INTERNATIONAL STANDARD

IEC 61156-5

First edition
2002-03

Multicore and symmetrical pair/quad cables for digital communications –

Part 5: Symmetrical pair/quad cables with transmission characteristics up to 600 MHz– Horizontal floor wiring – Sectional specification

Câbles multiconducteurs à paires symétriques et quartes pour transmissions numériques –

Partie 5: Câbles à paires symétriques et quartes avec caractéristiques de transmission allant jusqu'à 600 MHz – Câble capillaire – Spécification intermédiaire

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Câbles à paires symétriques et quartes avec caractéristiques de transmission allant jusqu'à 600 MHz –
Câble capillaire – Spécification intermédiaire*

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

Part 5: Symmetrical pair/quad cables with transmission characteristics up to 600 MHz – Horizontal floor wiring – Sectional specification

FOREWORD

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International Standard IEC 61156-5 has been prepared by subcommittee 46C: Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, RF connectors and accessories for communication and signalling.

The text of this standard is based on the following documents:

FDIS	Report on voting
46C/511/FDIS	46C/517/RVD

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

This standard should be read in conjunction with IEC 61156-1.

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

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

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- withdrawn;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

MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

Part 5: Symmetrical pair/quad cables with transmission characteristics up to 600 MHz – Horizontal floor wiring – Sectional specification

1 General

1.1 Scope

This sectional specification relates to IEC 61156-1: *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*. The cables described herein are specifically intended for horizontal floor wiring in class D, E and F channels, as defined in ISO/IEC 11801:2000, *Information technology – Generic cabling for customer premises* (see Table 1).

It covers individually screened (STP), common screened (FTP) and unscreened (UTP) pairs or quads having a pair count of four pairs or less. The transmission characteristics of the cables are specified at 20 °C. See Annex A for a discussion of cable performance at temperatures higher than 20 °C.

The designation "Category 5e" is used herein to describe an enhanced Category 5 cable and is used in the same context as "Category 5" in ISO/IEC 11801. This enhanced cable is designated Category 5e to differentiate it from the Category 5 cables described in IEC 61156-2, 61156-3, and 61156-4. Although both Category 5 and 5e cables are characterized to 100 MHz and can be used in Class D channels, Category 5e has additional requirements, as compared to Category 5, which make it preferred for use in systems utilizing four pairs transmitting simultaneously in both directions.

Table 1 – Cable categories

Cable designation	Maximum reference frequency MHz	Channel designation
Category 5e	100[a]	D
Category 6	250	E
Category 7	600	F

[a] Some characteristics are measured up to 125 MHz in order to comply with IEEE's request to specify the electrical performances up to a frequency 25 % higher than the referenced frequency.

These cables can be used for various communication systems that are under development and 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 sectional specification 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.

Though the recommended temperature range during installation is 0 °C +50 °C, the actual temperature range during installation should be indicated in the detail specification.

1.2 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.

ISO/IEC 11801:2000, *Information technology – Generic cabling for customer premises*

Publications cited in IEC 61156-1 also apply.

1.3 Installation considerations

Installation considerations will be addressed in a future revision of 1.3 of IEC 61156-1.

1.4 Climatic conditions

Under static conditions, the cables shall operate in the temperature range from –40 °C to +60 °C. The temperature dependence of the cables is specified for screened and unscreened cables, and should be taken into account for the design of an actual cabling systems.

2 Definitions, materials and cable construction

2.1 Definitions

See 2.1 of IEC 61156-1.

2.2 Materials and cable construction

2.2.1 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 the fire performance (such as burning properties, smoke generation, evolution of halogen gas, etc.).

2.2.2 Cable construction

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

2.2.3 Conductor

The conductor shall be a solid annealed copper conductor, in accordance with 2.2.3 of IEC 61156-1 and shall have a nominal diameter between 0,5 mm and 0,65 mm. Conductor diameter up to 0,8 mm may be used if compatible with the connecting hardware.

2.2.4 Insulation

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

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

The insulation may be solid or cellular with or without a solid dielectric skin. The insulation shall be continuous and shall have a thickness such that the completed cable meets the specified requirements. The nominal thickness of the insulation shall be compatible with the method of conductor termination.

2.2.5 Colour code of insulation

The colour code is not specified but shall be indicated in the relevant detail specification. The colours shall be readily identifiable and shall correspond reasonably with the standard colours shown in IEC 60304.

NOTE It is acceptable to mark or stripe the "a" wire with the colour of the "b" wire to facilitate pair identification.

2.2.6 Cable element

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

2.2.7 Screening of cable element

When required, the screen for the cable element shall be in accordance with 2.2.7 of IEC 61156-1.

2.2.8 Cable make-up

A cross web or any other spacer may be used to separate the cable elements. The cable elements, including cross webs or spacers, shall be assembled to form the cable core.

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

2.2.9 Screening of 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 2.2.9 of IEC 61156-1.

2.2.10 Sheath

The sheath material shall consist of a suitable thermoplastic 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.

2.2.11 Colour of sheath

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

2.2.12 Identification

Each length of cable shall be identified as to the manufacturer, and when required, the year of manufacture, using one of the following methods:

a) appropriately coloured threads or tapes;
b) with a printed tape;
c) printing on the cable core wrapping;
d) marking on the sheath.

Additional markings, such as length marking, etc., are permitted on the cable sheath. If used, such markings should be indicated in the relevant detail specification.

2.2.13 Finished cable

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

3 Characteristics and requirements

3.1 General remarks

This clause lists the characteristics and minimum requirements of a cable complying with this sectional specification. Test methods shall be in accordance with clause 3 of IEC 61156-1. A detail specification may be prepared to identify a specific product and its performance capabilities (see clause 4).

3.2 Electrical characteristics

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

3.2.1 Conductor resistance

When measured in accordance with 5.1 of IEC 60189-1, the maximum loop resistance shall not exceed 19,0 Ω/100 m of cable.

3.2.2 Resistance unbalance

The conductor resistance unbalance shall not exceed 2 %.

3.2.3 Dielectric strength

The test shall be performed on conductor/conductor and, where screen(s) are present, conductor/screen with 1,0 kV d.c. for 1 min or, alternately, 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 0,7kV a.c. for 1 min or, alternately, 1,7 kV a.c. for 2 s.

3.2.4 Insulation resistance

The test shall be performed both on

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

The minimum insulation resistance at 20 °C shall not be less than 5 000 MΩ/km.

3.2.5 Mutual capacitance

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

3.2.6 Capacitance unbalance pair to ground

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

3.2.7 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	60	1 000

3.2.8 Resistance of the screen

The d.c. resistance of the individual screens or an overall screen is not specified but may be indicated in the relevant detail specification.

3.3 Transmission characteristics

All the tests shall be carried out on a cable length of 100 m, unless otherwise specified.

3.3.1 Velocity of propagation, delay and differential delay (delay skew)

3.3.1.1 Velocity of propagation

The minimum velocity of propagation for any pair within the cable is equal to or greater than 0,6 × *c* for all frequencies between 4 MHz and the maximum referenced frequency. Value below 4 MHz are given only for information purposes (see 3.3.2).

NOTE The velocity of propagation, group velocity and phase velocity are approximately equal for frequencies greater than 4 MHz when measured on symmetric cables, i.e. when the cables are operated in a balanced mode.

3.3.1.2 Delay and differential delay (delay skew)

The delay for a specified length of cable is understood as the inverse of the velocity of propagation. The delay shall be less than or equal to:

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

where *f* is the frequency in MHz.

Differential delay (delay skew) is the difference in delay between any two pairs.

3.3.1.3 Differential delay (delay skew)

When the delay is measured at 10 ± 2 °C and 40 ± 1 °C, the maximum delay skew between any two pairs at a given temperature shall not be greater than 45 ns/100 m for cat5e and cat6 cables and 25 ns/100 m for cat7 cables in the frequency range from 4,0 MHz to the maximum referenced frequency.

3.3.1.4 Environmental effects

The differential delay (delay skew) between any two pairs due to temperature shall not vary by more than ±10 ns/100 m over the temperature range from –40 °C to +60 °C within the differential delay (delay skew) of 3.3.1.3.

3.3.2 Attenuation

3.3.2.1 General figures

The maximum attenuation α of any pair in the frequency range indicated in Table 3 shall be less than or equal to the value obtained from equation (2) using the corresponding values of the constants given in Table 3.

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

Table 3 – Attenuation, constant values

Cable designation	Frequency range MHz	Constants		
		a	***b***	***c***
Category 5e	4 – 125	1,967	0,023	0,100
Category 6	4 – 250	1,820	0,0169	0,250
Category 7	4 – 600	1,800	0,010	0,200
For Category 5e cables, the frequency range has been extended by 25 % to 125 MHz. In this case values above 100 MHz are for information only.				
NOTE See Annex B for information about ILD.				

The values in Table 4 are for information only. Because the measurement of attenuation at 1 MHz on a length of 100 m is prone to error, these values are given in brackets for reference purposes only.

Table 4 – Attenuation at 20 °C

Frequency MHz	Attenuation at 20 °C dB/100 m		
	Cable designation		
	Category 5e	**Category 6**	**Category 7**
1	[2,1]	[2,1]	[2,0]
4	4,1	3,8	3,7
10	6,5	6,0	5,9
16	8,3	7,6	7,4
20	9,3	8,5	8,3
31,25	11,7	10,8	10,4
62,5	17,0	15,5	14,9
100	22,0	19,9	19,0
125	[24,9]	22,5	21,4
200		29,2	27,5
250		33,0	31,0
300			34,2
600			50,1

3.3.2.2 Cat5e special consideration

The constants for Category 5e in Table 3 are based on the use of patch cables having a 20 % higher attenuation than the horizontal cable. When patch cables having an attenuation up to 50 % higher than the horizontal cable are used, the constants should be 1,910 8; 0,022 2, and 0,200 for *a*, *b*, and *c* respectively.

3.3.2.3 Environmental effects

The increase in attenuation due to elevated temperature shall not be greater than 0,4 %/°C, in the frequency range from 1 MHz to 250 MHz and 0,6 %/°C for frequencies above 250 MHz for unscreened cables and 0,2 %/°C for screened cables.

The method for determining compliance with this requirement is under consideration.

3.3.3 Unbalance attenuation

The minimum unbalance attenuation near-end (transverse conversion loss or TCL) shall be equal to or greater than the value obtained from equation (3) for the frequency ranges given in Table 5.

The formula for the TCL is

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

Table 5 – Unbalance attenuation near-end

Cable category	Frequency range for TCL MHz
Category 5e	1 – 100
Category 6	1 – 200
Category 7	1 – 200

NOTE Unbalance attenuation near-end (TCL) for Category 7 at frequencies greater than 200 MHz is for further study.

The minimum equal level unbalance attenuation far end (equal level transverse conversion transfer loss or EL TCTL) for all categories shall be equal to or greater than the value obtained from equation (4) for all frequencies in the range from 1 MHz to 30 MHz.

The formula for the EL TCTL is

$$\text{EL TCTL} = 35{,}0 - 20 \times \log_{10}(f) \quad \text{(dB)} \tag{4}$$

3.3.4 Near-end crosstalk (NEXT)

When measured in accordance with IEC 61156-1, the worst pair power sum near-end crosstalk, PS NEXT, of any pair in the frequency range indicated in Table 6 shall be equal to or greater than the value obtained from equation (5) using the corresponding value of PS NEXT(1) given in Table 6.

$$\text{PS NEXT}(f) = \text{PS NEXT}(1) - 15 \times \log_{10}(f) \quad \text{(dB)} \tag{5}$$

Table 6 – Worst pair PS NEXT values

Cable designation	Frequency range MHz	PS NEXT(1) dB
Category 5e	4 – 125	62,3
Category 6	4 – 250	72,3
Category 7	4 – 600	99,4

For Category 5e cables, the frequency range has been extended by 25 % to 125 MHz. Values above 100 MHz are for information only and are given in brackets.

The values given in Table 7 are for information only. For those frequencies where the calculated value of PS NEXT is greater than 75dB, the requirement shall be 75 dB.

Table 7 – PS NEXT

PS NEXT dB			
Frequency MHz	**Cable designation**		
	Category 5e	**Category 6**	**Category 7**
1	62	72	75
4	53	63	75
10	47	57	75
16	44	54	75
20	43	53	75
31,25	40	50	75
62,5	35	45	72
100	32	42	69
125	[31]	41	68
200		38	65
250		36	63
300			62
600			58

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

3.3.5 Far-end crosstalk (FEXT)

When measured in accordance with IEC 61156-1, the worst pair power sum equal level far-end crosstalk, PS EL FEXT, of any pair in the frequency range indicated in Table 8 shall be equal to or greater than the value obtained from equation (6) using the corresponding value of the PS EL FEXT(1) given in Table 8.

$$\text{PS EL FEXT}(f) = \text{PS EL FEXT}(1) - 20 \times \log_{10}(f) \quad (\text{dB for 100 m}) \qquad (6)$$

Table 8 – Worst pair PS EL FEXT

Cable designation	**Frequency range** MHz	**PS EL FEXT(1)** dB for 100 m
Category 5e	4 – 100	61,0
Category 6	4 – 250	65,0
Category 7	4 – 600	91,0
NOTE If FEXT loss is greater than 70 dB, EL FEXT loss has not to be measured		

For Category 5e cables, the frequency range has been extended by 25 % to 125 MHz. Values above 100 MHz are for information only and are given in brackets.

The values given in Table 9 are for information only. For those frequencies where the calculated value of PS EL FEXT is greater than 75 dB, the requirement shall be 75 dB.

Table 9 – PS EL FEXT

PS EL FEXT dB for 100 m			
Frequency MHz	**Cable designation**		
	Category 5e	**Category 6**	**Category 7**
1	61	65	75
4	49	53	75
10	41	45	71
16	37	41	67
20	35	39	65
31,25	31	35	61
62,5	25	29	55
100	21	25	51
125	19	23	49
200		19	45
250		17	43
300			41
600			35

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

3.3.6 Characteristic impedance

3.3.6.1 Open-short circuit impedance (input impedance)

The magnitude of the input impedance, when measured in a swept frequency mode (open-short circuit method per 3.3.6.2.2 of IEC 61156-1) over the frequency range from 4 MHz to the maximum referenced frequency shall meet the requirements given in Table 10.

Table 10 – Input impedance

Input impedance Ω			
Frequency range MHz	**Cable designation**		
	Category 5e	**Category 6**	**Category 7**
4 – 100	N ± 15	N ± 15	N ± 15
100 – 250		N ± 22	N ± 22
200 – 600			N ± 25
N = nominal impedance			

Measurement of input impedance is not required when the mean characteristic impedance of 3.3.8.2 is measured.

3.3.6.2 Function fitted impedance/mean characteristic impedance

When measured in accordance with 3.3.6.3, 3.3.6.3/3.3.6.2.3 or 3.3.6.3/3.3.6.2.3 to 3.3.6.2.5 of IEC 61156-1, the mean characteristic impedance shall be within ±5 % of the requested nominal impedance at 100 MHz.

3.3.7 Return loss (RL)

When measured in accordance with 3.3.7 of IEC 61156-1, the minimum return loss of any pair in the frequency range indicated in Table 11 shall be equal to or greater than the values in Table 11 for the respective categories.

Table 11 – Return loss

Cable category	Frequency range MHz	Return loss dB
All	4 – 10	$20{,}0 + 5{,}0 \times \log_{10}(f)$
All	10 – 20	25,0
Category 5e	20 – 125	$25{,}0 - 7{,}0 \times \log_{10}(f/20)$
Category 6 and Category 7	20 – 250	$25{,}0 - 7{,}0 \times \log_{10}(f/20)$
Category 7	250 – 600	$25{,}0 - 7{,}0 \times \log_{10}(f/20)$
NOTE Calculated values below 17,3 dB revert to a 17,3 dB plateau.		

For Category 5e cables, the frequency range has been extended by 25 % to 125 MHz. Values above 100 MHz are for information only.

3.3.8 Screening attenuation

Two grades of performance are recognized for screening attenuation. Screening attenuation is a part of the coupling attenuation. When measured separately, using the absorbing clamp method, the screening attenuation for cables containing a screen in the frequency range from 30,0 MHz to the maximum referenced frequency shall be equal to or greater than the values indicated below:

– for Grade 1 cables: ≥60 dB;

– for Grade 2 cables: ≥40 dB.

There are no requirements for unscreened cables.

3.3.9 Coupling attenuation

Three types of performance are recognised for coupling attenuation. When measured using the absorbing clamp method, the coupling attenuation in the frequency range from f = 30,0 MHz to the maximum referenced frequency shall be equal to or greater than the values indicated in Table 12.

Table 12 – Coupling attenuation

Coupling attenuation type	Frequency range MHz	Coupling attenuation dB
Type I	30 – 100	≥85,0
	100 to the maximum referenced frequency	$\geq 85{,}0 - 20 \times \log_{10}(f/100)$
Type II	30 – 100	≥55,0
	100 to the maximum referenced frequency	$\geq 55{,}0 - 20 \times \log_{10}(f/100)$
Type III	30 – 100	≥40,0
	100 to the maximum referenced frequency	$\geq 40{,}0 - 20 \times \log_{10}(f/100)$

3.3.10 Crosstalk in bundled cable

Bundled cables are also referred to as speed-wrap, whip or loomed cables. Bundled cables are an assembly of several individual cables. Crosstalk between individual cables comprising a bundled cable is only a consideration for unscreened cable designs.

For these cables the power sum crosstalk (both PS NEXT and PS EL FEXT) of any pair in one cable due to all disturbing pairs in the surrounding cables shall be 5 dB better than the power sum crosstalk requirement for the individual cable.

3.3.10.1 Crosstalk in hybrid bundled cables

Hybrid bundled cables are defined as bundled cables containing several individual cables of different categories. In this case the power sum crosstalk (PS NEXT and PS EL FEXT) of any pair in a cable of a specified category shall be 6 dB better than the power sum crosstalk for the specified category of the cable. The power sum crosstalk is defined as the total power coupled from all disturbing pairs in the surrounding and/or adjacent cables into the pair under consideration.

3.3.11 Alien crosstalk

Alien crosstalk is only a consideration for unscreened cables. Alien crosstalk is the combined capacitive and inductive crosstalk coupling from neighbouring cables into the cable under consideration. The neighbouring cables may be used for data communication under the same protocol or for entirely different protocols. The alien crosstalk is, therefore, statistical in nature, and cannot be compensated for. The installation of these cables in open trays or ducts requires an additional crosstalk margin in order to guarantee sufficient crosstalk isolation. As the cables in the tray or duct are not as systematically laid up as in bundled cables, the required crosstalk margin is lower than the power sum crosstalk margin for bundled cables.

For any application where the cables are installed partially parallel, an additional power sum crosstalk margin (for PS NEXT and PS EL FEXT) may be required to compensate for alien crosstalk.

3.4 Mechanical and dimensional characteristics and requirements

3.4.1 Dimensional requirements

The maximum cable diameter shall not exceed 20 mm. 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.

3.4.2 Elongation at break of the conductors

The minimum elongation of the conductor shall be 8 %.

3.4.3 Elongation at break of the insulation

The minimum value of the elongation at break of the insulation shall be 100 %.

3.4.4 Elongation at break of the sheath

The minimum value of the elongation at break of the sheath shall be 100 %.

3.4.5 Tensile strength of the sheath

The minimum tensile strength of the sheath shall be 9 MPa.

3.4.6 Crush test of the cable

The crush test of the cable is not specified but may be indicated in the relevant detail specification. If specified, the minimum force shall be 1 000 N.

3.4.7 Impact test of the cable

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

3.4.8 Bending under tension

The bending under tension test of the cable is not specified but may be indicated in the relevant detail specification (under consideration).

3.4.9 Tensile performance of the cable

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

During installation, the value of the pulling force shall not exceed 20 N per pair.

3.5 Environmental characteristics

3.5.1 Shrinkage of insulation

When tested at 100 °C ± 2 °C for 1 h, the shrinkage of the insulation shall be less than or equal to 5 %. The length of the sample shall be 150 mm, and the shrink-back shall be measured as the sum from both ends.

3.5.2 Wrapping test of insulation after thermal ageing

Not applicable.

3.5.3 Bending test of insulation at low temperature

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

3.5.4 Elongation at break of the sheath after ageing

The ageing regime shall be 7 days at 100 °C ± 2°C. The tensile strength shall not be less than 50 % of the unaged value.

3.5.5 Tensile strength of the sheath after ageing

The ageing regime shall be 7 days at 100 °C ± 2 °C. The elongation shall not be less than 70 % of the unaged value.

3.5.6 Sheath pressure test at high temperature

Not applicable.

3.5.7 Cold bend test of the cable

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

3.5.8 Heat shock test

Not applicable.

3.5.9 Flame propagation characteristics of a single cable

If required by local regulations and indicated in the relevant detail specification, the test shall be performed in accordance with the generic specification (IEC 61156-1).

3.5.10 Flame propagation characteristics of bunched cables

If required by local regulations and indicated in the relevant detail specification, the test shall be performed in accordance with the generic specification.

3.5.11 Acid gas evolution

If required by local regulations and indicated in the relevant detail specification, the test shall be performed in accordance with the generic specification.

3.5.12 Smoke generation

If required by local regulations and indicated in the relevant detail specification, the test shall be performed in accordance with the generic specification.

3.5.13 Toxic gas emission

Under consideration.

3.5.14 Combined flame and smoke test

Under consideration.

4 Introduction to the blank detail specification

The blank detail specification for cables, described in this standard is published as IEC 61156-5-1 and should be used to identify a specific product.

When completing the detail specification, the following information shall be supplied:

a) conductor size;
b) number of elements;
c) cable construction details;
d) category number (5e, 6, 7) to describe basic performance requirements;
e) nominal impedance of the cable;
f) flammability requirements.

Annex A
(informative)

Cable performance at temperatures higher than 20 °C

In order to ensure compliance of the horizontal cable with the requirements of this specification at temperatures greater than 20 °C, either a cable with a lower attenuation should be used or the maximum channel length should be decreased. The channel performance is outlined in ISO/IEC 11801 for a temperature of 20 °C. Here only the required attenuation improvement of the horizontal cable is considered.

The attenuation of patch cables is to all practical purposes very close to the requirement limits. Therefore, any elevated temperature of the patch cable has to be compensated for by the horizontal cable.

The reduction of the horizontal cable in the channel, and therefore also the reduction of the entire channel length should be calculated using ISO/IEC 11801.

Here attenuation improvement factors are given, which indicate the required attenuation improvement of the horizontal cable, in order to compensate for temperature.

The required attenuation improvement factors have been calculated based upon the channel model of ISO/IEC 11801, for the temperatures indicated and for four temperatures of the patch cable. These calculations are based upon the attenuation at the maximum referenced frequency for the different categories (see 1.1 of IEC 61156-5). The calculation is based on the full channel length according to ISO/IEC 11801 at 20 °C. For ease of use, the equation (A.1-7) may be used in conjunction with the factors indicated in Table A.1 or the Figures A.1 and A.2.

The exact steps of the calculation are given in the following:

For the attenuation of the cable at the reference temperature of 20 °C, we have:

$$\alpha_{\text{Cable at 20 °C}} = a \times \sqrt{f_{\text{Ref}}} + b \times f_{\text{Ref}} + \frac{c}{\sqrt{f_{\text{Ref}}}} \quad \text{(dB/100 m)} \qquad \text{(A.1)}$$

For the insertion loss of the channel, we have:

$$\alpha_{\text{Channel at 20 °C}} = (1 + 0{,}1 \times D) \times \alpha_{\text{Cable at 20 °C}} + 4 \times \alpha_{\text{Conn}} \times \sqrt{f_{\text{Ref}}}$$

$$\alpha_{\text{Channel at 20 °C}} = (1 + 0{,}1 \times D) \times \left(a \times \sqrt{f_{\text{Ref}}} + b \times f_{\text{Ref}} + \frac{c}{\sqrt{f_{\text{Ref}}}} \right) \quad \text{(dB/100 m)} \qquad \text{(A.2)}$$

$$+ 4 \times \alpha_{\text{Conn}} \times \sqrt{f_{\text{Ref}}}$$

where

$\alpha_{\text{Cable at 20°C}}$ is the attenuation of the cable at 20 °C and at the maximum referenced frequency;

$\alpha_{\text{Channel at 20°C}}$ is the insertion loss of the channel at 20 °C and at the maximum referenced frequency;

α_{Conn} is the insertion loss of the connectors in the channel (see 6.5.5 of ISO/IEC 11801; equals 0,04 for class D and 0,02 for class E and F channels);

f_{Ref} is the maximum referenced frequency in MHz (see 1.1);

a; b; c are the attenuation coefficients of the horizontal cable (see 3.3.3).

D is the increase of attenuation factor for patch cables with respect to horizontal cables (either 20 % or 50 %. See 3.3.3 of IEC 61156-6).

Average expected temperature differential of the horizontal cable with respect to 20 °C:

$$\Delta T_{\text{horizontal cable}} = \left(T_{\text{horizontal cable}} - 20\right) \quad (°\text{C}) \tag{A.3}$$

Average expected temperature differential of the patch cable with respect to 20 °C:

$$\Delta T_{\text{patch cable}} = \left(T_{\text{patch cable}} - 20\right) \quad (°\text{C}) \tag{A.4}$$

For the insertion loss of the channel at elevated average temperatures of the horizontal cable and the patch cable, we have then:

$$\begin{aligned}\alpha_{\text{Channel Temp}} = {} & 0{,}9 \times \alpha_{\text{Cable at 20°C}} \times \left(1 + \Delta T_{\text{horiz, cable}} \times \delta_{\text{horiz, cable}}\right) \\ & + 0{,}1 \times (1 + D) \times \alpha_{\text{Cable at 20°C}} \times \left(1 + \Delta T_{\text{patch cable}} \times \vartheta_{\text{patch cable}}\right) \\ & + 4 \times \alpha_{\text{Conn}} \times \sqrt{f_{\text{Ref}}}\end{aligned} \tag{A.5}$$

where

$\alpha_{\text{Channel temp}}$ is the insertion loss of the channel at an elevated temperature of the cables and at the maximum referenced frequency;

$\delta_{\text{horiz,cable}}$ is the temperature coefficient of attenuation increase of the horizontal cable in %/°C;

$\vartheta_{\text{patch cable}}$ is the temperature coefficient of attenuation increase of the patch cable in %/°C.

For the required attenuation improvement factor, which is required if the horizontal cable and the patch cable are exposed to higher temperatures than 20 °C, we obtain then:

$$\kappa = \frac{0{,}9 \times \alpha_{\text{Cable at 20 °C}} \times \left(\alpha_{\text{Channel temp}} - \alpha_{\text{Channel at 20° C}}\right)}{0{,}9 \times \alpha_{\text{Cable at 20 °C}}} \times 100 \quad (\%) \tag{A.6}$$

Hence, we get for the required attenuation of the horizontal cable at elevated temperatures of both the horizontal and the patch cable with the attenuation improvement factor of equation (A.6):

$$\alpha_{\text{Cable temp}}\left(f_{\text{Ref}}\right) = \frac{\kappa \times \alpha_{\text{Cable at 20 °C}}\left(f_{\text{Ref}}\right)}{100} \quad (\text{dB / 100 m}) \tag{A.7}$$

where

$\alpha_{\text{Cable temp}}(f_{\text{Ref}})$ is the attenuation of the cable required to cope with the elevated temperature of the cables and at the maximum referenced frequency;

$\alpha_{\text{Cable at 20°C}}(f_{\text{Ref}})$ is the specified attenuation of the cable at 20 °C at the maximum referenced frequency.

NOTE 1 If the increase in attenuation due to humidity is also to be considered, then the equation (B-9) of Annex B should be used (see also 3.3.3.2 of IEC 61156-6).

NOTE 2 The above outlined calculation can also take a temperature coefficient for the insertion loss of the connectors into account, if this should be necessary.

The calculated values are listed in Table A.1.

Table A.1 – Attenuation improvement factors (if the specified cables are used at temperatures higher than 20 °C)

Horizontal cable temp. °C	Required attenuation improvement factor %							
	Cat. 5e UTP Cat. 6 UTP				Cat. 5e FTP/STP Cat. 6 FTP/STP Cat. 7 STP			
	Patch cable attenuation derating							
	20 %				50 %			
	Temperature of patch cord °C							
	20	25	30	35	20	25	30	35
20	100,0	99,6	99,2	98,8	100,0	99,7	99,3	99,0
22	99,2	98,8	98,4	98,0	99,6	99,3	98,9	98,6
24	98,4	98,0	97,6	97,2	99,2	98,9	98,5	98,2
26	97,6	97,2	96,8	96,4	98,8	98,5	98,1	97,8
28	96,8	96,4	96,0	95,6	98,4	98,1	97,7	97,4
30	96,0	95,6	95,2	94,8	98,0	97,7	97,3	97,0
32	95,2	94,8	94,4	94,0	97,6	97,3	96,9	96,6
34	94,4	94,0	93,6	93,2	97,2	96,9	96,5	96,2
36	93,6	93,2	92,8	92,4	96,8	96,5	96,1	95,8
38	92,8	92,4	92,0	91,6	96,4	96,1	95,7	95,4
40	92,0	91,6	91,2	90,8	96,0	95,7	95,3	95,0
42	91,2	90,8	90,4	90,0	95,6	95,3	94,9	94,6
44	90,4	90,0	89,6	89,2	95,2	94,9	94,5	94,2
46	89,6	89,2	88,8	88,4	94,8	94,5	94,1	93,8
48	88,8	88,4	88,0	87,6	94,4	94,1	93,7	93,4
50	88,0	87,6	87,2	86,8	94,0	93,7	93,3	93,0
52	87,2	86,8	86,4	86,0	93,6	93,3	92,9	92,6
54	86,4	86,0	85,6	85,2	93,2	92,9	92,5	92,2
56	85,6	85,2	84,8	84,4	92,8	92,5	92,1	91,8
58	84,8	84,4	84,0	83,6	92,4	92,1	91,7	91,4
60	84,0	83,6	83,2	82,8	92,0	91,7	91,3	91,0

The Figures A.1 to A.2 represent the data of Table A.1 in a graphical form.

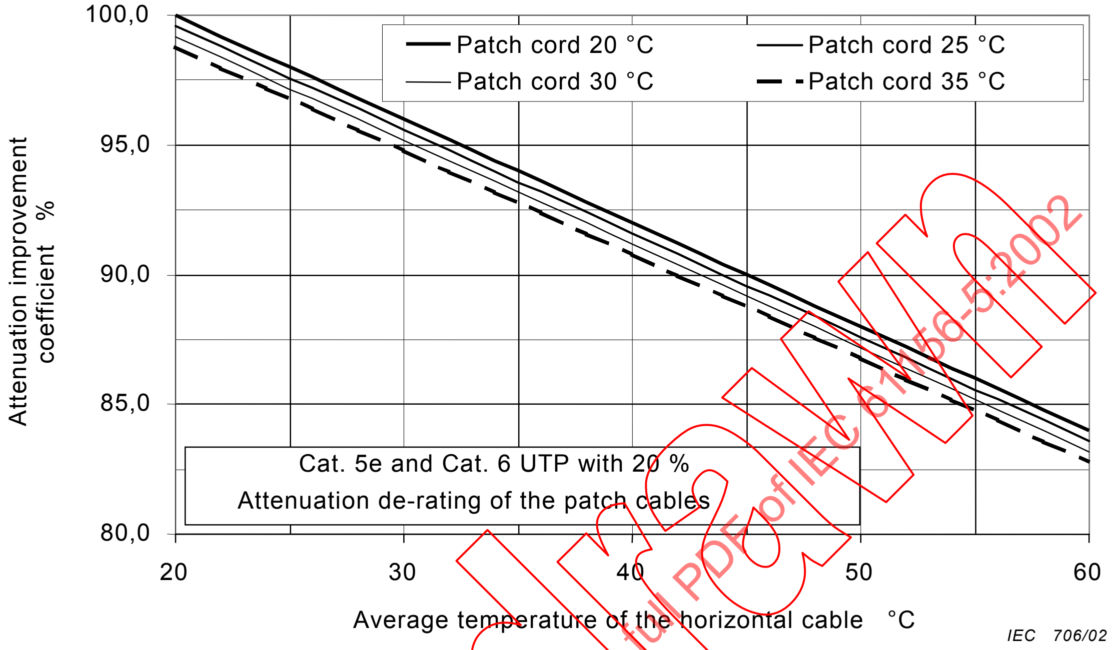

Figure A.1 – Attenuation improvement factor for Category 5e and Category 6 UTP with 20 % increase of attenuation of the patch cables relative to the horizontal cables

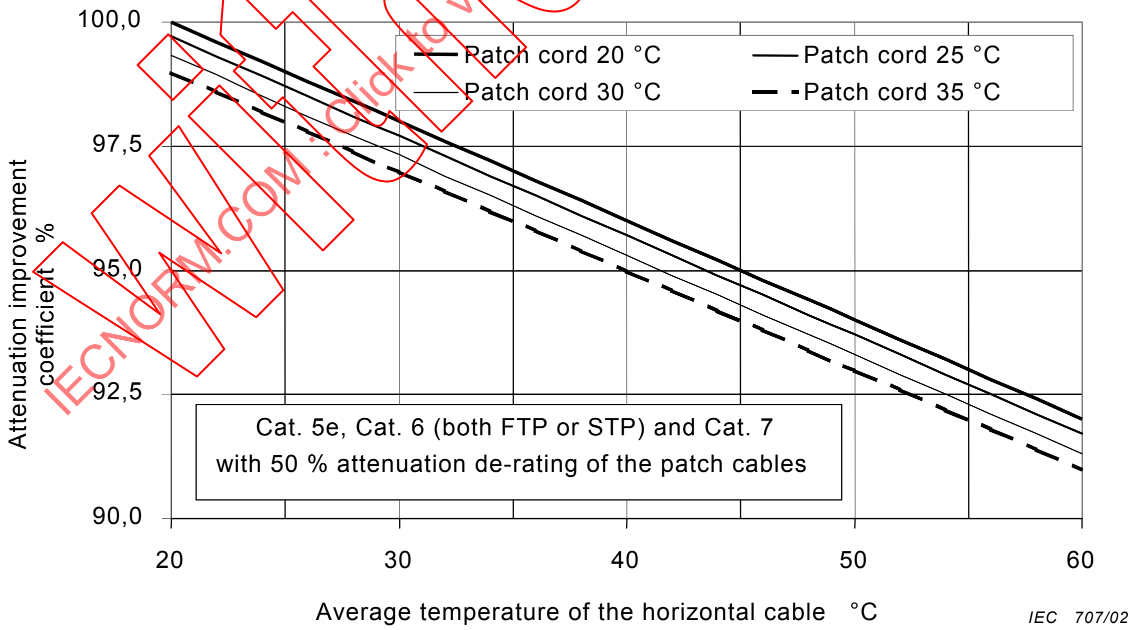

Figure A.2 – Attenuation improvement factor for Category 5e, Category 6 and Category 7 FTP/STP with 50 % Increase of attenuation of the patch cables relative to the horizontal cables

Annex B
(informative)

Insertion loss deviation as a result of cascading components with differing impedance

IEC 61156-1 specifies the measurement of attenuation as an insertion loss measurement. A concise definition of insertion loss is given for modeling purposes. It is derived under the assumption of short transmission lines with low round trip loss. This assumption is justified for all the components of channels and links, and in fact for the channel itself, even at maximum length. The derivation eliminates also the mismatch of generator and load, if they are connected back to back, thus that only the operational attenuation of the device under test or the cascaded component chain is represented.

The insertion loss (IL) of a homogeneous transmission line or any homogeneous device is the result of inserting the transmission line or device of impedance Z_o between a generator Z_G and a load Z_L. For differing impedance we get the following circuit diagram:

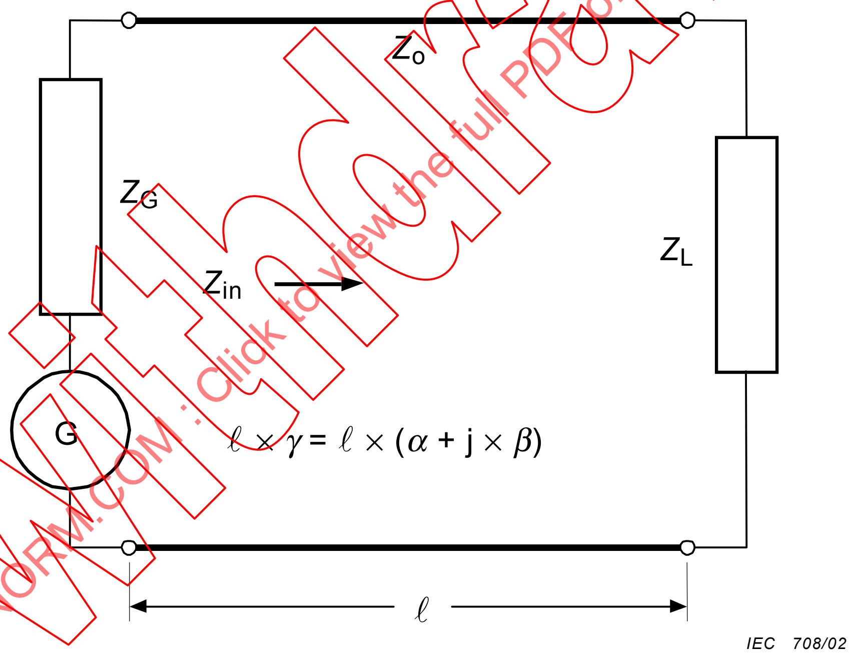

Figure B.1 – Insertion loss measurement – Circuit diagram

We have then the complex insertion loss of the transmission line, which consists of the image attenuation, the image phase and several complex reflection loss terms:

$$IL = \left[+ \alpha \times \ell + \ln\left(\frac{1}{\tau_1}\right) + \ln\left(\frac{1}{\tau_2}\right) - \ln\left(\frac{1}{\tau_3}\right) + \ln\left(\frac{1}{\tau_4}\right) \right] \quad \text{(Np)}$$
$$+ j \times \left(+ \beta \times \ell - \arg(\tau_1) - \arg(\tau_2) + \arg(\tau_3) - \arg(\tau_4) \right) \quad \text{(rad)} \qquad \text{(B.1)}$$

Corresponding to:

$$IL = \left[+ \alpha \times \ell + 20 \times \log\left(\frac{1}{\tau_1}\right) + 20 \times \log\left(\frac{1}{\tau_2}\right) - 20 \times \log\left(\frac{1}{\tau_3}\right) + 20 \times \log\left(\frac{1}{\tau_4}\right)\right] \quad \text{(dB)} \qquad \text{(B.2)}$$

$$+ j \times \left(+ \beta \times \ell - \arg(\tau_1) - \arg(\tau_2) + \arg(\tau_3) - \arg(\tau_4) \right) \quad \text{(rad)}$$

where

IL is the insertion loss of the transmission line in Np or dB;

τ_1 is the reflection loss coefficient (see note 1) due to the mismatch between the generator and the transmission line;

τ_2 is the reflection loss coefficient due to the mismatch between the transmission line and the load;

τ_3 is reflection loss coefficient due to the mismatch between generator and the load, if no transmission line would be present. This loss is inherent to generator and load, and has nothing to do with the insertion loss of the line or the component, hence is has to be subtracted (see note 2);

τ_4 is the resulting interaction loss coefficient for short transmission lines (see note 3);

ℓ is the length of transmission line in m;

α image and operational attenuation in Np/m or dB/m;

β phase angle, phase constant or image phase shift in rad.

NOTE 1 For junction reflections and losses, the following terms and definitions are used for a junction between the impedance Z_1 and Z_2 :

where

τ is the reflection loss coefficient $= \sqrt{1 - \rho^2} = \frac{\sqrt{P_t}}{\sqrt{P_i}}$

ρ is the reflection coefficient $= \frac{Z_2 - Z_1}{Z_2 + Z_1} = \frac{\sqrt{P_r}}{\sqrt{P_i}}$

A_t is the reflection loss $= 20 \times \log_{10}\left|\frac{1}{\tau}\right|$ (dB)

A_r is the return loss $= RL = 20 \times \log_{10}\left|\frac{1}{\rho}\right|$ (dB)

P_i is the incident power

P_r is the reflected power

P_t is the through power

NOTE 2 For cascaded components of course this is true only for the generator and load impedance at the extremes of the cascade.

NOTE 3 The interaction factor is unity, if $Z_o = Z_G$ and $Z_o = Z_L$, and close to unity if $|\gamma| >> 0$ or $\alpha >> 0$.