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INTERNATIONAL STANDARD

colour inside

Multicore and symmetrical pair/quad cables for digital communications – Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring – Sectional specification

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring – Sectional specification

FOREWORD

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This consolidated version of IEC 61156-6 consists of the third edition (2010) [documents 46C/903/FDIS and 46C/908/RVD] and its amendment 1 (2012) [documents 46C/955/CDV and 46C/968/RVC]. It bears the edition number 3.1.

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience. A vertical line in the margin shows where the base publication has been modified by amendment 1. Additions and deletions are displayed in red, with deletions being struck through.

International Standard IEC 61156-6 has been prepared by subcommittee 46C: Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, r.f. connectors, r.f. and microwave passive components and accessories.

This edition includes the following significant technical changes with respect to the previous edition:

a) new requirements for new cables $Cat6_A$, $Cat7_A$;
b) revised requirements and tests for the cables.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

This standard shall be read in conjunction with IEC 61156-1:2007.

The list of all the parts of the IEC 61156 series, under the general title: *Multicore and symmetrical pair/quad cables for digital communications*, can be found on the IEC website.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring – Sectional specification

1 Scope

This part of IEC 61156 makes reference to IEC 61156-1. The cables described herein are intended primarily for work area wiring as defined in ISO/IEC 11801 and ISO/IEC 24702.

It covers individually screened, common screened and unscreened pairs or quads. The transmission characteristics and the frequency range (see Table 1) of the cables are specified at 20 °C.

Table 1 – Cable categories

Cable designation	Maximum referenced frequency MHz
Category 5e	100
Category 6	250
Category 6_A	500
Category 7	600
Category 7_A	1 000

These cables can be used for various communication channels which use as many as four pairs simultaneously. In this sense, this sectional specification provides the cable characteristics required by system developers to evaluate new systems.

The cables covered by this standard are intended to operate with voltages and currents normally encountered in communication systems. These cables are not intended to be used in conjunction with low impedance sources, for example the electric power supplies of public utility mains, they are intended to be used to support the delivery of low voltage and power applications such as IEEE's 802.3af (Power over Ethernet) and 802.3at (Power over Ethernet Plus).

2 Normative references

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

IEC 61156-1:2007, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*

IEC 61156-6-1, *Multicore and symmetrical pair/quad cables for digital communications – Part 6-1: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring – Blank detail specification*

IEC 62153-4-5, *Metallic communication cables test methods – Part 4-5: Electromagnetic compatibility (EMC) – Coupling or screening attenuation – Absorbing clamp method*

IEC 62153-4-9, *Metallic communication cable test methods – Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, triaxial method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61156-1 apply.

4 Installation considerations

See Clause 4 of IEC 61156-1.

4.1 Climatic conditions

Under static conditions, the cables shall operate in the temperature range from –20 °C to +60 °C. The conductor and cable temperature dependence is specified for screened and unscreened cables and should be taken into account for the design of an actual cabling system.

5 Materials and cable construction

5.1 General remarks

The choice of materials and cable construction shall be suitable for the intended application and installation of the cable. Particular care shall be taken to meet any special requirements for EMC and fire performance (such as burning properties, smoke generation, evolution of halogen gas, etc.).

5.2 Cable construction

The cable construction shall be in accordance with the details and dimensions given in the relevant detail specification.

5.2.1 Conductor

The conductor shall be a solid or stranded annealed copper, in accordance with 5.2.1 of IEC 61156-1 and should have a nominal diameter between 0,4 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used.

5.2.2 Insulation

The conductor shall be insulated with a suitable material. Examples of suitable materials are

– polyolefin;
– fluoropolymer;
– low-smoke zero-halogen thermoplastic material.

5.2.3 Cable element

The cable element shall be a pair or quad and shall be twisted.

5.2.3.1 Screening of the cable element

When required, the screen for the cable element shall be in accordance with 5.2.3.1 of IEC 61156-1.

5.2.4 Cable make-up

A spacer may be used to separate the cable elements. The cable elements, including spacers, shall be assembled to form the cable core.

The core of the cable may be wrapped with a protective layer of non-hygroscopic and non-wicking material.

5.2.5 Screening of the cable core

When required by the relevant detail specification, a screen for the cable core shall be provided.

The screen shall be in accordance with 5.2.5 of IEC 61156-1.

5.2.6 Sheath

The sheath material shall consist of a suitable material.

Examples of suitable materials are

– polyolefin;
– PVC;
– fluoropolymer;
– low-smoke zero-halogen thermoplastic material.

The sheath shall be continuous, having a thickness as uniform as possible. A non-metallic ripcord may be provided. When provided, the ripcord shall be non-hygroscopic and non-wicking.

The colour of the sheath is not specified but it should be specified in the relevant detail specification.

5.2.7 Identification

Each length of cable shall be identified as to the supplier and, when required, a traceability code, using one of the following methods:

– appropriately coloured threads or tapes,
– with a printed tape,
– printing on the cable core wrapping,
– marking on the sheath.

Additional markings, such as length marking, etc., are permitted. If used, such markings shall refer to this specification.

The finished cable shall be adequately protected for storage and shipment.

6 Characteristics and requirements

6.1 General remarks

This clause lists the characteristics and minimum requirements of a cable complying with this standard. Test methods shall be in accordance with Clause 6 of IEC 61156-1.

6.2 Electrical characteristics and tests

NOTE The tests should be carried out on a cable length of not less than 100 m, unless otherwise specified.

6.2.1 Conductor resistance

The maximum conductor resistance at, or corrected to, 20 °C shall not exceed 14,5 Ω/100 m of cable.

6.2.2 Resistance unbalance

6.2.2.1 Resistance unbalance within a pair

The resistance unbalance shall not exceed 2 %.

~~**6.2.2.2 Resistance unbalance between pairs**~~

~~The pair-to-pair resistance unbalance shall not exceed 4 %.~~

6.2.3 Dielectric strength

There shall be no failures when a test is performed on conductor/conductor and, where screen(s) are present, a conductor/screen with 1,0 kV d.c. for 1 min or, alternatively, with 2,5 kV d.c. for 2 s. An a.c. voltage may be used. The a.c. voltage levels in these cases shall be 0,7 kV a.c. for 1 min or, alternatively, 1,7 kV a.c. for 2 s.

6.2.4 Insulation resistance

The test shall be performed on

– conductor/conductor;
– conductor/screen (when present).

The minimum insulation resistance at, or corrected to, 20 °C shall be not less than 5 000 MΩ.m.

6.2.5 Mutual capacitance

The mutual capacitance is not specified but may be indicated in the relevant detail specification.

6.2.6 Capacitance unbalance

The maximum capacitance unbalance pair to ground shall not exceed 1 600 pF/km at a frequency of 800 Hz or 1 000 Hz.

6.2.7 Transfer impedance

For cables containing a screen or screens, two grades of performance are recognized for transfer impedance. The transfer impedance shall not exceed the values shown in Table 2 at the discrete frequencies indicated for each grade.

Table 2 – Transfer impedance

Frequency MHz	Maximum surface transfer impedance mΩ/m	
	Grade 1	Grade 2
1	10	50
10	10	100
30	30	200
100	100	1 000

NOTE The screen longitudinal d.c. resistance of 30 mΩ/m or less is an indicator for fulfilling transfer impedance requirement of Grade 2. A measurement of d.c. resistance cannot replace a transfer impedance measurement.

6.2.8 Coupling attenuation

~~Three types of performance are recognized for coupling attenuation. When measured using the absorbing clamp method, the coupling attenuation in the frequency range from f = 30,0 MHz to 1 000 MHz shall meet the requirements indicated in Table 3.~~

~~**Table 3 – Coupling attenuation**~~

~~Coupling attenuation type~~	~~Frequency range MHz~~	~~Coupling attenuation dB~~
~~Type I~~	~~30 to 100~~	~~≥85~~
	~~100 to 1 000~~	~~≥85 – 20 × $\log_{10}$ (f/100)~~
~~Type II~~	~~30 to 100~~	~~≥55~~
	~~100 to 1 000~~	~~≥55 – 20 × $\log_{10}$ (f/100)~~
~~Type III~~	~~30 to 100~~	~~≥40~~
	~~100 to 1 000~~	~~≥40 – 20 × $\log_{10}$ (f/100)~~
~~NOTE For screened cables, the triaxial method of IEC 62153-4-9 may also be used.~~		

Four types of performance are recognized for coupling attenuation. When measured using the absorbing clamp method (IEC 62153-4-5) or the triaxial method (IEC 62153-4-9), the coupling attenuation in the frequency range from f = 30 MHz to 1 000 MHz shall meet the requirements indicated in Table 3. For screened cables, Type II is the minimum coupling attenuation requirement.

Table 3 – Coupling attenuation

Coupling attenuation type	Frequency range MHz	Coupling attenuation dB
Type I	30 to 100	> 85
Type I	100 to 1 000	> 85 – 20 × $\log_{10}$ (f/100)
Type Ib	30 to 100	> 70
Type Ib	100 to 1 000	> 70 – 20 × $\log_{10}$ (f/100)
Type II	30 to 100	> 55
Type II	100 to 1 000	> 55 – 20 × $\log_{10}$ (f/100)
Type III	30 to 100	> 40
Type III	100 to 1 000	> 40 – 20 × $\log_{10}$ (f/100)

6.2.9 Current-carrying capacity

The maximum current-carrying capacity is not specified but may be indicated in the relevant detail specification.

6.3 Transmission characteristics

NOTE All the tests should be carried out on a cable length of 100 m, unless otherwise specified. Cat 7a test lengths should be 50 m.

6.3.1 Velocity of propagation (phase velocity)

NOTE The requirements are not specified but may be indicated in the relevant detail specification.

6.3.2 Phase delay and differential delay (delay skew)

6.3.2.1 Phase delay

The phase delay, τ, shall not exceed the value obtained from Equation (1) in the frequency range from 4 MHz to the maximum referenced frequency,

$$\tau = 534 + \frac{36}{\sqrt{f}} \quad \text{(ns/100 m)} \tag{1}$$

where f is the frequency in MHz.

6.3.2.2 Differential delay (delay skew)

When measured at (20 ± 1) °C, the maximum delay skew between any two pairs shall not exceed 45 ns/100 m for cat5e, cat6, cat6$_A$ cables and 25 ns/100 m for cat 7 and cat 7$_A$ cables in the frequency range from 4 MHz to the maximum referenced frequency.

6.3.3 Attenuation

6.3.3.1 Attenuation at 20 °C ambient temperature

The maximum attenuation α of any pair in the frequency range indicated in Table 4 shall not exceed the value obtained from Equation (2) using the corresponding values of the constants a, b and c given in Table 4.

$$\alpha = \mathrm{a} \times \sqrt{f} + \mathrm{b} \times f + \frac{\mathrm{c}}{\sqrt{f}} \quad \text{(dB/100 m)} \tag{2}$$

where f is the frequency in MHz.

Table 4 – Attenuation, constant values

Cable designation	Frequency range MHz	Constants		
		a	b	c
Category 5e	1 to 100	2,866 [1)]	0,033	0,300
Category 6	1 to 250	2,730	0,026	0,375
Category 6_A	1 to 500	2,730	0,0136 5	0,375
Category 7	1 to 600	2,700	0,015	0,300
Category 7_A	1 to 1 000	2,700	0,007 5	0,300
The cable performance between 1 MHz and 4 MHz is achieved by design only and it is therefore not necessary to test for this performance below 4 MHz.				
[1)] 2,866 was arrived at by 1,5 × 1,91 = 2,866 as an approximate 150 % factor to accommodate smaller conductor stranding and also ILD since 2,866/1,5=1,9106 fitted the old 11801 model; the actual 150 % attenuation should be a factor of 2,951.				

6.3.3.2 Attenuation at elevated operating temperature

The increase in maximum attenuation obtained from Equation (2) due to elevated temperature shall not be more than:

– for unscreened cables, 0,4 %/°C, for the temperature range from 20 °C to 40 °C and 0,6%/°C for the temperature range from 40 °C to 60 °C;

– for screened cables, 0,2 %/°C in the temperature range from 20 °C to 60 °C.

6.3.4 Unbalance attenuation

Two levels of performance are recognized for unbalance attenuation. The minimum near-end unbalance attenuation (transverse conversion loss or TCL) shall be not less than the value obtained from Equation (3) (level 1) and from Equation (4) (level 2), in the frequency ranges given in Table 5.

$$TCL = 40{,}0 - 10 \times \log_{10}(f) \text{ (dB)} \quad (3)$$

$$TCL = 50{,}0 - 10 \times \log_{10}(f) \text{ (dB)} \quad (4)$$

Table 5 – Near-end unbalance attenuation

Cable category	Frequency range MHz
Category 5e	1 to 100
Category 6	1 to 250
Category 6_A	1 to 250
Category 7	1 to 250
Category 7_A	1 to 250

The minimum equal-level far-end unbalance attenuation (equal-level transverse conversion transfer loss or $EL\ TCTL$) for all categories shall not be less than the value obtained from Equation (5) for all frequencies in the range from 1 MHz to 30 MHz.

$$EL\ TCTL = 35{,}0 - 20 \times \log_{10}(f) \text{ (dB)/100 m} \quad (5)$$

6.3.5 Near-end crosstalk (*NEXT*)

The worst pair power sum near end crosstalk, *PS NEXT*, in the frequency range indicated in Table 6 shall not be less than the value obtained from Equation (6) using the corresponding value of *PS NEXT*(1) given in Table 6.

$$PS\ NEXT(f) = PS\ NEXT(1) - 15 \times \log_{10}(f) \quad \text{(dB)} \tag{6}$$

Table 6 – Worst pair *PS NEXT* values

Cable designation	Frequency range MHz	*PS NEXT* dB
Category 5e	1 to 100	62,3
Category 6	1 to 250	72,3
Category 6_A	1 to 500	72,3
Category 7	1 to 600	99,4
Category 7_A	1 to 1 000	105,4
The cable performance between 1 MHz and 4 MHz is achieved by design only and it is therefore not necessary to test for this performance below 4 MHz.		

For those frequencies where the calculated value of *PS NEXT* is greater than 75 dB, the requirement shall be 75 dB.

The minimum pair-to-pair *NEXT* for any pair combination shall be at least 3 dB better than the *PS NEXT* for any pair.

6.3.6 Attenuation to crosstalk ratio far end (*PS ACR-F*)

The worst pair power sum attenuation to crosstalk ratio far end, *PS ACR-F*, in the frequency range indicated in Table 7 shall not be less than the value obtained from Equation (7) using the corresponding value of the *PS ACR-F*(1) given in Table 7.

$$PS\ ACR-F(f) = PS\ ACR-F(1) - 20 \times \log_{10}(f) \quad \text{(dB /100 m)} \tag{7}$$

Table 7 – Worst pair *PS ACR-F*

Cable designation	Frequency range MHz	*PS ACR-F* dB/ 100 m
Category 5e	1 to 100	61,0
Category 6	1 to 250	65,0
Category 6_A	1 to 500	65, 0
Category 7	1 to 600	91,0
Category 7_A	1 to 1 000	91, 0
NOTE 1 If *FEXT* loss is greater than 70 dB, *ACR-F* loss may not be measured. NOTE 2 The cable performance between 1 MHz and 4 MHz is achieved by design only and it is therefore not necessary to test for this performance below 4 MHz.		

For those frequencies where the calculated value of *PS ACR-F* is greater than 75 dB, the requirement shall be 75 dB.

The minimum pair-to-pair *ACR-F* for any pair combination shall be at least 3 dB better than the *PS ACR-F* for any pair.

6.3.7 Alien (exogenous) near end crosstalk

Alien (exogenous) near-end crosstalk is only a measurement consideration for unscreened cables. For Type I and Type II screened cables as defined in Table 3, the alien (exogenous) near-end crosstalk is proven by design.

The *PS ANEXT* (power sum alien (exogenous) near-end crosstalk) of cable when tested in accordance with 6.3.7.1 of IEC 61156-1 shall be not less than the values obtained from Table 8.

Table 8 – *PS ANEXT*

Category	Frequency range MHz	Minimum *PS ANEXT* dB
$Cat6_A$	$1 \le f \le 500$	$92{,}5 - 15 \times \log_{10}(f)$
$Cat7_A$	$1 \le f \le 1\ 000$	$105 - 15 \times \log_{10}(f)$
NOTE Calculated values greater than 67 dB revert to a value of 67 dB.		

6.3.8 Alien (exogenous) far-end crosstalk (*AACR-F*)

Alien (exogenous) far end crosstalk is only a measurement consideration for unscreened cables. For Type I and Type II screened cables as defined in Table 3, the alien (exogenous) far-end crosstalk (*ACR-F*) is proven by design.

The *PS AACR-F* (power-sum alien attenuation to crosstalk ratio far end) of cable when tested in accordance with 6.3.8 of IEC 61156-1 shall be not less than the values obtained from Table 9.

Table 9 – *PS AACR-F* (*PS AELFEXT*)

Category	Frequency range MHz	Minimum *PS AACR-F* dB
$Cat6_A$	$1 \le f \le 500$	$78{,}2 - 20 \times \log_{10}(f)$
$Cat7_A$	$1 \le f \le 1\ 000$	$92 - 20 \times \log_{10}(f)$
Calculated values greater than 67 dB revert to a value of 67 dB.		

6.3.9 Alien (exogenous) crosstalk of bundled cables

The minimum requirement is not specified but should be stated in the relevant detail specification.

6.3.10 Impedance

The measured characteristic impedance in accordance with 6.3.10.1.1 of IEC 61156-1, for each cable category shall fall within the impedance template limits given in Figure 1. The relevant template limits are derived using Equation (8), Equation (9) and Equation (10) for the corresponding cable category, frequency range and return loss requirement given in Table 10.

Cables that meet the requirements of the template are not required to be measured for return loss; alternately, cables that meet the return loss requirements given in 6.3.11 are not required to be measured for characteristic impedance.

The upper impedance limit, Zu of the template is given by Equation (8),

$$Zu = Z_o \times \left(\frac{1+|\rho|}{1-|\rho|} \right) \quad (8)$$

The lower impedance limit, Zl of the template is given by Equation (9),

$$Zl = Z_o \times \left(\frac{1-|\rho|}{1+|\rho|} \right) \quad (9)$$

where

Z_o is 100 Ω;
ρ is the reflection coefficient.

The reflection coefficient, ρ, is calculated from Equation (10).

$$|\rho| = 10^{-\frac{RL}{20}} \quad (10)$$

where RL is the return loss given in 6.3.11.

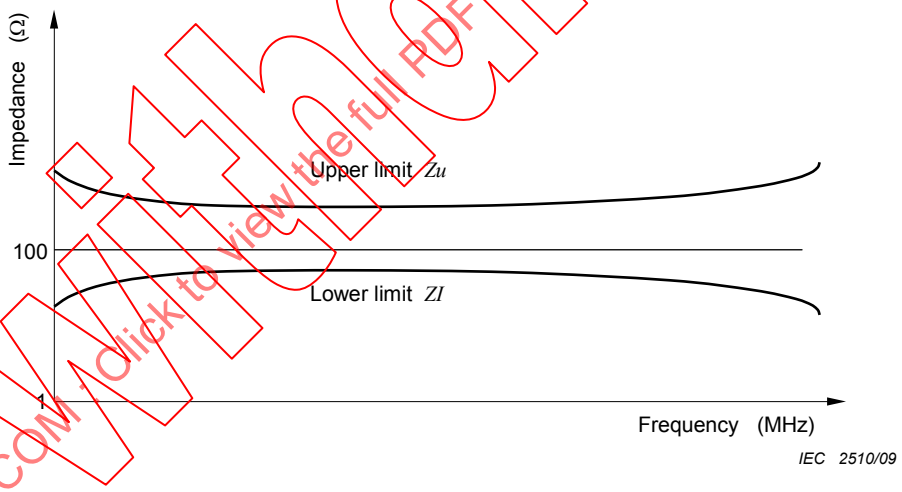

Figure 1 – Impedance template

6.3.11 Return loss (RL)

The minimum return loss of any pair in the frequency range indicated in Table 10 shall not be less than the values in Table 10 for the respective categories.

Table 10 – Return loss

Cable category	Frequency range MHz	Return loss dB
All (see Note 1)	1 to 10	$20{,}0 + 5{,}0 \times \log_{10}(f)$
All	10 to 20	25,0
Category 5e	20 to 100	$25{,}0 - 8{,}6 \times \log_{10}(f/20)$
Category 6	20 to 250	$25{,}0 - 8{,}6 \times \log_{10}(f/20)$
Category 6_A (see Note 2)	20 to 500	$25{,}0 - 8{,}6 \times \log_{10}(f/20)$
Category 7 (see Note 2)	20 to 600	$25{,}0 - 8{,}6 \times \log_{10}(f/20)$
Category 7_A (see Note 2)	20 to 600	$25{,}0 - 8{,}6 \times \log_{10}(f/20)$
Category 7_A	600 to 1 000	$15{,}6 - 8{,}6 \times \log_{10}(f/600)$
NOTE 1 The cable performance between 1 MHz and 4 MHz is achieved by design only and it is therefore not necessary to test for this performance below 4 MHz. NOTE 2 Calculated values below 15,6 dB revert to a 15,6 dB plateau.		

6.4 Mechanical and dimensional characteristics and requirements

6.4.1 Dimensional requirements

The overall diameter of insulation, the nominal thickness of the sheath and the maximum overall diameter of the sheath are not specified but shall be indicated in the relevant detail specification.

6.4.2 Elongation at break of the conductors

The minimum elongation of the conductor shall be not less than 8 %.

6.4.3 Tensile strength of the insulation

The tensile strength of the insulation is not specified but may be indicated in the relevant detail specification.

6.4.4 Elongation at break of the insulation

The minimum value of the elongation at break of the insulation shall be not less than 100 %.

6.4.5 Adhesion of the insulation to the conductor

The adhesion of the insulation to the conductor is not specified but may be indicated in the relevant detail specification.

6.4.6 Elongation at break of the sheath

The minimum value of the elongation at break of the sheath shall not be less than 100 %.

6.4.7 Tensile strength of the sheath

The minimum tensile strength of the sheath shall not be less than 9 MPa.

6.4.8 Crush test of the cable

The minimum force shall be 1 000 N.

6.4.9 Impact test of the cable

The impact resistance of the cable is not specified but may be indicated in the relevant detail specification.

6.4.10 Bending under tension

The bending performance of the cable is not specified but may be indicated in the relevant detail specification.

6.4.11 Repeated bending of the cable

The cable shall withstand 500 cycles without cracking of the insulation or sheath or loss of continuity in any metallic components.

6.4.12 Tensile performance of the cable

The tensile performance of the cable is not specified but may be indicated in the relevant detail specification.

6.4.13 Shock-test requirements of the cable

Not applicable.

6.4.14 Bump-test requirements of the cable

Not applicable.

6.4.15 Vibration-test requirements of a cable

Not applicable.

6.5 Environmental characteristics

6.5.1 Shrinkage of the insulation

When tested at (100 ± 2) °C for 1 h, the shrinkage of the insulation shall not exceed 5 %. The length of the sample shall be 150 mm, and the shrink-back shall be measured as the sum from both ends.

6.5.2 Wrapping test of the insulation after thermal ageing

Not applicable.

6.5.3 Bending test of the insulation at low temperature

The bending test of the insulated conductor shall be carried out at (–20 ± 2) °C. The mandrel diameter shall be 6 mm. There shall be no cracks in the insulation.

6.5.4 Elongation at break of the sheath after ageing

The ageing regime shall be seven days at (100 ± 2) °C. The tensile strength shall be not less than 50 % of the unaged value.

6.5.5 Tensile strength of the sheath after ageing

The ageing regime shall be seven days at (100 ± 2) °C. The elongation shall be not less than 70 % of the unaged value.