# IEC 61156-11

Edition 2.0 2023-05

# INTERNATIONAL STANDARD

**Multicore and symmetrical pair/quad cables for digital communications – Part 11: Symmetrical single pair cables with transmission characteristics up to 1,25 GHz – Horizontal floor wiring – Sectional specification**



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# MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

# Part 11: Symmetrical single pair cables with transmission characteristics up to 1,25 GHz – Horizontal floor wiring – Sectional specification

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IEC 61156-11 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 second edition cancels and replaces the first edition published in 2019. This edition constitutes a technical revision.

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

a) additional cable type in support of T1-C generic single pair cabling up to 1,25 GHz;
b) introduction of low frequency coupling attenuation as an integral parameter describing screening efficiency at frequencies below 30 MHz.

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

| Draft | Report on voting |
|---|---|
| 46C/1254/FDIS | 46C/1258/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.

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/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- withdrawn,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.

# MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

# Part 11: Symmetrical single pair cables with transmission characteristics up to 1,25 GHz – Horizontal floor wiring – Sectional specification

## 1 Scope

This part of IEC 61156 describes cables intended to be used for single balanced pair (office, home, industrial) applications according to ISO/IEC 11801-1. An example of existing application is 1000BASE-T1, see ISO/IEC TR 11801-9906. The transmission characteristics of these cables are specified up to a frequency of 1,25 GHz and at a temperature of 20 °C. The T1-C type cable is specified up to 600 MHz, the T1-D type cable up to 1,25 GHz. Depending on the MICE environment and the installation conditions either unscreened or screened cables can be used. A blank detail specification can be found in Annex A.

These cables can comprise more than one pair in the event that several systems are operated in parallel. In this case, refer to Clause 7.

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.

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

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

IEC 61156-5, *Multicore and symmetrical pair/quad cables for digital communications – Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Horizontal floor wiring – Sectional specification*

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

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

IEC 62153-4-9:2018, *Metallic communication cable test methods – Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, triaxial method*
IEC 62153-4-9:2018/AMD1:2020

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

## 3 Terms and definitions

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

## 4 Installation considerations

### 4.1 General remarks

Installation area considerations are defined in IEC 61156-1. Other areas may be considered.

### 4.2 Bending radius of installed cable

The minimum bending radius of the cable shall be equal to or less than four times the outside diameter of the cable unless otherwise specified.

### 4.3 Climatic conditions

Under static conditions, the cable shall operate at least in the temperature range of the environment from −20 °C to +60 °C.

The attenuation increase due to the elevated operating temperature (temperature of the environment) is described in 6.3.3.2.

In the case of application of remote powering, the maximum temperature of the conductor shall not exceed the maximum operation temperature under static conditions (60 °C) in order to maintain the integrity of the dielectric material performance which is aligned to the environmental temperature range.

Extended temperature ranges are permitted and shall be specified in the relevant detail specification.

## 5 Materials and cable construction

### 5.1 General remarks

For the purposes of this document, the requirements of IEC 61156-5 apply.

The choice of materials and cable construction shall be suitable for the intended application and installation of the cable and in line with the requirements of IEC 61156-1. Ensure that any requirements for EMC and fire performance (such as burning properties, smoke generation, evolution of halogen gas) are met. Regional regulations can apply as well.

### 5.2 Cable construction

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

### 5.3 Conductor

The conductor shall be a solid annealed copper conductor in accordance with the requirements of IEC 61156-1 and should have a nominal diameter between 0,4 mm and 0,65 mm. A conductor diameter of up to 1,05 mm may be used.

NOTE The conductor dimensions seen in practice are wider than those dimensions that correspond to the resistance requirements according to 6.2.1 and are therefore relevant for the design of the contact terminals of connecting hardware.

### 5.4 Insulation

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

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

The colour code shall be in accordance with IEC 60708 if not specified differently in the relevant detail specification.

### 5.5 Cable element

The cable element shall be a balanced twisted pair. The entire cable may comprise more than one cable element, see 6.3.5 and Clause 7.

### 5.6 Screening of the cable element

The screen of the cable element (if exists) shall be in accordance with the requirements of IEC 61156-1.

### 5.7 Cable make-up

Fillers or spacers may be used in the cable elements and to separate cable elements. The cable elements and their screens, if they are screened, may be covered by an intermediate jacket. This jacket shall be in accordance with 5.9. The core of the cable may be wrapped with a protective layer of non-hygroscopic and non-wicking material.

### 5.8 Screening of the cable core

For screened cables, a screen for the cable core shall be provided. The screen shall be in accordance with the requirements of IEC 61156-1.

### 5.9 Sheath

The sheath material shall consist of a suitable material. Examples of suitable materials are:

– polyolefin;
– PVC;
– fluoropolymer;
– low-smoke halogen-free 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.

### 5.10 Identification

Each length of cable shall be identified as to the supplier and, when required, a traceability code, using one or a combination 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, are permitted. If used, such markings shall refer to this document.

### 5.11 Finished cable

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

## 6 Characteristics and requirements

### 6.1 General remarks

Clause 6 lists the characteristics and minimum requirements of a cable complying with this document. Test methods shall be in accordance with the requirements of IEC 61156-1, except for the length of the cable under test which shall be as specified in Clause 6.

The computed requirements in dB, rounded to one decimal place, shall be used to determine compliance.

The tests for electrical characteristics in accordance with 6.2 shall be carried out on a cable length of not less than 100 m, unless otherwise specified.

The tests for transmission characteristics in accordance with 6.3 shall be carried out on a cable length of 100 m, unless otherwise specified. For T1-D type cables a length of 50 m may be used to improve accuracy at high frequencies.

For measurements over a wide frequency range as required for T1-D type cable, a balun-less measurement technique is recommended, see IEC TR 61156-1-2[1].

### 6.2 Electrical characteristics and tests

#### 6.2.1 Conductor resistance

The maximum conductor resistance at or corrected to 20 °C shall not exceed 72,5 Ω/km.

#### 6.2.2 Resistance unbalance

##### 6.2.2.1 Resistance unbalance within a pair

The resistance unbalance shall not exceed 2,0 %.

##### 6.2.2.2 Resistance unbalance between pairs

If applicable, for example in the case of bundled cables (see Clause 7), the pair-to-pair resistance unbalance shall not exceed 5,0 %.



[1] Currently under revision to become a TS.

### 6.2.3 Dielectric strength

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

### 6.2.4 Insulation resistance

The test shall be performed on:

– conductor/conductor;

– conductor/screen (if exists).

The minimum insulation resistance at or corrected to 20 °C shall be not less than 5 000 MΩ·km when tested immediately after the dielectric strength test.

### 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 1 200 pF/km at a frequency of 800 Hz or 1 000 Hz.

### 6.2.7 Transfer impedance

For screened cables, three grades of performance are recognised for transfer impedance. The transfer impedance measured in accordance with IEC 62153-4-3 shall not exceed the values of at least one grade shown in Table 1. Requirements at frequencies below 1 MHz are for further studies (ffs).

**Table 1 – Transfer impedance**

| Frequency range $f$ in MHz | Maximum surface transfer impedance in mΩ/m | | |
|---|---|---|---|
| | Grade 1 | Grade 1b | Grade 2 |
| 0,1 to 1 | 15 | 30 | 50 |
| 1 to 10 | $Z_t \leq 15(f)^{-0,176}$ | $Z_t \leq 30(f)^{-0,176}$ | $Z_t \leq 50(f)^{-0,301}$ |
| 10 to 20 | $Z_t \leq 10\frac{f}{10}$ | $Z_t \leq 20\frac{f}{10}$ | $Z_t \leq 23,392(f)^{0,631}$ |



### 6.2.8 Coupling attenuation and low frequency coupling attenuation

Three performance types for coupling attenuation are recognised. Coupling attenuation shall be measured using either the absorbing clamp method (IEC 62153-4-5) or the triaxial method for screened cables (IEC 62153-4-9). When measured using one of these methods, the coupling attenuation in the frequency range from $f$ = 30 MHz to 1 GHz for T1-C type cables or 1,25 GHz for T1-D type cables shall meet the requirements of Type I, Type Ib or Type II indicated in Table 2.

**Table 2 – Coupling attenuation**

| Coupling attenuation type | Frequency range<br>MHz | Coupling attenuation<br>dB |
|---|---|---|
| Type I | 30 to 100 | ≥ 85 |
| | 100 to1 000 for T1-C type cables<br>100 to 1 250 for T1-D type cables | ≥ 85 – 20 $\log_{10}$ ($f$ /100); $f$ in MHz |
| Type Ib | 30 to 100 | ≥ 70 |
| | 100 to 1 000 for T1-C type cables<br>100 to 1 250 for T1-D type cables | ≥ 70 – 20 $\log_{10}$ ($f$ /100); $f$ in MHz |
| Type II | 30 to 100 | ≥ 55 |
| | 100 to 1 000 for T1-C type cables<br>100 to 1 250 for T1-D type cables | ≥ 55 – 20 $\log_{10}$ ($f$ /100); $f$ in MHz |

For frequencies below 30 MHz three performance types for low frequency coupling attenuation are recognised (see Table 3). Low frequency coupling attenuation shall be measured using the triaxial method according to IEC 62153-4-9 in a tube of 3 m length.

**Table 3 – Low frequency coupling attenuation**

| Low frequency coupling attenuation type | Frequency range<br>MHz | Low frequency coupling attenuation<br>dB |
|---|---|---|
| Type I | 0,1 to 30 | ≥ 85-10 $\log_{10}$ ($f$ /30), 100 dB max. (ffs); $f$ in MHz |
| Type Ib | 0,1 to 30 | ≥ 70-10 $\log_{10}$ ($f$ /30), 85 dB max. (ffs); $f$ in MHz |
| Type II | 0,1 to 30 | ≥ 55-10 $\log_{10}$ ($f$ /30), 70 dB max. (ffs); $f$ in MHz |

Further details about the background of coupling attenuation versus low frequency coupling attenuation requirements are given in Annex B.

NOTE Coupling attenuation and low frequency coupling attenuation requirements according to Type II are not applicable for MICE E3.

### 6.2.9 Current-carrying capacity

The maximum current-carrying capacity is installation dependent and therefore not specified but may be indicated in the relevant detail specification. Further guidance with respect to current-carrying capacity is provided by ISO/IEC TS 29125.

NOTE Local regulations can apply when supplying remote power.

## 6.3 Transmission characteristics

### 6.3.1 Velocity of propagation (phase velocity)

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, $\tau$, shall not exceed the value obtained from Formula (1) in the frequency range from 0,1 MHz to 600 MHz for T1-C type cables or 1,25 GHz for T1-D type cables. The requirements from 0,1 MHz to 1 MHz are ffs.

$$\tau = 534 + \frac{36}{\sqrt{f}} \quad (1)$$

where

$\tau$ is the phase delay in ns/100 m;

$f$ is the frequency in MHz.

#### 6.3.2.2 Differential delay (delay skew)

If applicable, for example in the case of bundled cables (see Clause 7), the maximum delay skew between any two pairs, when measured at (20 ± 3) °C, shall not exceed 25 ns/100 m in the frequency range from 0,1 MHz to 600 MHz for T1-C type cables or 1,25 GHz for T1-D type cables. The requirements from 0,1 MHz to 1 MHz are ffs.

### 6.3.3 Attenuation ($\alpha$)

#### 6.3.3.1 Attenuation at 20 °C operating temperature

The maximum attenuation, $\alpha$, of any pair in the frequency range indicated in Table 4 shall not exceed the value obtained from Formula (2). The requirements from 0,1 MHz to 1 MHz are ffs.

$$\alpha = a\sqrt{f} + bf + c\sqrt{f} \quad (2)$$

where

$\alpha$ is the attenuation expressed in dB/100 m;

$a$, $b$, $c$ are constants indicated in Table 4;

$f$ is the frequency expressed in MHz.

**Table 4 – Attenuation equation constants**

| Frequency range MHz | Constants | | |
|---|---|---|---|
| | *a* | *b* | *c* |
| 0,1 to 600 for T1-C type cables<br>0,1 to 1 250 for T1-D type cables | 1,8 | 0,005 | 0,25 |

#### 6.3.3.2 Attenuation at elevated operating temperature

The increase of the maximum attenuation from Formula (2) due to elevated environmental temperature above 20 °C is obtained by calculation as follows:

– 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.

In the event of application of remote powering, the actual conductor temperature should be considered in order to calculate the attenuation increase. If an extended environmental temperature range is specified (see 4.3), the temperature coefficients given in 6.3.3.2 might not be applicable. The method provided in IEC 61156-1 should be used to determine temperature coefficients in this case.

### 6.3.4 Unbalance attenuation (TCL and EL TCTL)

The minimum near-end unbalance attenuation (transverse conversion loss (TCL)) shall not be less than the value obtained from Table 5 in the frequency range from 0,1 MHz to 600 MHz for T1-C type cables or 1,25 GHz for T1-D type cables. The requirements from 0,1 MHz to 1 MHz are ffs.

**Table 5 – TCL requirements**

| | **Screened cables**<br>dB | **Unscreened cables**<br>dB |
|---|---|---|
| Level 1 | $40 - 15 \log_{10} (f)$; $f$ in MHz; 40 dB maximum<br>7 dB minimum | $68 - 15 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>7 dB minimum |
| Level 2 | $68 - 15 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>7 dB minimum | $68 - 15 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>7 dB minimum |
| Level 3 | $68 - 15 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>7 dB minimum | $76 - 15 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>7 dB minimum |
| Level 4 | $68 - 15 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>7 dB minimum | $84 - 15 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>7 dB minimum |

The minimum equal-level far-end unbalance attenuation (equal-level transverse conversion transfer loss (EL TCTL)) shall not be less than the value obtained from Table 6 in the frequency range from 0,1 MHz to 600 MHz for T1-C type cables or 1,25 GHz for T1-D type cables. The requirements from 0,1 MHz to 1 MHz are ffs.

**Table 6 – EL TCTL requirements**

| | **Screened cables**<br>dB | **Unscreened cables**<br>dB |
|---|---|---|
| Level 1 | $40 - 20 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>6 dB minimum | $40 - 20 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>6 dB minimum |
| Level 2 | $50 - 20 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>6 dB minimum | $50 - 20 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>6 dB minimum |
| Level 3 | $60 - 20 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>6 dB minimum | $60 - 20 \log_{10} (f)$; $f$ in MHz; 53 dB maximum<br>6 dB minimum |



For calculation of EL TCTL, the TCTL and the attenuation measurement of the test specimen with the same length as defined in 6.1 shall be used.

### 6.3.5 Alien (exogenous) near-end crosstalk (PS ANEXT)

The PS ANEXT (power-sum alien near-end crosstalk) of the cable when tested in accordance with IEC 61156-1 shall be not less than the values obtained from Table 7. The requirements from 0,1 MHz to 1 MHz are ffs.

**Table 7 – PS ANEXT requirements**

| Cable type | Frequency range<br>MHz | PS ANEXT<br>dB |
|---|---|---|
| T1-C type cables | 0,1 to 100 | 70 |
| | 100 to 600 | $70 - 10 \log_{10} (f/100)$; $f$ in MHz |
| T1-D type cables | 0,1 to 100 | 75 |
| | 100 to 1 250 | $75 - 10 \log_{10} (f/100)$; $f$ in MHz |

For screened cables meeting the requirements of 6.2.7 and 6.2.8 (minimum Type I) ANEXT is proven by design (ffs).

### 6.3.6 Alien (exogenous) far-end crosstalk (PS AACR-F)

The PS AACR-F (power-sum alien attenuation to crosstalk ratio far-end) of the cable when tested in accordance with IEC 61156-1 shall not be less than the values obtained from Table 8. The requirements from 0,1 MHz to 1 MHz are ffs.

For calculation of AACR-F, the AFEXT and the attenuation measurement of the test specimen with a length as specified in 6.1 shall be used.

**Table 8 – PS AACR-F requirements**

| Cable type | Frequency range<br>MHz | PS AACR-F<br>dB |
|---|---|---|
| T1-C type cables | 0,1 to 600 | $98 - 20 \log_{10} (f)$; $f$ in MHz |
| T1-D type cables | 0,1 to 1 250 | $103 - 20 \log_{10} (f)$; $f$ in MHz |

If AFEXT up to 600 MHz is greater than 90 dB for T1-C type cables or greater than 90 dB up to 1 GHz and greater than 80 dB from 1 GHz to 1,25 GHz for T1-D type cables, it might not be possible to calculate the AACR-F and it can be assumed the criteria according to Table 8 are met.

For those frequencies where the calculated limit value of PS AACR-F is greater than 75 dB for T1-C type cables, the requirement shall be 75 dB.

For those frequencies where the calculated limit value of PS AACR-F is greater than 80 dB for T1-D type cables, the requirement shall be 80 dB.

For screened cables meeting the requirements in accordance with 6.2.7 and 6.2.8 (minimum Type Ib), AFEXT is proven by design.

### 6.3.7 Alien (exogenous) crosstalk of bundled cables

The relevant requirements of this document – especially those of 6.3.5 and 6.3.6 – apply; see also Clause 7.

### 6.3.8 Impedance

The fitted or mean characteristic impedance measured in accordance with IEC 61156-1 shall be 100 Ω ± 5 Ω at 100 MHz. A measurement of the input impedance is not sufficient to ensure return loss limits.

Recommendations given in IEC TR 61156-1-2 and IEC TR 61156-1-5 for improvement of measurement uncertainty can be considered.

### 6.3.9 Return loss (RL)

The minimum return loss of any pair in the frequency range indicated in Table 9 shall not be less than the values in Table 9.

**Table 9 – RL requirements**

| Frequency range<br>MHz | RL<br>dB |
|---|---|
| 0,1 to 1 | $20 + 10 \log_{10} (f)$; $f$ in MHz (ffs) |
| 1 to 10 | $20 + 5 \log_{10} (f)$; $f$ in MHz |
| 10 to 20 | 25 |
| 20 to 600 | $25 - 7 \log_{10} (f/20)$; $f$ in MHz<br>17,3 dB minimum |
| 600 to 1 250<br>T1-D type cables only | $17,3 - 10 \log_{10} (f/600)$; $f$ in MHz |

When using a balun-less measurement technique, the corresponding descriptions of IEC TR 61156-1-2 can be considered. Recommendations contained in IEC TR 61156-1-5 for improvement of measurement uncertainty by a correction technique can be considered.

## 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 conductor

The minimum elongation at break 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 any sheath shall be not less than 100 %.

### 6.4.7 Tensile strength of the sheath

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

#### 6.4.8 Crush test of the cable

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

#### 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

Not applicable.

#### 6.4.12 Tensile performance of the cable

The tensile strength 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 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 elongation at break after ageing shall not be 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 tensile strength after ageing shall be not less than 70 % of the unaged value.

#### 6.5.6 Sheath pressure test at high temperature

Not applicable.

#### 6.5.7 Cold bend test of the cable

The bending test shall be carried out at (−20 ± 2) °C. The mandrel diameter shall be eight times the overall diameter of the cable. There shall be no cracks in the sheath.

#### 6.5.8 Heat shock test

Not applicable.

#### 6.5.9 Damp heat steady state

Not applicable.

#### 6.5.10 Solar radiation

The resistance to solar radiation is not specified but may be specified in the relevant detail specification.

#### 6.5.11 Solvents and contaminating fluids

The resistance to solvents and contaminating fluids is not specified but may be specified in the relevant detail specification.

#### 6.5.12 Salt mist and sulphur dioxide

Not applicable.

#### 6.5.13 Water immersion

Not applicable.

#### 6.5.14 Hygroscopicity

The amount of moisture gained after 3 h shall not exceed 1 % in weight.

#### 6.5.15 Wicking

The test solution shall not wet the filter paper at the end of 6 h.

#### 6.5.16 Flame propagation characteristics of a single cable

If indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

#### 6.5.17 Flame propagation characteristics of bunched cables

If indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

#### 6.5.18 Halogen gas evolution

If indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

#### 6.5.19 Smoke generation

If indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

#### 6.5.20 Toxic gas emission

If indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

#### 6.5.21 Integrated fire test method for cables in environmental air handling spaces

If indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

## 7 Bundled cable requirements

### 7.1 General

In bundled cables, break-out cables or cable harnesses, several one-pair cables as described in this document may be bundled. Such arrangements shall be specified in a detail specification agreed on by the manufacturer and the customer. Relevant safety regulations in addition to this document shall be taken into account. The limits for alien crosstalk shall apply for the crosstalk between the one-pair cables as described in this document.

### 7.2 Single pairs sharing one sheath

#### 7.2.1 General

In the event that several pairs are operating in parallel in a multi-pair cable, the crosstalk between the pairs shall be considered. The most obvious case of four-pair cables is assumed in 7.2 for the requirements of near-end and far-end crosstalk. In the case of a different pair-count, the applicable power-sum requirements in this document for the relevant pair-count shall be met in order to achieve similar noise levels.

#### 7.2.2 Near-end crosstalk (NEXT)

The requirements of Table 10 apply to four-pair cables only. If applicable, the worst near-end crosstalk shall not be less than the values indicated in Table 10.

**Table 10 – NEXT and PS NEXT requirements**

| Frequency range<br>MHz | NEXT requirement<br>dB | PS NEXT requirement<br>dB |
|---|---|---|
| 1 to 600 for T1-C type cables<br>1 to 1 250 for T1-D type cables | $114 - 15 \log_{10} (f)$;<br>$f$ in MHz | $111 - 15 \log_{10} (f)$;<br>$f$ in MHz |

For those frequencies where the calculated value of NEXT is greater than 78 dB, the requirement shall be 78 dB. For those frequencies where the calculated value of PS NEXT is greater than 75 dB, the requirement shall be 75 dB.

### 7.2.3 Attenuation to crosstalk ratio far-end (PS ACR-F)

The requirements of Table 11 apply to four-pair cables only. If applicable, the pair-to-pair ACR-F in dB for any combination shall be greater than or equal to the value obtained from Table 11.

**Table 11 – ACR-F and PS ACR-F requirements**

| Frequency range<br>MHz | ACR-F requirement<br>dB | PS ACR-F requirement<br>dB |
|---|---|---|
| 1 to 600 for T1-C type cables<br>1 to 1 250 for T1-D type cables | $133 - 20 \log_{10} (f)$;<br>$f$ in MHz | $130 - 20 \log_{10} (f)$;<br>$f$ in MHz |

For calculation of ACR-F, the FEXT and the attenuation measurement of the test specimen with length as defined in 6.1 shall be used.

If FEXT up to 600 MHz is greater than 90 dB for T1-C type cables or greater than 90 dB up to 1 GHz and greater than 80 dB from 1 GHz to 1,25 GHz for T1-D type cables, the ACR-F may not be calculated.

For those frequencies where the calculated limit value of ACR-F is greater than 78 dB, the requirement shall be 78 dB. For those frequencies where the calculated value of PS ACR-F is greater than 75 dB, the requirement shall be 75 dB.

# Annex A
(informative)

## Blank detail specification

The blank detail specification determines the layout and style for detail specifications describing symmetrical single pair cables with transmission characteristics up to 1,25 GHz. Detail specifications, based on the blank detail specification, may be prepared by a national organization, a manufacturer, or a user. The detail specification should be written in accordance with the layout of the blank detail specification described here.

This blank detail specification includes additional recommended environmental characteristics and severities, which are derived from the environmental classifications that are specified for cabling for various environments. Environmental classifications are presented in ISO/IEC 11801-1 with three levels of severity in four areas: mechanical, ingress, climatic, and electromagnetic; thus, in tabular form, they are referred to as the "MICE table".

The numbers shown in brackets on this and the following pages correspond to the following items of required information, which shall be entered in the spaces provided.

[1] Name and address of the organization that has prepared the document.

[2] IEC document number, issue number and date of issue.

[3] Address of the organization from which the document is available.

[4] Related documents.

[5] Any other reference to the cable: national reference, trade name, etc.

[6] A complete description of the cable, which should include:

a) type and number of elements;

b) nominal impedance;

c) screening;

d) application;

e) other distinguishing performance characteristics.

[7] Details of the cable material and construction.

[8] Special requirements for bending radius or operating temperatures.

[9] List of cable characteristics, separated into electrical, transmission, mechanical and environmental characteristics.

[10] Appropriate subclause references to this document.

[11] Requirements applicable to the relevant cable. The values entered should meet as a minimum the requirements of this document.

[12] Comments – Relevant remarks.

| | | | |
|---|---|---|---|
| [1] Prepared by: | | [2] Document:<br>Issue:<br>Date: | |
| [3] Available from: | | [4] Generic specification: IEC 61156-1<br>Sectional specification: IEC 61156-11<br>Blank detail specification: IEC 61156-11:2023, Annex A | |
| [5] Additional references: | | | |
| [6] Cable description:<br>a) Type and number of elements:<br>b) Nominal impedance:<br>c) Screening:<br>d) Application:<br>e) Other distinguishing performance characteristics: | | | |
| **[7] Cable construction:** | Subclause | | [12] Comments |
| | 5.2 | Cable construction: | |
| | 5.3 | Conductor description: | |
| | 5.4 | Insulation description:<br>Maximum diameter:<br>Colour code of elements: | |
| | 5.5 | Cable element: | |
| | 5.6 | Screening of the cable element:<br>Tape material<br>Minimum overlap<br>Drain wire<br>Braid wire<br>Braid material | |
| | 5.7 | Cable make-up: | |
| | 5.8 | Screening of the cable core:<br>Tape material<br>Minimum overlap<br>Drain wire<br>Braid wire<br>Braid material | |
| | 5.9 | Sheath:<br>Material<br>Nominal thickness<br>Colour<br>Maximum overall diameter<br>Marking<br>Ripcord | |
| | 5.10 | Identification | |
| | 5.11 | Packaging of finished cable | |
| [8]<br>Minimum bending radius for static bending:<br>Minimum bending radius for dynamic bending:<br>Temperature range for installation:<br>Operating temperature range under static conditions:<br>C1: −10 °C to +60 °C<br>C2: −25 °C to +70 °C<br>C3: −40 °C to +70 °C | | | |

| [9]<br>Characteristics | [10]<br>Subclause | [11] | [12]<br>Comments |
|---|---|---|---|
| **Electrical characteristics** | **6.2** | | |
| Conductor resistance | 6.2.1 | ≤ .... Ω/km | |
| Resistance unbalance<br>Resistance unbalance within a pair<br>Resistance unbalance between pairs | 6.2.2<br>6.2.2.1<br>6.2.2.2 | <br>≤ .... %<br>≤ .... % | |
| Dielectric strength<br>Conductor/conductor<br>Conductor/screen | <br>6.2.3 | <br>..... kV (time of application)<br>..... kV (time of application) | |
| Insulation resistance<br>Conductor/conductor<br>Conductor/screen | <br>6.2.4 | <br>≥ ... MΩ·km<br>≥ ... MΩ·km | |
| Mutual capacitance | 6.2.5 | ≤ .... nF/km | |
| Capacitance unbalance pair to ground | 6.2.6 | ≤ .... pF/km | |
| Transfer impedance | 6.2.7 | | Cable should be according to Grade 1 or Grade 2, if screened. |
| Coupling attenuation<br><br>Low frequency coupling attenuation | 6.2.8<br><br>6.2.8 | .....dB<br>Cable type.....<br>.....dB<br>Cable type..... | Cable type should be Type I, Ib or II. |
| Current-carrying capacity | 6.2.9 | .....mA | The current-carrying capacity is dependent on the installation conditions in accordance with ISO/IEC TS 29125. |
| **Transmission characteristics** | **6.3** | | |
| Velocity of propagation | 6.3.1 | | |
| Phase delay<br>Differential delay (delay skew) | 6.3.2.1<br>6.3.2.2 | ≤ ... ns/100 m<br>≤ ... ns/100 m | |
| Attenuation<br>General figures<br>Environmental temperature effects | 6.3.3<br>6.3.3.1<br>6.3.3.2 | <br>≤ ... dB/100 m<br>≤ ... %/°C | |
| Unbalance attenuation near-end (TCL)<br>Unbalance attenuation far-end (EL TCTL) | 6.3.4<br>6.3.4 | ≥ ... dB<br>≥ ... dB | Cable grade shall be identified. |
| Near-end crosstalk | 7.2.2, if applicable | ≥ ... dB | |
| Attenuation to crosstalk ratio far-end | 7.2.3, if applicable | ≥ ... dB | |
| Power sum alien (exogenous) near-end crosstalk | 6.3.5 | ≥ ... dB | |
| Power sum alien (exogenous) attenuation to crosstalk ratio far-end crosstalk | 6.3.6 | ≥ ... dB | |
| Alien crosstalk of bundled cables | 6.3.7 | ≥ ... dB | In case additional requirements are specified. |
| Fitted or mean impedance | 6.3.8 | | |
| Return loss | 6.3.9 | ≥ ... dB | |