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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification



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

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

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Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

Part 1: Generic specification

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 61156-1:2007+AMD1:2009 CSV. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 61156-1 has been prepared by subcommittee 46C: Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2007 and Amendment 1 published in 2009. This edition constitutes a technical revision.

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

a) modification of the scope in Clause 1 and updating of normative references documents in Clause 2;

b) addition of PoE-related definitions in Clause 3;

c) clarification of differential-mode and common-mode resistors, correction of formulae and addition of IEC 62153-4-9 test method for coupling attenuation in Clause 6;

d) introduction of balunless measurement method in 6.3.1, modification of equipment requirements of unbalance attenuation in 6.3.5 and updating of balun's performance in Table 1;

e) deletion of 'three layers of cables on a drum' method in alien (exogenous) near-end crosstalk measurement in 6.3.8 and addition of terminated input impedance in 6.3.11.4.

The text of this International Standard is based on the following documents:

Draft	Report on voting
46C/1242/FDIS	46C/1249/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English and French.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 61156 series, published 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 this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

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MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

Part 1: Generic specification

1 Scope

This part of IEC 61156~~ is applicable to communication systems such as ISDN, local area networks and data communication systems and~~ specifies the definitions, requirements and test methods of multicore, symmetrical pair and quad cables.

This document is applicable to communication systems such as local area networks (LANs) and data communication cables. It is also applicable to cables used for industrial applications, customer premises wiring and generic cabling comprising installation cables and cables for work area wiring which are defined in ISO/IEC 11801 (all parts).

The cables covered by this document are intended to operate with voltages and currents normally encountered in communication systems. While 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 remote powering applications including but not restricted to Power over Ethernet as specified in ISO/IEC/IEEE 8802-3. More information on the capacity to support these applications according to the installation practices are given in IEC 61156-1-4, IEC TR 61156-1-6 and ISO/IEC TS 29125.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60028, *International standard of resistance for copper*

~~IEC 60050-726, *International Electrotechnical Vocabulary (IEV) – Part 726: Transmission lines and wave guides*~~

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Tests A: Cold*

~~IEC 60169-22, *Radio-frequency connectors – Part 22: RF two-pole bayonet coupled connectors for use with shielded balanced cables having twin inner conductors (Type BNO)*~~

IEC 60189-1:~~1986~~2018, *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 1: General test and measuring methods*~~1)~~

IEC 60304, *Standard colours for insulation for low-frequency cables and wires*

~~IEC 60332-1-1, *Tests on electric and optical fibre cables under fire conditions – Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus*~~

~~1) There exists a 2007 edition of 60189-1.~~

~~IEC 60332-2-1, *Tests on electric and optical fibre cables under fire conditions – Part 2-1: Test for vertical flame propagation for a single small insulated wire or cable – Apparatus*~~

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60332-2-2, *Tests on electric and optical fibre cables under fire conditions – Part 2-2: Test for vertical flame propagation for a single small insulated wire or cable – Procedure for diffusion flame*

~~IEC 60332-3-10, *Tests on electric cables under fire conditions – Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – Apparatus*~~

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*

IEC 60332-3-25, *Tests on electric and optical fibre cables under fire conditions – Part 3-25: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category D*

IEC 60708, *Low-frequency cables with polyolefin insulation and moisture barrier polyolefin sheath*

IEC 60754-2, *Test on gases evolved during combustion of ~~electric~~ materials from cables – Part 2: ~~Determination of the degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH and conductivity~~ Determination of acidity (by pH measurement) and conductivity*

~~IEC 60794-1-2:2003, *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures*~~

IEC 60794-1-21:2015, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical test methods*

~~IEC 60811-1-1:1993, *Common test methods for insulating and sheathing materials of electric cables and optical cables – Part 1: Methods for general application – Section 1: Measurement of thickness and overall dimensions – Tests for determining the mechanical properties*~~

~~IEC 60811-1-2:1985, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 1: Methods for general application – Section Two: Thermal ageing methods*~~

~~IEC 60811-1-3:1993, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 1: Methods for general application – Section Three: Methods for determining the density – Water absorption tests – Shrinkage test*~~

~~IEC 60811-1-4:1985, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 1: Methods for general application – Section Four: Test at low temperature*~~

~~IEC 60811-3-1:1985, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 3: Methods specific to PVC compounds – Section One: Pressure test at high temperature – Tests for resistance to cracking*~~

~~IEC 60811-4-2:2004, *Insulating and sheathing materials of electric cables – Common test methods – Part 4-2: Methods specific to polyethylene and polypropylene compounds – Tensile strength and elongation at break after conditioning at elevated temperature – Wrapping test*~~

~~*after conditioning at elevated temperature – Wrapping test after thermal ageing in air – Measurement of mass increase – Long-term stability test – Test method for copper-catalyzed oxidative degradation*~~

IEC 60811-201, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 201: General tests – Measurement of insulation thickness*

IEC 60811-202, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*

IEC 60811-203, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*

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

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

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

IEC 60811-504, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 504: Mechanical tests – Bending tests at low temperature for insulation and sheaths*

IEC 60811-506, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 506: Mechanical tests – Impact test at low temperature for insulations and sheaths*

IEC 60811-508, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulation and sheaths*

IEC 60811-509, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 509: Mechanical tests – Test for resistance of insulations and sheaths to cracking (heat shock test)*

IEC 60811-510, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 510: Mechanical tests – Methods specific to polyethylene and polypropylene compounds – Wrapping test after thermal ageing in air*

IEC 61034 (all parts), *Measurement of smoke density of cables burning under defined conditions*

IEC TR 61156-1-2[2], *Multicore and symmetrical pair/quad cables for digital communications – Part 1-2: Electrical transmission characteristics and test methods of symmetrical pair/quad cables*

IEC TR 61156-1-5, *Multicore and symmetrical pair/quad cables for digital communications – Part 1-5: Correction procedures for the measurement results of return loss and input impedance*

IEC 61196-1-105, *Coaxial communication cables – Part 1-105: Electrical test methods – Test for withstand voltage of cable dielectric*

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2 IEC TR 61156-1-2 is due to become a TS in 2023.

IEC 62012-1:~~2004~~2002, *Multicore and symmetrical pair/quad cables for digital communications to be used in harsh environments – Part 1: Generic specification*

IEC 62153-4-3:2013, *Metallic communication cables test methods – Part 4-3: Electromagnetic compatibility (EMC) – Surface transfer impedance – Triaxial method*

~~IEC 62153-4-4, *Metallic communication cables test methods – Part 4-4: Electromagnetic compatibility (EMC) – Shielded screening attenuation, test method for measuring of the screening attenuation a_s up to and above 3 GHz*~~

IEC 62153-4-5, *Metallic communication cables test methods – Part 4-5: Electromagnetic compatibility (EMC) –~~ Coupling or screening~~ Screening or coupling 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*

IEC 62255 (all parts), *Multicore and symmetrical pair/quad cables for broadband digital communications (high bit rate digital access telecommunication networks) – Outside plant cables*

ISO/IEC TS 29125:2017, *Information technology – Telecommunications cabling requirements for remote powering of terminal equipment*

~~ITU-T Recommendation G.117:1996, *Transmission aspects of unbalance about earth*~~

~~ITU-T Recommendation O.9:1999, *Measuring arrangements to assess the degree of unbalance about earth*~~

3 Terms and definitions

For the purposes of this document, the following terms and definitions~~, as well as those given in IEC 60050-726,~~ apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
resistance unbalance
difference in resistance of the conductors within a pair or one side of a quad or between pairs or quads

Note 1 to entry: Resistance unbalance is expressed as a percentage (%).

3.2
mutual capacitance
electrical charge storage parameter of a pair of conductors (or with respect to the side of a quad)

Note 1 to entry: Mutual capacitance is one of the four primary transmission line parameters: mutual capacitance, mutual inductance, resistance and conductance.

Note 2 to entry: Mutual capacitance is expressed in pF/m..

3.3
capacitance unbalance to earth
arithmetic difference of the capacitance to earth of the conductors of a pair or one side of a quad

Note 1 to entry: Capacitance unbalance is expressed in pF/m.

3.4
screen
continuous conducting layer or assembly of conducting layers having the function of reducing the penetration of an electric, magnetic or electromagnetic field into a given region

[SOURCE: IEC 60050-195:2021,195-02-37, modified – "continuous conducting layer or assembly of conducting layers having the function of reducing " has replaced "device intended to reduce "]

3.5
balun
~~balanced to unbalanced impedance matching transformer~~

device to provide impedance transformation between balanced and unbalanced components

[SOURCE:ISO/IEC 11801-4:2017, 3.1.2]

3.6
balunless
virtual balun used instead of the physical transformers, achieved by mathematical algorithm, and calculated from lumped parameters or distributed parameter network

3.7
transfer impedance
Z_T
quotient of the longitudinal voltage of an electrically short uniform cable, induced in the outer circuit – formed by the screen under test and the measuring jig – and the current fed into the inner circuit – the cable under test itself or vice versa, related to unit length

Note 1 to entry: Transfer impedance is expressed in mΩ/m.

[SOURCE: IEC 62153-4-3:2013, 3.3, modified – "of an electrically short uniform cable" has been added, "outer circuit" has replaced “matched outer circuit", “the cable under test itself" has been added, “related to unit length" has replaced "(see Figure 1)".]

3.8
coupling attenuation
a_c
~~ratio between the transmitted power through the conductors and the maximum radiated peak power, conducted and generated by the exited common-mode currents~~

for a screened balanced cable, the sum of the effects of the unbalance attenuation a_U of the symmetric pair and the screening attenuation a_s of the screen of the cable under test

Note 1 to entry: For electrically long devices, i.e. above the cut-off frequency, the coupling attenuation a_C is defined as the logarithmic ratio of the feeding power P_1 and the periodic maximum values of the coupled power $P_{r,\,max}$ in the outer circuit.

Note 2 to entry: Coupling attenuation is expressed in dB.

[SOURCE: IEC 62153-4-7:2021, 3.4, modified –“cable" has replaced “device", “sum of the effects’" has replaced “sum", Note 2 has been added.]

3.9
current carrying capacity
maximum current a cable circuit (one or several conductors) can support resulting in a specified increase of the surface temperature of the conductor beyond the ambient temperature, not exceeding the maximum allowed operating temperature of the cable

3.10
velocity of propagation
~~(~~**phase velocity**~~)~~
speed at which a sinusoidal signal propagates on a pair in the cable

Note 1 to entry: Velocity of propagation is expressed in m/s.

3.11
~~(~~**phase delay**~~)~~
delay
time duration between the instants that the wave front of a sinusoidal travelling wave, defined by a specified phase, passes two given points in a cable

Note 1 to entry: Phase delay is expressed in s/m.

3.12
differential phase delay
~~(~~**delay skew**~~)~~
difference in phase delay between any two pairs in the cable

Note 1 to entry: Differential phase delay (skew) is expressed in s.

3.13
attenuation
decrease in magnitude of power of a signal that propagates along a pair of a cable

Note 1 to entry: Attenuation is expressed in dB/m.

3.14
ambient temperature
temperature of the room or space surrounding the cable

Note 1 to entry: Ambient temperature is expressed in degree Celsius (°C).

3.15
operating temperature
surface temperature of the conductors of a cable

Note 1 to entry: The operating temperature is the sum of the ambient temperature and of the temperature increase due to the carried power.

Note 2 to entry: Operating temperature is expressed in degree Celsius (°C).

3.16
unbalance attenuation
UA
~~magnitude of power of a signal that propagates between the common-mode circuit and the differential-mode circuit of a cable~~

logarithmic ratio of the differential mode power to the common mode power in a balanced line, or vice versa

Note 1 to entry: Unbalance attenuation is expressed in dB.

Note 2 to entry: Unbalance attenuation is also often referred to as conversion loss: TCL (transverse conversion loss), TCTL (transverse conversion transfer loss), LCL (longitudinal conversion loss), LCTL (longitudinal conversion

transfer loss), EL TCTL (equal level transverse conversion transfer loss) and EL LCTL (equal level longitudinal conversion loss transfer loss).

3.17
transverse conversion loss
TCL
logarithmic ratio of the differential-mode circuit power at the near end and the common-mode coupling power measured at the near end

3.18
equal level transverse conversion transfer loss
EL TCTL
output-to-output measurement of the logarithmic ratio of the differential-mode circuit power at the near end and the common-mode coupling power measured at the far end

Note 1 to entry: EL TCTL is calculated by the difference between the measured TCTL and the differential-mode insertion loss of the disturbed pair.

3.19
near-end crosstalk
NEXT
magnitude of the signal power coupling from a disturbing pair at the near end to a disturbed pair measured at the near end

Note 1 to entry: Near-end crosstalk is expressed in dB.

3.20
far-end crosstalk
FEXT
magnitude of the signal power coupling from a disturbing pair at the near end to a disturbed pair measured at the far end

Note 1 to entry: Far-end crosstalk is expressed in dB.

3.21
power sum of crosstalk
PS
summation of the crosstalk power from all disturbing pairs into a disturbed pair

Note 1 to entry: The summation is applicable to near-end and far-end crosstalk.

Note 2 to entry: The power sum of crosstalk is expressed in dB.

~~**3.12**~~
~~**attenuation to crosstalk ratio, near-end**~~
~~*ACR-N*~~
~~arithmetic difference between the near-end crosstalk and the attenuation of the disturbed pair~~

~~NOTE Attenuation to crosstalk ratio, near-end, is expressed in dB.~~

3.22
attenuation to crosstalk ratio, far-end
ACR-F
arithmetic difference between the far-end crosstalk and the attenuation of the disturbed pair

Note 1 to entry: Attenuation to crosstalk ratio, far-end, is expressed in dB.

3.23
alien (exogenous) near-end crosstalk
ANEXT
near-end crosstalk where the disturbing and disturbed pairs are contained in different cables

Note 1 to entry: Alien (exogenous) near-end crosstalk is expressed in dB.

3.24
alien (exogenous) far-end crosstalk
AFEXT
far-end crosstalk where the disturbing and disturbed pairs are contained in different cables

Note 1 to entry: Alien (exogenous) far-end crosstalk is expressed in dB.

3.25
alien (exogenous) far-end crosstalk
AACR-F
far-end crosstalk where the disturbing and disturbed pairs are contained in different cables

Note 1 to entry: Alien (exogenous) far-end crosstalk is expressed in dB.

3.26
power sum of alien (exogenous) near-end crosstalk
~~*PSA*~~
PS ANEXT
summation of the near-end alien (exogenous) crosstalk power from all disturbing pairs into a disturbed pair in different cables

~~Note 1 The summation is applicable to near-end and far-end alien (exogenous) crosstalk.~~

Note 1 to entry: The power sum of alien (exogenous) near-end crosstalk is expressed in dB.

3.27
power sum of alien (exogenous) far-end crosstalk
PS AACR-F
summation of the alien (exogenous) far-end crosstalk power from all disturbing pairs into a disturbed pair in different cables

Note 1 to entry: The power sum of far-end alien (exogenous) crosstalk is expressed in dB.

3.28
characteristic impedance
Z_C
impedance at the input of a homogeneous line of infinite length

Note 1 to entry: The impedance value is expressed in Ω, ~~calculated~~ at relevant frequencies, as the square root of the product of the impedance measured at the near end (input) of a cable pair when the far end is terminated by ~~a short~~ an open circuit load and then an ~~open~~ short circuit load.

Note 2 to entry: The asymptotic value at high frequencies is denoted as Z_∞.

Note 3 to entry: The characteristic impedance of a homogeneous cable pair is given by the quotient of a voltage wave and current wave which are propagating in the same direction, either forwards or backwards.

Note 4 to entry: For homogeneous ideal cables, this test method yields a flat smooth curve over the whole frequency range. Real cables with distortions give curves with some roughness.

3.29
terminated input impedance
Z_{in}
impedance value, expressed in Ω, at relevant frequencies, measured at the near end (input) when the far end is terminated with the system nominal impedance, Z_R

~~(See IEC/TR 62152.)~~

3.30
fitted characteristic impedance
Z_m
impedance value, expressed in Ω, calculated by applying a least squares function fitting algorithm to the measured characteristic impedance values

3.31
mean characteristic impedance
Z_∞
asymptotic value at which the characteristic impedance approaches at sufficiently high frequencies (≈100 MHz) such that the imaginary part (phase angle) is insignificant

Note 1 to entry: Normally measured from the capacitance and time delay.

Note 2 to entry: Applicable for cables with frequency independence of mutual capacitance.

3.32
return loss
RL
ratio of reflected power to input power at the input terminals of a cable pair

Note 1 to entry: Return loss is expressed in dB.

3.33
bundled cable
grouping or assembly of several individual cables that are systematically laid up

Note 1 to entry: Bundled cables are also referred to as speed-wrap, whip, or loomed cables.

3.34
remote powering
supply of power to application specific equipment via balanced cabling

[SOURCE: ISO/IEC TS 29125:2017, 3.1.5]

3.35
safety extra-low voltage
SELV
AC voltage the RMS value of which does not exceed 50 V or ripple-free DC voltage the value of which does not exceed 120 V, between conductors, or between any conductor and reference earth, in an electric circuit which has galvanic separation from the supplying electric power system by such means as a separate-winding transformer

Note 1 to entry: Maximum voltage lower than 50 V AC or 120 V ripple-free DC may be specified in particular requirements, especially when direct contact with live parts is allowed.

Note 2 to entry: The voltage limit should not be exceeded at any load between full load and no-load when the source is a safety isolating transformer.

Note 3 to entry: Ripple-free qualifies conventionally an RMS ripple voltage of not more than 10 % of the DC component; the maximum peak value does not exceed 140 V for a nominal 120 V ripple-free DC system and 70 V for a nominal 60 V ripple-free DC system.

3.36
continuous operating temperature
COT
maximum temperature which ensures the stability and integrity of the material for the expected life of the equipment, or part, in its intended application

3.37
hygroscopic
characteristic of a material to absorb moisture from the atmosphere

3.38
wicking
longitudinal flow of a liquid in a material due to capillary action

4 Installation considerations

The cables shall be designed to meet the installation conditions encountered for each area as follows.

a) Equipment cables

The cables are used between work stations and peripheral equipment (for example, printer).

b) Work area cables

The cables are used between the work station and the communication outlets.

c) Horizontal floor wiring cables

The cables are used between the work area communication outlet and the communication closet.

d) Riser cables and building back-bone cables

The cables are used for horizontal installation or vertically between floors.

e) Campus cables

These cables are used to interconnect buildings and shall be suitable for outdoor installation. The cables ~~should~~ shall be sheathed and protected in accordance with IEC 62255 (all parts).

f) Delivery of power

For cables delivering power using only SELV systems for remote powering, the COT shall be considered.

NOTE The related document is IEC 60364-7-716.

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 (electromagnetic compatibility), fire performance, or SELV should be considered.

5.2 Cable constructions

5.2.1 General

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

5.2.2 Conductor

The conductor shall consist of annealed copper, uniform in quality and free from defects. The properties of the copper shall be in accordance with IEC 60028.

The conductor may be either solid or stranded. The solid conductor shall be circular in section and may be plain or metal-coated. The solid conductor shall be drawn in one piece. Joints in the solid conductor are permitted, provided that the breaking strength of a joint is not less than 85 % of the breaking strength of the unjointed solid conductor.

The stranded conductor shall consist of strands circular in section and assembled without insulation between them by concentric stranding or bunched.