SRI LANKA STANDARD 1186: 2021
UDC 621.315

SPECIFICATION FOR ELECTRIC CABLES -THERMOSETTING INSULATED, ARMOURED CABLES OF RATED VOLTAGE OF 600/1 000 V AND 1 900/3 300 V FOR FIXED INSTALLATIONS

(First Revision)

SRI LANKA STANDARDS INSTITUTION

Sri Lanka Standard

SPECIFICATION FOR ELECTRIC CABLES -THERMOSETTING INSULATED, ARMOURED CABLES OF RATED VOLTAGE OF 600/1 000 V AND 1 900/3 300 V FOR FIXED INSTALLATIONS

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SLS 1186: 2021

Gr. 18

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Sri Lanka Standards are subject to periodical revision in order to accommodate the progress made by industry. Suggestions for improvement will be recorded and brought to the notice of the Committees to which the revisions are entrusted.

This Standard does not purport to include all the necessary provisions of a contract

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FOREWORD

This Sri Lanka Standard was approved by the Sectoral Committee on Electric Cables and Conductors and was authorized for adoption as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on 2021-12-22. This is the first revision.

This Sri Lanka Standard specifies requirements for the construction and performance of thermosetting insulated, armoured cables of rated voltages of 600/1 000 V and 1 900/3 300 V. This Standard is applicable to cables for use in fixed installations in industrial areas, buildings or similar applications.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or an analysis shall be rounded off in accordance with SLS 102, in case if the method of rounding off is not specified in the text of this standard. The number of figures to be retained in the rounded off value, shall be the same as that of the specified value in this standard.

All values given in this standard is in SI units.

In the preparation of this standard, the assistance derived from the publication of **BS 5467: 2016** Electric cables – Thermosetting insulated, armoured cables of rated voltages of 600/1000V and 1900/3300V for fixed installations – Specification, of the British Standards Institution is gratefully acknowledged.

1 SCOPE

This Sri Lanka Standard specifies requirements for the construction and performance of thermosetting insulated, armoured cables of rated voltages of 600/1000 V and 1900/3300 V. This Standard is applicable to cables for use in fixed installations in industrial areas, buildings or similar applications.

This Standard specifies requirements for the following types of cables:

a) 600/1000 V cables, wire armoured and oversheathed, having single-core, two-, three-, four- and five-core stranded copper conductor;
b) 600/1000 V multicore auxiliary cables, wire armoured and oversheathed, stranded copper conductor; and

c) 1 900/3300 V cables, wire armoured and oversheathed, having single-core or three-core stranded copper conductor.

This Standard is applicable to cables that are designed for a maximum sustained conductor temperature of 90 ^{0}C and for maximum short-circuit conductor temperature of 250 ^{0}C (for a maximum of 5 s).

NOTE 1 *Limitation on the temperature of the cables may be imposed in situations where they might be touched or where they could touch other materials.*

NOTE 2 *Annex A gives a guide to the use installation of cables, Annex B gives armour wire tests, Annex C gives a compatibility test, Annex D gives an abrasion resistance test, Annex E gives an insulation resistance constant test on oversheath, Annex F gives the resistance of conductor and armour, Annex G gives the gross cross-sectional area of armour, Annex H gives a test for shrinkage of oversheath on cable, Annex I gives guidance on type tests.*

2 NORMATIVE REFERENCE

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

ISO 6892-1,	Metallic materials - Tensile testing – Method of test at ambient temperature
IEC 60050-461,	International electrotechnical vocabulary – Part 461: Electric cables
BS EN 60229,	Electric cables - Tests on extruded oversheaths with a special protective function
SLS 1282:Part 3	Specification for insulating and sheathing materials for cables - Part 1: Cross linked elastomeric insulating compounds - Section 1.2: General 90 ^{o}C application
BS 7655-1.3,	Specification for insulating and sheathing materials for cables - Part 1: Elastomeric insulating compounds - Section 1.3: XLPE
BS 7655-4.2,	Specification for insulating and sheathing materials for cables - Part 4: PVC sheathing compounds - Section 4.2: General application
BS EN 10244-2:2009	Steel wire and wire products - Non-ferrous metallic coatings on steel wire - Part 2: Zinc or zinc alloy coatings
SLS EN 50395	Electrical test methods for low voltage energy cables
SLS EN 50396	Non electrical test methods for low voltage energy cables
SLS 695	Conductors of insulated cables and cords.
SLS 906	Electric cables - Spark-test method.
SLS 1007 -1-2:2008+A1:2020	Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable - Procedure for 1 kW pre-mixed flame

SLS IEC 60811-401, Electric and optical fibre cables- Test methods for non-metallic materials - Part 401: Miscellaneous tests- Thermal ageing methods - Ageing in an air oven

SLS IEC 60811-501, Electric and optical fibre cables- Test methods for non-metallic materials - Part 501: Mechanical tests - Tests for determining the mechanical properties of insulating and sheathing compounds

SLS IEC 60811-502, Electric and optical fibre cables- Test methods for non-metallic materials - Part 502: Mechanical tests - Shrinkage test for insulation

3 TERMS AND DEFINITIONS

For the purposes of this Standard, the terms and definitions given in IEC 60050-461 and the following apply.

2.1 Cable manufacturer:

Organization that has the capability to both produce and control the conformity of cable made to this Standard

NOTE *See **12.1a)** for information on marking the cable with the cable manufacturer 's name and identifier*

2.2 length of lay:

axial length of one complete turn of the helix formed by one cable component.

2.3 tests

3.3.1 routine tests, R: tests made on all production cable lengths to demonstrate their integrity

3.3 .2 sample tests. S:tests made on samples of completed cable, or components taken from a completed cable, adequate to verify that the product meets the design specifications

3.3.3 type tests, T:tests made before supplying, on a general commercial basis, a type of cable covered by this Standard, in order to demonstrate satisfactory performance characteristics to meet the intended application

***NOTE** Type tests are of such a nature that after they have been made, they need not be repeated unless changes are made in the cable materials, design or type of manufacturing process, which might change the performance characteristics.*

3.4 values

3.4.1 approximate value:

value which is only indicative

NOTE *Values described as "approximate" do not constitute requirements to be checked by measurement.*

3.4.2 nominal value:value by which a quantity is designated

NOTE *Nominal values usually give rise to values to be checked by measurements taking into account specified tolerances*.

3.5 voltages

3.5.1 maximum voltage, U_m: maximum sustained power-frequency voltage between phase conductors for which the cable is suitable

3.5.2 rated voltage, U_0: nominal power-frequency voltage between conductor(s) and earth for which the cable is suitable

3.5.3 rated voltage, U: nominal power-frequency voltage between phase conductors for which the cable is suitable

3 RATED VOLTAGE

The cables shall be designated by the rated voltages, U_0 and U, expressed in the form U_0 / U
The rated voltages recognized for the purpose of this standard shall be 600/1000 V and 1900/3300 V

NOTE *The maximum permitted operating voltages of the system are stated in Table **1**.*

Table 1 - Maximum permitted voltages against rated voltage of cable

Rated voltage of cable U_0 / U V	**Maximum permitted operating voltage of the system**			
	a.c		**d.c**	
	Conductor-earth, U_0 max V	**Conductor-Conductor, U_m** V	**Conductor-earth** V	**Conductor-conductor** V
(1)	**(2)**	**(3)**	**(4)**	**(5)**
600 / 1000	700	1200	900	1800
1900 / 3300	2 100	3600	2700	5400

In an alternating current system, the rated voltage of the cable shall be at least equal to the nominal voltage of the system for which it is intended.

4 CONDUCTORS

The conductors shall be annealed copper, circular or shaped, as given in Table 4 to Table 11 inclusive, and shall conform to the requirements of SLS 695, Class 2.

5 INSULATION

5.1 Type of insulation

The insulation shall be type GP 8 conforming to BS 7655-1.3, or type GP 6 conforming to BS 7655-1.2. The manufacturer shall declare which insulation type the insulation meets.

5.2 Application

The insulation shall be applied by an extrusion process and cross-linked. The insulation shall be applied either in a single layer, or in a numbers of layers. Each individual layer shall be compact and homogeneous.

Where more than one layer is used, the complete insulation shall be tested as though it were a single layer.

NOTE 1 *The manufacturer should demonstrate that all insulated cores are, as a continuous and ongoing part of the manufacturing process, subject to spark testing in accordance with SLS 906, using only a.c. or d.c. or method*

NOTE 2 *Insulation applied in more than one layer does not conform to the definition of "double insulation" given, for instance, in BS 7671.*

The manufacturer shall have the option to apply a tape or tapes under and/or over the insulation. These tapes shall not be considered as part of the insulation for the purposes of testing or measurement.

It shall be possible to remove the insulation without damage to the insulation itself or to the conductor. This shall be checked by visual examination.

6.3 Thickness of insulation

The mean value of the radial thickness of the insulation, when measured in accordance with BS EN 50396,4.1, shall be not less than the relevant value given in Table 4 to Table 11. The

smallest value measured, t_m, shall not fall below 90% of the relevant value given in Table 4 to Table 11 by more than 0.1 mm, i.e.:

$$t_m \geq 0.9\, t_n - 0.1$$

where:

t_m is the smallest value measured, in millimetres (mm);

t_n is the radial thickness given in Table 4 to Table 11, in millimetres (mm).

The thickness of any tape(s) over either the conductor or the insulation shall not be included in the measurement of the thickness of the insulation.

6 IDENTIFICATION OF CORES

6.1 General

The cores of all cables shall be identified either by:

a) colour; or

b) numbers.

6.2 Coloured cores

Unless otherwise agreed between the manufacturer and the purchaser, the colour coding shall be in accordance with the following standard sequence.

a) Single-core: brown or blue.

b) Two core: brown, blue.

c) Three-core: brown, black, grey.

d) Four-core: blue, brown, black, grey.

e) Five-core: green-and-yellow, blue, brown, black, grey.

It shall be permitted to use other identification colours subject to agreement with the manufacturer, taking into account core colour requirements specified in BS 7671 or other standards. Where alternative identification colours are used, the marking requirement as stated in 12.4 shall not be applicable.

NOTE *Attention is to drawn to BS 7671, Appendix 7, where other core colours that are still required outside the EU are given.*

The colour shall be applied:

1) throughout the insulation; or

2) throughout the outermost layer of insulations that comprise more than one layer; or

3) via a dedicated colouring layer.

Conformity shall be checked by visul examination.

6.3 Numbered cores

Numbers shall be marked sequentially starting with the number 1.
All cores that are numbered shall be of the same insulation colour.

Numbers on each core, shall be printed in a colour contrasting with that of the insulation and shall be legible. Each number shall be repeated at intervals not greater than 70 mm.·

Conformity shall be checked by visual examination and measurement.

6.4 Bi-colour combination

On the core marked with the bi-colour combination green-and-yellow, the distribution of the colours shall be such that for any 15 mm length of core, one of these colours shall cover not less than 30% and not more than 70% of the surface of the core, while the other colour shall cover the remainder of the surface. Conformity shall be checked by measurement.

NOTE 1 *In the case of shaped cores, one colour may be applied as one or more stripes, provided that both colours remain readily visible.*

NOTE 2 *In cases of dispute, and where appropriate to the method of colour marking of the insulation, a suitable test for checking conformity is given in BS EN 50396, 5.2, for circular cores, and in BS 8573:2012, Annex F, for shaped cores.*

6.5 Clarity and durability

The colour or number used for core identification shall be clearly identifiable and durable such that it cannot be removed, when tested in accordance with BS EN 50396, 5.1.

7 LAYING-UP

The cores of cables having two, three, four or five cores shall be laid up with a uni-directional lay or right-hand-left-hand alternating direction of lay. Where standard colour coding of cores has been used, the cores shall be laid up in the sequence given in 7.2.

Auxiliary cables having up to and including seven cores shall be laid-up with a uni-directional lay or with a right-hand-left-hand alternating direction of lay.

For multicore auxiliary cables of greater than seven cores the direction of lay shall alternate for each successive layer.

Numbered cores shall be laid-up in number sequence.

Conformity shall be checked by visual examination.
The maximum length of lay for core with circular conductors shall not exceed 65 times the diameter of the laid-up cores, and the maximum length of lay for core with shaped conductors shall not exceed 80 times the diameter of the laid-up cores.
Conformity shall be checked by the method give 17.2.

It shall be permitted for the manufacturer to apply synthetic fillers or binder tapes.

It shall be possible to remove the fillers and/or tape(s), if any, from the cable without damaging the insulation of the cores.

Conformity shall be checked by visual examination.

9. BEDDING

9.1 General

The bedding shall consist of an extruded layer of polymeric material consistent with the operating temperature of the cable. When tested in accordance with BS EN 60811-501, it shall have a tensile strength of not less than 4 N/mm^2 and elongation at break of not less than 50 %. It shall be possible to remove the bedding without damaging the insulation of the core(s). This shall be checked by visual examination.

9.2 Thickness of bedding

When measured in accordance with SL EN 50396, 4.2, the smallest value, t_m, of the radial thickness of bedding shall not fall below 80% of the relevant nominal value given in Table 4 to Table 11, as applicable, by more than 0.2 mm, i.e.:

$$t_m \geq 0.8\, t_n - 0.2$$

where:
t_m is the smallest value measured, in millimetres (mm);
t_n is the nominal thickness, given in Table 4 to Table 11, in millimetres (mm).

10 ARMOUR

10.1 General

The armour shall consist of a single layer of wires having nominal dimensions as given in Table 4 to Table 11, as appropriate. The armour shall be applied helically with a left-hand lay for cables having up to and including five cores. For multicore auxiliary cables the armour shall be applied helically with a direction of lay opposite to that of the final layer of cores, except

when the cores of the cable have been laid-up with alternating right-hand- left-hand lay in which case the armour shall be applied with either a right-hand or a left-hand lay.

The manufacturer shall have the option to apply a tape or tape under and/or over the armour.

The maximum length of lay for the armour wires of nominal wire diameter up to and including 1.6 mm shall not exceed 20 times-the diameter over the armour.

The maximum length of lay for the armour wires of nominal wire diameter 2.0 mm and greater shall not exceed 15 times the diameter over the armour.

Conformity shall be checked by the test method given in 17.3.

10.2 Armour wire

Armour wire for cables having two or more cores shall consist of a single layer of galvanized steel wires. Armour wire for single-core cables shall consist of a single layer of aluminium wires.

The armour wire shall conform to the following.

a) When determined in accordance with B.1, the diameter of the round armour wires, whether of galvanized steel or plain aluminium, shall fall within the minimum and the maximum wire diameters given in Table 2.
b) When determined in accordance with B.2, the mass of zinc coating of galvanized steel armour wire shall be not less than the relevant value given in Table 2.
c) When tested in accordance with B.3, the mechanical characteristics of galvanized armour wires shall be such that none of the wires shall break.
d) When tested in accordance with B.4, the tensile strength of aluminium armour wires shall be not less than 125 N/mm^2.

Table 2 - Diameter of steel armour wire and mass of zinc coating

Nominal wire diameter Mm	Wire diameter		Minimum mass of zinc coating g/m^2
	Minimum mm	Maximum mm	
(1)	(2)	(3)	(4)
0.9	0.85	0.95	112
1.25	1.18	1.32	150
1.6	1.51	1.69	172
2.0	1.90	2.10	180
2.5	2.37	2.63	195
3.15	2.99	3.31	206

10.3 Joints

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

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

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

10.4 Armour resistance

When measured and corrected to 20 ^{O}C in accordance with B.5 the d.c. resistance of the armour of the completed cable shall not exceed the relevant value given in Table F.1, Table F.2 or Table F.3, as applicable.

NOTE *For the purposes of calculating maxi mum fault current, it Is also necessary to know the gross cross-sectional area of arm our wires. This information is given in Annex G.*

11 OVERSHEATH

11.1 General

The oversheath shall be an extruded layer of PVC material conforming to the requirements of Type 9 specified in BS. 7655 - 4.2.

NOTE *Oversheaths are normally black and, when properly formulated and compounded, this provides good resistance to deterioration from outdoor exposure to light. Oversheaths with colours other than black can be provided by agreement between the manufacturer and the purchaser but; unless such oversheaths also include additives to protect the cable from UV, the cables are not suitable for all exposure conditions.*

11.2 Application

The oversheath shall be applied in a single layer over the armour.

Conformity shall be checked by visual examination.

11.3 Thickness of oversheath

When measured in accordance with SL EN 50396, 4.2, the smallest value, t_m, of the radial thickness of oversheath shall not fall below 80% of the relevant nominal value given in Table 4 to Table 11 by more than 0.2 mm, i.e.:

$$t_m \geq 0.80\ t_n - 0.2$$

where:

t_m is the smallest value measured, in millimetres (mm);

t_n is the nominal thickness, given in Table 4 to Table 11, in millimetres (mm).

11.4 Spark testing of oversheath

When tested in accordance with the a.c. or d.c. test methods and the test voltages specified in BS EN 62230, there shall be no breakdown of the overs heath.

12 CABLE MARKING AND ADDITIONAL INFORMATION

12.1 External marking

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

Element	**Example of marking**
a) Cable manufacturer	Manufacturer's name and their unique factory identifier

NOTE 1 *A simplified version of the manufacturers name, or a trading name of the manufacturer, may be used in place of the full name.*

NOTE 2 *Any suitable method may be used to unambiguously identify the manufacturer's factory.*

NOTE 3 *The manufacturer's own trademark or equivalent may be added but this cannot be used instead of the manufacturer's name or identifier.*

b) Electric cable	ELECTRIC CABLE
c) Voltage designation	600/1000 V 600/1000 V AUX 1900/3300 V

NOTE 4 *See 12.2.*

d) Number of cores and nominal area of conductor	4 x 70

NOTE 5 *See 12.3.*

e) Year of manufacture	ZZZZ

NOTE 6 *The year of manufacture may take the form of the actual year (e.g. 2016) or a coded year identifier assigned by the manufacturer*.

f) Standard core color identifier	H

NOTE 7 *See 12.4.*

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

For cables with overall diameters greater than 15 mm, items a) to d) inclusive shall appear, in any sequence that is deemed neither to confuse nor conflict, on two or more primary lines along the axis of the cables, approximately equally spaced around the circumference of the cable. Items e), f) and g) shall appear on either one of the primary lines, or on a secondary line or lines, in any sequence that is deemed neither to confuse nor conflict.

For cables with overall diameters up to and including 15 mm, items a) to g) inclusive shall appear on one or more primary lines along the axis of the cables. Where more than one line is used, they shall be approximately equally spaced around the circumference of the cable.

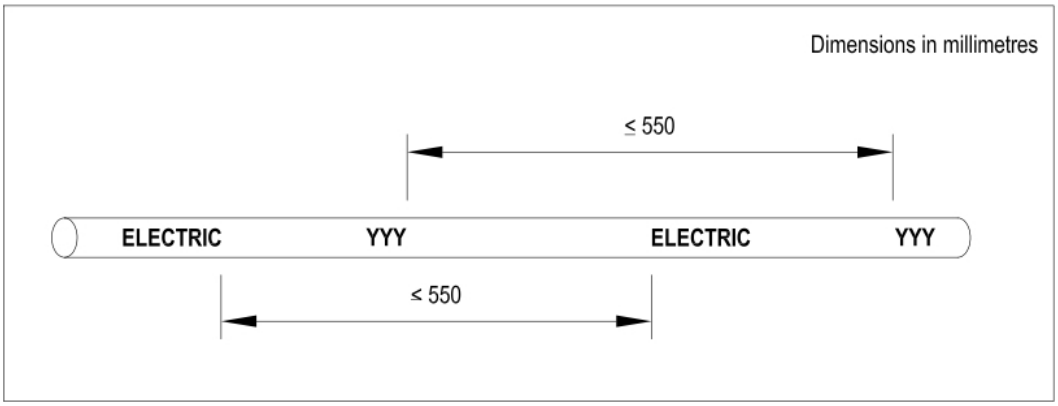
NOTE 8 *The order in which the elements of marking appear along the length of the oversheath is not prescribed, but it is preferred that they be in the order a) to g) as shown in this subclause.*

The letters and figures shall consist of upright block characters.

The distance between the beginning of one complete group of specified markings [items a) to g)] and the beginning of the next identical complete group of the markings shall be not more than 550 mm in accordance with Figure 1.

Conformity of the marking shall be checked by visual examination and measurement of at least two complete groups of specified markings.

Figure 1 An example of the marking on the oversheath of the cable



12.2 Voltage designation identifier

Cables manufacture to Table 4 to Table 8 with coloured cores shall be marked with the voltage designation of 600/1000 V.

Cables manufactured to Table 9 and cables manufactured to Table 5 to Table 8 with numbered cores shall be marked with the voltage designation of 600/1 000 V AUX.

Cables manufactured to Table 10 and Table 11 shall be marked with the voltage designation of 1900/3300 V.

12.3 Number of cores and cross-sectional area identifier

Cables shall be marked with the number of cores they contain and the nominal cross-sectional area of the conductors they contain, i.e.:

N x A

where:

N is the number of cores;

A is the nominal cross-sectional area of conductor.

12.4 Standard core colour identifier

When the standard core colour combinations are used in accordance with 7.2, the letter "H" shall be included in the marking on the external oversheath of the cable in accordance with 12.1.

12.5 The mark of an approval organization

If the mark of an approval organization is used, it shall be embossed or indented throughout the length of the external over sheath of the cable.

The mark shall be in the form of symbol(s) specified by the approval organization, and the maximum distance between marks shall be not greater than 1 100 mm.

12.6 Additional information

Any additional information shall be embossed, indented or printed throughout the length of the oversheath of the cable.

The additional information shall be in one continuous string that does not render illegible the marking specified in 12.1 to 12.5. The distance between the start of one mark and the start of the next identical mark shall be not greater than 1 100 mm.

Any additional information shall not conflict or cause confusion with the marking in 12.1 to 12.5.

NOTE 1 *Marking that is considered to conflict or confuse includes but is not limited by:*

a) marking of codes of practice; and

b) marking of test standards that are already in this Standard including performance requirements. e.g. BS EN 60332-7-2.

NOTE 2 *Marking that is considered not to conflict or confuse includes but is not 4 limited by:*

1) marking of a test standard that is not included in this Standard; and

2) marking of the cables intended application.

12.1 Clarity and durability of additional information

Where the additional information is applied by printing it shall be clearly identifiable and durable such that it cannot be removed when tested in accordance with BS EN 50396, 5.1.

13 END SEALING

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

14 SCHEDULE OF TESTS

The tests to be performed on cables specified in this Standard shall be as scheduled in Table 3, which refers to the relevant clauses of this standard specifying the requirements and test methods as well as the category of each test that applies, i.e. T, S or R (as defined in Clause 3).

Table 3 Schedule of tests

Test	Requirements given in Clause	Test method	Test Category
(1)	**(2)**	**(3)**	**(4)**
Conductors	**5**	SLS 695	S
Insulation: – Material – Application – thickness	 **6.1** **6.2** **6.3**	 BS 7655- 1.2 or BS 7655 - 1.3 Visual examination SLS EN 50396, 4.1.	 T S S
Core identification: – colours/numbers – durability	 **7.2, 7.3, 7.4** **7.5**	 Visual examination and measurement SLS EN 50396, 5.1	 S S
Laying-up: – direction and sequence of lay – length of lay of assembled cores – fillers and binders	 **8** **8** **8**	 Visual examination 17.2 Visual examination	 S S S
Bedding: – Material – application – thickness	 **9.1** **9.1** **9.2**	 SLS IEC 60811-501 Visual examination SLS EN 50396, 4.2	 T S S
Armour: – armour lay length – armour wire diameter – mass of zinc coating – wrapping test – tensile strength (aluminium wire) – armour resistance	 **10.1** **10.2a)** **10.2b)** **10.2c)** **10.2d)** **10.4**	 **17.3** **B.1** **B.2** **B.3** **B.4** **B.5**	 S S T T T S
Oversheath: - material - application - thickness - spark test	 **11.1** **11.2** **11.3** **11.4**	 BS 7655-4.2 Visual examination SLS EN 50396, 4.2 SLS EN 62230	 T S S R
Cable marking: - durability of printed information	**12** **12.7**	Visual examination and Measurement SLS EN 50396, 5.1	S T
Conductor resistance	**16.2**	SLS 695	R
Voltage test on complete cable	**16.3**	SLS EN 50395, 10.3	R

Table 3 Schedule of tests (Concluded)

Test	Requirements given in Clause	Test method	Test Category
(1)	**(2)**	**(3)**	**(4)**
Flame propagation on single cable	**17.4**	SLS 1007-1-2	S
Ovality	**17.5**	17.5	S
Compatibility	**18.2**	Annex C	T
Shrinkage test on insulation	**18.3**	SLS IEC 60811-502	T
Abrasion	**18.4**	Annex D	T
Insulation resistance of oversheath	**18.5**	Annex E	T
Shrinkage test on oversheath	**18.6**	Annex H	T

NOTE 1 *Tests classified as sample (S) or routine (R) might be required as part of a type approval scheme.*

NOTE 2 *The order of the tests in this schedule does not imply a sequence of testing.*

15 TEST CONDITIONS

15.1 Temperature

Tests shall be performed at a temperature of (20 ± 15) ^{O}C, unless otherwise specified in the details for the particular test.

15.2 Frequency and waveform of power frequency test voltages

The frequency of the alternating test voltages shall be in the range of 49 Hz to 61 Hz, unless otherwise specified in the particular test. The waveform shall be substantially sinusoidal.

16 ROUTINE TESTS

COMMENTARY ON CLAUSE 16

In some tests, the preparation and presentation of the test sample can have a critical effect on the result of the tests, so test samples should always be prepared carefully.

16.1 General

Routine tests shall be performed in accordance with Table 3 as indicated by the symbol R in Column 4.

NOTE *The requirements for routine testing which are not fully covered by earlier clauses are detailed in 16.2 and 16.3.*

16.2 Conductor resistance

The d.c. resistance of each conductor shall conform to Clause 5 when measured in accordance with BS EN 60228 and corrected to 20 ^{O}C. The measurement shall be made on a drum length of completed cable or on a 1 m sample taken from that drum.

16.3 Voltage test on completed cable

16.3.1 Test for single-core cable

The completed 600/1 000 V single-core cable shall be tested in accordance with SLS EN 50395, 10.3, using a test voltage of 3 500 V a.c. r.m.s. for 5 min, and there shall be no breakdown of the insulation.

The completed 1 900/3 300 V single-core cable shall be tested in accordance with SLS EN 50395, 10.3, using a test voltage of 6 500 V a.c. r.m.s. for 5 min, and there shall be no breakdown of the insulation.

16.3.2 Test for multicore cable

The completed 600/1 000 V multicore cable shall be tested in accordance with SLS EN 50395, 10.3, using a test voltage of 3 500 V a.c. r.m.s. for 5 min between conductors, and between each conductor and the armour which shall be earthed. There shall be no breakdown of the insulation.

The completed 600/1 000 V multicore auxiliary cables shall be tested as a 600/1 000 V multicore cable and the cores may be suitably connected for successive application of the test voltage to limit the total testing time. The sequence of connections shall ensure that the voltage is applied, for the time given, between each conductor and each other conductor, and between each conductor and the armour which shall be earthed. There shall be no breakdown of the insulation.

The completed 1 900/3 300 V 3-core cable shall be tested in accordance with SLS EN 50395, 10.3, using a test voltage of 11 250 V a.c. r.m.s. for 5 min between conductors, and a test voltage of 6 500 V a.c. r.m.s. between each conductor and the armour which shall be earthed. There shall be no breakdown of the insulation.

17 SAMPLE TESTS

COMMENTARY ON CLAUSE 17

In some tests, the preparation and presentation of the sample can have a critical effect on the result of the tests, so test samples should always be prepared carefully.

17.1 General

Sample tests shall be performed in accordance with Table 3, as indicated by the symbol S in Column 4.

NOTE *The requirements for sample testing which are not fully covered by earlier clauses are detailed in 17.2 to 17.5.*

17.2 Length of lay of assembled cores

The length of lay of laid-up cores shall be determined by measuring the length of two pitches of a sample and dividing by 2.

If the cores of the cable have been laid up using the right-hand-left-hand alternating direction method, only the right-hand or left-hand portion of the laid-up cores shall be used (i.e. not the transition between direct ions of lay). The result shall be taken as the length of lay of the laid-up cores.

17.3 Length of lay of armour wires

The length of lay of the laid-up armour wires shall be determined by measuring the length of two pitches of a sample and dividing this length by 2. The result shall be taken as the length of lay of the armour wires.

17.4 Flame propagation on a single cable

When tested in accordance with SLS 1007-1-2:2008+A 1:2020, the sample of completed cable shall conform to Annex A of that standard.

17.5 Ovality

A test sample shall be taken from a cable from three places, separated by at least 1 m. Two diameter measurements shall be taken at the same cross-section of the cable, covering the maximum and minimum values. The difference between each of the two values and their mean shall not exceed 15%.

18 TYPE TESTS

COMMENTARY ON CLAUSE 18

In some tests, the preparation and presentation of the test sample can have a critical effect on the result of the tests, so test samples should always be prepared carefully.

18.1 General

Type tests shall be performed in accordance with Table 3, as indicated by the symbol T in Column 4.

NOTE The requirements for type testing which are not fully covered by earlier clauses are detailed in 18.2 to 18.6. Guidance on type testing given in Annex I.

18.2 Compatibility

When a sample of complete cable is tested in accordance with Annex C, the insulation and oversheath shall conform to the requirements given in Table C.1. In addition, at the end of the test period in the oven, the blotting paper shall be free of stains.

18.3 Shrinkage of insulation

When a 200 mm sample of core is tested at (130±2) ^{0}C for 1 h in accordance with SLS IEC 60811-502, the shrinkage of the insulation shall not exceed 4%.

The test shall be performed on all cables, for cables having up to five-cores, each core shall be tested. For multicore auxiliary cables, five cores selected at random shall be tested.

18.4 Abrasion resistance

When a sample of complete cable is tested in accordance with Annex D, the oversheath shall be deemed to be satisfactory provided that, following the test, examination of the sample with normal or corrected vision without magnification reveals no cracks or splits in the external surface.

18.5 Insulation resistance constant of oversheath

When a sample of complete cable is tested in accordance with Annex E, the value of K shall be not less than 0.0 035 MΩ.km.

18.6 Shrinkage of oversheath

When a sample of complete cable is tested at (80 ± 2) °C for 4 h in accordance with Annex H, the shrinkage of the oversheath shall not exceed 4%.

Table 4 Single-core 600/ 1 000 V cables with copper conductors

Nominal cross-sectional area of conductor [A] mm²	**Radial thickness of insulation** mm	**Nominal thickness of extruded bedding** mm	**Nominal aluminium armour wire diameter** mm	**Nominal thickness of oversheath** mm	**Approximate overall diameter** mm
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
50	1.0	0.8	0.9	1.5	17.5
70	1.1	0.8	1.25	1.5	20.2
95	1.1	0.8	1.25	1.6	22.3
120	1.2	0.8	1.25	1.6	24.2
150	1.4	1.0	1.6	1.7	27.4
185	1.6	1.0	1.6	1.8	30.0
240	1.7	1.0	1.6	1.8	32.8
300	1.8	1.0	1.6	1.9	35.6
400	2.0	1.2	2.0	2.0	40.5
500	2.2	1.2	2.0	2.1	44.2
630	2.4	1.2	2.0	2.2	48.8
800	2.6	1.4	2.5	2.4	55.4
1 000	2.8	1.4	2.5	2.5	60.6

[A] Circular or compacted circular stranded conductor (Class 2)

Table 5 Two-core 600/ 1 000 V cables with copper conductors

Nominal cross-sectional area of conductor mm^2	**Radial thickness of insulation** mm	**Nominal thickness of extruded bedding** mm	**Nominal aluminium armour wire diameter** mm	**Nominal thickness of oversheath** mm	**Approximate overall diameter** mm
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
1.5 [A)]	0.6	0.8	0.9	1.3	12.1
2.5 [A)]	0.7	0.8	0.9	1.4	13.6
4 [A)]	0.7	0.8	0.9	1.4	14.7
6 [A)]	0.7	0.8	0.9	1.4	15.9
10 [A)]	0.7	0.8	0.9	1.5	18.0
16 [A)]	0.7	0.8	1.25	1.5	20.4
25 [A)]	0.9	0.8	1.25	1.6	24.1
25 [B)]	0.9	0.8	1.25	1.6	20.4
35 [A)]	0.9	1.0	1.6	1.7	27.7
35 [B)]	0.9	1.0	1.6	1.7	23.3
50 [A)]	1.0	1.0	1.6	1.9	30.8
50 [B)]	1.0	1.0	1.6	1.8	25.8
70 [A)]	1.1	1.2	2.0	2.0	36.2
70 [B)]	1.1	1.0	1.6	1.9	29.0
95 [A)]	1.1	1.2	2.0	2.1	40.2
95 [B)]	1.1	1.2	2.0	2.0	33.1
120 [A)]	1.2	1.2	2.0	2.1	44.1
120 [B)]	1.2	1.2	2.0	2.1	36.1
150 [B)]	1.4	1.2	2.0	2.2	39.3
185 [B)]	1.6	1.4	2.5	2.4	44.7
240 [B)]	1.7	1.4	2.5	2.5	49.0
300 [B)]	1.8	1.6	2.5	2.6	53.5
400 [B)]	2.0	1.6	2.5	2.8	59.0

[A)] Circular or compacted circular stranded conductor (Class 2)

[B)] Shaped stranded conductor (Class 2)

Table 6 Three-core 600/ 1 000 V cables with copper conductors

Nominal cross-sectional area of conductor mm^2	**Radial thickness of insulation** mm	**Nominal thickness of extruded bedding** mm	**Nominal aluminium armour wire diameter** mm	**Nominal thickness of oversheath** mm	**Approximate overall diameter** mm
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
1.5 [A)]	0.6	0.8	0.9	1.3	12.6
2.5 [A)]	0.7	0.8	0.9	1.4	14.1
4 [A)]	0.7	0.8	0.9	1.4	15.3
6 [A)]	0.7	0.8	0.9	1.4	16.6
10 [A)]	0.7	0.8	1.25	1.5	19.5
16 [A)]	0.7	0.8	1.25	1.6	21.6
25 [A)]	0.9	1.0	1.6	1.7	26.7
25 [B)]	0.9	1.0	1.6	1.7	23.6
35 [A)]	0.9	1.0	1.6	1.8	29.4
35 [B)]	0.9	1.0	1.6	1.8	25.7
50 [A)]	1.0	1.0	1.6	1.9	32.5
50 [B)]	1.0	1.0	1.6	1.8	28.5
70 [A)]	1.1	1.2	2.0	2.0	38.3
70 [B)]	1.1	1.0	1.6	1.9	32.2
95 [A)]	1.1	1.4	2.0	2.2	42.6
95 [B)]	1.1	1.2	2.0	2.1	37.0
120 [A)]	1.2	1.4	2.5	2.3	48.1
120 [B)]	1.2	1.2	2.0	2.2	40.4
150 [B)]	1.4	1.4	2.5	2.3	45.5
185 [B)]	1.6	1.4	2.5	2.4	49.8
240 [B)]	1.7	1.4	2.5	2.6	55.1
300 [B)]	1.8	1.6	2.5	2.7	60.2
400 [B)]	2.0	1.6	2.5	2.9	66.6

[A)] Circular or compacted circular stranded conductor (Class 2)

[B)] Shaped stranded conductor (Class 2)

Table 7 Four-core 600/ 1 000 V cables with copper conductors

Nominal cross-sectional area of conductor mm^2	**Radial thickness of insulation** mm	**Nominal thickness of extruded bedding** mm	**Nominal aluminium armour wire diameter** mm	**Nominal thickness of oversheath** mm	**Approximate overall diameter** mm
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
1.5 [A)]	0.6	0.8	0.9	1.3	13.3
2.5 [A)]	0.7	0.8	0.9	1.4	15.0
4 [A)]	0.7	0.8	0.9	1.4	16.4
6 [A)]	0.7	0.8	0.9	1.5	18.7
10 [A)]	0.7	0.8	1.25	1.5	21.1
16 [A)]	0.7	0.8	1.25	1.6	23.4
25 [A)]	0.9	1.0	1.6	1.7	28.9
25 [B)]	0.9	1.0	1.6	1.7	26.1
35 [A)]	0.9	1.0	1.6	1.8	31.9
35 [B)]	0.9	1.0	1.6	1.8	28.6
50 [A)]	1.0	1.2	2.0	2.0	36.6
50 [B)]	1.0	1.0	1.6	1.9	32.0
70 [A)]	1.1	1.2	2.0	2.2	41.9
70 [B)]	1.1	1.2	2.0	2.1	37.7
95 [A)]	1.1	1.4	2.5	2.3	48.1
95 [B)]	1.1	1.2	2.0	2.2	41.7
120 [A)]	1.2	1.4	2.5	2.4	52.6
120 [B)]	1.2	1.4	2.5	2.3	47.1
150 [B)]	1.4	1.4	2.5	2.4	51.4
185 [B)]	1.6	1.4	2.5	2.6	56.6
240 [B)]	1.7	1.6	2.5	2.7	63.0
300 [B)]	1.8	1.6	2.5	2.9	68.8
400 [B)]	2.0	1.8	3.15	3.2	78.1

[A)] Circular or compacted circular stranded conductor (Class 2)

[B)] Shaped stranded conductor (Class 2)

Table 8 Five-core 600/ 1 000 V cables with copper conductors

Nominal cross-sectional area of conductor [A] mm^2	Radial thickness of insulation mm	Nominal thickness of extruded bedding mm	Nominal aluminium armour wire diameter mm	Nominal thickness of oversheath mm	Approximate overall diameter mm
(1)	(2)	(3)	(4)	(5)	(6)
1.5	0.6	0.8	0.9	1.4	14.3
2.5	0.7	0.8	0.9	1.4	16.1
4	0.7	0.8	0.9	1.5	17.8
6	0.7	0.8	1.25	1.5	20.0
10	0.7	0.8	1.25	1.6	22.9
16	0.7	1.0	1.6	1.7	26.6
25	0.9	1.0	1.6	1.8	31.5
35	0.9	1.0	1.6	1.9	34.8
50	1.0	1.2	2.0	2.0	40.4
70	1.1	1.2	2.0	2.2	46.3

[A] Circular or compacted circular stranded conductor (Class 2)

Table 9 Multicore auxiliary 600/ 1 000 V cables with copper conductors

Number of cores [A]	Nominal cross-sectional area of conductor [B] mm^2	Radial thickness of insulation mm	Thickness of extruded bedding mm	Nominal steel armour wire diameter mm	Nominal thickness of oversheath mm	Approximate overall diameter mm
(1)	(2)	(3)	(4)	(5)	(6)	(1)
7	1.5	0.6	0.8	0.9	1.4	15.2
12	1.5	0.6	0.8	1.25	1.5	19.4
19	1.5	0.6	0.8	1.25	1.6	22.2
27	1.5	0.6	1.0	1.6	1.7	26.7
37	1.5	0.6	1.0	1.6	1.7	29.0
7	2.5	0.7	0.8	0.9	1.4	17.1
12	2.5	0.7	0.8	1.25	1.6	22.4
19	2.5	0.7	1.0	1.6	1.7	26.6
27	2.5	0.7	1.0	1.6	1.8	30.7
37	2.5	0.7	1.0	1.6	1.8	33.8
7	4	0.7	0.8	1.25	1.5	19.7
12	4	0.7	1.0	1.6	1.6	25.7
19	4	0.7	1.0	1.6	1.7	29.3
27	4	0.7	1.0	1.6	1.9	34.4
37	4	0.7	1.2	2.0	2.0	39.2

A) The number of cores given here are preferred. Other numbers up to a maximum of 37 are permitted subject to agreement between the purchaser and the manufacturer and, where such numbers are manufactured, the dimensional details should be as for the next highest preferred numbers of cores. Auxiliary cable with 2-5 cores are made in accordance with Table 5 to Table 8 as relevant.

B) Circular or compacted circular stranded conductor (Class 2)

Table 10 Single-core 1 900/ 3 300 V cables with copper conductors

Nominal cross-sectional area of conductor A) mm^2	**Radial thickness of insulation** mm	**Nominal thickness of extruded bedding** mm	**Nominal aluminium armour wire diameter** mm	**Nominal thickness of oversheath** mm	**Approximate overall diameter** mm
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
50	2.0	0.8	1.25	1.6	20.6
70	2.0	0.8	1.25	1.6	22.4
95	2.0	0.8	1.25	1.6	24.3
120	2.0	1.0	1.6	1.7	27.2
150	2.0	1.0	1.6	1.7	28.8
185	2.0	1.0	1.6	1.8	30.8
240	2.0	1.0	1.6	1.8	33.5
300	2.0	1.0	1.6	1.9	36.1
400	2.0	1.2	2.0	2.0	40.5
500	2.2	1.2	2.0	2.1	44.2
630	2.4	1.2	2.0	2.2	48.8
800	2.6	1.4	2.5	2.4	55.4
1 000	2.8	1.4	2.5	2.5	60.6

A) Circular or compacted circular stranded conductor (Class 2)

Table 11 Three-core 1 900/ 3 300 V cables with copper conductors

Nominal cross-sectional area of conductor mm^2	**Radial thickness of insulation** mm	**Nominal thickness of extruded bedding** mm	**Nominal aluminium armour wire diameter** mm	**Nominal thickness of oversheath** mm	**Approximate overall diameter** mm
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
16 [A)]	2.0	1.0	1.6	1.8	29.3
25 [A)]	2.0	1.0	1.6	1.8	32.2
35 [A)]	2.0	1.0	1.6	1.9	34.8
35 [B)]	2.0	1.0	1.6	1.9	31.1
50 [B)]	2.0	1.2	2.0	2.0	34.7
70 [B)]	2.0	1.2	2.0	2.1	38.0
95 [B)]	2.0	1.2	2.0	2.2	41.4
120 [B)]	2.0	1.4	2.5	2.3	45.7
150 [B)]	2.0	1.4	2.5	2.4	48.5
185 [B)]	2.0	1.4	2.5	2.5	51.9
240 [B)]	2.0	1.6	2.5	2.6	56.9
300 [B)]	2.0	1.6	2.5	2.7	51.2
400 [B)]	2.0	1.6	2.5	2.9	66.6

[A)] Circular or compacted circular stranded conductor (Class 2)

[B)] Shaped stranded conductor (Class 2)

Annex A (Informative) Guide to use and installation of cables

NOTE *The details given in this annex are intended only as general technical guidance and not as interpretation of any UK statutory regulations.*

A.1 Aim

The aim of this annex is to inform users about characteristics and limitations of electric cables and thereby minimize their misuse.

It is assumed that the design of installations and the specification, purchase and installation of cables specified in this Standard is entrusted to people who meet the definition of a skilled person or instructed person, as given in BS 7671 (IET wiring regulations)

NOTE The definitions (taken from BS 7671) are:

- Skilled person (electrically) - Person who possesses, as appropriate to the nature of the electrical work to be undertaken, adequate education; training or practical skills, and who is able to perceive risks and avoid hazards which electricity can create;
- Instructed person (electrically) - Person adequately advised or supervised by a skilled person (as defined) to enable that person to perceive risks and to avoid hazards which electricity can create.

In cases of doubt as to the suitability of a cable for a particular use, specific guidance should be obtained from the manufacturer.

A.2 General

Cables should be installed and used in association with other equipment in accordance with BS 7671 as appropriate.

In special environments, the appropriate regulations and codes of practice should be observed.

The cables specified in this Standard are intended for installation in air, in building, or for either direct burial in the ground (in free draining soil) or installation within cable ducts that are buried in the ground (in free draining soil). When cables are to be installed in any other environment, guidance should be sought.

Multicore auxiliary cables are frequently used for interconnection of systems, control circuitry and small power circuits. Some codes of practice, dependent on the application and where it is being used might limit the use of such cables and the relevant standards would need to be consulted.

NOTE 2 *Attention is drawn to the fact that in countries outside the UK, corresponding national regulations might apply.*

A.3 Maximum operating, short circuit and overload temperatures

The cables specified in this Standard are suitable for use where the combination of ambient temperature and temperature rise due to load results a conductor temperature not exceeding 90 ^{o}C. In the case of short circuit, the maximum allowable time is 5 s and the maximum conductor temperature should not exceed 250 ^{o}C. In the case of overload, the maximum allowable time is 4 h and the maximum conductor temperature should not exceed 156 ^{o}C. Repeated short circuits and overloads can potentially damage the cable and lead to premature failure.

These operating, short-circuit and overload temperatures are based on the intrinsic properties of the insulating material.

The accessories that are used in the cable system with mechanical and/or soldered connections should be:

a) suitable for the temperature adopted for the cable;

b) able to accommodate a cable conductor operating temperature of 90 ^{o}C; and

c) able to accommodate the over load and short circuit temperatures.

A.4 Voltage ratings

The rated voltage of the cable for a given application should be suitable for the operating conditions of the system in which the cable is used. To facilitate the selection of the cable, such systems are divided into the following three categories.

a) **Category A**, which comprises those systems in which any phase conductor that comes in con tact with earth, or an earth conductor, is disconnected from the system within 1 min.

b) **category B**, which com p rises those systems that, under fault conditions, are operated for a short time with one phase earthed. This period, according to IEC 60183, should not exceed 1 h. For cables specified in the is British Standard, a longer period, not exceeding 8 h on any occasion, can be tolerated. The total duration of earth faults in any year should not exceed 125 h.

c) **Category C**, which comprises all systems that do not fall into categories A or B.

NOTE *In a system where an earth fault is not automatically and promptly isolated, the extra stresses on be insulation of cables during the earth fault reduce the life of the cables to a certain*

degree. If the system is expected to be opera ted fairly often with a perm anent earth fault, it might be advisable to classify the system into a higher category.

Table A.1 gives the lowest rated voltage of cable that should be used for an a.c. system according to the system voltage and category.

Table A .1 Selection of cables for a.c. systems

System voltage		**System category**	**Minimum rated voltage of cable**
Nominal voltage (U) KV	**Maximum sustained Voltage** (U_m) kV		(U_0/U) kV
(1)	**(2)**	**(3)**	**(4)**
Up to 1.0	1.2	A, B or C	0.6/1 .0
1.9 to 3.3	3.6	A or B	1.9/3.3

The nominal system voltage, U, given in Table A .1 is the nominal voltage between phases.

The maximum sustained system voltage, U_m, is the highest voltage between phases that can be sustained under normal operating conditions at any time and at any point in the system. It excludes transient voltage variations, due, for example, to lightning impulses, fault conditions and rapid disconnection of loads.

600/1000 V cables are suitable for d.c. systems operating at up to 900 V conductor to earth or at up to 1 800 V between conductors.

1900/3300 V cables are suitable for d.c. systems operating at up to 2700 V conductor to earth or between conductors at up to 5400 V.

However, consideration should be given to the peak value when determining the voltage of a d.c. system derived from rectifiers, bearing in mind that smoothing does not modify the peak value when the rectifiers are operating on an open circuit.

A.5 Cable selection and system design

A.5.1 The cables specified in this Standard are intended for fixed installations and to be used for the supply of electrical energy up to the rated voltage indicated on the cable. A.4 classifies the voltage ratings of cables manufactured in accordance with this standard. These ratings should not be exceeded.

A.5.2 These cables are intended for use within a nominal power frequency range of 49 Hz to 6 1 Hz.

A.5.3 For current ratings of cables installed in arid around buildings, reference should be made to BS 7671. For current rating of cables installed direct in ground or in ducts in ground, reference should be made to BS 7671.

A.5.4 Due to the relatively high conductor temperature, there is a risk of drying out the surrounding soil, causing an increase in thermal resistivity, which in turn would lead to the cable temperature rising to a higher value than anticipated. For cable laid directly in the ground or within cable ducts in the ground, a suitable de-rating factor should be applied or a lower maximum sustained conductor operating temperature, assumed to take into account the possible effects of soil drying out.

A.5.5 In addition to the current ratings, the following should be taken into account:

a) the capability of the cable to withstand the worst anticipated fault and overload condition of the system;

b) the earth loop impedance;

c) the operating characteristics of the connected equipment; and

d) the voltage drop requirements during normal load or motor starting conditions.

In installations which include cable joints and terminations, the performance of these accessories should be taken into account in deciding the maximum operating temperature of the cable.

A.5.6 The possible effects of transient over-voltages should be recognized as they can be detrimental to cables.

A.6 Environment and application

COMMENTARY ON A.6

If cables in accordance with this specification are exposed to localized heat, solar radiation or high temperature ambient conditions, or there is a possibility of higher soil thermal resistivity, the current carrying capacity is likely to be reduced.

A.6.1 Cables specified in this Standard are not specifically designed for use:

a) as self -supporting aerial cables;
b) as submarine cable or for laying in water-logged conditions;
c) where subsidence is likely, unless special precautions are taken to minimize damage;

d) where any exposure to excessive heat is involved;
e) where the oversheath is subjected to a voltage test after installation.

A.6.2 Protection against mechanical damage, appropriate to the cable and the installation conditions, should be provided.

A.6.3 Cables could be harmed by exposure to corrosive products or solvent substances, especially petroleum-based chemicals or their vapours. This should be avoided.

A.6.4 Special precautions are required where cables are to be installed in potentially explosive gas atmospheres. Precautions should be taken in accordance with BS EN 60079-14.

A.6.5 The standard oversheathing compounds supplied on the cables specified in this Standard do not provide protection against damage by rodents, termites, etc.

A.6.6 Loaded cables can have high surface temperatures and protection against accidental contact should be provided.

A.6.7 Cables specified in, this Standard when exposed to the effects of external fire produce harmful smoke and fumes, and might propagate fire especially when bundled together. When circumstances dictate, consideration should be given to the use of cables manufactured in accordance with BS 6724.

A.7 INSTALLATION

A.7.1 General

Cables specified in this Standard are designed for use in fixed installations in industrial areas, buildings and similar applications. They are also suitable for either direct burial in the ground (free draining soil) or installation within cable ducts that are buried in the ground (free draining soil).

The cables specified in this Standard are designed for fixed installations only, so they should not to be used where they would be subject to flexing.

A.7.2 Minimum temperature during installation

The cables specified in this Standard should only be installed when both the cable and ambient temperatures are above 0 ^{o}C and have been so for at least the previous 24 h, or where special precautions have been taken to maintain the cable above this temperature.

A.7.3 Minimum installation radius

None of the cables specified in this standard should be bent during installation to a radius smaller than 8D where D is the measured overall diemeter of the cable.

Wherever possible, larger installation radii should be used.

A.7.4 Preventing damage to cable

Precautions should be taken to avoid mechanical damage to the cables before and during installation.

Careful planning of the route and the method of installation of cable can limit the likelihood of the cable being damaged during installation.

The following points should be taken into account when deciding cable routeing.

NOTE 1 *This is not an exhaustive list, as every installation is different.*

a) The minimum installation radius of the cable should not be exceeded (see A.7.3).

b) The number of bends should be reduced to the minimum possible and installation arrangements made accordingly.

c) Maximum pulling tensions as advised by the cable manufacturer should not be exceeded.

   NOTE 2 *Exceeding the manufacturer's recommended maximum pulling tensions could result in damage to the cable.*

d) Maximum sidewall pressure as advised by the cable manufacturers should not be exceeded.

e) Cables guides should be used where there is a danger of cable oversheath coming into contact with sharp edges.

f) Rollers, side rollers, skid plates, guides at ducts entry and exit points, and lubricants can aid installation.

g) A sufficient number of staff should be available to ensure the cable can be installed safely and without damage.

h) Care should be taken to ensure that the cable is not twisted as it is installed

i) The installation speed should not be such that it requires the supply drum to be turned in a dangerous manner.

j) If the cable is being attached to a pulling rope, it should be done in such a manner as not to cause damage to the cable, or a sufficient length of cable should be sacrificed.

Care should be exercised during installation to avoid any damage to cable coverings. This is particularly important in wet environments. The protective caps should not be removed from the ends of the cable until immediately prior to termination or jointing. When the caps have been removed the unprotected ends of the cable should not be exposed to moisture.
Where such damage might have occurred, the seals should be inspected. If moisture ingress has occurred either a sufficient length of cable should be sacrificed or corrective actions should be made. The seals should be remade if necessary.

A.7.5 Selection of cable glands, accessories and associated tools

The selection of cable glands, accessories and any associated tools should take account of all aspects of intended use of the cable and its fire resistance, As such, products that are suitable for use should be selected from the following.

a) Cable glands, when used, should conform to BS EN 50262 or BS EN 62444.

b) Cable joints when used should conform to BS EN 50393.

c) Cable cleats when used, should conform to BS EN 61914.

d) Cable ties when used, should conform to BS EN 62275.

A.7.6 Earth fault currents

Owing to the absence of a metal sheath, all earth fault currents return through the armour unless there is a parallel bonding connection to relieve them of some of the fault current. In either event it is necessary to ensure that there is no discontinuity in the return circuit via the armour and the resistance added by bonds and clamps is kept to a minimum.

Careful attention should therefore be paid to the design of all bonding clamps in joints and terminations to ensure that each armour wire contributes equally to the conductance of the bonding connection and that the resistance of the material replacing the armour is not higher than that of the equivalent length of connected armour of the cable.

It is also important to ensure that all armour wires and all faces of armour clamps or connectors making connectors with them are thoroughly cleaned during installation and that the clamps are adequately tightened to ensure good electrical contact.

Bonding clamps in joints Should be electrically connected with a conducting material having a conductance at least equal to that of the length of armour it replaces, and with adequate thermal capacity to avoid excessive overheating under short circuit conditions.

Provision should be made for earthing the armour to the main earth system at the supply end by means of a metallic bond of adequate conductance, the bonding connection being as short and straight as possible.

Special precautions might be necessary to eliminate the risk of corrosion, especially corrosion due to the use of dissimilar metals.

A.7.7 Joints and terminations

For compound filled joints, the design of the box and the composition of the filling compound should provide an effective seal to prevent moisture gaining access to the conductor ferrules and armour connections.

The filling compound should be compatible with the materials of the cable components with which it comes into contact. Account should be taken of the pouring temperatures or the temperatures resulting from exothermic reaction.

Compound filling is not necessary for terminations, provided that adequate clearances are maintained between phases and between each phase and earth.

The minimum clearances should be related to the voltage and category of the system and the environmental conditions.

Where the required clearances cannot be achieved, some other means of insulation should be provided.

The selection of cable joints and terminations should take account of the performance requirements of the cable and the intended application.

A.8 Storage and handling of drums

NOTE A detailed guide to the safe handling of cable drums is given in BS 8512.

A.8.1 Cable drums should be regularly inspected during storage to assess their physical condition.

A.8.2 Battens, where applied, should not be removed from drums until the cable is about to be installed.

A.8.3 When handling drums, precautions should be taken to avoid injury taking into account the weight, method and direction of rolling, lifting, protruding nails and splinters.

4.8.4 Care should be taken to avoid deterioration of drums or their becoming a hazard to the general public.

A.9 Waste and scrap cable

Information and guidance on the incineration of scrap cable should be obtained from the Environment Agency or equivalent national or regional bodies.

A .10 Voltage test after installation

A voltage test after installation is not a requirement of this standard. If, however, a test is made it should be performed with direct current, the value of the voltage being as given in Table A.2.

Table A .2 Test voltages after installation

Cable voltage Designation **V**	**D.C test voltage**	
	Between conductor **V**	**Between each conductor and Armour** **V**
(1)	**(2)**	**(3)**
600/1 000 1900/3 300	3 500 10 000	3 500 7000

During the test, the voltage should be increased gradually to the full value and maintained continuously for 15 min. The test should be made between conductors and between each conductor and the armour.

No breakdown should occur.

Sequential testing may be used to reduce overall testing time for multicore auxiliary cables.

The test voltages given in Table A.2 are intended for cables immediately after installation and not for cables that have been in service. When testing is required after cables have been in service, regardless of service duration, the manufacturer should be consulted for the appropriate test conditions, which depend on the individual circumstances.

Care should be taken when voltage testing cables during and immediately after installation, as repeated testing can lead to premature failure of the cable.

Annex B Armour wire tests (Normative)

B.1 Measurement of diameter of round wire armour

Take at random, from one sample of completed cable, 10% of the total number of wires, rounded up or down, and determine the diameter of each wire with a micrometer by taking two measurements at right angles to each other. Take the mean of all the measurements as the wire diameter.

B.2 Mass of zinc coating of galvanized steel wire

Take at random, from one sample of completed cable, 10% of the total number of wires, rounded up or down, and determine the mass of zinc coating by either a gravimetric or gas volumetric method in accordance with BS EN 10244-2:2009, 5.2. Take the average of all the measurements as being the mass of zinc coating.

B.3 Wrapping test for galvanized steel wire

Take at random, from one sample of completed cable, 10% of the total number of wires, rounded up or down. Wrap each wire round a cylindrical mandrel for one complete turn. The mandrel shall have a diameter of approximately four times the specified nominal diameter (see Table 2) of the wire under test.

B.4 Tensile test for aluminium wires

Take at random, from one sample of completed cable, 10% of the total number of wires, rounded up or down. Measure the tensile strength of each wire in accordance with BS EN ISO 6892- 1.

The load shall be applied gradually and the rate of separation of the jaws of the testing machine shall be not less than 25 mm/min and not greater than 100 mm/min. The initial distance between the grips of the machine shall be (250 ± 2) mm.

The average of all the measurements shall be taken as being the tensile strength.

B.5 Armour resistance test

Determine the d.c. resistance of the armour by measuring the resistance of all the armour wires of the completed cable connected together.

Use the temperature correction multiplication factors, k_t, given in Table B.1, to correct the measured resistance at t ^{o}C to 20 ^{o}C.

Table B.1 Temperature correction multiplication factors

Temperature of armour at time of measurement, t °C	Correction factor K_1	
	Galvanized steel wire armour	Aluminium wire armour
(1)	(2)	(3)
5	1.072	1.064
6	1.067	1.059
7	1.062	1.055
8	1.057	1.050
9	1.052	1.046
10	1.047	1.042
11	1.042	1.037
12	1.037	1.033
13	1.033	1.029
14	1.028	1.025
15	1.023	1.020
16	1.018	1.016
17	1.014	1.012
18	1.009	1.008
19	1.005	1.004
20	1.000	1.000
21	0.996	0.996
22	0.991	0.992
23	0.987	0.988
24	0.982	0.984
25	0.978	0.980
26	0.974	0.977
27	0.969	0.973
28	0.965	0.969
29	0.961	0.965
30	0.957	0.962
31	0.953	0.958
32	0.949	0.954
33	0.945	0.951
34	0.941	0.947
35	0.937	0.943
NOTE The values of correction factor k_t are based on resistance temperature coefficients at 20 °C of 0.0045 per K for galvanized steel wire and 0.0040 per K for aluminium wire.		

Annex C Compatibility test (Normative)

C.1 General

This test determines whether the insulation and oversheath are likely to deteriorate due to contact with the other components in the cable.

C.2 Procedure

C.2.1 Prepare a test sample by ageing it in an air oven in accordance with SLS IEC 60811- 401, 4.2.3.4, for 7 days at (100 ±2) ^{o}C.

C.2.2 Place a sheet of clean white blotting paper under each test sample in the oven during the ageing to detect any exudate that might drip from the cable.

C.2.3 After completion of the ageing test, the tensile strength and the elongation at break for insulation and oversheath shall conform to Table C.1 when measured in accordance with SLS IEC 60811-501.

Table C.1 Compatibility requirements

Component	Parameter	Requirement		
		GP 8	GP 6	Type 9
(1)	(2)	(3)	(4)	(5)
Insulation	Minimum tensile strength (N/mm^2)	12.5	8.5	-
	Minimum percentage elongation at break	200	200	-
	Maximum percentage variation [A)] of tensile strength	±25	±30	-
	Maximum percentage variation [A)] of elongation at break	±25	±30	-
Oversheath	Minimum tensile strength (N/mm^2)	-	-	12.5
	Minimum percentage elongation at break	-	-	150
	Maximum percentage variation [A)] of tensile strength	-	-	±25
	Maximum percentage variation [A)] of elongation at break	-	-	±25

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

Annex D Abrasion resistance test (Normative)

D.1 General

This test determines the abrasion resistance of the complete cable.

D.2 Test method

A sample of the complete cable shall be tested in accordance with BS EN 60229, 4.1.2.1, using the vertical load specified in Table D.1.

Table D.1 Vertical load requirements

Overall measured diameter of cable		**Force**
Greater than or equal to mm	Greater than or equal to Less than mm	N
(1)	**(2)**	**(3)**
-	10	10
10	20	15
20	30	35
30	40	65
40	50	105
50	60	155
60	70	210
70	80	270
80	90	340

Annex E Insulation resistance constant test on oversheath (Normative)

E.1 Procedure

Immerse a length of at least 5 m of completed cable for at least 12 h in water at (20 ±5) ^{O}C, leaving a length of about 250 mm at each end projecting above the water. Maintain the temperature of the water at (20 ±1) ^{O}C for the 30 min immediately preceding the test. Apply a voltage of between 80 V and 500 V d.c. between the armour and the water. Measure the insulation resistance 1 min after the application of the voltage.

E.2 Calculation of results

Calculate the insulation resistance constant (K value) in MΩ·km from the equation:

$$K = \frac{IR}{1000 \log_{10} (D/d)}$$

where:

D is the diameter over the oversheath in millimetres (mm);
d is the diameter over armour in millimetres (mm);
I is the immersed length of cable in metres (m);
R is the insulation resistance of the length of the cable in megohms (MΩ).

Annex F Resistance of conductor and armour (Normative)

The maximum values of the conductor resistance and of the resistance of the aluminium wire and galvanized steel wire armour single-core and multicore cables with rated voltage of 600/1 000 V and 1 900/3 300 V, as designated in Table 2 to Table 9 shall be as specified in Table F.1, Table F.2 and Table F.3.

Table F.1 Maximum resistance of conductor and armour for single-core cable

Nominal cross-sectional area of conductor mm^2	**Maximum resistance per km of cable at 20 ^{0}C**		
	Copper conductor Ω	**Aluminium wire armour**	
		Cables with stranded copper conductor	
		600/1000 V Ω	**1 900/3 300 V** Ω
(1)	**(2)**	**(3)**	**(4)**
50	0.387	1.3	0.75
70	0.268	0.75	0.67
95	0.193	0.67	0.6 1
120	0.153	0.61	0.42
150	0.124	0.42	0.39
185	0.0991	0.38	0.37
240	0.0754	0.34	0.34
300	0.0601	0.31	0.31
400	0.0470	0.22	0.22
500	0.0366	0.20	0.20
630	0.0283	0.18	0.18
800	0.0221	0.13	0.13
1000	0.0176	0.12	0.12

Table F.2 Maximum resistance of conductor and armour for two-, three-, four- and five-core cable

Nominal cross-sectional area of conductor mm²	Maximum resistance per km of cable 20 °C					
	Copper conductor	Steel wire armour				
		Two-core	Three-core		Four-core	Five-core
		600/1 000V	600/1 000V	1 900/3 300V	600/ 1 000V	600/ 1 000V
	Ω	Ω	Ω	Ω	Ω	Ω
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.5 A)	12.1	10.2	9.5	-	8.8	8.2
2.5 A)	7.41	8.8	8.2	-	7.7	6.8
4 A)	4.61	7.9	7.5	-	6.8	6.2
6 A)	3.08	7.0	6.7	-	4.3	3.9
10 A)	1.83	6.0	4.0	-	3.7	3.4
16 A)	1.15	3.7	3.5	1.9	3.1	2.2
25 A)	0.727	3.2	2.3	1.7	2.1	1.8
25 B)	0.727	3.7	2.5	-	2.3	-
35 A)	0.524	2.2	2.1	1.6	1.9	1.6
35 B)	0.524	2.6	2.3	1.8	2.0	-
50 A)	0.387	2.0	1.8	-	1.3	1.1
50 B)	0.387	2.3	2.0	1.3	1.8	-
70 A)	0.268	1.4	1.3	-	1.2	0.94
70 B)	0.268	2.0	1.8	1.2	1.2	-
95 A)	0.193	1.2	1.2	-	0.76	-
95 B)	0.193	1.4	1.3	1.1	1.1	-
120 A)	0.153	1.1	0.76	-	0.69	-
120 B)	0.153	1.3	1.2	0.76	0.76	-
150 B)	0.1243	1.2	0.78	0.71	0.68	-
185 B)	0.0991	0.82	0.71	0.65	0.61	-
240 B)	0.0754	0.73	0.63	0.59	0.54	-
300 B)	0.0601	1.67	0.58	0.55	0.49	-
400 B)	0.0470	0.59	0.52	0.50	0.35	-

A) Circular or compacted circular stranded conductor (Class 2)

B) Shaped stranded conductor (Class 2)

Table F.3 Maximum resistance of conductor and armour for 600/ 1 000 V multicore auxiliary cables

Nominal cross-sectional area of conductor mm^2	Maximum resistance per km of cable 20 ^0C					
	Copper conductor	Steel wire armour : number of cores [A)]				
		7	12	19	27	37
	Ω	Ω	Ω	Ω	Ω	Ω
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.5	12.1	7.5	4.0	3.5	2.3	2.0
2.5	7.41	6.3	3.5	2.3	1.9	1.7
4.0	4.61	4.0	2.3	2.0	1.7	1.2

[A)] For a non-preferred number of cores, the maximum resistance shall not be greater than that of the next lowest preferred number of cores. For 6-core cables this shall be as for 5-core cables.

Annex G Gross cross-sectional area of armour (Information)

Table G.1, Table G.2 and Table G.3 give gross-sectional areas of armour for use in calculating the maximum fault current permissible for conformity to BS 7671:2008+A3:2015, Clause 54.

Table G.1 Gross cross-sectional area of armour wires for the single-core 600/1 000 V cables

Nominal cross-sectional area of conductor mm^2	Gross cross-sectional area of armour wires mm^2
(1)	(2)
50	26
70	42
95	47
120	52
150	76
185	84
240	94
300	104
400	147
500	163
630	182
800	260
1 000	284

NOTE *The values stated in Table G.1 are indicative only and for specific values required to calculate pulling tensions the manufacturer should be consulted.*

Table G.2 -Gross cross-sectional area of armour wires for two-, three-, four- and five-core 600/1 000 V cable

Nominal cross-sectional area of conductor mm²	Gross cross-sectional area of armour wires			
	Two-core mm²	Three-core mm²	Four-core mm²	Five-core mm²
(1)	(2)	(3)	(4)	(5)
1.5 A)	15	16	17	19
2.5 A)	17	19	20	22
4 A)	19	20	22	25
6 A)	22	23	36	40
10 A)	26	39	42	46
16 A)	42	45	50	72
25 A)	51	72	80	88
25 B)	42	62	70	-
35 A)	74	80	90	100
35 B)	60	68	78	-
50 A)	86	92	131	144
50 B)	68	78	90	-
70 A)	128	138	150	166
70 B)	80	90	131	-
95 A)	144	153	220	
95 B)	113	128	147	-
120 A)	160	220	245	
120 B)	125	141	206	-

Table G.2- Gross cross-sectional area of armour wires for two-, three-, four- and five-core 600/1 000 V cable

Nominal cross-sectional area of conductor mm²	Gross cross-sectional area of armour wires			
	Two-core mm²	Two-core mm²	Four-core mm²	Five-core mm²
(1)	(2)	(3)	(4)	(5)
150 B)	138	201	230	-
185 B)	191	220	255	-
240 B)	215	250	289	-
300 B)	235	269	319	-
400 B)	265	304	452	-

A) Circular or compacted circular stranded conductor (Class 2).

B) Shaped stranded conductor (Class 2).

NOTE *The values stated in Table G.2 are indicative only. For specific values required to calculate pulling tensions the manufacturer should be consulted.*

Table G.3- Gross cross-sectional area of armour wires for 600/ 1 000 V auxiliary cable

Nominal cross-sectional area mm^2	**Gross cross-sectional area of armour wires number of cores**				
	7 mm^2	**12 mm^2**	**19 mm^2**	**27 mm^2**	**37 mm^2**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
1.5	20	39	45	70	78
2.5	24	45	70	84	94
4	39	68	80	96	138

NOTE 1 *For a non-preferred number of cores, the gross cross-sectional area of armour is at least equal to that of the next lowest preferred number of cores. For 6-core cables this is as for 5 core cables.*

NOTE 2 *The values stated in Table G.3 are indicative only. For specific values required to calculate pulling tensions the manufacturer should be consulted.*

Annex H Test for shrinkage of oversheath on cable (Normative)

H.1 General

This test determines the shrinkage of the oversheath during heat treatment.

H.2 Selection of samples

Take one sample of each cable to be tested, about 300 mm in length, and at least 500 mm away from the end of the cable length.

H.3 Preparation of test piece

Within an interval of not more than 5 min from the time of cutting the sample, mark a test length of (200 ±5) mm on the middle part of the test piece. Measure the distance between the marks to an accuracy of 0.5 mm.

Prepare the test piece by removing the oversheath from both ends of the sample up to positions between 2 mm and 5 mm away from the marks. Bind the armour wires at each end of the test piece.

H.4 Procedure

Perform the test in a n electrically heated air oven capable of maintaining a temperature of (80 ± 2) ^{O}C. Support the test piece by means of a freshly prepared talc bath. The combined volume of talc bath and test piece shall not exceed 10% of the volume of the oven. Preheat the oven with the test apparatus, including the talc bath, in place for a minimum of 2 h at 80 ^{O}C before the test piece is introduced.

Support the test piece horizontally on the surface of the talc bath. Ensure that there is sufficient depth of talc so that the test piece does not touch the bottom of the bath. Spread the talc evenly, without compacting it, at the start of the test, so as to permit free movement of the oversheath. Introduce the test piece into the oven, and maintain it at a temperature of (80 ±2) ^{O}C for 4 h. At the end of this period, remove the apparatus with the test piece in place, and allow it to cool to room temperature.

Re-measure the distance between the two marks on the test piece to an accuracy of 0.5 mm.

H.5 Evaluation of results

Calculate the difference in the distance between the marks before the heat treatment and after the heating and cooling, and record the shrinkage as a percentage of the distance between the marks before treatment.

Annex I Guidance on type tests (Informative)

I.1 General

Type tests, after they have been completed, need not be repeated unless changes have been made that affect conformity to the performance requirements. This means that type tests are not normally required on cables for any individual contracts provided that such type tests have already been successfully performed by the manufacture.

I.2, I.3 and I.4 give guidance as to the amount of type testing that might be required.

I.2 Sample selection for type tests

Type tests for components may be performed on any one cable sample.

NOTE The results of these type tests are not determined by the cable size or construction.

For the type tests on finished cable, conformity to the requirements should be confirmed for the complete range of cables in this standard by selecting samples for testing as follows:

a) for single-core cables specified in Table 4 the smallest and largest conductor size should be tested;

b) for multicore cables specified in Table 5 to Table 8 the smallest conductor size with smallest number of cores, and the largest conductor size with the largest number of cores for that size should be tested.

c) for multicore auxiliary cables specified in Table 9 any one cable should be tested; and

d) for cables specified in Table 10 and Table 11 any one cable from each table should be tested.

Where multiple ranges from the above selection are being covered, consideration may be given to reduce the number of cable samples taken.

In addition, where manufacturers wish to demonstrate conformity of cables to this standard, the cable samples should be subjected to full dimensional checks and to all other sample (S) and routine (R) tests given in Table 3.

1.3 Type tests

1.3.1 Insulation material test (see 6.1)

One test should be performed for each grade of insulation material on any one cable from the range of cables selected.

1.3.2 Bedding material test (see 9.1)
One test should be performed for each grade of bedding material on any one cable from the range of cables selected.

1.3.3 Armour wire test (see 10.2)
One test should be performed on each size and material grade of armour wire from the range of cables selected.

1.3.4 Oversheath material test (see 11.1)
One test should be performed for each grade of oversheath material on any one cable from the range of cables selected

1.3.5 Durability of printing test (see 12.7)
One test should be performed on any one cable from the range of cables selected.

1.3.6 Compatibility test (see 18.2)
One test should be performed on each cable selected.

1.3.7 Shrinkage test on insulation (see 18.3)
One test should be performed on each cable selected.

1.3.8 Length of lay of assembles cores (see 17.2)
NOTE This test is classified as a sample test. The guidance given below applies to type testing.

One test should be performed on each cable selected.

1.3.9 Length of lay of armour wires (see 17.3)
NOTE This test is classified as a sample test. The guidance given below applies to type testing.

One test should be performed on each cable selected.

1.3.10 Abrasion test (see 18.4)
One test should be performed on each cable selected.

1.3.11 Insulation resistance constant of oversheath (see 18.5)
One test should be performed on each cable selected.

1.3.12 Shrinkage of oversheath (see 18.6)
One test should be performed on each cable selected.

1.4 Change of material

The tests referred to in 1.3 assume that the materials are consistent throughout the range of cables for which conformity is to be confirmed. Where a change occurs, additional testing should be included to ensure that such changes are adequately examined.

1.5 Evidence of type testing

When evidence of type testing is required, this should be stated at the enquiry stage. Due to the possible variations in cable designs, it should not be assumed that full type test information is available for the size and type of cable of a particular enquiry.

A certificate of type test signed by the representative of a competent witnessing body, or a properly authorized report by the manufacturer giving the test results, is acceptable.

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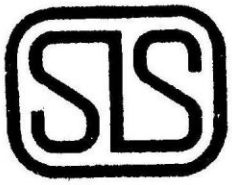

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