum length of lay (mm)	215	240
maximum length of lay (mm)	290	325
Minimum average thickness of PVC oversheath (mm)	1.8	1.8
Minimum thickness of PVC oversheath at any point (mm)	1.43	1.43
Approximate overall diameter (mm)	22.6	24.8
Maximum d.c. resistance per km of cable at 20 °C:		
a) phase (Ω)	1.2	0.868
b) concentric neutral (Ω)	1.3	0.91

Table 10. Requirements for compatibility of insulation and oversheath

Component	Test	Requirement		
		TI 1	GP 8	TM 1
Insulation	Minimum tensile strength (N/mm^2)	12.5	12.5	–
	Minimum elongation at break (%)	125	200	–
	Maximum variation[1)] of tensile strength (%)	20	25	
	Maximum variation[1)] of elongation at break (%)	20	25	–
Oversheath	Minimum tensile strength (N/mm^2)	–	–	12.5
	Minimum elongation at break (%)	–	–	125
	Maximum variation[1)] of tensile strength (%)	–	–	20
	Maximum variation[1)] of elongation at break (%)	–	–	20

[1)] The variation is the difference between the respective values obtained prior to and after heat treatment expressed as a percentage of the former.

List of references

Normative references

British Standards publications

BRITISH STANDARDS INSTITUTION, London

BS 6360 : 1991	*Specification for conductors in insulated cables and cords*
BS 7655	*Specification for insulating and sheathing materials for cables.*
BS 7655 : Part 1 :	*Elastomeric insulating compounds*
BS 7655 : Section 1.3 : 1993	*XLPE*
BS 7655 : Part 3 :	*PVC insulating compounds*
BS 7655 : Section 3.1 : 1993	*Harmonized types*
BS 7655 : Part 4 :	*PVC sheathing compounds*
BS 7655 : Section 4.1 : 1993	*Harmonized types*
BS 7870 :	*LV & MV polymeric insulated cables for use by distribution and generation utilities*
BS 7870 : Part 1 : 1996	*General*
BS 7870 : Part 2 : 1996	*Methods of test*
BS EN 60811	*Insulating and sheathing materials of electric cables. Common test methods*
BS EN 60811 : Part 1 :	*General applications*
BS EN 60811 : Section 1-2 : 1995	*Thermal ageing methods*

Informative references

British Standards publications

BRITISH STANDARDS INSTITUTION, London

BS 4066 (series)	*Tests on electric cables under fire conditions*

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