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Remarks:

PLEASE NOTE:

- **The technical committee, SABS TC 66 responsible for the preparation of this standard has reached consensus that the attached document should become a South African standard. It is now made available by way of public enquiry to all interested and affected parties for public comment, and to the technical committee members for record purposes. Any comments should be sent by the indicated closing date, either by mail, or by fax, or by e-mail to**

  SABS Standards Division
  Attention: Compliance and Development department
  Private Bag X191
  Pretoria
  0001

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  Any comment on the draft must contain in its heading the number of the clause/subclause to which it refers. A comment shall be well motivated and, where applicable, contain the proposed amended text.

- **The public enquiry stage will be repeated if the technical committee agrees to significant technical changes to the document as a result of public comment. Less urgent technical comments will be considered at the time of the next amendment.**

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Edition 4

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Electric cables — Cross-linked polyethylene (XLPE) insulated cables for rated voltages 3,8/6,6 kV to 19/33 kV

Published by SABS Standards Division
1 Dr Lategan Road Groenkloof ✉ Private Bag X191 Pretoria 0001
Tel: +27 12 428 7911 Fax: +27 12 344 1568
www.sabs.co.za

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Table of changes

Change No.	Date	Scope

Foreword

This South African standard was approved by National Committee SABS TC 66, *Electric cables,* in accordance with procedures of the SABS Standards Division, in compliance with annex 3 of the WTO/TBT agreement.

This document, by reference, forms part of the *Compulsory specification for the safety of medium-voltage electric cables*, as published by Government Notice No. R. 1164 (Government Gazette 25306) of 15 August 2003.

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This edition supersedes SANS 1339:2006 (edition 3.2).

Annex A forms an integral part of this standard. Annexes B and C are for information only.

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Electric cables — Cross-linked polyethylene (XLPE) insulated cables for rated voltages 3,8/6,6 kV to 19/33 kV

1 Scope

1.1 This standard specifies the construction, materials, dimensions and test requirements for single-core and three-core cross-linked polyethylene (XLPE) insulated cables with copper or aluminium conductors, for use at operating voltages in the range 3,8/6,6 kV to 19/33 kV.

1.2 The standard is applicable to the following cable types:

a) single-core and three-core cables for 3,8/6,6 kV to 19/33 kV;

b) armoured and unarmoured,

c) with or without a metallic sheath.

1.3 The cables are designed for use at a maximum continuous conductor operating temperature of 90 °C and a maximum short-circuit conductor temperature of 250 °C.

NOTE If cables directly buried in the ground operate under continuous load (100 % load factor) at the above maximum operating temperatures, irreversible drying out of the surrounding soil might occur with an unacceptable progressive increase in the conductor operating temperature. If such operating conditions are anticipated, appropriate precautions should be taken.

1.4 When the cables are to be installed by direct burial in the ground, a polyethylene sheath is normally recommended. Provision is also made for cables to be installed in air, sheathed with PVC or with materials exhibiting one or more of the following properties:

– reduced flame propagation;

– low smoke emission; or

– zero halogen emission.

2 Normative references

The following referenced documents are indispensable for the applicaton 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. Information on currently valid national and international standards can be obtained from the SABS Standards Division.

IEC 60502-2, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) – Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV).*

SANS 1411-1, *Materials of insulated electric cables and flexible cords – Part 1: Conductors.*

SANS 1411-2, *Materials of insulated electric cables and flexible cords – Part 2: Polyvinyl chloride (PVC).*

SANS 1411-4, *Materials of insulated electric cables and flexible cords – Part 4: Cross-linked polyethylene (XLPE).*

SANS 1411-5, *Materials of insulated electric cables and flexible cords – Part 5: Halogen-free, flame-retardant materials.*

SANS 1411-6, *Materials of insulated electric cables and flexible cords – Part 6: Armour.*

SANS 1411-7, *Materials of insulated electric cables and flexible cords – Part 7: Polyethylene (PE).*

SANS 6281-2, *Test methods for impregnated paper-insulated electric cables – Part 2: Tests on metallic sheaths.*

SANS 6282-1, *Test methods for bare conductors and conductors of insulated electric cables – Part 1: Conductor resistance.*

SANS 6283, *Test methods for armouring of insulated electric cables.*

SANS 6284-1, *Test methods for cross-linked polyethylene (XLPE) insulated electric cables – Part 1: Tests on XLPE insulation.*

SANS 6284-2, *Test methods for cross-linked polyethylene (XLPE) insulated electric cables – Part 2: Tests on extruded semi-conducting screens.*

SANS 6284-3, *Test methods for cross-linked polyethylene (XLPE) insulated electric cables – Part 3: Tests on finished cable.*

SANS 6284-5, *Test methods for cross-linked polyethylene (XLPE) insulated electric cables – Part 5: Ageing tests.*

SANS 6286, *Test methods for sheathing of insulated electric cables.*

SANS 6291, *Partial discharge measurements on power cables.*

SANS 10005, *The preservative treatment of timber.*

SANS 60332-3-24/IEC 60332-3-24, *Tests on electric and optical fibre cables under fire conditions – Part 3-24: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category C.*

SANS 60754-2/IEC 60754-2, *Test on gases evolved during combustion of materials from cables – Part 2: Determination of degree of acidity of gases by measuring pH and conductivity.*

SANS 60811-1-1/IEC 60811-1-1, *Common test methods for insulating and sheathing materials of electric cables and optical cables – Part 1-1: Methods for general application – Measurement of thickness and overall dimensions – Tests for determining the mechanical properties.*

SANS 61034-2/I EC 61034-2, *Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements.*

3 Definitions

For the purposes of this standard, the definitions given in SANS 1411-1, SANS 1411-2, SANS 1411-4, SANS 1411-5, SANS 1411-6 and SANS 1411-7 and the following apply. In the case of conflicting requirements, the definitions given below take precedence.

3.1
acceptable
acceptable to the authority administering this standard, or to the parties concluding the purchase contract, as relevant

3.2
armouring
mechanical protection for a cable, comprising a single layer of galvanized steel wires or, for a single-core cable, a layer of aluminium or copper wires

3.3
bedding
layer of extruded compound applied to a cable over the core or laid-up core assembly to form a circular base for the armour or the sheath and to prevent damage to the core or cores by the armour

3.4
binder
tape or tapes applied helically over the laid-up core assembly to locate the fillers and to hold the cores in close contact

3.5
conductor
that portion of a cable that is designed to carry load current

3.6
conductor screen
extruded layer of semi-conducting material that provides stress relief at the inner surface of the XLPE insulation

3.7
core
single, insulated and screened conductor without protective covering

3.8
core screen
insulation screen
extruded layer of semi-conducting material that provides stress relief at the outer surface of the XLPE insulation

3.9
dielectric
electrical insulation

3.10
direction of lay
lateral direction of inclination to the axis of the cable of the receding helix formed by an armour wire or a core in a three-core cable

3.11
filler
material placed in the interstices of the cores of a three-core cable

3.12
metallic screen
copper tape(s) applied helically to each core of a cable or copper wires, applied either helically or with an S-Z lay to each core of a cable

3.13
metallic sheath
lead, lead alloy or an aluminium sheath applied around a cable

3.14
partial discharge
electrical discharge that occurs when the stress within a void in a dielectric, or at the surface of a contaminant in the dielectric, or in a gap between the dielectric and the conductor or core screen, exceeds the electrical strength of that void or gap or of the dielectric material surrounding the contaminant

3.15
partial discharge extinction voltage
voltage at which partial discharges of a defined magnitude cease

3.16
pitch circle diameter
PCD
diameter of the circle inscribed through the centres of the laid-up cores of a three-core cable

3.17
rated voltage
voltage at which the cable is designed to operate, expressed as two values U_o/U where U_o is the power frequency r.m.s. voltage between phase and neutral or earth, and U is the power frequency r.m.s. voltage between phases

3.18
routine test
R
test conducted at the manufacturer's works on all cable lengths during manufacture or in the finished state, as appropriate

3.19
sample test
S
test conducted on a regular basis at the manufacturer's works or on representative samples taken by the manufacturer, or as requested by the purchaser at the time of enquiry or order

3.20
type test
T
test conducted before a type of cable covered by this standard is supplied on a general commercial basis, in order to demonstrate that the cable has the necessary performance characteristics for the intended application. The test is of such a nature that, after it has been successfully completed, it need not be repeated unless changes are made in the cable materials or design that might change the performance characteristics of the cable

3.21
type A cable
cable having a metallic sheath or wire armour (or both)

3.22
type B cable
cable having no armour

4 General requirements

4.1 Type

The cable shall be of one of the following types (all types for operation on 3,8/6,6 kV to 19/33 kV systems):

– **type A**: three-core, individually copper tape screened, metallic sheathed and / or single-wire armoured ;

– **type B**: three-core, individually copper tape screened, unarmoured;

– **type A**: single-core, copper tape or wire screened, metallic sheathed and / or aluminium or copper wire armoured;

– **type B**: single-core, copper tape or wire screened, unarmoured.

4.2 Cable operating voltage

The operating voltages for earthed systems (defined by the relationship U_o /U recognized for the purposes of this standard) shall be 3 800/6 600 V (3,8/6,6 kV), 6 350/11 000 V (6,35/11 kV), 12 700/22 000 V (12,7/22 kV), and 19 000/33 000 V (19/33 kV).

4.3 Materials and construction

4.3.1 Conductors

Conductors shall be circular, stranded and compacted to class 2 of SANS 1411-1.

4.3.2 Conductor screen

4.3.2.1 Composition

The conductor screen shall comprise a layer of extruded cross-linked semi-conducting material, co-extruded with the insulation and core screen.

4.3.2.2 Application

The conductor screen shall be applied either direct to the conductor or, at the discretion of the manufacturer, over a semi-conducting barrier tape. The outer surface of the conductor screen shall be smooth and shall be in continuous adherent contact with the inner surface of the XLPE insulation. The screen shall be readily removable from the conductor.

4.3.2.3 Thickness

When determined in accordance with 5.4, the thickness of the conductor screen shall be at least 0,5 mm.

4.3.2.4 Resistivity

When measured in accordance with 5.6, the volume resistivity of the conductor screen shall not exceed 500 Ω·m at 90 °C.

4.3.3 Insulation

4.3.3.1 Composition

The insulation shall comprise a solid extrusion of unfilled cross-linked polyethylene (XLPE), and shall comply with the requirements for type A of SANS 1411-4.

4.3.3.2 Thickness

The nominal thickness of the insulation shall be that given in the appropriate construction table (tables 10 to 25). When determined in accordance with 5.4, the average thickness shall be greater than or equal to the nominal thickness. The minimum thickness at a point may be less than the nominal thickness provided that the difference does not exceed 0,1 mm + 10 % of the nominal thickness.

4.3.4 Core screen

4.3.4.1 Composition

The core screen shall comprise a layer of extruded cross-linked semi-conducting material, co-extruded with the conductor screen and insulation.

4.3.4.2 Application

The inner surface of the core screen shall be smooth and shall be in continuous adherent contact with the outer surface of the insulation. The core screen shall be removable without causing damage to the underlying insulation. Unless a fully bonded core screen is specified, the force required to remove the semi-conducting layer from the insulation, when determined in accordance with 5.7, shall be not less than 0,5 N/mm and not more than 7,5 N/mm.

4.3.4.3 Thickness

When determined in accordance with 5.4, the thickness of the extruded layer shall be not less than 0,5 mm.

4.3.4.4 Resistivity

When measured in accordance with 5.6, the volume resistivity of the extruded core screen shall not exceed 500 Ω·m at 90 °C.

4.3.5 Bedding tape

4.3.5.1 General

A semi-conducting bedding tape shall be applied over the extruded semi-conducting core screen.

4.3.5.2 Identification

The bedding tape shall be clearly identified as being semi-conducting.

4.3.6 Core identification

The cores of three-core cables shall be identified by the numbers 1, 2, 3, printed as numerals or words either direct on the extruded semi-conducting core screen or on the semi-conducting bedding tapes of each core, or by other acceptable means.

4.3.7 Metallic screen

4.3.7.1 General

Each core shall have a metallic screen, which consists of an annealed copper tape or tapes or, in the case of single core cables, of either an annealed copper tape(s) or wires, applied helically over a semi-conducting bedding tape.

4.3.7.2 Application

Copper tape(s) shall be applied helically with a minimum overlap of 15 %. The tape(s) shall be electrically continuous. Any joints shall be made to an acceptable standard of workmanship and so finished that no sharp edges or protrusions remain.

Copper wires shall be applied helically and spaced with an average gap not greater than 4 mm. No gap shall exceed 8 mm. At the discretion of the manufacturer, a copper equalizing tape may be applied, and a binder tape may be applied over the copper wire screen.

4.3.7.3 Thickness

The total nominal thicknesses of the copper tape or tapes shall be as given in the construction tables (see tables 10 to 25).

In the case of single-core cables with copper wire screens, the total cross-sectional area (excluding the equalizing tape, if applied) shall be equivalent to that of a copper taped core. The wire shall be at least 0,9 mm in diameter.

4.3.8 Laying-up of cores

4.3.8.1 General

Cores of three-core cables shall be laid up with a right-hand lay.

4.3.8.2 Fillers

Interstitial fillers shall be used to ensure that the finished cable has an acceptably circular profile. The type of filler used shall be at the discretion of the manufacturer.

4.3.9 Equalizing binder

When so required, an equalizing binder, which consists of an annealed copper tape of nominal thickness 0,1 mm, shall be applied helically with a minimum overlap of 15 % over the laid-up core assembly. The tape shall be electrically continuous. Any joints shall be made to an acceptable standard of workmanship and so finished that no sharp edges or protrusions remain.

4.3.10 Metallic sheath

4.3.10.1 General

Where cables are to be installed by direct burial in aggressive environments such as petrochemical plants, a protective metallic sheath may be included. The metallic sheath shall be applied as a continuous tube that is impervious to moisture.

4.3.10.2 Material

Lead sheaths for all single-core cables and three-core unarmoured cables, shall be lead alloy E. Pure lead may be used for armoured three-core cables. When determined in accordance with 5.15.1, the composition of lead or lead alloy sheaths shall comply with the values given in the appropriate column of table 1. The composition of aluminium sheaths for single-core and three-core cables shall comply with the values given in table 1.

The malleability of the lead sheath shall be such that, when tested in accordance with 5.15.2, the sheath does not split or crack when the internal diameter of the expanded section reaches 150 % of the original internal diameter.

NOTE Pure lead sheaths are susceptible to cracking resulting from vibration. Cables with pure lead sheaths should therefore not be used near roads or railway lines where they may be subject to excessive vibration and should also not be transported over long distances.

4.3.10.3 Heat barrier

An acceptable heat barrier shall be provided immediately under the lead or lead alloy or corrugated aluminium sheath.

4.3.10.4 Thickness of metallic sheath

When measured in accordance with 5.4, the thickness of the metallic sheath shall be not less than the appropriate value given in table 3.

4.3.10.5 Depth and Pitch of corrugated aluminium sheaths

The minimum corrugation depth of the corrugated aluminium sheath at any point should not be less than

$$-2 \times 10^{-4}\, d^2 + 4{,}8 \times 10^{-2}\, d + 1{,}82 \text{ mm}$$

where

d is the nominal diameter under the corrugated aluminium sheath, in mm

The minimum corrugated pitch of the corrugated aluminium sheath at any point should not be less than that indicated in table 2.

Table 1 — Composition of lead or aluminium sheaths

1	2	3	4	5	6	7	8
Element	**Content %**				**Element**	**Content %**	
	Material					**Material**	
	Lead alloy E		**Lead**			**Corrugated Aluminium**	
	Min.	**Max.**	**Min.**	**Max.**		**Min.**	**Max.**
Antimony	0,15	0,25	–	0,15	Silicon	–	0,08
Tin	0,35	0,45	–	0,10	Iron	–	0,13
Copper	–	0,06	–	0,06	Copper	–	0,005
Bismuth	–	0,05	–	0,05	Manganese	–	0,006
Tellurium	–	0,005	–	0,01	Magnesium	–	0,02
Silver	–	0,005	–	0,01	Zinc	–	0,015
Zinc	–	0,002	–	0,002	Titanium	–	0,005
Total other metals	–	0,01	–	0,01	Total other metals	–	0,02
Lead	remainder		99,7	–	Aluminium	99,8	–

Table 2 — Pitch of corrugation

Dimensions in millimetres

1	2	3	4	5	6	7	8	9	10	11
Nominal diameter under corrugated aluminium sheath	≤24	>24 ≤30	>30 ≤34	>34 ≤44	>44 ≤54	>54 ≤64	>64 ≤74	>74 ≤84	>84 ≤94	>94 ≤100
Minimum Pitch of Corrugation	11	12	13	14	15	16	17	18	19	20

Table 3 — Dimensional requirements for metallic-sheathed cables

Dimensions in millimetres

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Nominal diameter over heat barrier	> 20 ≤ 25	> 25 ≤30	> 30 ≤35	> 35 ≤40	> 40 ≤45	> 45 ≤50	> 50 ≤55	> 55 ≤60	> 60 ≤65	> 65 ≤70	> 70 ≤75	> 75 ≤80	> 80 ≤5	> 85 ≤90	> 90 ≤95	> 95
Minimum thickness of lead sheath	1,6	1,7	1,9	2,1	2,3	2,5	2,7	2,9	3,1	3,3	3,5	3,7	3,9	4,1	4,3	4,5
Minimum thickness of CSA sheath	1,3	1,3	1,3	1,3	1,4	1,4	1,5	1,5	1.6	1,8	1,9	2,0	2,1	2,2	2,3	2,5
Nominal diameter over lead sheath	> 20 ≤25	> 25 ≤30	> 30 ≤35	> 35 ≤40	> 40 ≤45	> 45 ≤50	> 50 ≤55	> 55 ≤60	> 60 ≤65	> 65 ≤70	> 70 ≤75	> 75 ≤80	> 80 ≤85	> 85 ≤90	> 90 ≤95	> 95
Nominal thickness of armour bedding type A cables	1,6	1,8	2,2	2,2	2,4	2,4	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6
Nominal diameter of armour wires	2,0	2,0	2,5	2,5	2,5	3,15	3,15	3,15	3,55	3,55	3,55	3,55	3,55	3,55	3,55	3,55
Nominal diameter under outer sheath type A or type B Cables	> 20 ≤25	> 25 ≤30	> 30 ≤35	> 35 ≤40	> 40 ≤45	> 45 ≤50	> 50 ≤55	> 55 ≤60	> 60 ≤65	> 65 ≤70	> 70 ≤75	> 75 ≤80	> 80 ≤85	> 85 ≤90	> 90 ≤95	> 95
Nominal thickness of outer sheath	1,6	1,8	2,0	2,2	2,4	2,6	2,8	3,0	3,2	3,4	3,6	3,8	4,0	4,2	4,4	4,6

4.3.11 Bedding under armour of armoured cables

4.3.11.1 General

Bedding shall consist of a layer of either extruded PVC type B1 to SANS 1411-2 or halogen-free material type HFB1, closely fitting the underlying core or laid-up core assembly. The profile of the cable after extrusion of the bedding shall be acceptably circular.

4.3.11.2 Thickness

The nominal thickness of the extruded bedding shall be as given in the appropriate construction table (see tables 10 to 13 and 18 to 21). When the thickness is determined in accordance with 5.4, the average thickness shall be not less than the nominal thickness. The minimum thickness at any point may be less than the nominal thickness, provided that the difference does not exceed 0,1 mm + 15 % of the nominal thickness.

4.3.12 Armour

4.3.12.1 General

Armour for single-core cables to be used in a.c. circuits shall comprise a single layer of aluminium or copper wires, and for three-core cables, a single layer of galvanized steel wires, all complying with the requirements of SANS 1411-6.

NOTE Armour wires are not required for corrugated aluminium sheathed single-core and three-core cables.

4.3.12.2 Dimensions

Armour wires shall be applied helically with a left-hand lay.

NOTE In the construction tables, a lay length of nine times the pitch circle diameter (PCD) (see 3.16) was used.

The nominal diameter of armour wires shall be as given in the appropriate construction table (tables 10 to 13 and 18 to 21). Larger diameter wires may be used if agreed upon with the purchaser (see annex A) at the time of placing an order.

4.3.12.3 Joints

Any joints in armour wires shall be made to an acceptable standard of workmanship without sharp edges or protrusions. When multiple joints in armour wires are necessary, they shall be acceptably staggered.

4.3.13 Outer sheath

4.3.13.1 General

The outer sheath of the cable shall be a uniform extrusion of one of the following materials:

Polyvinyl chloride (PVC):	Type S5 to SANS 1411-2;
Medium-density Polyethylene (MDPE):	Type PS2 to SANS 1411-7;
Flame retardant PVC (FR PVC):	Type S5[1] to SANS 1411-2; and
Zero halogen (NH):	Type HFS2 to SANS 1411-5.

NOTE A guide to the selection of sheathing materials is given in annex B.

The nominal density of MDPE shall be 0,94 g/cm^3 and shall be tested in accordance with 5.1 of SANS 1411-7.

4.3.13.2 Thickness

The nominal thickness of the extruded outer sheath shall be as given in the appropriate construction table (see tables 10 to 25). When the thickness is determined in accordance with 5.4, the average thickness shall be not less than the nominal thickness. The minimum thickness at any point may be less than the nominal thickness, provided that the difference does not exceed 0,1 mm + 15 % of the nominal thickness for an unarmoured cable or 0,1 mm + 20 % of the nominal thickness for an armoured cable.

4.3.13.3 Conductive coating

When so required, to allow a d.c. voltage test to be carried out on the outer surface of the sheath, a graphite coating or a coating with similar conductive properties may be applied to the outer surface of the sheath.

NOTE Under certain circumstances, the application of a test current to a conductive coating (i.e. graphite) can result in a fire hazard.

1) Type S5 is formulated to also comply with the requirements of 4.5.1.

4.3.14 Water blocking

4.3.14.1 General

Where radial or longitudinal water blocking (or both) is required, it shall be specified by the user at the time of order. Where applicable, the construction method used in order to achieve the water blocking shall be stated.

Where longitudinally water blocked cable is offered the test given in 5.16 shall be carried out.

4.4 Electrical requirements

4.4.1 Conductor resistance

When a cable is tested in accordance with 5.5, the d.c. resistance of each conductor shall not exceed the appropriate maximum value given in SANS 1411-1.

4.4.2 Voltage withstand

When a cable is tested in accordance with 5.9, each core of the cable shall withstand a test voltage of the appropriate value given in table 6.

4.4.3 Partial discharge magnitude

When a cable is subjected to a partial discharge test in accordance with 5.10, the partial discharge magnitude at 1,73 U_o shall not exceed 5 pC.

4.4.4 DC voltage test on outer sheath

If a conductive coating is specified (see 4.3.13.3), the outer sheath of the cable shall withstand, without breakdown, a direct voltage of 10 kV applied for a period of 1 min in accordance with 5.8.

The leakage current in milliamperes at the end of the 1 min test shall be recorded.

4.5 Additional requirements for flame retardant, low smoke emission and zero halogen cables

4.5.1 Reduced fire propagation

When a cable designed to have reduced fire propagation (flame retardant) properties is tested in accordance with 5.11, the maximum height of the charred portion on the test sample above the bottom edge of the burner shall not exceed 2,5 m.

4.5.2 Low smoke emission

When a cable that is designed to have low smoke emission under fire conditions is tested in accordance with 5.12, the level of light transmittance throughout the test shall be not less than 70 % when a single cable is tested and not less than 60 % when two cables are tested.

4.5.3 Zero halogen

When a cable designed to have zero halogen emission under fire conditions is tested in accordance with 5.13, the halogen acid gas emission from all components obtained from the finished cable shall comply with the relevant requirements of SANS 1411-5.

4.6 Type approval test

4.6.1 General

The following sequence of tests shall be carried out either at the manufacturer's works or at the laboratories of the acceptable testing authority, before a type of cable covered by this standard is supplied on a general commercial basis, in order to demonstrate that the cable has the necessary performance characteristics for the intended application. The test is of such a nature that, after it has been successfully completed, it need not be repeated unless changes are made to the cable materials or design that might affect the performance characteristics of the cable.

4.6.2 Test sequence

4.6.2.1 Bending test

Two samples of cable shall be subjected to the bending test in accordance with 5.14.2. When visually examined after completion of the bending test, the first sample shall show no sign of splitting or cracking of the extruded plastic sheath or significant displacement of any armour wires, screening tapes or semi-conducting bedding tapes.

The second sample is used for the remainder of the test sequence. When tested in accordance with 5.14.3, the partial discharge magnitude at 1,73 U_o shall not exceed 5 pC.

4.6.2.2 Load cycling test

After successful completion of the bending test and partial discharge test, the sample shall be subjected to the load cycling test in 5.14.4. No breakdown of the sample shall occur.

4.6.2.3 Partial discharge test

When tested in accordance with 5.14.5, the partial discharge magnitude at 1,73 U_o shall not exceed 5 pC.

4.6.2.4 Impulse voltage test

When the sample is tested in accordance with 5.14.6, it shall successfully withstand 10 negative and 10 positive impulses of the appropriate value given in table 7.

4.6.2.5 Four-hour high voltage a.c. withstand test

After successful completion of the impulse voltage test, the sample shall be subjected, in accordance with 5.14.7, to the test voltage given in table 9, for a period of 4 h. No breakdown of the sample shall occur.

4.7 Ageing tests

4.7.1 General

The following ageing tests, carried out on samples of triple-extruded core, are designed to demonstrate the long-term reliability of the materials used and their resistance to the growth of water trees.

An ageing test at 50 Hz or at 500 Hz shall be completed before a type of cable covered by this standard is supplied on a general commercial basis, and may thus be considered to be part of the type approval testing procedure. The test shall be carried out either at the manufacturer's works or at

the laboratories of the acceptable testing authority. It need not be repeated unless changes are made to the cable materials or design that might affect the long-term reliability of the cable.

4.7.2 50 Hz ageing test

When the 12 samples, which have been subjected to the two year ageing test at 3 U_o in accordance with 5.14.8, are tested to breakdown in 5 min 1 U_o steps, the calculated 5 min withstand stress at the conductor screen shall equal or exceed

a) 22 kV/mm for at least five of the samples,

b) 18 kV/mm for at least nine of the samples, and

c) 14 kV/mm for all of the samples.

4.7.3 500 Hz ageing test

When the 12 samples, which have been subjected to the 3 000 h ageing test at 3 U_0 in accordance with 5.14.9, are tested to breakdown in 5 min 1 U_0 steps, the calculated 5 min withstand stress at the conductor screen shall equal or exceed

a) 22 kV/mm for at least five of the samples,

b) 18 kV/mm for at least nine of the samples, and

c) 14 kV/mm for all of the samples.

5 Inspection and methods of test

5.1 Inspection

Visually inspect each drum of cable for compliance with all the relevant requirements of this standard for which tests to assess compliance are not included in 5.4 to 5.16.

5.2 Tests

For convenience, the properties to be tested, the test category, the test methods and the subclause giving the requirements are listed in table 4.

5.3 Conditions of test and range of approval

5.3.1 The following conditions of test shall apply:

a) unless otherwise specified, all tests are carried out at ambient temperature and pressure; and

b) unless otherwise specified, tests are carried out at power frequency (50 Hz) with a waveform that is substantially sinusoidal.

Table 4 — List of tests

1	2	3	4	5
Component	**Test property**	**Category**	**Test method**	**Requirement**
Conductor	Construction	S	SANS 1411-1	4.3.1
Conductor screen	Thickness	S	SANS 6284-2	4.3.2.3
XLPE insulation	Composition	S	SANS 1411-4	4.3.3.1
	Thickness	S	SANS 6284-1	4.3.3.2
Core screen	Adhesion	S	SANS 6284-2	4.3.4.2
	Thickness	S	SANS 6284-2	4.3.4.3
Metallic core screen	Assembly	R	Visual examination	4.3.7.1
	Wire size (Where applicable)	S	By Measurement	4.3.7.3
Fillers and binders	Acid gas emission	T	SANS 60754-2	4.5.3
Core(s)	Identification	R, S	Visual examination	4.3.6
	Laying up	R	Visual examination	4.3.8.1
Lead or lead alloy sheath (where applicable)	Composition	S[a]	SANS 6281 -2	4.3.10.2
	Malleability	S	SANS 6281 -2	4.3.10.2
	Thickness	S	SANS 6281 -2	4.3.10.4
Bedding	Physical properties	S	SANS 1411-2 or 1411-5	4.3.11.1
	Thickness	S	SANS 60811-1-1	4.3.11.2
	Acid gas emission	T	SANS 60754-2	4.5.3
Armour	Properties	S	SANS 1411-6	4.3.12.1
	Wire diameter	S	SANS 6283	4.3.12.2
Outer sheath	Physical properties	S	SANS 1411-2, SANS1411-5 or SANS1411-7	4.3.13.1
	Thickness	S	SANS 60811-1-1	4.3.13.2
	Acid gas emission	T	SANS 60754-2	4.5.3

Table 4
(concluded)

1	2	3	4	5
Component	**Test property**	**Category**	**Test method**	**Requirement**
Finished cable	Marking	R	Visual examination	7.2.1
	Conductor resistance	R	SANS 6282-1	4.4.1
	Resistivity of semi-conducting	S	SANS 6284-2	4.3.2.4
	Voltage withstand	R	SANS 6284-3	4.4.2
	Partial discharge test	R	SANS 6291	4.4.3
	DC voltage test on outer sheath	R	SANS 6286	4.4.4
	Fire propagation	T	SANS 60332-3-24	4.5.1
	Smoke emission	T	SANS 61034-2	4.5.2
	Halogen emission	T	SANS 60754-2	4.5.3
Type approval test	Bending test	T	SANS 6284-3	4.6.2.1
	Partial discharge test	T	SANS 6291	4.6.2.1
	Load cycling test	T	SANS 6284-3	4.6.2.2
	Partial discharge test	T	SANS 6291	4.6.2.3
	Impulse voltage withstand	T	SANS 6284-3	4.6.2.4
	Four-hour high voltage withstand	T	SANS 6284-3	4.6.2.5
Ageing test	50 Hz, 2 year test	T	SANS 6284-5	4.7.2
	500 Hz, 3 000 h test	T	SANS 6284-5	4.7.3

NOTE 1 In column 3 of this list, a code letter is given that identifies the test as suitable for use as routine tests (R), sample tests (S) or type tests (T), but compliance with the requirements of this standard may only be fully determined from the results of tests carried out on samples of completed cable(s), using all the test methods given and a sampling procedure agreed upon. During production control, a manufacturer may use any test method that he deems necessary to ensure compliance with this standard, but, in the case of dispute, only the appropriate standard test methods may be used.

NOTE 2 The frequency of testing required and the test methods to be used are the subject of a separate agreement between the authority administering this standard and the permit holder.

[a] Certified values from the material supplier may be regarded as acceptable.

5.3.2 For one type of cable, approval of the full range of cross-sections given in the relevant tables shall be obtained by successfully completing the type tests on a cable cross section of either 185 mm^2 or 300 mm^2, provided that the design stress of the relevant cables does not exceed the appropriate design stress.

5.3.3 Approval is independent of the cable conductor material. Tests may therefore be carried out on cables having either aluminium or copper conductors.

5.3.4 Approval of voltage ranges of cables shall be obtained up to and including the voltage tested, provided that the design stress of the relevant cables does not exceed the design stress of the tested cables.

5.3.5 In general, approval of a single core cable design shall be obtained by successful testing of the relevant three core cable design. The converse shall not apply. Table 5 is applicable.

5.3.6 In general, approval of an unarmoured cable design shall be obtained by successful testing of the relevant armoured cable design. The converse shall not apply. Table 5 is applicable.

5.3.7 If approval is sought for a cable with a different outer sheath material than the one originally tested, a sample of the finished cable must be resubmitted for testing. However, only the outer sheath will be tested.

5.3.8 Approval is restricted to the electrical design and type of the cables on which tests have been conducted.

Table 5 — Range of approval

1	2	3	4	5	6	7	8	9	10	11	11	12	13	14	15	16	17
	Cable submitted for testing																
	Table	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	10	×	×	×	×					×	×	×	×				
	11		×	×	×						×	×	×				
	12			×	×							×	×				
	13				×								×				
	14	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	15		×	×	×		×	×	×		×	×	×		×	×	×
	16			×	×			×	×			×	×			×	×
	17				×				×				×				×
	18									×	×	×	×				
	19										×	×	×				
	20											×	×				
	21												×				
	22									×	×	×	×	×	×	×	×
	23										×	×	×		×	×	×
	24											×	×			×	×
	25												×				×

5.4 Dimensions

Use the procedures given in SANS 6281-2, SANS 6283, SANS 6284-1, SANS 6284-2 and SANS 60811-1-1 to determine the

a) thickness of extruded conductor and core screens,

b) thickness of XLPE insulation on each core,

c) thickness of copper screening tapes,

d) thickness of lead sheath, where applicable,

e) thickness of bedding,

f) diameter of armour wire, and

g) thickness of outer sheath.

5.5 Conductor resistance

Use SANS 6282-1.

5.6 Resistivity of extruded semi-conducting screens

Use SANS 6284-2.

5.7 Adhesion of extruded core screen

Use SANS 6284-2.

5.8 DC voltage test on outer sheath

If a conductive coating is specified, use SANS 6286.

5.9 Voltage withstand test

Use SANS 6284-3 but apply the appropriate test voltage given in column 2 of table 6 for a period of 5 min.

Table 6 — Test voltages

1	2	3
Voltage rating of cable U_o/U kV	**Test voltage**	
	3,5 U_o *(r.m.s)* kV	**1,73 U_o *(r.m.s)*** kV
3,8/6,6	13	6,6
6,35/11	22	11
12,7/22	44	22
19/33	66	33

5.10 Partial discharge magnitude

Use SANS 6291, using a sample of cable of length 10 m or a full drum length, as applicable. Raise the voltage to the appropriate value given in column 2 of table 6, and hold it at that value for 1 min. Lower the voltage to the value given in column 3 of table 6, and note and record the partial discharge magnitude at that voltage. If the partial discharge magnitude at that voltage exceeds the value specified in 4.4.3, lower the voltage to the value at which partial discharge extinction occurs, and note and record that voltage.

NOTE If the partial discharge test immediately follows the voltage withstand test in 5.9, the test voltage may simply be lowered to the appropriate value given in column 3 of table 6 and the partial discharge magnitude noted and recorded.

5.11 Fire propagation

Use SANS 60332-3-24, category C.

5.12 Smoke emission

Use SANS 61034-2. Two cable samples shall be included where the outside diameter, as given in the appropriate construction table (see tables 10 to 25), is less than or equal to 40 mm. Only one sample is required for cables that have a tabulated outside diameter exceeding 40 mm.

5.13 Halogen emission

Use SANS 60754-2.

5.14 Type approval tests

5.14.1 Test sample

Where only cable is to be tested, a sample of length at least 10 m between terminations will be required. Where accessories are to be included in the type approval test, a sample of length 15 m or longer might be necessary. All cable to be used in the type test shall be subjected to the bending test given in 5.14.2. A second length, which will be subjected to the bending test and physical examination, will also be required. All the tests given in 5.14.2 to 5.14.7 shall be applied successively to the same sample.

5.14.2 Bending test

Use SANS 6284-3. The diameter of the test cylinder shall be as follows:

- for single-core unarmoured cables: $20(D + d)$;
- for single-core armoured cables: $15(D + d)$;
- for three-core unarmoured cables: $15(D + d)$; and
- for three-core armoured cables: $12(D + d)$;

where D is the nominal diameter of the cable and d is the nominal diameter of the conductor given in the construction tables (tables 10 to 25).

Check the second sample for compliance with 4.6.2.1.

5.14.3 Partial discharge measurements

Use SANS 6291. Raise the voltage to the appropriate value given in column 2 of table 6, and hold it at that value for 1 min. Lower the voltage to the value given in column 3 of table 6, and note and record the partial discharge magnitude at that voltage.

5.14.4 Load cycling

Use SANS 6284-3. Heat the cable conductor(s) to a maximum temperature between 95 °C and 100 °C in a period of 6 h and allow the cable to cool for 18 h. Repeat this daily loading cycle until a total of 10 loading cycles has been completed. During the loading cycles apply the appropriate voltage given in table 7 to the conductor(s) with all metallic screening and armouring earthed. Check for compliance with 4.6.2.2.

Table 7 — Load cycling test voltage

1	2
Voltage rating of cable U_o/U kV	**Test voltage during load cycling $2\ U_o$** kV
3,8/6,6	8
6,35/11	13
12,7/22	25
19/33	38

5.14.5 Partial discharge measurements

After successful completion of the load cycling test, repeat the partial discharge test in 5.14.3 and check for compliance with 4.6.2.3.

5.14.6 Impulse voltage test

After successful completion of the partial discharge test in 5.14.5, subject the sample to the impulse voltage test in accordance with SANS 6284-3. Apply 10 positive and 10 negative polarity full wave impulses to each core of the cable at the appropriate voltage given in table 8. Check for compliance with 4.6.2.4.

Table 8 — Impulse test voltage

1	2
Voltage rating of cable U_o/U kV	**Peak value of impulse voltage** kV
3,8/6,6	75
6,35/11	95
12,7/22	150
19/33	200

5.14.7 Four-hour high voltage a.c. withstand test

Use SANS 6284-3. Raise the voltage to the appropriate value given in column 2 of table 9, and hold it at that value for 4 h. Check for compliance with 4.6.2.5.

Table 9 — Four-hour test voltage

1	2
Voltage rating of cable U_o/U	**Test voltage $4\ U_o$**
kV	kV
3,8/6,6	15
6,35/11	25
12,7/22	51
19/33	76

5.14.8 50 Hz ageing test

Use SANS 6284-5. The test shall be carried out on triple-extruded core of 6,35/11 kV rating, with copper or aluminium conductors in the size range 95 mm^2 to 400 mm^2. A test on one size in the range will provide approval for all sizes and voltages of cable covered by SANS 1339.

5.14.9 500 Hz ageing test

Use SANS 6284-5. The test shall be carried out on triple-extruded core of 6,35/11 kV rating, with copper or aluminium conductors in the size range 95 mm^2 to 400 mm^2. A test on one size in the range will provide approval for all sizes and voltages of cable covered by this standard.

NOTE It is recommended that up to three additional samples be included in the above ageing tests to provide data on the change in breakdown strength with time and the rate of growth of water trees. Samples may be taken at agreed intervals and subjected to the 1 U_o 5 min step breakdown test. Specimens taken from the middle of each of these additional samples and from the middle of the type test sample that has the lowest breakdown strength, should be examined for water tree growth in accordance with the method given in annex A of SANS 6284-5.

5.15 Additional tests on lead sheathed cables

5.15.1 Composition of lead or lead alloy sheaths Use the methods given in SANS 6281-2.

5.15.2 Belling test for lead or lead alloy sheaths Use the method given in SANS 6281-2.

5.16 Water penetration test

The water penetration test shall be applied to those designs of cable where the manufacturer claims that barriers to longitudinal water penetration have been included in the cable design. The test is designed to meet the requirements for buried cables and is not intended to apply to cables that are constructed for use as submarine cables.

The test is applicable to the following cable designs:

a) a barrier is included that prevents longitudinal water penetration in the region of the metallic layers;

b) a barrier is included that prevents longitudinal water penetration along the conductor.

The apparatus, sampling and test procedure shall be in accordance with annex F of IEC 60502-2 with the provision that the value of 100 °C is replaced by the words "boiling point".

NOTE It should be noted that if radial water blocking is required, consideration should be given to specifying a polyethylene outer sheath in conjunction with a metallic sheath (e.g. lead).

6 Construction tables

Tables 10 to 25 give constructional details of the complete range of cables covered by this standard.

Table 10 — Construction table for 3,8/6,6 kV single-core type A cables

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conductor size	mm^2	50	70	95	120	150	185	240	300	400	500	630	800	1 000
Nominal diameter over conductor	mm	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4	24,3	27,3	31,0	34,1	39,5
Insulation thickness														
Nominal	mm	2,5	2,5	2,5	2,5	2,5	2,5	2,6	2,8	3,0	3,2	3,2	3,2	3,2
Minimum at a point	mm	2,15	2,15	2,15	2,15	2,15	2,15	2,24	2,42	2,60	2,78	2,78	2,78	2,78
Nominal diameter over insulation	mm	15,9	17,4	19,2	20,9	22,1	23,9	26,5	29,5	32,8	36,2	39,9	43,0	48,4
Nominal diameter over semi-conducting core screen	mm	17,9	19,4	21,2	22,9	24,1	25,9	28,5	31,5	34,8	38,2	41,9	45,0	50,4
Nominal thickness of copper tape	mm	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Bedding thickness														
Nominal	mm	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,3	1,4	1,4	1,5
Minimum at a point	mm	0,92	0,92	0,92	0,92	0,92	0,92	0,92	0,92	0,92	1,00	1,09	1,09	1,17
Nominal diameter over bedding	mm	21,2	22,7	24,5	26,2	27,4	29,2	31,8	34,8	38,1	41,7	45,6	48,7	54,3
Nominal diameter of armour wires	mm	1,6	1,6	1,6	1,6	1,6	2,0	2,0	2,0	2,0	2,5	2,5	2,5	2,5
Nominal diameter over armour wires	mm	24,4	25,9	27,7	29,4	30,6	33,2	35,8	38,8	42,1	46,7	50,6	53,7	59,3
Minimum cross-section of armour[a]	mm^2	84,4	90,5	96,5	102,5	106,6	144,5	157,1	169,6	185,4	255,3	279,8	294,5	328,9
Outer sheath thickness														2,9
Nominal	mm	1,8	1,8	1,9	1,9	2,0	2,0	2,1	2,2	2,3	2,5	2,6	2,7	2,12
minimum at a point	mm	1,24	1,24	1,32	1,32	1,40	1,40	1,48	1,56	1,64	1,80	1,88	1,96	
Nominal overall diameter of cable	mm	28,4	29,9	31,9	33,6	35,0	37,6	40,4	43,6	47,2	52,2	56,3	59,6	65,7

[a] Based on a lay ratio of 9.

Table 11— Construction table for 6,35/11 kV single-core type A cables

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conductor size	mm^2	50	70	95	120	150	185	240	300	400	500	630	800	1 000
Nominal diameter over conductor	mm	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4	24,3	27,3	31,0	34,1	39,5
Insulation thickness														
Nominal	mm	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4
	mm	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96
Nominal diameter over insulation	mm	17,9	19,4	21,2	22,9	24,1	25,9	28,3	30,9	33,8	36,8	40,5	43,6	49,0
Nominal diameter over semi-conducting core screen	mm	19,9	21,4	23,3	24,9	26,1	27,9	30,3	32,9	35,8	38,8	42,5	45,6	51,0
Nominal thickness of copper tape	mm	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Bedding thickness	mm	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,3	1,4	1,4	1,5
Nominal minimum at point	mm	0,92	0,92	0,92	0,92	0,92	0,92	0,92	0,92	0,92	1,00	1,09	1,09	1,17
Nominal diameter over bedding	mm	23,2	24,7	26,5	28,2	29,4	31,2	33,6	36,2	39,1	42,3	46,2	49,3	54,9
Nominal diameter of armour wires	mm	1,6	1,6	1,6	1,6	2,0	2,0	2,0	2,0	2,0	2,5	2,5	2,5	2,5
Nominal diameter over armour wires	mm	26,4	27,9	29,7	31,4	33,4	35,2	37,6	40,2	43,1	47,3	51,2	54,3	59,9
Minimum cross-section of armour[a]	mm^2	90,5	96,5	104,6	110,6	144,5	153,9	163,4	175,9	188,5	260,2	279,8	299,4	333,8
Outer sheath thickness	mm	1,8	1,9	1,9	2,0	2,1	2,1	2,2	2,2	2,4	2,5	2,6	2,7	2,9
Nominal minimum at point	mm	1,24	1,32	1,32	1,40	1,48	1,48	1,56	1,56	1,72	1,80	1,88	1,96	2,12
Nominal overall diameter of cable	mm	30,3	32,1	33,9	35,8	38,0	39,8	42,4	45,0	48,4	52,8	56,9	60,2	66,3

[a] Based on a lay ratio of 9.

Table 12 — Construction table for 12,7/22 kV single-core type A cables

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conductor size	mm^2	50	70	95	120	150	185	240	300	400	500	630	800	1 000
Nominal diameter over conductor	mm	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4	24,3	27,3	31,0	34,1	39,5
Insulation thickness Nominal Minimum at a point	 mm mm	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85
Nominal diameter over insulation	mm	22,5	24,0	25,8	27,5	28,7	30,5	32,9	35,5	38,4	41,4	45,1	48,2	53,6
Nominal diameter over semi-conducting core screen	mm	24,5	26,0	27,8	29,5	30,7	32,5	34,9	37,5	40,4	43,4	47,1	50,2	55,6
Nominal thickness of copper tape	mm	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Bedding thickness Nominal Minimum at a point	 mm mm	 1,2 0,92	 1,2 0,92	 1,2 0,92	 1,2 0,92	 1,2 0,92	 1,2 0,92	 1,2 0,92	 1,3 1,00	 1,3 1,00	 1,4 1,09	 1,4 1,09	 1,5 1,17	 1,6 1,26
Nominal diameter over bedding	mm	27,8	29,3	31,1	32,8	34,0	35,8	38,2	41,0	43,9	47,1	50,8	54,1	59,7
Nominal diameter of armour wires	mm	1,6	2,0	2,0	2,0	2,0	2,0	2,0	2,5	2,5	2,5	2,5	2,5	2,5
Nominal diameter over armour Wires	mm	31,0	33,3	35,1	36,8	38,0	39,8	42,2	46,0	48,9	52,1	55,8	59,1	64,7
Minimum cross-section of armour[a]	mm^2	108,6	144,5	153,9	160,2	166,5	175,9	185,4	250,3	270,0	284,7	309,3	328,9	358,3
Outer sheath thickness Nominal minimum at a point	 mm mm	 2,0 1,40	 2,0 1,40	 2,1 1,48	 2,1 1,48	 2,2 1,56	 2,2 1,56	 2,3 1,64	 2,4 1,72	 2,5 1,80	 2,6 1,88	 2,8 2,04	 2,9 2,12	3,0 2,20
Nominal overall diameter of cable	mm	35,4	37,7	39,7	41,4	42,8	44,6	47,3	51,3	54,4	57,8	62,0	65,5	71,3
[a] Based on a lay ratio of 9.														

Table 13 — Construction table for 19/33 kV single-core type A cables

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conductor size	mm^2	50	70	95	120	150	185	240	300	400	500	630	800	1 000
Nominal diameter over conductor	mm	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4	24,3	27,3	31	34,1	39,5
Insulation thickness Nominal minimum at a point	mm mm	8,0 7,10	8,0 7,10	8,0 7,10	8,0 7,10	8,0 7,10	8,0 7,10	8,0 7,10	8,0 7,10	8,0 7,10	8,0 7,10	8,0 7,10	8,0 7,10	8,0 7,10
Nominal diameter over insulation	mm	28,0	29,5	31,3	33,0	34,2	36,0	38,4	41,0	43,9	46,9	50,6	53,7	59,1
Nominal diameter over semi-conducting core screen	mm	30,0	31,5	33,3	35,0	36,2	38,0	40,4	43,0	45,9	48,9	52,6	55,7	61,1
Nominal thickness of copper tape	mm	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Bedding thickness Nominal Minimum at a point	 mm mm	 1,2 0,92	 1,2 0,92	 1,2 0,92	 1,2 0,92	 1,3 1,00	 1,3 1,00	 1,3 1,00	 1,4 1,09	 1,4 1,09	 1,5 1,17	 1,5 1,17	 1,6 1,26	 1,7 1,34
Nominal diameter over bedding	mm	33,3	34,80	36,60	38,30	39,70	41,50	43,90	46,70	49,60	52,80	56,50	59,80	65,40
Nominal diameter of armour wires	mm	2,0	2,0	2,0	2,0	2,5	2,5	2,5	2,5	2,5	2,5	2,5	3,15	3,15
Nominal diameter over armour Wires	mm	37,3	38,8	40,6	42,3	44,7	46,5	48,9	51,7	54,6	57,8	61,5	66,1	71,7
Minimum cross-section of armour[a]	mm^2	163,4	169,6	179,1	185,4	245,4	255,3	270,0	284,7	299,4	319,1	338,7	459,8	498,8
Outer sheath thickness Nominal Minimum at a point	 mm mm	 2,2 1,56	 2,2 1,56	 2,3 1,64	 2,3 1,64	 2,4 1,72	 2,5 1,80	 2,5 1,80	 2,6 1,88	 2,7 1,96	 2,8 2,04	 2,9 2,12	 3,1 2,28	 3,2 2,36
Nominal overall diameter of cable	mm	42,1	43,6	45,7	47,4	50,0	52,0	54,4	57,4	60,5	64,0	67,9	72,9	78,7
[a] Based on a lay ratio of 9.														

Table 14 — Construction table for 3,8/6,6 kV single-core type B cables

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conductor size	mm^2	50	70	95	120	150	185	240	300	400	500	630	800	1 000
Nominal diameter over conductor	mm	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4	24,3	27,3	31,0	34,1	39,5
Insulation thickness														
Nominal	mm	2,5	2,5	2,5	2,5	2,5	2,5	2,6	2,8	3,0	3,2	3,2	3,2	3,2
Minimum at a point	mm	2,15	2,15	2,15	2,15	2,15	2,15	2,24	2,42	2,60	2,78	2,78	2,78	2,78
Nominal diameter over insulation	mm	15,9	17,4	17,2	20,9	22,1	23,9	26,5	29,5	32,8	36,2	39,9	43,0	48,4
Nominal diameter over semi-conducting core screen	mm	17,9	19,4	21,2	22,9	24,1	25,9	28,5	31,5	34,8	38,2	41,9	45	50,8
Total nominal thickness of copper tapes	mm	0,3	0,3	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Outer sheath thickness														
Nominal	mm	1,6	1,7	1,7	1,8	1,9	1,9	1,9	2,0	2,2	2,3	2,4	2,5	2,6
Minimum at a point	mm	1,34	1,34	1,43	1,43	1,51	1,51	1,51	1,60	1,77	1,85	1,94	2,02	2,11
Nominal overall diameter of cable	mm	22,7	24,4	26,2	28,2	29,2	31,2	33,8	37,0	40,7	44,4	48,3	51,6	57,2

Table 15 — Construction table for 6,35/11 kV single-core type B cables

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conductor size	mm^2	50	70	95	120	150	185	240	300	400	500	630	800	1 000
Nominal diameter over conductor	mm	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4	24,3	27,3	31,0	34,1	39,5
Insulation thickness	mm	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4
Nominal minimum at a point	mm	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96
Nominal diameter over insulation	mm	17,7	19,2	21,0	22,7	23,9	25,7	28,1	30,7	33,6	36,6	40,3	43,4	48,8
Nominal diameter over semi-conducting core screen	mm	19,7	21,2	23,0	24,7	25,9	27,7	30,1	32,7	35,6	38,6	42,3	45,4	50,8
Total nominal thickness of copper tapes	mm	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2
Outer sheath thickness	mm	1,7	1,7	1,8	1,8	1,9	1,9	2,0	2,1	2,2	2,3	2,4	2,5	2,6
Nominal minimum at a point	mm	1,34	1,34	1,43	1,43	1,51	1,51	1,60	1,68	1,77	1,85	1,94	2,02	2,11
Nominal overall diameter of cable	mm	24,7	26,2	28,3	30,0	31,4	33,2	35,8	38,4	41,5	44,8	48,7	52,0	57,6

Table 16 — Construction table for 12,7/22 kV single-core type B cables

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conductor size	mm^2	50	70	95	120	150	185	240	300	400	500	630	800	1 000
Nominal diameter over conductor	mm	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4	24,3	27,3	31,0	34,1	39,5
Insulation thickness Nominal Minimum at a point	 mm mm	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85	 5,5 4,85
Nominal diameter over insulation	mm	21,9	23,4	25,2	26,9	28,1	29,9	32,3	34,9	37,8	40,8	44,5	47,6	53,0
Nominal diameter over semi-conducting core screen	mm	23,9	25,4	27,2	28,9	30,1	31,9	34,3	36,9	39,8	42,8	46,5	49,6	55,0
Total nominal thickness of copper tapes	mm	0,3	0,3	0,3	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Outer sheath thickness Nominal minimum at a point	mm mm	1,8 1,43	1,9 1,51	1,9 1,51	2,0 1,60	2,0 1,60	2,1 1,68	2,2 1,77	2,2 1,77	2,3 1,85	2,4 1,94	2,5 2,02	2,7 2,19	2,8 2,28
Nominal overall diameter of cable	mm	29,2	30,9	32,7	34,6	35,8	37,6	40,2	42,8	46,0	49,2	53,1	56,6	62,3

Table 17 — Construction table for 19/33 kV single-core type B cables

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Nominal overall diameter of cable	mm	29,2	30,9	32,7	34,6	35,8	37,6	40,2	42,8	46,0	49,2	53,1	56,6	62,3
Conductor size	mm^2	50	70	95	120	150	185	240	300	400	500	630	800	1 000
Nominal diameter over conductor	mm	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4	24,3	27,3	31,0	34,1	39,5
Insulation thickness	mm	8,0	8,0	8,0	8,0	8,0	8,0	8,0	8,0	8,0	8,0	8,0	8,0	8,0
Nominal minimum at a point	mm	7,10	7,10	7,10	7,10	7,10	7,10	7,10	7,10	7,10	7,10	7,10	7,10	7,10
Nominal diameter over insulation	mm	26,9	28,4	30,2	31,9	33,1	34,9	37,3	39,9	42,8	45,8	49,5	52,6	58,0
Nominal diameter over semi-conducting core screen	mm	28,9	30,4	32,2	33,9	35,1	36,9	39,3	41,9	44,8	47,8	51,5	54,6	60,0
Total nominal thickness of copper tapes	mm	0,25	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Outer sheath thickness	mm	2,0	2,0	2,1	2,1	2,2	2,2	2,3	2,4	2,5	2,6	2,7	2,8	3,0
Nominal minimum at a point	mm	1,60	1,60	1,68	1,68	1,77	1,77	1,85	1,94	2,02	2,11	2,19	2,28	2,45
Nominal overall diameter of cable	mm	34,5	35,9	37,9	39,6	41,0	42,8	45,5	48,3	51,4	54,6	58,5	61,9	67,7

Table 18 — Construction table for 3,8/6,6 kV three-core type A cables

1	2	3	4	5	6	7	8	9	10	11	12	13
Conductor size	mm^2	16	25	35	50	70	95	120	150	185	240	300
Nominal diameter over conductor	mm	4,8	6,0	7,2	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4
Insulation thickness	mm	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,6	2,8
Nominal minimum at a point	mm	2,15	2,15	2,15	2,15	2,15	2,15	2,24	2,42	2,60	2,78	2,78
Nominal diameter over insulation	mm	12,3	13,5	14,7	15,9	17,4	19,2	20,9	22,1	23,9	26,5	29,5
Nominal diameter over semi-conducting core screen	mm	14,3	15,5	16,7	17,9	19,4	21,2	22,9	24,1	25,9	28,5	31,5
Nominal thickness of copper tape	mm	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Nominal diameter over copper tape	mm	15,2	16,4	17,6	18,8	20,3	22,1	23,8	25,0	26,8	29,4	32,4
Nominal diameter over laid-up cores	mm	32,8	35,3	37,9	40,5	43,7	47,6	51,3	53,9	57,8	63,4	69,8
Bedding thickness	mm	1,2	1,2	1,2	1,3	1,3	1,4	1,5	1,5	1,6	1,7	1,8
Nominal minimum at a point	mm	0,92	0,92	0,92	1,00	1,00	1,09	1,17	1,17	1,26	1,34	1,43
Nominal diameter over bedding	mm	35,4	38,0	40,6	43,4	46,6	50,7	54,6	57,2	61,3	67,1	73,8
Nominal diameter of steel armour wires	mm	2,0	2,0	2,0	2,5	2,5	2,5	2,5	2,5	3,15	3,15	3,15
Nominal diameter over armour wires	mm	39,4	42,0	44,6	48,4	51,6	55,7	59,6	62,2	67,6	73,4	80,1
Minimum cross-section of armour[a]	mm^2	172,8	185,4	197,9	265,1	284,7	309,3	328,9	343,6	467,6	514,3	561,1
Outer sheath thickness	mm	2,2	2,2	2,3	2,5	2,6	2,7	2,8	2,9	3,0	3,2	3,5
Nominal minimum at a point	mm	1,56	1,56	1,64	1,80	1,88	1,96	2,04	2,12	2,20	2,36	2,60
Nominal overall diameter of cable	mm	44,2	46,8	49,6	53,9	57,3	61,6	65,7	68,6	74,2	80,4	87,8
[a] Based on a lay ratio of 9.												

Table 19 — Construction table for 6,35/11 kV three-core type A cables

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Conductor size	mm^2	16	25	35	50	70	95	120	150	185	240	300	400
Nominal diameter over conductor	mm	4,8	6,0	7,2	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4	24,3
Insulation thickness	mm	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4
Nominal minimum at a point	mm	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96
Nominal diameter over insulation	mm	14,1	15,3	16,5	17,7	19,2	21,0	22,7	23,9	25,7	28,1	30,7	33,6
Nominal diameter over semi-conducting core screen	mm	16,1	17,3	18,5	19,7	21,2	23	24,7	25,9	27,7	30,1	32,7	35,6
Nominal thickness of copper tape	mm	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Nominal diameter over copper tape	mm	17,0	18,2	19,4	20,6	22,1	23,9	25,6	26,8	28,6	31,0	33,6	36,5
Nominal diameter over laid-up cores	mm	36,6	39,2	41,8	44,4	47,6	51,5	55,2	57,8	61,6	66,8	72,4	78,7
Bedding thickness	mm	1,2	1,3	1,3	1,4	1,4	1,5	1,6	1,6	1,7	1,8	1,9	2,0
Nominal minimum at a point	mm	0,92	1,00	1,00	1,09	1,09	1,17	1,26	1,26	1,34	1,43	1,51	1,6
Nominal diameter over bedding	mm	39,3	42,1	44,7	47,5	50,7	54,8	58,7	61,3	65,4	70,8	76,6	83,1
Nominal diameter of steel armour wires	mm	2,0	2,5	2,5	2,5	2,5	2,5	2,5	3,15	3,15	3,15	3,15	3,15
Nominal diameter over armour wires	mm	43,3	47,1	49,7	52,5	55,7	59,8	63,7	67,6	71,7	77,1	82,9	89,4
Minimum cross-section of armour[a]	mm^2	191,6	285,3	270,0	289,6	309,3	328,9	353,4	467,6	498,8	537,7	584,5	639,0
Outer sheath thickness	mm	2,3	2,4	2,5	2,6	2,7	2,8	3,0	3,1	3,2	3,4	3,6	3,8
Nominal minimum at a point	mm	1,64	1,72	1,80	1,88	1,96	2,04	2,20	2,28	2,36	2,52	2,68	2,84
Nominal overall diameter of cable	mm	48,3	52,4	55,2	58,2	61,6	66,0	70,3	74,4	78,7	84,5	90,8	97,7

[a] Based on a lay ratio of 9.

Table 20 — Construction table for 12,7/22 kV three-core type A cables

1	2	3	4	5	6	7	8	9	10	11	12
Conductor size	mm^2	25	35	50	70	95	120	150	185	240	300
Nominal diameter over conductor	mm	6,0	7,2	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4
Insulation thickness											
Nominal	mm	5,5	5,5	5,5	5,5	5,5	5,5	5,5	5,5	5,5	5,5
Minimum at a point	mm	4,85	4,85	4,85	4,85	4,85	4,85	4,85	4,85	4,85	4,85
Nominal diameter over insulation	mm	19,5	20,7	21,9	23,4	25,2	26,9	28,1	29,9	32,3	34,9
Nominal diameter over semi-conducting core screen	mm	21,5	22,7	23,9	25,4	27,2	28,9	30,1	31,9	34,3	36,9
Nominal thickness of copper tape	mm	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Nominal diameter over copper tape	mm	22,4	23,6	24,8	26,3	28,1	29,8	31,0	32,8	35,2	37,8
Nominal diameter over laid-up cores	mm	48,3	50,9	53,4	56,7	60,6	64,2	66,8	70,7	75,9	81,5
Bedding thickness											
Nominal	mm	1,5	1,5	1,5	1,6	1,7	1,7	1,8	1,9	2,0	2,0
Minimum at a point	mm	1,17	1,17	1,17	1,26	1,34	1,34	1,43	1,51	1,60	1,60
Nominal diameter over bedding	mm	51,6	54,2	56,7	60,2	64,3	68,0	70,8	74,9	80,3	85,9
Nominal diameter of steel armour wires	mm	2,5	2,5	2,5	3,15	3,15	3,15	3,15	3,15	3,15	3,15
Nominal diameter over armour wires	mm	56,6	59,2	61,7	66,5	70,6	74,3	77,1	81,2	86,6	92,2
Minimum cross-section of armour[a]	mm^2	314,2	328,9	343,6	459,8	491,0	514,3	537,7	568,9	607,9	646,8
Outer sheath thickness											3,9
Nominal	mm	2,7	2,8	2,9	3,0	3,2	3,3	3,4	3,6	3,7	2,92
Minimum at a point	mm	1,96	2,04	2,12	2,20	2,36	2,44	2,52	2,68	2,76	
Nominal overall diameter of cable	mm	62,5	65,3	68,1	73,1	77,6	81,5	84,5	89,1	94,7	100,7

[a] Based on a lay ratio of 9.

Table 21 — Construction table for 19/33 kV three-core type A cables

1	2	3	4	5	6	7	8	9	10
Conductor size	mm^2	50	70	95	120	150	185	240	300
Nominal diameter over conductor	mm	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4
Insulation thickness									
Nominal	mm	8,0	8,0	8,0	8,0	8,0	8,0	8,0	8,0
Minimum at a point	mm	7,10	7,10	7,10	7,10	7,10	7,10	7,10	7,10
Nominal diameter over insulation	mm	26,9	28,4	30,2	31,9	33,1	34,9	37,3	39,9
Nominal diameter over semi-conducting core screen	mm	28,9	30,4	32,2	33,9	35,1	36,9	39,3	41,9
Nominal thickness of copper tape	mm	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Nominal diameter over copper tape	mm	29,8	31,3	33,1	34,8	36,0	37,8	40,2	42,8
Nominal diameter over laid-up cores	mm	64,2	67,5	71,3	75,0	77,6	81,5	86,6	92,2
Bedding thickness									
Nominal	mm	1,8	1,8	1,9	2,0	2,0	2,1	2,2	2,3
Minimum at a point	mm	1,43	1,43	1,52	1,60	1,60	1,69	1,77	1,85
Nominal diameter over bedding	mm	68,2	71,4	75,5	79,4	82,0	86,1	91,5	97,3
Nominal diameter of steel armour wires	mm	3,15	3,15	3,55	3,55	3,55	3,55	3,55	3,55
Nominal diameter over armour wires	mm	74,5	77,7	82,6	86,5	89,1	93,2	98,6	104,4
Minimum cross-section of armour[a]	mm^2	522,1	545,5	653,3	683,0	702,8	732,4	781,9	831,4
Outer sheath thickness									
Nominal	mm	3,4	3,5	3,6	3,7	3,8	3,9	4,1	4,3
Minimum at a point	mm	2,52	2,60	2,68	2,76	2,84	2,92	3,08	3,24
Nominal overall diameter of cable	mm	82,0	85,4	90,5	94,6	97,4	101,8	107,6	113,9
[a] Based on a lay ratio of 9.									

Table 22 — Construction table for 3,8/6,6 kV three-core type B cables

1	2	3	4	5	6	7	8	9	10	11	12	13
Conductor size	mm^2	16	25	35	50	70	95	120	150	185	240	300
Nominal diameter over conductor	mm	4,8	6,0	7,2	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4
Insulation thickness Nominal Minimum at a point	 mm mm	 2,5 2,15	 2,5 2,15	 2,5 2,15	 2,5 2,15	 2,5 2,15	 2,5 2,15	 2,5 2,24	 2,5 2,42	 2,5 2,60	 2,6 2,78	 2,8 2,78
Nominal diameter over insulation	mm	12,3	13,5	14,7	15,9	17,4	19,2	20,9	22,1	23,9	26,5	29,5
Nominal diameter over semi-conducting core screen	mm	14,3	15,5	16,7	17,9	19,4	21,2	22,9	24,1	25,9	28,5	31,5
Total nominal thickness of copper tapes	mm	0,2	0,2	0,2	0,2	0,2	0,1	0,1	0,1	0,1	0,1	0,1
Nominal diameter over copper tapes	mm	15,4	16,6	17,8	19,0	20,5	22,1	23,8	25,0	26,8	29,4	32,4
Nominal diameter over laid-up cores	mm	33,2	35,8	38,4	40,9	44,2	47,6	51,3	53,9	57,8	63,4	69,8
Outer sheath thickness Nominal minimum at a point	 mm mm	 2,0 1,60	 2,1 1,69	 2,2 1,77	 2,3 1,86	 2,4 1,94	 2,5 2,03	 2,6 2,11	 2,7 2,20	 2,8 2,28	 3,0 2,45	 3,2 2,62
Nominal overall diameter of cable	mm	37,6	40,4	43,2	46,0	49,5	53,1	57,0	59,8	63,9	70,0	76,9

Table 23 — Construction table for 6,35/11 kV three-core type B cables

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Conductor size	mm^2	16	25	35	50	70	95	120	150	185	240	300	400
Nominal diameter over conductor	mm	4,8	6,0	7,2	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4	24,3
Insulation thickness	mm	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4
Nominal minimum at a point	mm	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96	2,96
Nominal diameter over insulation	mm	14,1	15,3	16,5	17,7	19,2	21,0	22,7	23,9	25,7	28,1	30,7	33,6
Nominal diameter over semi-conducting core screen	mm	16,1	17,3	18,5	19,7	21,2	23	24,7	25,9	27,7	30,1	32,7	35,6
Total nominal thickness of copper tapes	mm	0,2	0,2	0,2	0,2	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Nominal diameter over copper tapes	mm	17,2	18,4	19,6	20,8	22,3	23,9	25,6	26,8	28,6	31,0	33,6	36,5
Nominal diameter over laid-up cores	mm	37,1	39,7	42,2	44,8	48,1	51,5	55,2	57,8	61,6	66,8	72,4	78,7
Outer sheath thickness	mm	2,2	2,2	2,3	2,4	2,5	2,7	2,8	2,9	3,0	3,1	3,3	3,5
Nominal minimum at a point	mm	1,77	1,77	1,86	1,94	2,03	2,20	2,28	2,37	2,45	2,54	2,71	2,88
Nominal overall diameter of cable	mm	41,9	44,5	47,3	50,1	53,6	57,4	61,3	64,1	68,2	73,6	79,7	86,4

Table 24 — Construction table for 12,7/22 kV three-core type B cables

1	2	3	4	5	6	7	8	9	10	11	12
Conductor size	mm^2	25	35	50	70	95	120	150	185	240	300
Nominal diameter over conductor	mm	6,0	7,2	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4
Insulation thickness											
Nominal	mm	5,5	5,5	5,5	5,5	5,5	5,5	5,5	5,5	5,5	5,5
minimum at a point	mm	4,85	4,85	4,85	4,85	4,85	4,85	4,85	4,85	4,85	4,85
Nominal diameter over insulation	mm	19,5	20,7	21,9	23,4	25,2	26,9	28,1	29,9	32,3	34,9
Nominal diameter over semi-conducting core screen	mm	21,5	22,7	23,9	25,4	27,2	28,9	30,1	31,9	34,3	36,9
Total nominal thickness of copper tapes	mm	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Nominal diameter over copper tapes	mm	22,4	23,6	24,8	26,3	28,1	29,8	31,0	32,8	35,2	37,8
Nominal diameter over laid-up cores	mm	48,3	50,9	53,4	56,7	60,6	64,2	66,8	70,7	75,9	81,5
Outer sheath thickness											
Nominal	mm	2,7	2,8	2,9	3,0	3,1	3,2	3,4	3,5	3,7	3,8
Minimum at a point	mm	1,96	2,28	2,37	2,45	2,54	2,62	2,79	2,88	3,05	3,13
Nominal overall diameter of cable	mm	54,2	57,0	59,8	63,3	67,4	71,3	74,3	78,4	84,0	89,8

Table 25 — Construction table for 19/33 kV three-core type B cables

1	2	3	4	5	6	7	8	9	10
Conductor size	mm^2	50	70	95	120	150	185	240	300
Nominal diameter over conductor	mm	8,4	9,9	11,7	13,4	14,6	16,4	18,8	21,4
Insulation thickness	mm	8,0	8,0	8,0	8,0	8,0	8,0	8,0	8,0
Nominal minimum at a point	mm	7,10	7,10	7,10	7,10	7,10	7,10	7,10	7,10
Nominal diameter over insulation	mm	26,9	28,4	30,2	31,9	33,1	34,9	37,3	39,9
Nominal diameter over semi-conducting core screen	mm	28,9	30,4	32,2	33,9	35,1	36,9	39,3	41,9
Total nominal thickness of copper tapes	mm	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Nominal diameter over copper tapes	mm	29,8	31,3	33,1	34,8	36,0	37,8	40,2	42,8
Nominal diameter over laid-up cores	mm	64,2	67,5	71,3	75,0	77,6	81,5	86,6	92,2
Outer sheath thickness	mm	3,3	3,4	3,5	3,7	3,8	3,9	4,1	4,2
Nominal minimum at a point	mm	2,71	2,79	2,88	3,05	3,13	3,22	3,39	3,47
Nominal overall diameter of cable	mm	71,5	74,9	79,0	83,1	85,9	90,0	95,7	101,5

7 Packing and marking

7.1 Packing

7.1.1 Drums

Unless otherwise required (see annex A), cables shall be packed on wooden drums. The moisture content of the wood shall not exceed 20 %. When wooden drums are required to be resistant to biological attack (see annex A), the wood shall have been impregnated (by pressure or in a hot/cold tank) in accordance with SANS 10005, with a class C preservative or with chromated copper arsenate.

7.1.2 Drum barrels

Unless otherwise required (see annex A), the diameter of the drum barrel shall be at least 25 D for single-core cables and 15 D for three-core cables, where D is the nominal overall diameter of the cable.

7.1.3 Sealing

Before being secured to the drum, both ends of every cable shall be sealed by means of a heat shrink cap or by other acceptable means, to prevent the ingress of moisture.

The outer end shall be secured to the drum and the inner end shall be protected in an acceptable manner against mechanical damage.

7.2 Marking

7.2.1 Marking of cables

The following information shall be legibly printed, indented or embossed on one or more lines along the extruded outer sheath of the cable. The letters and numerals shall be upright characters of height not exceeding 13 mm but not less than 3 mm. The gap between the end of one legend and the beginning of the next shall not exceed 300 mm:

a) the manufacturer's name or trademark (or both);

b) the year of manufacture;

c) the operating voltage (U_o/U) for which the cable has been designed, given in kilovolts (kV); and

d) when applicable, any special properties, e.g. flame-retardant (FR) properties, low smoke (LS) emission properties, zero halogen (NH) emission properties, or any combination of these. As an alternative, a colour coded stripe may be used as follows:

– RED stripe : cables with a flame-retardant sheath;

– ORANGE stripe : armoured cables with a flame-retardant bedding and sheath; and

– WHITE stripe : cables with zero halogen emission.

7.2.2 Marking of drums

A flange of each cable drum shall bear the following information in indelible and legible marking. The marking may be painted, gouged or branded on the flange. The information in (a) to (e) may,

however, be detailed on a durable label firmly attached to the flange:

a) the manufacturer's name or trademark (or both);

b) the rated voltage, and type of cable;

c) whether single-core or three-core, the conductor size, and whether copper or aluminium;

d) the length, in metres;

e) the year of manufacture;

f) the gross mass, in kilograms, of cable and drum;

g) the instruction "NOT TO BE LAID FLAT";

h) the serial number or other identification;

i) an arrow with the words "ROLL THIS WAY" to indicate the direction in which the drum is to be rolled in order to prevent the cable from unwinding; and

j) if the wood from which the drum was made has been treated in accordance with 7.1.1, a 50 mm high capital letter "T", surrounded by a circle of outside diameter 65 mm.

Annex A
(normative)

Notes to purchasers

The following requirements shall be specified in tender invitations and in each order or contract:

a) the cable type (see 4.1);

b) the cable operating voltage *(U_o/U)* (see 4.2);

c) whether single-core or three-core;

d) the conductor size, and

– the required sustained (continuous) current rating;

– the method of installation (by direct burial, drawn into pipes or installed in air) and the proximity and loading of adjacent cables;

– if by direct burial, the soil thermal resistivity, soil temperature and depth of burial;

– if drawn into pipes, the length of pipe run, the pipe diameter and soil conditions;

– the ambient air temperature and method of installation if the cables are to be installed in air; and

– whether the cables will be exposed to the sun;

e) copper or aluminium conductors;

f) system protection, symmetrical and earth fault currents and fault clearance times (see annex B); "In the case of single core cables whether a copper tape or wire screen is required (see 4.3.7)

g) whether an equalizing binder is required (see 4.3.9);

h) whether a metallic sheath is required (see 4.3.10);

i) whether longitudinal water blocking is required (see 4.3.14)

j) whether radial water blocking is required (see 4.3.14)

NOTE 1 A cable having a polyethylene (PE) outer sheath is considered to have improved radial water blocking capabilities.

NOTE 2 A cable having a metallic sheath (as defined in 3.13) is considered to have full radial water blocking capabilities.

k) whether larger diameter armour wires will be acceptable (see 4.3.12.2);

l) the type of outer sheath required (see 4.3.13.1);

m) whether a conductive coating is required on the outer sheath (see 4.3.13.3);

n) cable lengths required;

o) whether cables shall be packed on wooden drums (see 7.1.1);

p) whether the wood in wooden drums is to be resistant to biological attack (see 7.1.1);

q) the size of the drum, if a special size is required (see 7.1.2); and

r) whether additional electrical tests (type tests) or ageing tests are required (see 4.6, 4.7 and annex B).

NOTE When any such additional tests are required, the requirement(s) should be clearly stated in any tender invitations, and the costs of the tests agreed upon between the purchaser and the manufacturer.

Annex B
(informative)

Points to be considered by the purchaser

B.1 Cable types

B.1.1 General

Cables to this standard are categorized as type A or type B cables. Type A and type B cables are described in B.1.2 and B.1.3 and illustrated in figure B.1.

B.1.2 Type A cables (see figure B.1)

Type A cables are designed to carry high earth fault currents, comparable with system symmetrical fault currents, as might occur on a distribution system with a solidly earthed neutral.

Single-core type A cables are supplied with a metallic sheath or aluminium wire or copper wire armouring (AWA) (or both).

Three-core type A cables are supplied with a metallic sheath or galvanized steel wire armouring (SWA) (or both).

The earth fault rating of the cable will depend on the allowable temperature rise of the outer sheath. The minimum cross-sectional area of the armouring of type A cables are given in the construction tables. The 1-second earth fault rating is obtained by multiplying this area by the k factor given in table B.1.

Table B.1 — *k* factors for calculating the earth fault rating of type A cables

1	2	3	4	5
Sheath material	**Temperature rise** °C	**Single-core (AWA)**	**Constant *k***	
			Single-core (CWA)	**Three-core (SWA)**
PE	70 - 180	83,0	125,5	45,5
PVC	70 - 200	89,0	134,8	48,8
NH	70 - 150	72,2	109,2	39,6

If, for example, a three-core 95 mm^2 6,35/11 kV cable were to be supplied with a polyethylene sheath, the 1-second earth fault rating of the galvanized steel wire armour would be calculated as follows:

The cross-sectional area of the armouring is 328,9 mm^2 (see column 8 of table 19);

The *k* factor for SWA/PE is 45,5 (see column 5 of table B.1) giving a 1-second earth fault rating I of I = 328,9 × 45,5 A or 15,0 kA.

The rating for other fault clearance times may be calculated by dividing the 1-second rating I by the

square root of the required clearance time. The 0,5-second earth fault rating in the above example would then be

I = 15,0 kA / $\sqrt{0,5}$

$= 21,2$kA

B.1.3 Type B cables (see figure B.1)

Type B cables are designed for use on a system where the earth fault current is limited to 1 000 A for 1 s or where the product of the square of the fault current in amperes and the fault clearance time in seconds does not exceed 10^6.

A type B cable would be suitable for use, for example, on a system where the earth fault current is limited to 1,41 kA for 0,5 s.

The thickness of copper tapes or wires used on type B cables has been based on a maximum current density of 50 A/mm^2, which tests have shown will enable the cable to be safely spiked.

B.2 Symmetrical fault current ratings

Symmetrical fault current ratings are based on an adiabatic temperature rise of 160 °C from an operating temperature of 90 °C to a maximum short-circuit temperature of 250 °C.

The symmetrical fault current ratings for copper and aluminium conductors are given in table B.2.

Table B.2 — Symmetrical fault current ratings

1	2	3	4	5	6	7
Conductor size mm^2	**Maximum symmetrical fault current-carrying capacity** kA					
	Copper conductor			**Aluminium conductor**		
	0,5 s	**1 s**	**3 s**	**0,5 s**	**1 s**	**3 s**
16	3,1	2,2	1,2			
25	4,8	3,4	2,0	3,0	2,1	1,2
35	6,7	4,7	2,7	4,2	3,0	1,7
50	9,1	6,4	3,7	5,7	4,0	2,3
70	13,1	9,3	5,3	8,2	5,8	3,4
95	18,2	12,9	7,4	11,4	8,0	4,6
120	22,9	16,2	9,4	14,4	10,2	5,9
150	28,3	20,0	11,6	17,7	12,5	7,2
185	35,4	25,1	14,5	22,2	15,7	9,1
240	46,6	32,9	19,0	29,1	20,6	11,9
300	58	41,3	23,9	36,4	25,7	14,8
400	75	53	30,5	46,8	33,1	19,1
500	96	68	39,2	60	42,5	24,5
630	124	88	51	78	55	31,7
800	159	112	65	99	70	40,5
1 000	199	141	81	125	88	51

B.3 Current ratings

The maximum sustained (continuous) current rating of cables that comply with the requirements of this standard are given in SANS 10198-4.

B.4 Outer protection

Cables made to this standard are manufactured with an extruded outer sheath. Where cables are to be installed by direct burial in the ground or drawn into pipes, a polyethylene sheath is normally recommended. A graphite coating or a coating with similar conductive properties may be applied to the outer surface of the sheath to facilitate the testing of the sheath during manufacture and after installation (see 4.3.13.3).

Where cables are to be installed in air, and there is a possibility that they might be involved in a fire, a polyethylene sheath should not be used unless the cables are coated with some form of fire-protective material. The type of outer sheath to be used will depend on whether the cables are to be installed outdoors or indoors. If the cables are to be installed outdoors in free air, a flame-retardant PVC outer sheath would be suitable. If, however, the cables are to be installed in enclosed cable tunnels or within a building where the dense smoke and toxic fumes given off by burning PVC would pose an additional hazard, then a halogen-free sheath should be specified.

Where cables are to be installed by direct burial, a polyethylene outer sheath should be considered in order to provide improved radial water blocking capabilities. For full radial water blocking capabilities, a cable having a metallic sheath (as defined in 3.13) may be considered.

B.5 Handling and installation

Cables should be handled and installed in accordance with the recommendations given in SANS 10198-2, SANS 10198-8 and SANS 10198-11.

The minimum installation bending radii for cables manufactured to this standard are given in table B.3.

Table B.3 — Minimum installation bending radii

1	2	3
Type of cable		**Minimum bending radius**
Single-core	unarmoured	20*D*
Single-core	armoured	20*D*
Three-core	unarmoured	15*D*
Three-core	armoured	12*D*
NOTE *D* is the nominal diameter of the cable.		

B.6 Voltage test after installation or repair

After installation or repair, cables should be tested in accordance with SANS 10198-13.

Figure B.1 — Type A and type B single-core and three-core cables

Annex C
(informative)

Quality verification of cross-linked polyethylene (XLPE) insulated electric cables

When a purchaser requires ongoing verification of the quality of cross-linked polyethylene (XLPE) insulated electric cables, it is suggested that instead of concentrating solely on evaluation of the final product, he also direct his attention to the manufacturer's quality system. In this connection it should be noted that SANS 9001 covers the provisions of an integrated quality system.

Bibliography

SANS 60270/I EC 60270, *High-voltage test techniques – Partial discharge measurements.*

SANS 60754-1/IEC 60754-1, *Test on gases evolved during combustion of materials from cables – Part 1: Determination of the amount of halogen acid gas.*

SANS 61034-1/IEC 61034-1, *Measurement of smoke density of cables burning under defined conditions – Part 1: Test apparatus.*

SANS 9001/ISO 9001, *Quality management systems – Requirements.*

SANS 10198-1, *The selection, handling and installation of electric power cables of rating not exceeding 33 kV – Part 1: Definitions and statutory requirements.*

SANS 10198-2, *The selection, handling and installation of electric power cables of rating not exceeding 33 kV – Part 2: Selection of cable type and methods of installation.*

SANS 10198-3, *The selection, handling and installation of electric power cables of rating not exceeding 33 kV – Part 3: Earthing systems – General provisions.*

SANS 10198-4, *The selection, handling and installation of electric power cables of rating not exceeding 33 kV – Part 4: Current ratings.*

SANS 10198-8, *The selection, handling and installation of electric power cables of rating not exceeding 33 kV – Part 8: Cable laying and installation.*

SANS 10198-11, *The selection, handling and installation of electric power cables of rating not exceeding 33 kV – Part 11: Jointing and termination of screened polymeric-insulated cables.*

SANS 10198-13, *The selection, handling and installation of electric power cables of rating not exceeding 33 kV – Part 13: Testing, commissioning and fault location.*

SANS 6282-3, *Test methods for bare conductors and conductors of insulated electric cables – Part 3: Mechanical tests.*

SANS 6284-4, *Test methods for cross-linked polyethylene (XLPE) insulated electric cables – Part 4: Tests after installation.*