INTERNATIONAL STANDARD

ISO/IEC 11801

1995

AMENDMENT 2
1999-12

Amendment 2

Information technology –
Generic cabling for customer premises

Amendement 2

Technologies de l'information –
Câblage générique des locaux d'utilisateurs

PRICE CODE N

For price, see current catalogue

FOREWORD

Amendment 2 to International Standard ISO/IEC 11801 was prepared by subcommittee 25: Interconnection of information technology, of ISO/IEC joint technical committee 1: Information technology.

Attention is drawn to the possibility that some of the elements in this amendment may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

General

Update references to tables, the numbers of which have been changed.

Page 2

Insert, in the existing list, the titles of the following standards:

IEC 60793-1 (all parts), *Optical fibres – Part 1: Generic specification*

IEC 60874-19 (all parts), *Connectors for optical fibres and cables*

IEC 61035-1, *Specification for conduit fittings for electrical installations – Part 1: General requirements*

IEC 61280-4 (all parts), *Fibre optic communication subsystem basic test procedures – Part 4: Fibre optic requirements*

IEC 61935-1,— *Generic specification for the testing of generic cabling in accordance with ISO/IEC 11801 – Part 1: Test methods* [1)]

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3.1 Definitions

Add a new definition and renumber the following ones:

3.1.34
permanent link
the transmission path between two mated interfaces of generic cabling, excluding equipment cables, work area cables and cross-connections

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1) To be published.

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4 Conformance

Add the following new paragraph:

References to the requirements and classifications specified in this International Standard shall specifically differentiate components and systems conforming to ISO/IEC 11801 (1995) from those that are qualified according to ISO/IEC 11801 (1995), including amendment 1 (1999) and amendment 2 (1999), by specifically referencing ISO/IEC 11801 (1995), including amendment 1 (1999) and amendment 2 (1999). For the purpose of component marking and system identification, it is appropriate to directly reference the year of publication of the second amendment, or to use a specific designation that provides linkage to it.

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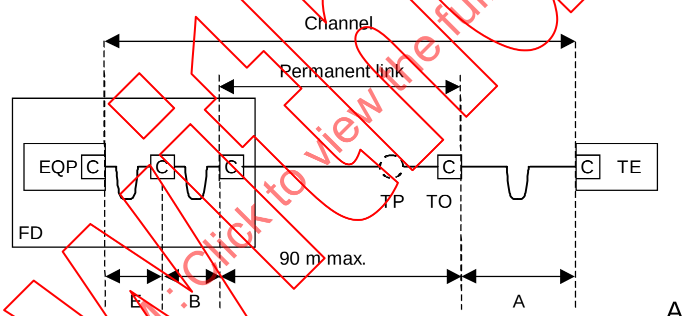
6.1.1 Horizontal distances

Replace the entire subclause by the following new subclause:

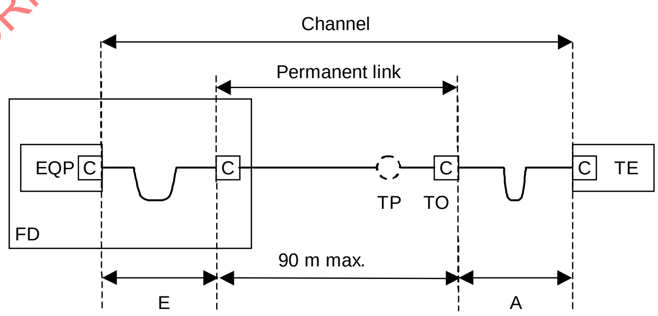
The maximum horizontal cable length shall be 90 m independent of medium (see figure 6). This is the cable length from the mechanical termination of the cable in the floor distributor to the telecommunications outlet in the work area.

In establishing the maximum length of the horizontal channel, the optional use of a crossconnect or an interconnect places different requirements on the total length of the flexible cables used. Figure 7 shows examples of horizontal channel implementations which reflect these differing requirements of maximum cable length.



A + B + E = 9 m maximum

Figure 7a – Balanced copper horizontal cabling (with crossconnect)



A + E = 10 m maximum

Figure 7b – Balanced copper horizontal cabling (with interconnect)

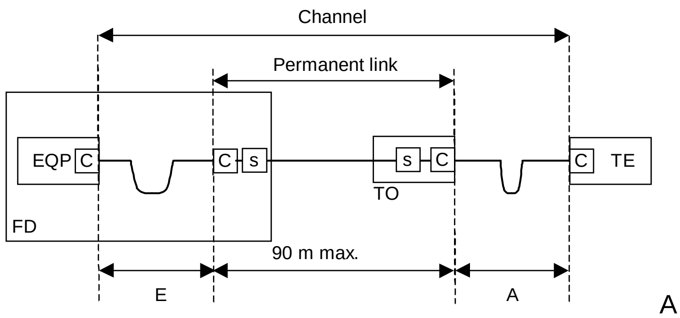


Figure 7c – Optical fibre cabling (with interconnect)

Key

C connection (e.g. plug and jack or mated optical connection)

S optical fibre splice

EQP application specific equipment

NOTE 1 All lengths are mechanical lengths.

NOTE 2 See annex C for further information on flexible cables.

Figure 7 – Examples of horizontal channel implementation

In figure 7a, the maximum total length of work area cable equipment cable and patch cord is 9 m based upon flexible cables with 50 % greater attenuation than the horizontal cable and includes a crossconnect in the floor distributor. In figure 7b, the maximum total length of work area cable and equipment cable is 10 m also based upon flexible cables with 50 % greater attenuation than the horizontal cable and includes an interconnect in the floor distributor. In both cases the transition point is optional. It is required that the performance of the horizontal cabling is not degraded by the inclusion of the transition point.

For optical fibre, the implementation is shown in figure 7c. An optical fibre splice, in accordance with clause 9, is allowed at both ends of the horizontal cable.

See clause 9 and annex C for requirements for patch cords and other flexible cables. In all cases, equipment cables that meet or have better performance characteristics than patch cord requirements are recommended.

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7 Link specifications

Replace the existing title and text of this clause by the following new text:

7 Permanent link and channel specifications

7.1 Permanent links and channels

7.1.1 General

This clause defines the permanent link and channel performance requirements of installed generic cabling. The performance of the cabling is specified for individual permanent links and channels and for two different media types (balanced cables and optical fibre). A tutorial on the material in this clause is provided in annex F.

The design rules of clause 6 can be used to create generic cabling links and channels containing components specified in clauses 8 and 9. It is not necessary to measure every parameter specified in this clause as conformance may also be proven by suitable design. The permanent link and channel specifications in this clause allow for the transmission of defined classes of applications over distances other than those of clause 6, and/or using media and components with different transmission performances than those of clauses 8 and 9.

The permanent link and channel performance requirements specified in this clause shall be met at each interface specified for each medium.

The performance requirements described in this clause may be used as verification tests for any implementation of this International Standard, using the test methods defined, or referred to, by this clause. The permanent link requirements are primarily intended to provide a basis for the acceptance testing of installed cabling. The channel requirements are primarily for application developers but are able to be used for troubleshooting where application support is under development.

Permanent link and channel performance specifications shall be met for all temperatures at which the cabling is intended to operate. Performance testing may be carried out at ambient temperature, but there shall be adequate margins to account for temperature dependence of cabling components as per their specifications. The effects of ageing should also be taken into account. In particular, consideration should be given to measuring performance at worst case temperatures, or calculating worst case performance based on measurements made at other temperatures.

Care should be exercised in the interpretation of any results obtained from alternative test methods or practices. When needed, correlation factors should be identified and applied.

7.1.2 Permanent links

The performance of a permanent link is specified at and between interfaces to the link. The permanent link comprises only passive sections of cable and connecting hardware. A transition point may also be included in the horizontal subsystem. Active and passive application specific hardware is not addressed by this International Standard (figure 11).

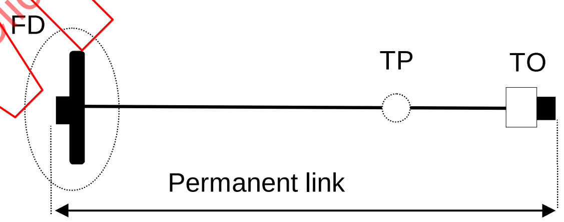


Figure 11 – Permanent link

Figure 12a shows an example of terminal equipment in the work area connected to a host using three links; two optical fibre links and a balanced cable link. The optical fibre and balanced cable links are connected together using an optical fibre to balanced cable converter, a cross-connect and two equipment cables. Interfaces to the cabling are at each end of a permanent link. Interfaces to the cabling are specified at the TO and at any point where application specific equipment is connected to the cabling; the work area and equipment cables are not included in the permanent link.

Interfaces to the cabling are at each end of a permanent link. Interfaces to the cabling are specified at the TO and at any point where application specific equipment is connected to the cabling; the work area and equipment cables are not included in the permanent link.

NOTE For balanced cabling the limits for the permanent link in this clause are calculated on the basis of 90 m of installed cable and two connections.

7.1.3 Channels

The performance of the channel is specified at and between interfaces to the channel. The cabling comprises only passive sections of cable, connecting hardware, work area cords, equipment cords and patch cords.

Figure 12b shows an example of terminal equipment in the work area connected to a host using two channels; an optical fibre channel and a balanced cabling channel. The optical fibre and balanced cabling channels are connected together using an optical fibre to balanced cable converter. There are four channel interfaces; one at each end of the copper channel, and one at each end of the optical fibre channel. Equipment connections are not considered to be part of the channel. All work area, equipment cables and patch cords are included in the channel.

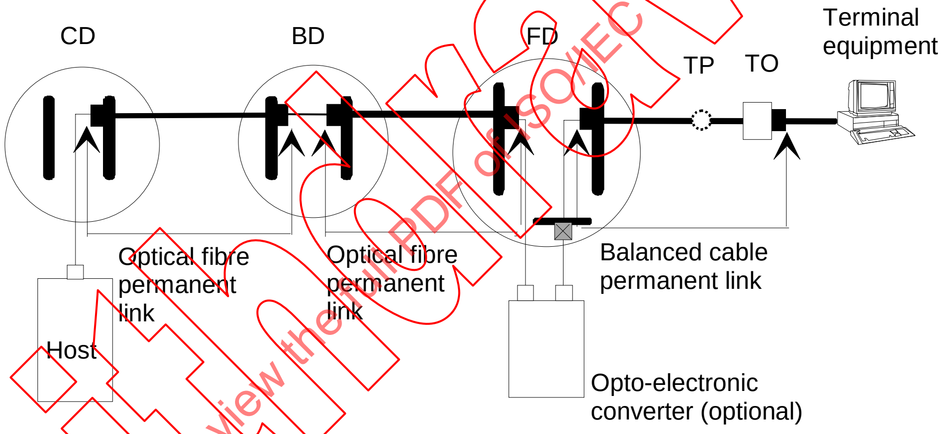


Figure 12a – Location of cabling interfaces and extent of associated permanent links

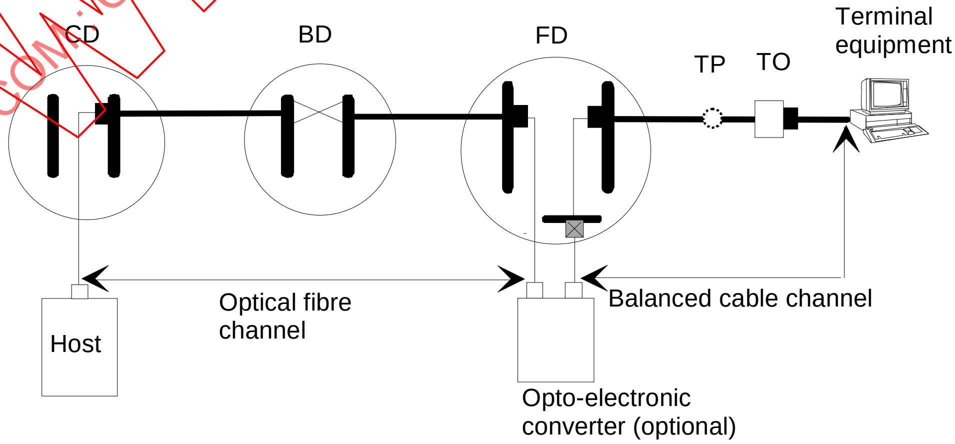
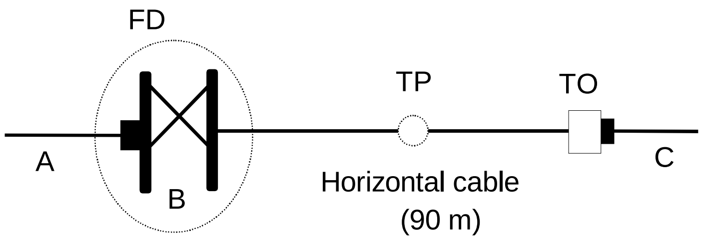
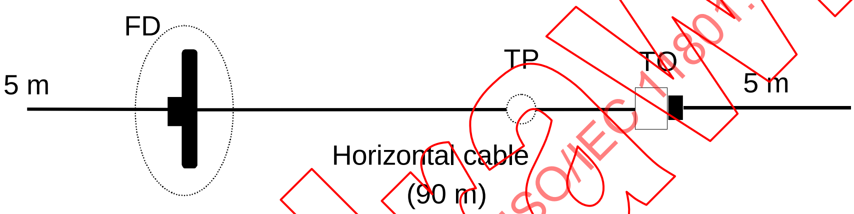


Figure 12b – Location of cabling interfaces and extent of associated channels



NOTE For balanced cabling, this example assumes the use of flexible cables with 50 % greater attenuation (dB/m) than the horizontal cable, and a cross-connection in the floor distributor, thus 3 connections. In this case, the maximum length of work area, equipment, and patch cable is 9 m. A longer channel length may be achieved by using flexible cables with better attenuation performance.

Figure 12c – Class D channel implementation (with cross-connection)



NOTE For balanced cabling, this example assumes the use of flexible cables with 50 % greater attenuation (dB/m) than the horizontal cable. In this case, the maximum length of work area and equipment cables is 10 m. This example results in a calculated channel attenuation of 23,9 dB at 100 MHz using category 5 component requirements.

Figure 12d – Class D channel implementation (with interconnection)

Key

■ Interface to the generic cabling

☒ Optional interface when using a crossconnection

Figure 12 – Examples of cabling systems

7.2 Classification of applications, links and channels

7.2.1 Application classification

Five application classes for cabling have been identified for the purposes of this International Standard. This ensures that the limiting requirements of one system do not unduly restrict other systems.

The application classes are:

Class A includes speech band and low-frequency applications. Copper cabling permanent links and channels supporting* Class A applications are referred to as Class A permanent links and Class A channels respectively.

Class B includes medium bit rate data applications. Copper cabling permanent links and channels supporting* Class B applications are referred to as Class B permanent links and Class B channels respectively.

Class C	includes high bit rate data applications. Copper cabling permanent links and channels supporting* Class C applications are referred to as Class C permanent links and Class C channels respectively.
Class D	includes very high bit rate data applications. Copper cabling permanent links and channels supporting* Class D applications are referred to as Class D permanent links and Class D channels respectively.
Optical Class	includes high and very high bit rate data applications. Optical fibre permanent links and channels supporting* Optical Class applications are referred to as Optical Class permanent links and Optical Class channels respectively.

NOTE *Permanent link specifications are provided for field test verification. Channel values provide minimum requirements for application support.

Annex G gives examples of applications that fall within the various classes.

7.2.2 Link and channel classification

Generic cabling, when configured to support particular applications, comprises one or more permanent links and channels. Five permanent link and channel classes are defined, which relate to the application classes as indicated in 7.2.1.

Permanent link/channel class A	specified up to 100 kHz
Permanent link/channel class B	specified up to 1 MHz
Permanent link/channel class C	specified up to 16 MHz
Permanent link/channel class D	specified up to 100 MHz
Optical permanent link/channel class	specified to support applications specified at 10 MHz and above.

For copper cabling, a class A to D permanent link or channel is specified so that channels will provide the minimum transmission performance to support applications of the related application class. Links and channels of a given class will support all applications of a lower class. Permanent link/channel class A is regarded as the lowest class.

Optical parameters are specified for single-mode and multimode optical fibre permanent links and channels.

Class C and D permanent links and channels correspond to full implementations of category 3 and category 5 horizontal cabling subsystems respectively, as specified in 6.1.[1)]

Table 2 relates the permanent link and channel classes to the categories of clauses 8 and 9. This table indicates the channel length over which the various applications may be supported.

The distances presented are based on NEXT loss (for copper cables), bandwidth (for optical fibre cables), and attenuation limits for various classes. Other characteristics of applications, for example propagation delay, may further limit these distances.

1) The use of link in clause 6 allows for a wider range of configurations than a permanent link in this amendment.

Table 2 – Channel lengths achievable with different categories and types of cabling

Medium	Channel length				
	Class A	Class B	Class C	Class D	Optical class
Category 3 balanced cable (8.1)	2 km	200 m	100 m [1]	–	–
Category 4 balanced cable (8.1)	3 km	260 m	150 m [2]	–	–
Category 5 balanced cable (8.1)	3 km	260 m	160 m [2]	100 m [1]	–
150 Ω balanced cable (8.2)	3 km	400 m	250 m [2]	150 m [2]	–
Multimode optical fibre (8.4)	N/A	N/A	N/A	N/A	2 km [3]
Singlemode optical fibre (8.5)	N/A	N/A	N/A	N/A	3 km [4]

1) The 100 m distance includes a 90 m length permanent link and a maximum allowance of 10 m of flexible cable for patch cords/jumpers, work area and equipment connections.

2) For distances greater than 100 m of balanced cable in the horizontal cabling subsystem, the applicable application standards should be consulted.

3) The minimum bandwidth for a 2 km multimode optical link is specified in 7.4.2. Multimode applications may be limited to distances shorter than 2 km. Consult application standards for limitations.

4) 3 km is a limit defined by the scope of the International Standard and not a medium limitation.

Consideration should be given, when specifying and designing cabling, to the possible future connection of cabling subsystems to form longer links and channels. The performance of these longer links and channels will be lower than that of any of the individual subsystem links and channels from which they are constructed. Measurement of permanent links and channels should be made initially, upon installation of each cabling subsystem. Testing of combined subsystems should be performed as required by the application.

7.3 Balanced cabling permanent links and channels

7.3.1 General

The parameters specified in this subclause apply to permanent links and channels with shielded or unshielded cable elements, with or without an overall shield, unless explicitly stated otherwise. Unless stated otherwise, outline test configurations for all measurements on balanced cabling are given in annex A. Specialised test instruments are required for high frequency field measurements on balanced cabling. The maximum application frequencies are based on required permanent link and channel characteristics, and are not indicated by the maximum specified frequency for the cabling. In the following tables, the requirements for attenuation, NEXT loss, Power Sum NEXT loss, ACR, Power Sum ACR, ELFEXT and Power Sum ELFEXT are given for discrete frequencies only. Transmission requirements shall also be met for all intermediate frequencies. Requirements at intermediate frequencies are derived by linear interpolation between frequencies on a semi-logarithmic (NEXT loss, Power Sum NEXT loss, ACR, Power Sum ACR, ELFEXT and Power Sum ELFEXT) or logarithmic (attenuation) scale.

7.3.2 Nominal impedance

The designed nominal impedance of a permanent link and channel shall be 100 Ω, 120 Ω, or 150 Ω. The nominal impedance of permanent links and channels should be achieved by suitable design, and the appropriate choice of cables and connecting hardware.

The variation of the input impedance of a permanent link and channel is characterised by the return loss. The characteristic impedance of cables used in a permanent link and channel shall be in accordance with the requirements of clause 8.

7.3.3 Return loss

The return loss of a permanent link and channel shall meet or exceed the values shown in tables 3 and 4. The return loss shall be measured according to IEC 61935-1. The return loss shall be measured from both ends to allow a correct evaluation of the permanent link or channel. Terminations that are matched to the nominal impedance of the cable (specifically 100 Ω, 120 Ω, 150 Ω) shall be connected to the cabling elements under test at the remote end of the permanent link or channel.

Table 3 – Minimum return loss for permanent link

Frequency MHz	**Minimum return loss** dB	
	Class C	**Class D**
$1 \leq f < 16$	15	17
$16 \leq f < 20$	N/A	17
$20 \leq f \leq 100$	N/A	17-7 log(f/20)

Table 4 – Minimum return loss for a channel

Frequency MHz	**Minimum return loss** dB	
	Class C	**Class D**
$1 \leq f < 16$	15	17
$16 \leq f < 20$	N/A	17
$20 \leq f \leq 100$	N/A	17-10 log(f/20)

7.3.4 Attenuation (insertion loss)

The attenuation of a permanent link and channel shall not exceed the values shown in tables 5 and 6 respectively, and shall be consistent with the design values of cable length and cabling materials used. The attenuation of the permanent link or channel shall be measured according to IEC 61935-1, except that the measured attenuation shall not be scaled to a standard length. Class D permanent links and channels should comprise cables, which closely follow the square root of frequency attenuation characteristic above 1 MHz.

The values in tables 5 and 6 are based on the requirements of the applications listed in annex G.

Table 5 – Maximum attenuation values for a permanent link

Frequency MHz	**Maximum attenuation** dB			
	Class A	**Class B**	**Class C**	**Class D**
0,1	16,0	5,5	N/A	N/A
1,0	N/A	5,8	3,1	2,1
4,0	N/A	N/A	5,8	4,1
10,0	N/A	N/A	9,6	6,1
16,0	N/A	N/A	12,6	7,8
20,0	N/A	N/A	N/A	8,7
31,25	N/A	N/A	N/A	11,0
62,5	N/A	N/A	N/A	16,0
100,0	N/A	N/A	N/A	20,6

Table 6 – Maximum attenuation values for a channel

Frequency MHz	Maximum attenuation dB			
	Class A	Class B	Class C	Class D
0,1	16,0	5,5	N/A	N/A
1,0	N/A	5,8	4,2	2,5
4,0	N/A	N/A	7,3	4,5
10,0	N/A	N/A	11,5	7,0
16,0	N/A	N/A	14,9	9,2
20,0	N/A	N/A	N/A	10,3
31,25	N/A	N/A	N/A	12,8
62,5	N/A	N/A	N/A	18,5
100,0	N/A	N/A	N/A	24,0

7.3.5 NEXT loss

7.3.5.1 Pair-to-pair NEXT loss

The pair-to-pair NEXT loss of a permanent link and channel shall meet or exceed the values shown in tables 7 and 8 respectively, and shall be consistent with the design values of cable length and cabling materials used. The NEXT loss shall be measured according to IEC 61935-1 except that the measured NEXT loss shall not be adjusted for length. The NEXT loss shall be measured from both ends to allow a correct evaluation of the permanent link or channel. See also A.1.1.

The values in tables 7 and 8 are based on the NEXT loss requirements of the applications listed in annex G.

Table 7 – Minimum NEXT loss for a permanent link

Frequency MHz	Minimum NEXT loss dB			
	Class A	Class B	Class C	Class D
0,1	27,0	40,0	N/A	N/A
1,0	N/A	25,0	40,1	61,2
4,0	N/A	N/A	30,7	51,8
10,0	N/A	N/A	24,3	45,5
16,0	N/A	N/A	21,0	42,3
20,0	N/A	N/A	N/A	40,7
31,25	N/A	N/A	N/A	37,6
62,5	N/A	N/A	N/A	32,7
100,0	N/A	N/A	N/A	29,3

Table 8 – Minimum NEXT loss for a channel

Frequency MHz	Minimum NEXT loss dB			
	Class A	Class B	Class C	Class D
0,1	27,0	40,0	N/A	N/A
1,0	N/A	25,0	39,1	60,3
4,0	N/A	N/A	29,3	50,6
10,0	N/A	N/A	22,7	44,0
16,0	N/A	N/A	19,3	40,6
20,0	N/A	N/A	N/A	39,0
31,25	N/A	N/A	N/A	35,7
62,5	N/A	N/A	N/A	30,6
100,0	N/A	N/A	N/A	27,1

Equipment connectors are not accounted for in table 8 and may contribute to additional crosstalk degradation.

7.3.5.2 Power Sum NEXT loss (PSNEXT)

The PSNEXT parameter is applicable to class D only. The PSNEXT of a class D permanent link and channel shall meet or exceed the values shown in tables 9 and 10 respectively. PSNEXT is computed from pair-to-pair NEXT as follows:

$$PSNEXT = -10\log\left(10^{\frac{-NEXT_{pp,1}}{10}} + 10^{\frac{-NEXT_{pp,2}}{10}} + 10^{\frac{-NEXT_{pp,3}}{10}}\right)$$

Table 9 – Minimum PSNEXT loss for a permanent link

Frequency MHz	Minimum PSNEXT loss dB
	Class D
1,0	58,2
4,0	48,8
10,0	42,5
16,0	39,3
20,0	37,7
31,25	34,6
62,5	29,7
100,0	26,3

Table 10 – Minimum PSNEXT loss for a channel

Frequency MHz	Minimum PSNEXT loss dB
	Class D
1,0	57,3
4,0	47,6
10,0	41,0
16,0	37,6
20,0	36,0
31,25	32,7
62,5	27,6
100,0	24,1

Power Sum NEXT is met if measured pair-to-pair NEXT values for each pair combination are at least 1,8 dB better than those specified in tables 7 and 8 for permanent links and channels respectively.

7.3.6 Attenuation to crosstalk loss ratio

7.3.6.1 Pair-to-pair ACR

This is the difference between the NEXT loss and the attenuation of the cabling in dB. It is related to, but distinct from, the signal to crosstalk ratio (SCR) which accommodates the transmit and receive signal levels of an application. By applying the requirements of 7.3.3, 7.3.4 and 7.3.5, the transmission requirements of the applications listed in annex G will be met. The ACR of cabling is calculated by:

$$ACR = a_N - a \quad \text{(dB)}$$

where

ACR is the attenuation to crosstalk loss ratio;

a_N is the NEXT loss, measured between any two pairs of the cabling. The NEXT loss shall be measured according to IEC 61935-1, except that the measured NEXT loss shall not be adjusted for length;

a is the attenuation of the cabling when measured according to IEC 61935-1, except that the measured attenuation shall not be scaled to a standard length.

Table 11 – Minimum ACR values for permanent link

Frequency MHz	Minimum ACR dB
	Class D
1,0	59,1
4,0	47,7
10,0	39,4
16,0	34,5
20,0	32,0
31,25	26,6
62,5	16,7
100,0	8,7

Table 12 – Minimum ACR values for channels

Frequency MHz	**Minimum ACR** dB
	Class D
1,0	57,8
4,0	46,1
10,0	37,0
16,0	31,4
20,0	28,7
31,25	22,9
62,5	12,1
100,0	3,1

7.3.6.2 Power Sum ACR (PSACR)

The PSACR parameter is applicable to class D only. The PSACR of a class D permanent link and channel shall meet or exceed the values shown in tables 13 and 14 respectively. The Power Sum ACR is computed from Power Sum NEXT and attenuation as follows:

PSACR = PSNEXT – a

Table 13 – Minimum PSACR values for permanent link

Frequency MHz	**Minimum ACR** dB
	Class D
1,0	56,1
4,0	44,7
10,0	36,4
16,0	31,5
20,0	29,0
31,25	23,6
62,5	13,7
100,0	5,7

Table 14 – Minimum PSACR values for channels

Frequency MHz	**Minimum ACR** dB
	Class D
1,0	54,8
4,0	43,1
10,0	34,0
16,0	28,4
20,0	25,7
31,25	19,9
62,5	9,1
100,0	0,1

7.3.7 ELFEXT

7.3.7.1 Pair-to-pair ELFEXT

The ELFEXT shall be measured from both ends to allow a correct evaluation of the permanent link or channel.

Table 15 – Minimum ELFEXT values for permanent link

Frequency MHz	Minimum ELFEXT dB Class D
1,0	59,6
4,0	47,6
10,0	39,6
16,0	35,5
20,0	33,6
31,25	29,7
62,5	23,7
100,0	19,6

Table 16 – Minimum ELFEXT values for channels

Frequency MHz	Minimum ELFEXT dB Class D
1,0	57,0
4,0	45,0
10,0	37,0
16,0	32,9
20,0	31,0
31,25	27,1
62,5	21,1
100,0	17,0

7.3.7.2 Power Sum ELFEXT

The PSELFEXT parameter is applicable to class D only. The PSELFEXT of a class D permanent link and channel shall meet or exceed the values shown in tables 17 and 18 respectively. PSELFEXT is computed from pair-to-pair ELFEXT as follows:

$$PSELFEXT = -10\log\left(10^{\frac{-ELFEXT_{pp,1}}{10}} + 10^{\frac{-ELFEXT_{pp,2}}{10}} + 10^{\frac{-ELFEXT_{pp,3}}{10}}\right)$$

Table 17 – Minimum Power Sum ELFEXT values for permanent link

Frequency MHz	Minimum PSELFEXT dB Class D
1,0	57,0
4,0	45,0
10,0	37,0
16,0	32,9
20,0	31,0
31,25	27,1
62,5	21,1
100,0	17,0

Table 18 – Minimum Power Sum ELFEXT values for channels

Frequency MHz	Minimum PSELFEXT dB Class D
1,0	54,4
4,0	42,4
10,0	34,4
16,0	30,3
20,0	28,4
31,25	24,5
62,5	18,5
100,0	14,4

Power Sum ELFEXT is met if measured pair-to-pair ELFEXT values for each pair combination are at least 2,2 dB better than those specified in tables 15 and 16 for permanent links and channels respectively.

7.3.8 DC loop resistance

The loop resistance of pairs shall be less than the values given in table 19 for each class of application. These figures are derived from application requirements. The d.c. loop resistance shall be measured according to IEC 61935-1. A short circuit is applied at the remote end of the pair and the loop resistance is measured at the near end. The measured value should be consistent with the length and diameter of the conductors used in the cable.

Table 19 – Maximum d.c. loop resistance

Cabling class	Class A	Class B	Class C	Class D
Maximum loop resistance Ω	560	170	40	40

7.3.9 Propagation delay

The propagation delay, measured according to IEC 61935-1, shall be less than the limits given in tables 20 and 21. These limits are derived from system requirements. Any measured or calculated values should be consistent with the lengths and materials used in the cabling.

Table 20 – Maximum propagation delay for permanent link

Measurement frequency MHz	**Class**	**Delay** µs
$1 \le f \le 16$	C	$0{,}486 + 0{,}036/\sqrt{f}$
$1 \le f \le 100$	D	$0{,}486 + 0{,}036/\sqrt{f}$

Table 21 – Maximum propagation delay for a channel

Measurement frequency MHz	**Class**	**Delay** µs
$1 \le f \le 16$	C	$0{,}544 + 0{,}036/\sqrt{f}$
$1 \le f \le 100$	D	$0{,}544 + 0{,}036/\sqrt{f}$

The class C and D channel delay requirements ensure that the delay requirements of the applications listed in annex G are fulfilled.

7.3.10 Delay skew

The difference in propagation delay between any two pairs in a cabling channel shall be less than the limits given in tables 22 and 23.

Table 22 – Maximum delay skew for permanent link

Measurement frequency MHz	**Class**	**Delay skew** µs
$1 \le f \le 16$	C	0,043
$1 \le f \le 100$	D	0,043

Table 23 – Maximum delay skew for a channel

Measurement frequency MHz	**Class**	**Delay skew** µs
$1 \le f \le 16$	C	0,050
$1 \le f \le 100$	D	0,050

7.3.11 Longitudinal to differential conversion loss (balance)

The longitudinal conversion loss, measured as LCL and as LCTL according to ITU-T Recommendation G.117, should exceed the values shown in table 24.

Table 24 – Longitudinal to differential conversion loss

Frequency MHz	Minimum longitudinal to differential conversion loss dB			
	Class A	Class B	Class C	Class D
0,1	30	45	45	45
1,0	N/A	20	30	40
4,0	N/A	N/A	f.f.s.	f.f.s.
10,0	N/A	N/A	25	30
16,0	N/A	N/A	f.f.s.	f.f.s.
20,0	N/A	N/A	N/A	f.f.s.
100,0	N/A	N/A	N/A	f.f.s.

The measurement of these values on installed systems is not yet well established. It is sufficient to verify the values by design.

7.3.12 Transfer impedance of shield

This parameter applies to shielded cabling only. The measurement of transfer impedance for installed cabling is not well developed. Connector termination practices may be verified by laboratory measurements of representative samples of short lengths of terminated cable. The transfer impedance requirements for shielded cables and connectors in clauses 8 and 9 should be applied. See clause 10 for guidance on the use of shielded cabling.

7.4 Optical fibre permanent links/channels

7.4.1 General

The performance requirements for optical fibre permanent links/channels assume that each optical fibre permanent link/channel employs a single optical wavelength in one transmission window only. Application standards employing wavelength multiplexing are not yet available for listing in annex G. All application specific hardware for wavelength multiplexing is installed in the equipment area and in the work area, which both are outside the scope of this International Standard. The requirements for the wavelength multiplexing and demultiplexing components will be found in the application standards. There are no special requirements for generic cabling concerning wavelength multiplexing.

The performance requirements of single-mode and multimode optical fibre permanent links/channels are considered in this subclause.

Unless otherwise stated, test procedures are described in IEC 61280-4.

7.4.2 Optical attenuation

The maximum attenuation (insertion loss) shall not exceed the values specified in table 25 in the wavelength windows specified in tables 26 and 27. The allowable attenuation of optical fibre permanent links/channels is application dependent. Consult the application standards for limitations.

The attenuation values given in table 25 have been calculated for optical fibre permanent links/channels in each cabling subsystem, assuming a worst case installation philosophy of a connector and a splice at each end of each subsystem.

Table 25 – Attenuation of optical fibre cabling subsystems

Cabling subsystem	Link/channel length [1)] m	Attenuation dB			
		Singlemode		Multimode	
		1 310 nm	1 550 nm	850 nm	1 300 nm
Horizontal	100	2,2	2,2	2,5	2,2
Building backbone	500	2,7	2,7	3,9	2,6
Campus backbone	1 500	3,6	3,6	7,4	3,6

[1)] The link/channel lengths and attenuation values given here are achievable using optical fibre components meeting the minimum requirements of 8.4, 8.5 and 9.4.
Different link lengths could be achieved if other optical fibre components were used.

Table 26 – Wavelength windows for multimode optical fibre cabling

Nominal wavelength nm	Lower limit nm	Upper limit nm	Reference test wavelength nm	Maximum spectral width FWHM nm
850	790	910	850	50
1 300	1 285	1 330	1 300	150

Table 27 – Wavelength windows for singlemode optical fibre cabling

Nominal wavelength nm	Lower limit nm	Upper limit nm	Reference test wavelength nm	Maximum spectral width FWHM nm
1 310	1 288	1 339	1 310	10
1 550	1 525	1 575	1 550	10

7.4.3 Multimode modal bandwidth

For multimode optical fibre permanent links/channels the optical modal bandwidth shall exceed the minimum values shown in table 28.

Table 28 – Minimum optical modal bandwidth

Wavelength nm	**Minimum bandwidth** MHz
850	100
1 300	250

The dispersion of the optical fibre used in the optical link/channel shall be measured in accordance with the test methods described in IEC 60793-1. See table 2 for achievable distances.

7.4.4 Return loss

The optical return loss of any interface of an optical link/channel shall exceed the values shown in table 29.

Table 29 – Minimum optical return loss

Multimode		**Singlemode**	
850 nm	**1 300 nm**	**1 310 nm**	**1 550 nm**
20 dB	20 dB	26 dB	26 dB

7.4.5 Propagation delay

For some applications, knowledge of the delay of optical fibre permanent links/channels is important to ensure compliance with end-to-end delay requirements of complex networks consisting of multiple cascaded links/channels. For this reason, it is important to know the lengths of optical fibre permanent links/channels. It is possible to calculate propagation delay based on cable performance (see clause 8).

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8 Cable requirements

Delete second paragraph NOTE.

Replace the fourth paragraph by the following text:

In the following tables, the requirements for attenuation and NEXT loss are given for discrete frequencies only. They have to be fulfilled, however, for all intermediate frequencies. Requirements at intermediate frequencies are derived by linear interpolation between two specified frequencies on a semi-logarithmic (NEXT loss) or logarithmic (attenuation) scale. Requirements for Power Sum NEXT loss, ELFEXT, and Power Sum ELFEXT are under study.

For multimode and single mode fibre, a conservative conversion value for unit propagation delay of 5,00 ns/m (0,667 c) may be used. This value can be used to calculate channel delay without verification.

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8.1 General requirements for 100 Ω and 120 Ω balanced cable

Replace table 15 by the following table:

Table 30 – Mechanical characteristics of 100 Ω and 120 Ω balanced cables

Cable characteristics		Units	Subsystem		Test method
1	Mechanical characteristics		Backbone	Horizontal	Subclause
1.1	Diameter of conductor [1]	Mm	0,4 to 0,65		3.4.1 of IEC 61156-1
1.2	Diameter over insulated conductor [2]	Mm	≤1,4		3.4.1 of IEC 61156-1
1.3	Number of conductors in a cable element	per pair/per quad	2/4		
1.4	Shield around cable element [3]		Optional. Refer to clause 10		
1.5	Number of cable	Pairs	≥4	2*n* (*n* = 1, 2, 3, ...)	
	Elements in a unit [4]	Quads	≥2	*n* (*n* = 1, 2, 3, ...)	
1.6	Shield around cable unit [3]		Optional		
1.7	Number of cable units in a cable		≥1 [4]		
1.8	Shield around cable [3]		Optional. Refer to clause 9		
1.9	Outer diameter of cable [5]	Mm	≤90	≤20	3.4.1 of IEC 61156-1
1.10	Temperature range without mechanical degradation [6]	°C	Installation: 0 to +50 Operation: –20 to +60		f.f.s.
1.11	Minimum bending radius for pulling during installation		8 times outer cable diameter		3.4.8 of IEC 61156-1
1.12	Minimum bending radius installed		6 (f.f.s.) times outer cable diameter	4 (f.f.s.) times outer cable diameter	f.f.s.
1.13	Pulling strength [7]	$N/mm^2 \times Cu_{min}$	≥50		3.4.9 of IEC 61156-1
1.14	Fire rating		According to IEC 61156 unless otherwise requested by local regulation		As applicable
1.15	Colour coding [8]		As required by local regulations preferably IEC 60708-1		
1.16	Cable marking		As required by local regulations or national specifications		

[1] Conductor diameters below 0,5 mm may not be compatible with all connecting hardware.

The two measured values using the IEC method must be averaged and then compared to the limit for compliance verification.

[2] Diameters over the insulated conductor up to 1,6 mm may be used if they meet all other performance requirements. These cables may not be compatible with all connecting hardware.

[3] If it is intended to use cables with shielding, care shall be taken that the connecting hardware is properly designed to terminate the shielding.

[4] Care has to be taken to meet the NEXT loss requirements given in 8.3.

[5] Should be minimised to make best use of duct and crossconnect capacity (see clause 9).

In case of under carpet cable the value is not applicable.

[6] For certain applications (e.g. precabling buildings in cold climate) a cable with a lower temperature bending performance of –30 °C may be required.

[7] This is an indication for cable performance, installation needs are for further study. This results in a maximum pulling force of 50 N/mm^2 times copper conductor cross-section, excluding shields, if present.

[8] For cables with fewer cable elements than those specified by IEC 60708, pair colours should be consistent with all pairs or quads specified starting from 1 up to the number of elements in the cable.

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8.1 General requirements for 100 Ω and 120 Ω balanced cable

Replace table 16 by the following table:

Table 31 – Electrical characteristics of 100 Ω and 120 Ω balanced cables

Cable characteristics				Cable category [3]			Test method [3]
2	Electrical characteristics at 20 °C	Units	MHz	3	4	5	
2.1	Maximum d.c. loop resistance	Ω/100 m	d.c.	19,2 [1]	19,2 [1]	19,2 [1]	3.2.1 of IEC 61156-1
2.2	Nominal phase velocity of propagation		1 10 100	0,4 c 0,6 c N/A	0,6 c 0,6 c N/A	0,65 c 0,65 c 0,65 c	3.3.1 of IEC 61156-1
2.3	Minimum NEXT loss [2]	dB at 100 m cable length	0,772	43	58	64	3.3.4 of IEC 61156-1
			1	41	56	62	
			4	32	47	53	
			10	26	41	47	
			16	23	38	44	
			20	N/A	36	42	
			31,25	N/A	N/A	40	
			62,5	N/A	N/A	35	
			100	N/A	N/A	32	
2.4	Maximum resistance unbalance	%	d.c.	3	3	3	3.2.2 of IEC 61156-1
2.5	Minimum longitudinal conversion loss	dB	0,064	45 (f.f.s.)	45 (f.f.s.)	45 (f.f.s.)	ITU-T O.9
2.6	Maximum capacitance unbalance pair to ground	pF/km	0,0008 or 0,001	3 400	3 400	3 400	3.2.6 of IEC 61156-1
2.7	Maximum transfer Impedance (only applicable when shields are present)	mΩ/m	1	50	50	50	3.2.7 of IEC 61156-1
			10	100	100	100	
			100	N/A	N/A	f.f.s.	
2.8	Minimum d.c. insulation resistance	MΩ km	d.c.	150	150	150	3.2.4 of IEC 61156-1
2.9	Dielectric strength conductor/conductor and conductor/shield		d.c. or	1 kV, 1 min or 2,5 kV, 2 s			3.2.3 of IEC 61156-1
			a.c.	700 V, 1 min or 1,7 kV, 2 s			
2.10	Minimum structural return loss	dB at 100 m cable length	1 to <10	12 (f.f.s.)	21 (f.f.s.)	23 (f.f.s.)	IEC 61156-1 f.f.s.
			10 to <16	10 (f.f.s.)	19 (f.f.s.)	23 (f.f.s.)	
			16 to <20	N/A	18 (f.f.s.)	23 (f.f.s.)	
			20 to 100	N/A	N/A	23-10log (*f*/20) (f.f.s.)	
2.11	Delay skew	ns/100 m	1 to <16	45	45	45	IEC 61935-1
			16 to <20		45	45	
			20 to 100			45	

[1] If all other values are fulfilled, the maximum d.c. loop resistance may be as high as 30 Ω /100 m.

[2] Unless otherwise specified, cable NEXT loss performance shall be characterised using "worst case pair combination" testing. See 8.3 for additional NEXT loss requirements for balanced cables.

[3] The test method shall be as stated in the column "Test method" while the required value shall meet the values stated in the column "Cable category".

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8.1.1 Additional requirements for 100 Ω balanced cable

Replace table 17 by the following table:

Table 32 – Additional electrical characteristics of 100 Ω balanced cables

Cable characteristics				Cable category			Test method
3	Electrical characteristics at 20 °C	Units	MHz	3	4	5	
3.1	Characteristic impedance	Ω	0,1	75 to 150	75 to 150	75 to 150	IEC 61156-1
			≥1	100 ± 15	100 ± 15	100 ± 15	(U.C.)
3.2	Maximum attenuation	dB/ 100 m	0,064	0,9	0,8	0,8	3.3.2 of IEC 61156-1
			0,256	1,3	1,1	1,1	
			0,512	1,8	1,5	1,5	
			0,772	2,2	1,9	1,8	
			1	2,6	2,1	2,1	
			4	5,6	4,3	4,3	
			10	9,8	7,2	6,6	
			16	13,1	8,9	8,2	
			20	N/A	10,2	9,2	
			31,25	N/A	N/A	11,8	
			62,5	N/A	N/A	17,1	
			100	N/A	N/A	22,0	

Delete table 18.

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8.1.2 Additional requirements for 120 Ω balanced cable

Replace table 19 by the following table:

Table 33 – Additional electrical characteristics of 120 Ω balanced cables

Cable characteristics				Cable category		Test method
3	Electrical characteristics at 20 °C	Units	MHz	4	5	
3.1	Characteristic Impedance	Ω	0,1	75 to 150	75 to 150	IEC 61156-1
			≥1	120 ± 15	120 ± 15	
3.2	Maximum attenuation	dB/ 100 m	0,064	0,8	0,8	3.3.2 of IEC 61156-1
			0,256	1,1	1,1	
			0,512	1,5	1,5	
			0,772	1,7	1,5	
			1	2,0	1,8	
			4	4,0	3,6	
			10	6,7	5,2	
			16	8,1	6,2	
			20	9,2	7,0	
			31,25	N/A	8,8	
			62,5	N/A	12,5	
			100	N/A	17,0	

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8.2 General requirements for 150 Ω balanced cable

Replace table 20 by the following table:

Table 34 – Mechanical characteristics of 150 Ω balanced cables

Cable characteristics		Units	Requirement	Test method
1	Mechanical characteristics			
1.1	Diameter of conductor 1)	mm	0,6 – 0,66	3.4.1 of IEC 61156-1
1.2	Diameter over insulated conductor 2)	mm	≤2,6	3.4.1 of IEC 61156-1
1.3	Number of conductors in a cable element	per pair/ per quad	2/4	
1.4	Shield around cable element		Optional. Refer to clause 10	
1.5	Number of cable elements in a unit	pairs:	2	
		quads:	1	
1.6	Shield around cable unit		Yes, but optional, if 1.4 is fulfilled. Refer to clause 10	
1.7	Number of cable units in a cable		≥1	
1.8	Shield around cable		Optional. Refer to clause 10	
1.9	Outer diameter of cable 3)	mm	≤11	3.4.1 of IEC 61156-1
1.10	Temperature range without mechanical degradation	°C	Installation: 0 to + 50	f.f.s.
			Operation: –20 to + 60	f.f.s.
1.11	Minimum bending radius for pulling during installation	cm	7,5	3.4.9 of IEC 61156-1
1.12	Minimum bending radius installed		f.f.s.	f.f.s.
1.13	One time bend radius	mm	20	
1.14	Pulling strength 4)	N/mm^2 × Cu_{min}	≥50	3.4.8 of IEC 61156-1
1.15	Fire rating		According to IEC 61156-1 unless otherwise requested by local regulation.	As applicable
1.16	Colour coding		Preferably IEC 60708 or pair 1: red/green pair 2: orange/black	
1.17	Cable marking		As required by local rules or national specifications	

1) The two measured values using the IEC method must be averaged and then compared to the limit for compliance verification.

2) Values above 1,6 mm may not be compatible with all connecting hardware.

3) Only for cables with one cable unit.

4) This is an indication for cable performance, installation needs are for further study. This results in a maximum pulling force of 50 N/mm^2 times copper conductor cross-section, excluding shields, if present.