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

Part 7: Specification for power cables having rated voltages of 3.8/6.6 kV and 6.35/11 kV with special fire performance for use in power stations —

Section 7.1: Single core and 3-core cables with halogenated materials and with aluminium or steel wire armouring

(Implementation of HD 622)

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Contents

Foreword

This section of BS 7870 has been prepared by Subcommittee GEL/20/16, under the direction of Technical Committee GEL/20.

BS 7870 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_0/U up to and including 19/33 kV and is published as a series of separate parts and sections, as listed in the table in the foreword of BS 7870-1.

BS 7870-7.1 specifies a range of PVC sheathed reduced fire propagation performance cables. It implements HD 622-3H and is to be read in conjunction with BS 7870-1 and BS 7870-2.

BS 7870-7.2 specifies a range of halogen-free sheathed cables, having reduced fire propagation performance and low emission of smoke when affected by fire, and implements HD 622-4H.

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.

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 and ii, pages 1 to 21 and a back cover.

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1 Scope

This section of BS 7870 specifies requirements for the construction, dimensions and mechanical and physical properties of single core and 3-core cross-linked polyethylene (XLPE) or ethylene propylene rubber (EPR) insulated and PVC sheathed cables, with aluminium or steel wire armouring, having reduced fire propagation performance.

It specifies requirements for the following categories of cable:

a) single core XLPE or EPR insulated aluminium wire armoured 3.8/6.6 kV;

b) 3-core XLPE or EPR insulated aluminium wire armoured or steel wire armoured 3.8/6.6 kV;

c) single core XLPE or EPR insulated aluminium wire armoured 6.35/11 kV;

d) 3-core XLPE or EPR insulated aluminium wire armoured or steel wire armoured 6.35/11 kV.

This section of BS 7870 is applicable to cables for fixed installations that are mainly intended for use in power generating plants and substations, and where the combination of ambient temperature and temperature rise due to loading current results in a conductor temperature not exceeding 90 °C.

This section of BS 7870 is not applicable to cables designed for installation within the containment areas of nuclear power plants (LOCA), or cables specifically designed to be radiation-resistant.

NOTE Annex A contains a "guide to use" for the cables specified in this section of BS 7870.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 6360, *Specification for conductors in insulated cables and cords.*

BS 7870-1, *LV and MV polymeric insulated cables for use by distribution and generation utilities — Part 1: General.*

BS 7870-2:1999, *LV and MV polymeric insulated cables for use by distribution and generation utilities — Part 2: Methods of test.*

BS 7870-7.2, *LV and MV polymeric insulated cables for use by distribution and generation utilities — Part 7: Specification for power cables having rated voltages of 3.8/6.6 kV and 6.35/11 kV with special fire performance for use in power stations — Section 7.2: Single core and 3-core cables with halogen-free materials and with aluminium or steel wire armouring.*

BS EN 50265-2-1, *Common test methods for cables under fire conditions — Test for resistance to vertical flame propagation for a single insulated conductor or cable — Part 2: Procedures — Section 2.1: 1 kW pre-mixed flame.*

BS EN 60811-1-1:1995, *Insulating and sheathing materials of electric cables — Common test methods — Part 1: General application — Section 1.1: Measurement of thickness and overall dimensions — Tests for determining the mechanical properties.*

BS EN 60811-1-2:1995, *Insulating and sheathing materials of electric cables — Common test methods — Part 1: General application — Section 1.2: Thermal ageing methods.*

BS EN 60811-1-3:1995, *Insulating and sheathing materials of electric cables — Common test methods — Part 1: General application — Section 1.3: Methods for determining the density — Water absorption tests — Shrinkage test.*

BS EN 60811-1-4:1995, *Insulating and sheathing materials of electric cables — Common test methods — Part 1: General application — Section 1.4: Test at low temperatures.*

BS EN 60811-2-1:1995, *Insulating and sheathing materials of electric cables — Common test methods — Part 2: Methods specific to elastomeric compounds — Section 2.1: Ozone resistance, hot set and mineral oil immersion tests.*

BS EN 60811-3-1:1995, *Insulating and sheathing materials of electric cables — Common test methods — Part 3: Methods specific to PVC compounds — Section 3.1: Pressure test at high temperature — Tests for resistance to cracking.*

BS EN 60811-3-2:1995, *Insulating and sheathing materials of electric cables — Common test methods — Part 3: Methods specific to PVC compounds — Section 3.2: Loss of mass test — Thermal stability test.*

BS ISO 4589-2:1996, *Plastics — Determination of burning behaviour by oxygen index — Part 2: Ambient-temperature test.*

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 designations of cables in this standard are:

a) 3.8/6.6 (7.2) kV;

b) 6.35/11 (12) kV.

4 General requirements

4.1 Identification of cores in 3-core cables

The cores of 3-core cables shall be unmarked.

4.2 Thickness of insulation

The mean value of the thickness of insulation, excluding semi-conducting layers, shall be not less than the specified value for each type and size of cable shown in Table 1, Table 2, Table 3 and Table 4.

If the thickness at any place is less than the specified value, the difference shall not exceed 0.1 mm + 10 % of the specified value.

Conformity shall be checked by the test specified in BS 7870-2:1999, **2.1.1**.

4.3 Thickness of extruded bedding

The minimum thickness of extruded bedding shall not fall below the specified value for each type and size of cable shown in Table 1, Table 2, Table 3 and Table 4 by more than 15 % + 0.1 mm.

Conformity shall be checked by the test given in BS 7870-2:1999, **2.1.2**.

4.4 Thickness of oversheath

The minimum thickness at any point of the oversheath shall not fall below the specified value for each type and size of cable shown in Table 1, Table 2, Table 3 and Table 4 by more than 0.2 mm + 20 % of the specified value.

Conformity shall be checked by the test given in BS 7870-2:1999, **2.1.2**.

Table 1 — Single core 3 800/6 600 V cable with stranded aluminium or copper circular conductors

Nominal cross-sectional area of conductor[a] mm²	Thickness of insulation mm	Thickness of extruded bedding mm	Nominal armour wire diameter mm	Thickness of oversheath mm	Approximate overall diameter mm
50	2.5	1.2	1.6	1.8	26.7
70	2.5	1.2	1.6	1.8	28.4
95	2.5	1.2	1.6	1.9	30.3
120	2.5	1.2	1.6	1.9	31.9
150	2.5	1.2	1.6	2.0	33.5
185	2.5	1.2	2.0	2.0	36.1
240	2.6	1.2	2.0	2.1	38.9
300	2.8	1.2	2.0	2.2	41.8
400	3.0	1.2	2.0	2.3	45.5
500	3.2	1.3	2.5	2.5	50.5
630	3.2	1.4	2.5	2.6	54.6
800[b]	3.2	1.4	2.5	2.7	60.8
1 000[b]	3.2	1.5	2.5	2.9	65.9

[a] Circular compacted stranded conductor class 2.
[b] These sizes apply to cables with copper conductors only.

Table 2 — 3-core 3 800/6 600 V cable with stranded aluminium or copper circular conductors

Nominal cross-sectional area of conductor[a] mm²	Thickness of insulation mm	Thickness of extruded bedding mm	Nominal armour wire diameter[b] mm	Thickness of oversheath mm	Approximate overall diameter mm
50	2.5	1.3	2.5	2.5	50.3
70	2.5	1.3	2.5	2.6	54.2
95	2.5	1.4	2.5	2.7	58.3
120	2.5	1.5	2.5	2.8	62.1
150	2.5	1.5	2.5	2.9	65.3
185	2.5	1.6	2.5	3.0	69.6
240	2.6	1.7	2.3	3.2	75.8
300	2.8	1.8	3.15	3.5	83.8
400	3.0	2.0	3.15	3.7	92.1

[a] Circular compacted stranded conductor class 2.
[b] Armour wires may be of aluminium or galvanized steel.

Table 3 — Single core 6 350/11 000 V cable with stranded aluminium or copper circular conductors

Nominal cross-sectional area of conductor[a] mm²	Thickness of insulation mm	Thickness of extruded bedding mm	Nominal armour wire diameter[b] mm	Thickness of oversheath mm	Approximate overall diameter mm
50	3.4	1.2	1.6	1.8	28.5
70	3.4	1.2	1.6	1.9	30.4
95	3.4	1.2	1.6	1.9	32.1
120	3.4	1.2	1.6	2.0	33.9
150	3.4	1.2	2.0	2.1	36.3
185	3.4	1.2	2.0	2.1	38.1
240	3.4	1.2	2.0	2.2	40.7
300	3.4	1.2	2.0	2.2	43.0
400	3.4	1.2	2.0	2.4	46.5
500	3.4	1.3	2.5	2.5	50.9
630	3.4	1.4	2.5	2.6	55.0

[a] Circular compacted stranded conductor class 2.

Table 4 — 3-core 6 350/11 000 V cable with stranded aluminium or copper circular conductors

Nominal cross-sectional area of conductor[a] mm²	Thickness of insulation mm	Thickness of extruded bedding mm	Nominal armour wire diameter[b] mm	Thickness of oversheath mm	Approximate overall diameter mm
50	3.4	1.4	2.5	2.6	54.6
70	3.4	1.4	2.5	2.7	58.5
95	3.4	1.5	2.5	2.8	62.6
120	3.4	1.6	2.5	3.0	66.6
150	3.4	1.6	2.5	3.1	69.8
185	3.4	1.7	2.5	3.2	74.1
240	3.4	1.8	3.15	3.4	81.2
300	3.4	1.9	3.15	3.6	86.8

[a] Circular compacted stranded conductor class 2.
[b] Armour wires may be of aluminium or galvanized steel.

4.5 Marking

4.5.1 *External marking*

The external surface of all cables shall be legibly marked with the following elements:

Element	Example of marking
a) Electric cable	ELECTRIC CABLE
b) Voltage designation	6 600 V or 11 000 V
c) British Standard number[1)]	BS 7870-7.1
d) Manufacturer's identification	XYZ
e) The number of cores, type and nominal conductor area, e.g.	
1) Copper conductor cable	3 × 185
2) Aluminium conductor cable	1 × 400 AL

The marking of elements a) to d) shall be by embossing, by indenting on the oversheath, or by other durable means agreed with the purchaser.

Elements a), b) and c) shall appear, in any sequence that is deemed neither to confuse nor to conflict, on two or more primary lines along the axis of the cable, approximately equally spaced around the circumference of the cable.

Elements d) and e) shall appear on at least one line.

NOTE Elements d) and e) may be on one of the primary lines or a secondary line or lines and need not be on the same line.

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 elements a), b) and c), and not greater than 1 100 mm for elements d) and e).

Conformity shall be checked by visual examination and measurement.

4.5.2 *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 use of an identification thread or externally by marking on the surface of the cable.

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

If the identification is by marking on the external surface, the distance between the end of one element of marking and the beginning of the next identical element shall be not greater than 1 100 mm.

Conformity shall be checked by visual examination and measurement.

4.5.3 *Mark of an approval organization*

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

If the mark is on the external surface of the cable, it shall be in the form of the symbol(s) specified by the approval organization, and the distance between the end of one element of marking and the beginning of the next identical element shall be not greater than 1 100 mm.

Conformity shall be checked by visual examination and measurement.

[1)] Marking BS 7870-7.1:2003 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.

4.5.4 *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 **4.5.1**, **4.5.2** and **4.5.3**.

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

Conformity shall be checked by visual examination and measurement.

4.6 Routine tests

4.6.1 *Voltage test*

The cable shall be tested in accordance with BS 7870-2:1999, **3.2.1**, using a voltage of $4U_0$, gradually imposed and held for a period of 15 min. No breakdown shall occur.

4.6.2 *D.C. test on oversheath of single core cables*

When tested in accordance with BS 7870-2:1999, **3.2.3.1**, the oversheath shall not break down during the application of 8 kV/mm of specified thickness of insulation of oversheath, subject to a maximum of 25 kV.

4.6.3 *Spark test on oversheath*

Spark testing of the oversheath shall be carried out in accordance with BS 7870-2:1999, **3.6.1**. No failure shall occur.

4.6.4 *Partial discharge test*

The cable shall be subjected to a partial discharge test in accordance with BS 7870-2:1999, **3.10.3**. The voltage shall be raised to $2.25U_0$, held for not more than 1 min, and reduced to $2U_0$, at which voltage the discharge magnitude (q) shall not exceed 10 pC.

4.7 Sample tests

4.7.1 *Thickness measurement*

A sample shall be taken from one end of each drum length of cable selected for the test, and any portion of the cable that may have suffered damage shall be discarded. The thickness of insulation, extruded bedding and oversheath shall be measured in accordance with the tests specified in Table 5.

If any of the thicknesses measured does not conform to the requirements specified in **6.3.2**, **6.3.5** and **6.3.7**, two further samples shall be checked for the non-conforming factors. If both the further samples meet the specified requirements, the cable shall be deemed to conform, but if either sample does not meet the specified requirements, the cable shall be deemed not to conform.

4.7.2 *Strippability of extruded semi-conducting insulation screen*

The screen shall be capable of removal without impairing the performance of the insulation. When tested in accordance with BS 7870-2:1999, **2.2.8.6**, the force required to remove the screen shall be not less than 18 N and not more than 80 N.

Table 5 — Schedule of tests

Test	Category of test	Test method in accordance with BS 7870-2:1999 unless otherwise specified	Requirement given in clause	
			Single core cables	3-core cables
Electrical tests				
Conductor resistance	R	**3.1.1**	**6.3.1**	**6.3.1**
Voltage test:				
— cores	R	**3.2.1**	**4.6.1**	**4.6.1**
— oversheath	R	**3.2.3.1**	**4.6.2**	—
Spark test on oversheath	R	**3.6.1**	**4.6.3**	**4.6.3**
Resistance test on bedding and oversheath	T	**3.3.4**	**4.8.4**	—
Partial discharge test	R	**3.10.3**	**4.6.4**	**4.6.4**
Sequential type test	T	See **4.8.6** in present section	**4.8.6**	**4.8.6**
Provision covering constructional and dimensional characteristics				
Conductor material and construction	S	BS 6360	**6.3.1**	**6.3.1**
Conductor screen resistivity	T	**3.9.3**	**4.8.2**	**4.8.2**
Insulation thickness	S	**2.1.1**	**4.2** and **6.3.2**	**4.2** and **6.3.2**
Insulation screen:				
a) non-metallic:				
— resistivity	T	**3.9.3**	**4.8.2**	**4.8.2**
— strippability	S	**2.2.8.6**	**4.7.2**	**4.7.2**
b) metallic:				
— fault capacity	T	Design	**6.3.3.2**	**6.3.3.2**
Assembly of cores	S	Visual	—	**6.3.4**
Bedding thickness	S	**2.1.2**	**4.3** and **6.3.5**	**4.3** and **6.3.5**
Armour:				
a) diameter	S	**2.1.4.3**	**6.3.6**	**6.3.6**
b) mass of zinc coating (steel)	T	**2.5.1.1**	—	**6.3.6**
c) wrapping test (steel)	T	**2.3.2**	—	**6.3.6**
d) tensile test (aluminium)	T	**2.3.1.1**	**6.3.6**	**6.3.6**
Oversheath thickness	S	**2.1.2**	**4.4** and **6.3.7**	**4.4** and **6.3.7**
Cable markings	R	Visual examination and measurement	**4.5**	**4.5**
Mechanical properties				
Insulation	T	Table 12	**6.3.2**	**6.3.2**
Extruded bedding	T	Table 13	**6.3.5**	**6.3.5**
Oversheath	T	Table 13	**6.3.7**	**6.3.7**
Cold bend test	T	**2.4.1.1**	**4.8.5**	**4.8.5**
Compatibility test	T	**2.4.12.2**	**4.8.3** and Table 6	**4.8.3** and Table 6
Tests under fire conditions				
Oxygen index: insulation, bedding and oversheath	T and S	BS ISO 4589-2	**4.9.3**	**4.9.3**
Flame propagation:				
a) single cable	S	BS EN 50265-2-1	BS EN 50265-2-1: 1999, Annex A	BS EN 50265-2-1: 1999, Annex A
b) bunched cables	T	**4.1.1**	**4.9.2**	**4.9.2**

4.8 Type tests

4.8.1 *General*

Satisfactory completion of all type tests on the following sizes shall be deemed to be sufficient to cover the full range of cables listed in Table 1, Table 2, Table 3 and Table 4, for the particular insulating material (XLPE or EPR):

a) for 3-core cables: 70 mm^2 or 95 mm^2 6.35/11 kV cable;

b) for single core cables: 500 mm^2 or 630 mm^2 6.35/11 kV cable.

NOTE The cables tested may have either copper or aluminium conductors, and either steel or aluminium wire armouring.

To cover the full range of 3.8/6.6 kV cables only, the same two sizes as above, but of 3.8/6.6 kV rating, shall be tested.

4.8.2 *Measurement of extruded semi-conducting screen resistivity*

When measured in accordance with BS 7870-2:1999, **3.9.3**, the resistivity shall not exceed 500 Ω·m at 90 °C.

4.8.3 *Compatibility test*

When tested in accordance with BS 7870-2:1999, **2.4.12.2**, the sample being aged for 7 days at (100 ± 2) °C, the performance shall conform to the values specified in Table 6.

Table 6 — Compatibility test

Component	Parameter	Requirements		
		XLPE	EPR	PVC
Insulation	Maximum % variation[a] of tensile strength	25	30	—
	Maximum % variation[a] of elongation at break	25	30	—
Oversheath	Minimum tensile strength N/mm^2	—	—	12.5
	Minimum % elongation at break	—	—	150
	Maximum % variation[a] of tensile strength	—	—	25
	Maximum % variation[a] of elongation at break	—	—	25
Conductor screen	Maximum resistivity at 90 °C, Ω·m	1 000		
Core screen	Maximum resistivity at 90 °C, Ω·m	1 000		
	Strippability force, N/13 mm	18 to 80		

[a] The variation is the difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter.

4.8.4 *Bedding and oversheath resistance test*

This shall be measured on a single core cable between the insulation metal screen and the armour, and between the armour and the water as described in BS 7870-2:1999, **3.3.4**, except that the nominal voltage shall be not less than 500 V d.c.

The insulation resistance shall be not less than 1 MΩ·km when corrected to 20 °C.

4.8.5 *Cold bending test*

When tested in accordance with BS 7870-2:1999, **2.4.1.1**, the 11 V cables shall be subjected to the conditions shown in Table 7.

Table 7 — Cold bending test

Temperature	Diameter of test cylinder		Parameter to be measured
	3-core cable	Single core cable	
0 °C	12 ($D + d$)	15 ($D + d$)	Partial discharge

NOTE D is the approximate overall diameter in millimetres (mm); d is the diameter of the conductor in millimetres (mm).

The partial discharge shall be measured in accordance with BS 7870-2:1999, **3.10.3**. The voltage shall be raised to $2.25U_0$, held for not more than 1 min, and reduced to $2U_0$ at which voltage the discharge magnitude (q) shall not exceed 5 pC.

4.8.6 *Sequential type testing*

4.8.6.1 *General*

A cable length shall be subjected to the sequence of tests given in **4.8.6.2** to **4.8.6.8**. The cable length shall be not less than 10 m between terminations, excluding any joints that may be included in the test loop.

NOTE 1 Tests for power factor measurements may be carried out on separate lengths.

NOTE 2 Since the performance in these tests is not dependent on the type of bedding and oversheath, sequential type tests on the same sizes of halogen-free sheathed cable to BS 7870-7.2 can be accepted in lieu of testing the cables above.

4.8.6.2 *Partial discharge test*

The partial discharge shall be measured in accordance with BS 7870-2:1999, **3.10.3**. The voltage shall be raised to $2.25U_0$, held for not more than 1 min, and reduced to $2U_0$ at which voltage the discharge magnitude (q) shall not exceed 5 pC.

4.8.6.3 *Bend test*

When tested in accordance with BS 7870-2:1999, **2.4.1.1**, the cables shall be subjected to the conditions shown in Table 8.

Table 8 — Bend test

Temperature	Diameter of test cylinder		Parameter to be measured
	3-core cable	Single core cable	
Ambient	12 ($D + d$)	15 ($D + d$)	Partial discharge
NOTE D is the approximate overall diameter in millimetres (mm); d is the diameter of the conductor in millimetres (mm).			

The partial discharge shall be measured in accordance with BS 7870-2:1999, **3.10.3**. The voltage shall be raised to $2.25U_0$, held for not more than 1 min, and reduced to $2U_0$ at which voltage the discharge magnitude (q) shall not exceed 5 pC.

4.8.6.4 *Power factor variation with voltage*

When the power factor of each core is measured in accordance with BS 7870-2:1999, **3.11.2** at room temperature and at voltages of $0.5U_0$, $1.0U_0$ and $2.0U_0$, the measured values shall not exceed those specified in Table 9.

Table 9 — Power factor variation with voltage

Property	XLPE	EPR
Maximum tan δ at U_0	40×10^{-4}	200×10^{-4}
Maximum increase in tan δ ($0.5U_0$ to $2.0U_0$)	20×10^{-4}	25×10^{-4}

4.8.6.5 *Power factor variation with temperature*

When the power factor of each core is measured in accordance with BS 7870-2:1999, **3.11.2**, at a minimum voltage of 2 kV, the measured values shall not exceed those specified in Table 10.

Table 10 — Power factor variation with temperature

Property	XLPE	EPR
Maximum tan δ at ambient temperature	40×10^{-4}	200×10^{-4}
Maximum tan δ at elevated temperature 95 °C to 100 °C	80×10^{-4}	400×10^{-4}

4.8.6.6 *Heating cycle test*

The heating cycle test shall be carried out in accordance with BS 7870-2:1999, **3.8.1**. The partial discharge shall then be measured in accordance with BS 7870-2:1999, **3.10.3**. The voltage shall be raised to $2.25U_0$, held for not more than 1 min, and reduced to $2U_0$ at which voltage the discharge magnitude (q) shall not exceed 5 pC.

4.8.6.7 *Impulse testing*

When tested in accordance with BS 7870-2:1999, **3.2.4.1**, no breakdown of the insulation shall occur when the sample is subjected to 10 positive and 10 negative pulses at the appropriate level as specified in Table 11. The test shall be applied at a conductor temperature of 95 °C to 100 °C and for 3-core cables the three cores shall be tested in sequence.

Table 11 — Impulse testing

Rated voltage of cable (U) kV	Impulse voltage kV
6.6	75
11	95

4.8.6.8 *Four-hour voltage test*

When tested in accordance with BS 7870-2:1999, **3.2.1.1**, there shall be no failure when a power frequency voltage of $4U_0$ is applied for 4 h.

4.9 Fire performance tests

4.9.1 *Sample selection*

The flame propagation and oxygen index tests specified in **4.9.2** and **4.9.3** shall be performed on the following cable sizes.

a) For single core cables, test a single core 6.6 kV or 11 kV cable in the range 300 mm^2 to 500 mm^2.

b) For 3-core cables, test a 3-core 6.6 kV or 11 kV cable of size 70 mm^2 or 95 mm^2.

The cables tested may have copper or aluminium conductors and steel or aluminium wire armour, and satisfactory performance shall be deemed to be acceptable to cover the other conductor and armour materials. However, a test shall only be accepted as covering the particular insulating material (XLPE or EPR) used in the sample.

4.9.2 *Flame propagation test*

For type tests, the cable shall be subjected to the test specified in BS 7870-2:1999, **4.1.1**. The cable shall be deemed to conform if, after burning has ceased, or the flames have been extinguished:

a) penetration to the conductor has been achieved on the entire front row of cables; and

b) after the cables have been wiped clean, the charred portion has not reached a height exceeding 2.5 m above the bottom edge of the burner, measured at the front and rear and, where applicable, between the cables in the assembly.

For sample tests, the finished cable shall be tested in accordance with and shall meet the requirements specified in BS EN 50265-2-1. After the test the cable shall conform to the performance recommendations given in BS EN 50265-2-1:1999, Annex A.

4.9.3 *Oxygen index test*

For type tests, the absolute oxygen index of samples of insulation, bedding and oversheath, taken from the complete cable, shall be determined in accordance with the test method given in BS ISO 4589-2. The values obtained shall be used to enable a nominal value, together with suitable tolerances for sample tests, to be agreed between manufacturer and purchaser.

For sample tests, the oxygen index of the insulation, bedding and oversheath shall be determined in accordance with the test method given in BS ISO 4589-2. The values obtained shall fall within the agreed tolerances of the nominal value.

4.10 Resistance to water

If cables are to be buried in the ground and it is considered necessary to show evidence of long-term water resistance testing, the cables shall be tested in accordance with and shall conform to the requirements specified in BS 7870-2:1999, **5.4.8**.

5 Cables without metallic coverings

Not applicable.

6 Cables with metallic coverings

6.1 Cable designation

(Under consideration by CENELEC TC20.)

6.2 Rated voltage

The rated voltages shall be 3.8/6.6 kV and 6.35/11 kV.

6.3 Construction

6.3.1 *Conductor*

The conductors shall be of the material and type detailed in Table 1, Table 2, Table 3 and Table 4 and shall conform to the requirement of BS 6360, class 2 for stranded conductors.

All conductors shall be circular stranded compacted copper or aluminium.

6.3.2 *Insulation*

The insulation shall be either cross-linked polyethylene (XLPE) or ethylene propylene rubber (EPR) conforming to the non-electrical requirements given in Table 12. The insulation thicknesses shall conform to the values specified in Table 1, Table 2, Table 3 and Table 4.

6.3.3 *Screens*

6.3.3.1 *Non-metallic*

Non-metallic screens shall be applied to all cables in the form of extruded layers. The insulation and screens shall be applied in the same operation.

6.3.3.2 *Metallic*

Metallic screens shall be applied to all cables and shall be in the form of a helically applied copper tape having a fault capacity of at least 1 000 A for 1 s. The screens shall be in contact for 3-core cables.

6.3.4 *Assembly of cores*

For 3-core cables the cores shall be laid up with a right-hand direction of lay. Fillers shall be used, if necessary, to form a substantially compact and round cable. The filler shape shall not prevent electrical contact between the screens.

6.3.5 *Extruded bedding*

The bedding shall consist of an extruded layer of PVC compound conforming to the requirements given in Table 13. The thickness shall conform to the values given in Table 1, Table 2, Table 3 and Table 4.

Table 12 — Requirements for non-electrical tests for 90 °C insulation

Test	Unit	Type of compound		Test method described in
		EPR	XLPE	
Tensile strength and elongation at break				
Properties in the state as delivered				BS EN 60811-1-1:1995, **9.1**
Values to be obtained for the tensile strength:				
— median, min.	N/mm^2	8.5	12.5	
Values to be obtained for the elongation at break:				
— median, min.	%	200	200	
Properties after ageing in air oven				BS EN 60811-1-2:1995, **8.1.3**
Ageing conditions:				
— temperature	°C	135	135	
— duration of treatment	h	168	168	
Values to be obtained for the tensile strength:				
— median, min.	N/mm^2	—	—	
— variation[a], max.	%	30	25	
Values to be obtained for the elongation at break:				
— median, min.	%	—	—	
— variation[a], max.	%	30	25	
Properties after ageing in air bomb				BS EN 60811-1-2:1995, **8.2**
Ageing conditions:				
— temperature	°C	127	—	
— duration of treatment	h	40	—	
Value to be obtained for the tensile strength:				
— median, min.	N/mm^2	—	—	
— variation[a], max.	%	30	—	
Values to be obtained for the elongation at break:				
— median, min.	%	—	—	
— variation[a], max.	%	30	—	
Hot set test				BS EN 60811-2-1:1995, Clause **9**
— temperature	°C	250	200	
— time under load	min	15	15	
— mechanical stress	N/mm^2	0.2	0.2	
— max. elongation under load	%	175	175	
— max. elongation after unloading	%	15	15	
Ozone resistance test				BS EN 60811-2-1:1995, Clause **8**
— temperature	°C	25 ± 2	—	
— duration	h	30	—	
— ozone concentration	ppm	250 to 300	—	
— visual examination		No cracks	—	
Shrinkage test				BS EN 60811-1-3:1995, Clause **10**
— temperature	°C	—	130	
— duration	h	—	1	
— shrinkage, max.	%	—	4	
Water absorption				BS EN 60811-1-3:1995, **9.2**
— temperature	°C	85	85	
— duration	h	336	336	
— max. variation of mass	mg/cm^2	5	1	

[a] The variation is the difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter.

Table 13 — Requirements for non-electrical tests of PVC bedding and oversheath

Test	Unit	Type of compound	Test method described in
		PVC	
Tensile strength and elongation at break			
Properties in the state as delivered:			BS EN 60811-1-1:1995, **9.2**
Values to be obtained for the tensile strength:			
— median, min.	N/mm^2	12.5	
Values to be obtained for the elongation at break:			
— median, min.	%	150	
Properties after ageing in air oven:			BS EN 60811-1-2:1995, **8.1**
Ageing conditions:			
— temperature	°C	100	
— duration of treatment	h	168	
Values to be obtained for the tensile strength:			
— median, min.	N/mm^2	12.5	
— variation[a], max.	%	±25	
Values to be obtained for the elongation at break:			
— median, min.	%	150	
— variation[a], max.	%	±25	
Loss of mass test			BS EN 60811-3-2:1995, **8.2**
Ageing conditions:			
— temperature	°C	100	
— duration of treatment	h	168	
Value to be obtained for the loss of mass, max.	mg/cm^2	1.5	
Heat shock test			BS EN 60811-3-1:1995, **9.2**
— temperature	°C	150	
— duration of treatment	h	1	
— visual examination		No cracks	
Pressure test at high temperature			BS EN 60811-3-1:1995, **8.2**
— force exerted by blade		[b]	
— duration of heating under load		[b]	
— temperature	°C	90	
— median of the depth of penetration, max.	%	50	
Elongation test at low temperature			BS EN 60811-1-4:1995, **8.4**
— temperature	°C	–15	
— period of application of low temperature		[b]	
— elongation without break, min.	%	20	
Impact test at low temperature			BS EN 60811-1-4:1995, **8.5**
— temperature	°C	–15	
— period of application of low temperature		[b]	
— mass of hammer		[b]	

[a] The variation is the difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter.
[b] See test method.

6.3.6 *Armour*

The armour shall consist of a single layer of wires applied helically with a left-hand direction of lay. For all single core cables the armour shall consist of aluminium wire. For 3-core cables the armour shall consist of aluminium or steel wire.

The armouring shall conform to the following requirements, as appropriate.

a) When measured in accordance with BS 7870-2:1999, **2.1.4.3**, the diameter of round armour wire shall fall within the minimum and maximum wire diameters specified in Table 14.

b) When measured in accordance with BS 7870-2:1999, **2.5.1.1**, the mass of zinc coating of galvanized steel armour wire shall be not less than that given in Table 15.

c) The wire shall be subjected to the wrapping test specified in BS 7870-2:1999, **2.3.2**, and shall not break.

d) When measured in accordance with BS 7870-2:1999, **2.3.1.1**, the tensile strength of aluminium armour wires shall be not less than 125 N/mm^2.

Table 14 — Diameter of round wire armour

Nominal diameter of wire	Wire diameter	
	Minimum	Maximum
mm	mm	mm
1.25	1.18	1.32
1.6	1.51	1.69
2.0	1.90	2.10
2.5	2.37	2.63
3.15	2.99	3.31

Table 15 — Mass of zinc coating

Nominal diameter of armour wire	Minimum mass of zinc coating
mm	g/m^2
1.25	150
1.6	172
2.0	180
2.5	195
3.15	206

Joints in steel armour wire shall be brazed or welded and any surface irregularity shall be removed.

Joints in aluminium wires shall be made by cold pressure or fusion welding and all surface irregularities shall be removed.

Any joint in any wire shall be not less than 1 m from the nearest joint in any other armour wire in the complete cable.

6.3.7 *Oversheath*

The oversheath shall consist of an extruded layer of black PVC compound conforming to the requirements given in Table 13.

The oversheath thickness shall conform to the specified value in Table 1, Table 2, Table 3 and Table 4.

If the resistance of the oversheath is to be determined after the cable has been installed, the oversheath for single core cables shall have a suitable semi-conducting coating. The coating shall be capable of withstanding the rigours of installation and shall adhere to the surface of the sheath when the cable is operating at maximum conductor temperature.

6.4 Tests

Conformity to the requirements of **6.3** shall be checked by inspection and by the tests specified in Table 5.

Annex A (informative)
Guide to use

A.1 General

This annex gives guidance on the selection, storage, transport and disposal of the cables specified in this section of BS 7870.

A.2 Object

The object of this annex is to provide recommendations for the selection, storage, transportation, installation and disposal of the cables specified in this section of BS 7870.

A.3 Recommendations for selection

A.3.1 *Permissible application*

These cables may be installed indoors and outdoors for fixed installations on walls and metallic structures, in ducts or buried direct. These cables should not be installed where the emission of corrosive fumes and excessive smoke in the event of a fire is forbidden.

A.3.2 *Maximum permissible voltages*

The maximum permissible voltages for the cables are shown in Table A.1.

Table A.1 — Maximum permissible voltages

System voltage		System category	Minimum rated voltage of cable
Nominal voltage kV	Maximum sustained voltage kV		kV
6.6 or 6	7.2	A or B	3.8/6.6
6.6 or 6	7.2	C	6.35/11
11 or 10	12.0	A or B	6.35/11

A.3.3 *Earth fault current*

The wire armouring on these cables possesses a substantial earth fault capacity. Further information should be obtained from the cable manufacturer.

For medium voltage (MV) installations it is common practice to earth the copper tape screen at both ends of the cable, whilst earthing the wire armour at one end only, normally the supply end. In this situation, the earth fault magnitude should be limited by earthing the transformer through an appropriate impedance, such that the earth fault level in the copper screen is kept at $\leqslant$1 000 A. Where the armour of MV cables is to be used as part of the earth fault circuit, values of gross cross-sectional areas and armour resistances are given, for information, in Table A.2, Table A.3, Table A.4 and Table A.5.

Table A.2 — Armour resistance for 3.8/6.6 kV cables

Nominal cross-sectional area of conductors	3-core cables				Single core cables	
	Steel wire armour		Aluminium wire armour		Aluminium wire armour	
	Cables with stranded copper conductors	Cables with stranded aluminium conductors	Cables with stranded copper conductors	Cables with stranded aluminium conductors	Cables with stranded copper conductors	Cables with stranded aluminium conductors
mm^2	Ω	Ω	Ω	Ω	Ω	Ω
50	0.68	0.68	0.14	0.14	0.43	0.43
70	0.63	0.63	0.13	0.13	0.40	0.40
95	0.58	0.58	0.12	0.12	0.38	0.38
120	0.54	0.54	0.12	0.12	0.36	0.36
150	0.52	0.52	0.11	0.11	0.34	0.34
185	0.48	0.48	0.097	0.097	0.25	0.25
240	0.44	0.44	0.089	0.089	0.23	0.23
300	0.32	0.32	0.064	0.064	0.22	0.22
400	0.29	0.29	0.058	0.058	0.20	0.20
500	—	—	—	—	0.14	0.14
630	—	—	—	—	0.13	0.13
800	—	—	—	—	0.12	—
1 000	—	—	—	—	0.11	—

Table A.3 — Armour resistance for 6.35/11 kV cables

Nominal cross-sectional area of conductors	3-core cables				Single core cables	
	Steel wire armour		Aluminium wire armour		Aluminium wire armour	
	Cables with stranded copper conductors	Cables with stranded aluminium conductors	Cables with stranded copper conductors	Cables with stranded aluminium conductors	Cables with stranded copper conductors	Cables with stranded aluminium conductors
mm^2	Ω	Ω	Ω	Ω	Ω	Ω
50	0.63	0.63	0.13	0.13	0.40	0.40
70	0.58	0.58	0.12	0.12	0.37	0.37
95	0.53	0.53	0.11	0.11	0.35	0.35
120	0.50	0.50	0.11	0.11	0.34	0.34
150	0.48	0.48	0.097	0.097	0.25	0.25
185	0.45	0.45	0.092	0.092	0.23	0.23
240	0.33	0.33	0.067	0.067	0.22	0.22
300	0.31	0.31	0.063	0.063	0.21	0.21
400	—	—	—	—	0.19	0.19
500	—	—	—	—	0.14	0.14
630	—	—	—	—	0.13	0.13

Table A.4 — Gross cross-sectional areas of armour wires for 3.8/6.6 kV cables

Nominal cross-sectional area of conductors	Cross-sectional area of armour wires	
	Single core cables with stranded conductors	3-core cables with stranded conductors
mm^2	mm^2	mm^2
50	74	230
70	80	250
95	84	269
120	90	289
150	96	304
185	128	328
240	141	358
300	150	498
400	166	553
500	230	—
630	250	—
800	284	—
1 000	309	—

Table A.5 — Gross cross-sectional areas of armour wires for 6.35/11 kV cables

Nominal cross-sectional area of conductors	Cross-sectional area of armour wires	
	Single core cables with stranded conductors	3-core cables with stranded conductors
mm^2	mm^2	mm^2
50	80	250
70	86	269
95	92	294
120	96	314
150	128	328
185	141	348
240	147	483
300	157	514
400	169	—
500	230	—
630	255	—

A.4 Recommendations for storage, transport and disposal

A.4.1 *Storage*

Cable drums should be regularly inspected to assess their physical condition.

Battens, when supplied, should not be removed until cable is required for installation.

A.4.2 *Transport*

Cable drums having a flange diameter exceeding 1 m and weighing more than 250 kg gross should be transported in an upright condition. The drums should be protected against movement. Loading and unloading should be facilitated by suitable devices to avoid damage to both cable and drum. When moving drums, due regard should be paid to the weight, method and direction of rolling, protruding nails and wood splinters.

A.4.3 *Incineration of scrap cable*

The incineration of scrap cable should be undertaken only by a licensed contractor. For further information, the Environment Agency should be contacted.

A.4.4 *Cable and sealing*

Both ends of every length of cable should be sealed in such a manner as to include the oversheath and to inhibit the ingress of moisture during storage, delivery and up to the time of jointing.

A.5 Recommendations for cable laying and installation

A.5.1 *General*

The choice of cable should take into account the cable route, method of laying and service conditions.

The latter should include:

a) the proximity of other cables and their mutual heating effect;

b) the specific earth resistance;

c) protection against solar radiation;

d) the earth loop impedance;

e) the capability of the cable to withstand the worst anticipated fault conditions of the system;

f) the leakage of stray currents;

g) attack from solvent substances;

h) soil subsidence and other forms of violent vibrations;

i) protection against mechanical damage during and after installation.

The following provisions should also be made.

1) When cables are laid in ducts, the correct size of duct should be used to avoid damage during installation and overheating.

2) Where cables are laid in surface troughs, there should be adequate ventilation which, however, will not permit the entry of debris.

3) The cable support system should be designed to avoid damage or danger under normal or fault conditions.

A.5.2 *Environmental conditions*

The lowest recommended temperature of the cable during installation is 0 °C, but care should be taken to ensure that the cable temperature has been above 0 °C for the preceding 24 h.

Loaded cables may have a surface temperature that requires protection against accidental contact.

A.5.3 *Pulling tensions*

The maximum pulling load should not exceed the following values:

a) for copper conductors, 50 N/mm^2 of cross-sectional area (CSA);

b) for aluminium conductors, 30 N/mm^2 of CSA.

CSA refers only to the conductor(s).

Where long lengths of cable are to be pulled along difficult routes, where the tension increases sharply due to bends, the values for maximum side wall pressure (tension divided by bending radius) recommended by the supplier should be taken into account.

A.5.4 *Bending radii*

During installation, no cable should be bent to a smaller radius than the following, where D is the tabulated overall diameter:

a) for armoured 3-core cables, 12D;

b) for armoured single core cables, 20D.

A.5.5 *Cable installation*

There should be a significant measure of similarity between the way in which cables are installed for the test for fire propagation and the actual installations.

There should be compatibility between all jointing materials and components of the cable.

All bonds for earthing should have adequate conductance, be as short and straight as possible and be protected against corrosion, especially where dissimilar metals are involved.

A.6 Tests after installation

A.6.1 *General*

If tests are required after installation, they should consist of:

a) a d.c. test on the cable insulation;

b) a test on the oversheath.

A.6.2 *D.C. test on cable insulation*

The d.c. test should be carried out in accordance with Table A.6, with the voltage applied for 5 min.

Table A.6 — D.C. test on cable insulation

System voltage kV	D.C. voltage applied, core to earth kV
3.8/6.6	15
6.35/11	25

The manufacturer should be consulted before carrying out this test on cables that have been in service.

A.6.3 *Test on oversheath*

Where an outer conductive layer is applied to the oversheath, a d.c. voltage equal to 4 kV/mm of tabulated thickness (10 kV maximum) should be applied for 1 min.

If this test is carried out after jointing, the joints should be suitably insulated from earth.

Bibliography

Standards publications

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HD 604 S1:1994, *0.6/1 kV and 1.9/3.3 kV power cables with special fire performance for use in power stations.*

HD 605 S1:1994, *Electric cables — Additional test methods.*

HD 620 S1:1996, *Distribution cables with extruded insulation for rated voltages from 3.6/6 (7.2) kV up to and including 20.8/36 (42) kV.*

HD 622 S1:1996, *Power cables having rated voltage from 3.6/6 (7.2) kV up to and including 20.8/36 (42) kV with special fire performance for use in power stations.*

HD 626 S1:1996, *Overhead distribution cables of rated voltage $U_0/U(U_m)$: 0.6/1 (1.2) kV.*

HD 627 S1:1996, *Multicore and multipair cable for installation above and below ground.*

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