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INTERNATIONAL STANDARD

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Optical fibre cables –
Part 1-1: Generic specification – General

IEC 60794-1-1:2015-11(en)

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INTERNATIONAL
ELECTROTECHNICAL
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FOREWORD

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International Standard IEC 60794-1-1 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This fourth edition cancels and replaces the third edition, published in 2011. This edition constitutes a technical revision.

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

a) the expansion of the definitions, graphical symbols, terminology and abbreviations content, with the aim of making this standard the default and reference for all others in the IEC 60794-x series;
b) the inclusion of updated and expanded optical fibre, attenuation and bandwidth sections, with the aim of making this standard the default and reference for all others in the IEC 60794-x series.

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

CDV	Report on voting
86A/1651/CDV	86A/1667/RVC

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

A list of all parts in the IEC 60794 series, published under the general title *Optical fibre cables*, can be found on the IEC website.

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 the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

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

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OPTICAL FIBRE CABLES –

Part 1-1: Generic specification – General

1 Scope

This part of IEC 60794 applies to optical fibre cables for use with communication equipment and devices employing similar techniques and to cables having a combination of both optical fibres and electrical conductors.

The object of this standard is to establish uniform generic requirements for the geometrical, transmission, material, mechanical, ageing (environmental exposure), climatic and electrical properties of optical fibre cables and cable elements, where appropriate.

2 Normative references

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

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

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

IEC 60793-1-21, *Optical Fibres Part 1-21: Measurement methods and test procedures – Coating geometry*

IEC 60793-1-40, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

IEC 60793-1-44, *Optical fibres – Part 1-44: Measurement methods and test procedures – Cut-off wavelength*

IEC 60793-1-46, *Optical fibres – Part 1-46: Measurement methods and test procedures – Monitoring of changes in optical transmittance*

IEC 60793-1-48, *Optical fibres – Part 1-48: Measurement methods and test procedures – Polarization mode dispersion*

IEC 60793-2, *Optical fibres – Part 2: Product specifications – General*

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

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

IEC 60794-1-22, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental tests methods*

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

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

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

IEC TR 61931, *Fibre optic – Terminology*

ISO 14001, *Environmental management systems – Requirements with guidance for use*

ISO 14064-1, *Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
no change in attenuation
acceptance criterion for attenuation measurement that includes an allowance for measurement uncertainty arising from measurement errors or calibration errors due to a lack of suitable reference standards

Note 1 to entry: For a practical interpretation, the following values shall be used:

a) no change in attenuation, single-mode (Class B): the total uncertainty of measurement shall be ≤ ± 0,05 dB for attenuation or ≤±0,05 dB/km for attenuation coefficient. Any measured value within this range shall be considered as “no change in attenuation”

The requirement for these parameters is indicated as “No change (≤ ± 0,05 dB or ≤ ± 0,05 dB/km)”.

By agreement between customer and supplier, minor deviation from this limit may be accepted at some low frequency, e.g. less than 10%. However for mechanical tests no deviation in excess of 0,15 dB shall be accepted. For environmental tests no deviation in excess of 0,10 dB/km shall be accepted.

b) no change in attenuation, multimode (Category A1): the total uncertainty of measurement shall be ≤ ±0,2 dB for attenuation or ≤ ±0,2 dB/km for attenuation coefficient

Any measured value within this range shall be considered as “no change in attenuation”.

The requirement for these parameters is indicated as “No change (≤ ± 0,2 dB or ≤ ± 0,2 dB/km)”.

By agreement between customer and supplier, minor deviation from this limit may be accepted at some low frequency, e.g. less than 10%. However for mechanical tests no deviation in excess of 0,5 dB shall be accepted. For environmental tests no deviation in excess of 0,5 dB/km shall be accepted.

c) no change in attenuation, plastic optical fibre (Category A4): the total uncertainty of measurement for this standard shall be ≤ 2 % of maximum specified attenuation in IEC 60793-2-40 Annex A to G

Any measured value within this range shall be considered as “no change in attenuation”.

3.2
allowable change in attenuation
<during mechanical and environmental tests> change in attenuation that may be a value larger than the no change limits, depending on fibre category, single-mode or multimode, cable design and application

3.3
link design attenuation
LDA
statistical average attenuation value for a link of concatenated cables

3.4
no change in fibre strain
acceptance criterion for fibre strain measurement that includes an allowance for measurement uncertainty arising from measurement errors or calibration errors due to a lack of suitable reference standards

Note 1 to entry: For a practical interpretation, the total uncertainty of measurement shall be ±0,05 % strain. Any measured value within this range shall be considered as “no change in strain”.

3.5
allowable change in fibre strain
<during mechanical and environmental tests> level of strain that will not compromise fibre mechanical reliability for some of the parameters specified

Note 1 to entry: For 1 % proof-tested fibres, the fibre strain under long term tensile load (T_L) shall not exceed 20 % of this fibre proof strain (equal to absolute 0,2 % strain) and there shall be no change in attenuation during the test

Under short term tensile load (T_S) the fibre strain shall not exceed 60 % of the fibre proof strain and the attenuation change during test shall be measured and recorded.

Other criteria may be agreed between the customer and the supplier.

For fibres proof tested at higher levels the safe long-term load will not scale linearly with proof strain, so a lower percentage of the proof strain is applicable. For greater than 1 % up to 2 % proof-tested fibres, the strain at T_L shall be limited to 17 % of the proof-test strain (equal to absolute 0,34 % strain for 2 % proof tested fibres).

3.6
cable load definitions (non-aerial applications)

3.6.1
long term load
T_L
acceptable amount of long term load which the cable may experience during operation (i.e. after installation is completed)

Note 1 to entry: Long term load may be due to residual loading from the installation process and/or environmental effect. This is the rated maximum load for which a cable is subject to in long term tests.

3.6.2
short term load
T_S
TM
acceptable amount of short-term load that can be applied to a cable without permanent degradation of the characteristics of the fibres, cable elements or sheath

Note 1 to entry: Short term load is often called rated installation load.

3.7
cable load definitions and tensile testing terminology
(self-supporting aerial applications)

3.7.1
maximum allowable tension
MAT
maximum tensile load that may be applied to the cable without detriment to the performance requirements (e.g. attenuation, fibre reliability) due to fibre strain

Note 1 to entry: Due to installation codes the MAT value is sometimes restricted to be less than 60 % of the breaking tension of the cable.

3.7.2
strain margin
value of cable elongation at the onset of fibre strain

Note 1 to entry: Strain margin may also be expressed as cable load (N) at the onset of fibre strain.

3.7.3
breaking tension
tensile load that will produce physical rupture of the cable

Note 1 to entry: The breaking tension may be calculated, provided that the design model has been validated.

3.7.4
maximum installation tension
MIT
maximum recommended stringing tension during installation

3.7.5
rated tensile strength
RTS
summation of the product of nominal cross-sectional area, nominal tensile strength and stranding factor for each load bearing material in the cable construction

Note 1 to entry: See IEC 60794-4:2003, Annex A for details of the recommended method to calculate breaking tension of OPGW.

3.7.6
creep
tendency of a solid material to slowly move or deform permanently under the influence of stress

Note 1 to entry: The information derived from creep testing may be used in the sag-tension calculations during the design layout of aerial optical cables used along electrical power lines.

3.8
cable section
individual reel of cable, as produced

3.9
fittings
hardware used for stringing and clipping of aerial cables to the structures (e.g. towers, poles) at the end of the installation procedure

Note 1 to entry: Suspension, dead end, vibration damper and bonding clamps hardware are designed for a specific size and/or type of aerial cable.

3.10
cable element
component of a cable designed to house and protect the optical fibres

Note 1 to entry: Changed from “fibre optic unit” in IEC 60794-4-10 to “cable element” to be consistent with IEC 60794-1-23 and also to avoid confusion with IEC 60794-5-20.

3.11
polarization mode dispersion (PMD) terms

3.11.1
differential group delay
DGD
relative time delay between the two fundamental polarization modes (principal states of polarization) at the end of an optical fibre cable, at a particular time and wavelength

Note 1 to entry: Differential group delay is expressed in ps.

3.11.2
polarization mode dispersion (PMD) value
average of DGD values across wavelengths

Note 1 to entry: The polarization mode dispersion value is expressed in ps.

3.11.3
polarization mode dispersion (PMD) coefficient
PMD value of an optical fibre cable divided by the square root sum of its length (km)

Note 1 to entry: The polarization mode dispersion coefficient is expressed in ps/√km.

3.11.4
link
length of cable composed of a number of individual cable sections

Note 1 to entry: Link PMD values are generally calculated according to the formulae given in IEC TR 61282-3:2006 but may be measured.

3.12
recovery time
time allowed for any of the tests before performing the after test measurement

Note 1 to entry: For a practical interpretation, this is typically 5 minutes minimum.

3.13
Ruggedized cable
cable having enhanced mechanical performances

3.14
terminated cable assembly
length of cable provisioned with a connector at each end

Note 1 to entry: The following synonyms are used in ISO/IEC 11801: patch cords, work area cords and equipment cords.

3.15
aerial cable types

3.15.1
all dielectric self-supporting
ADSS
cable that is capable to endure aerial installation and provide long term service, without any external tensile support

3.15.2
optical attached cable
OPAC
dielectric cable that is not self-supported, but attached to an electrical earth wire or phase conductor, using one of the following attachment methods: wrapped, lashed or preform attached

3.15.3
wrapped
lightweight flexible non-metallic (“wrap”) cable that can be wrapped helically around either the earth wire or the phase conductor using special machinery

3.15.4
lashed
non-metallic cables that are installed longitudinally alongside the earth wire, the phase conductor or on a separate support cable (on a pole route) and are held in position with a binder or adhesive cord

3.15.5
preform/spiral attached
cable similar to the lashed cables but attached with the use of special preformed spiral attachment clips

3.15.6
optical ground wire
OPGW
metallic optical cable that has the dual performance functions of a conventional ground wire with telecommunication capabilities

3.16
composite cable
optical fibre cable containing more than one fibre category

3.17
hybrid cable
cable that contains more than one media type, including but not limited to optical fibres and/or twisted pair/quad cables and/or coaxial cables

3.18
rounding error
rule of “rounding half away from zero” when the results recorded display more than the significant number of digits required in the acceptance criteria

EXAMPLE 1: Against a requirement of 0,22 dB/km maximum attenuation, values up to 0,224 dB/km conform, whilst values of 0,225 dB/km and above are failures.

EXAMPLE 2: Against a requirement of ± 0,05 dB, values between -0,054 and +0,054 are deemed acceptable.

3.19
maximum allowable ovality
largest permissible ovality of the optical unit or its component calculated as: $(d1 - d2) / (d1 + d2)$ in % where:

$d1$ is the maximum measured diameter of the cable or the component;

$d2$ is the minimum diameter of the cable or the component at the same cross-section as $d1$.

3.20
breakout cable
cable consisting of subunits which may be separate fibre optical cables surrounded by a sheath of suitable material

Note 1 to entry: In the application this outer sheath of the breakout cable can be removed over a certain length and the subunits can be used as separate fibre optic cables.

4 Graphical symbols and abbreviations

For the purposes of this document, the abbreviations given in IEC TR 61931 as well as the following apply

ADSS	all dielectric self-supporting
APL	aluminium/polyethylene laminate
ΔD	minimum wall thickness of a microduct
ΔD’	minimum thickness of the outer sheath of a protected microduct
D	nominal outer diameter of a microduct cable
d	nominal outer diameter of a cable (including microduct fibre units)
dc	nominal outer diameter of a conduit or subduct
DS	detail specification
ID	nominal inner diameter of a microduct
I/O-port	input/output port for launching OF cables into and out of a pipe
λ_{CC}	cable cut-off wavelength
$\lambda_{operational}$	operational wavelength
LDA	link design attenuation (tbd)
m	mass of 1 km of cable (in the context of tensile testing)
MAOC	maximum allowable ovality of cable
MAT	maximum allowable tension
MIT	maximum installation tension
n x d	The product of a variable and the cable outer diameter used for determining appropriate sizes for bends, mandrels, etc.
n x OD	The product of a variable and the outer diameter of a microduct used for determining appropriate sizes for bends, mandrels, etc.
n x OD’	The product of a variable and the outer diameter of a protected microduct used for determining appropriate sizes for bends, mandrels, etc.
OD	nominal outer diameter of a microduct
OD’	nominal outer diameter of a protected microduct
OPAC	optical attached cable (or optical power attached cable)
OPGW	optical ground wire
PE	polyethylene
RTS	rated tensile strength
SPL	steel/polyethylene laminate
SZ	technique in which the lay reverses direction periodically
t_1	temperature cycling dwell time
T_{A1}	temperature cycling test low-temperature limit according to IEC 60794-1-22, Method F1

T_{A2}	temperature cycling test secondary low-temperature limit according to IEC 60794-1-22, Method F1
T_{B1}	temperature cycling test high-temperature limit according to IEC 60794-1-22, Method F1
T_{B2}	temperature cycling test secondary high-temperature limit according to IEC 60794-1-22, Method F1
$\mathrm{T_L}$	long term load
$\mathrm{T_S}$	short term load
W	weight of 1 km of cable, microduct fibre unit or any form of ducting, as applicable

5 Optical fibre cables

Optical fibre cables, containing optical fibres and possibly electrical conductors, consist of the following types:

– indoor cables;
– patch cords;
– premises cabling;
– cables for installation in ducts and lashed aerial cables;
– cables for direct burial;
– cables for installation in tunnels;
– aerial cables;
– drop cables;
– underwater cables for lakes, river crossings and coastal applications;
– microduct cabling;
– cables for utility rights of way such as sewers, gas pipes and water pipes;
– overhead cables (power lines);
– optical cables for rapid/multiple deployment;
– other optical fibre cable types not listed above.

6 Materials

6.1 Optical fibre

6.1.1 General

Optical fibres shall meet the requirements of IEC 60793-2. Annex A gives guidance on application performance standards.

6.1.2 Attenuation coefficient

The maximum cabled fibre attenuation coefficient shall conform to Annex A. Particular values may be agreed between the customer and supplier.

The attenuation coefficient shall be measured in accordance with IEC 60793-1-40.

6.1.3 Attenuation uniformity – Attenuation discontinuities

The local attenuation shall not have point discontinuities in excess of 0,10 dB for single-mode fibre and 0,20 dB for multimode fibre, when measured in accordance with IEC 60793-1-40.

6.1.4 Cable cut-off wavelength

For single-mode fibre, the cable cut-off wavelength λ_{cc} shall be less than the operational wavelength, when measured in accordance with IEC 60793-1-44.

Unless otherwise stated, this shall be:

a) $\lambda_{cc} \leq$ 1 260 nm for fibre categories B1.1, B1.3 and B6;

b) $\lambda_{cc} \leq$ 1 270 nm for fibre category B2;

c) $\lambda_{cc} \leq$ 1 450 nm for fibre categories B4 and B5;

d) $\lambda_{cc} \leq$ 1 530 nm for fibre category B1.2.

6.1.5 Fibre colouring

If the primary coated fibres are coloured for identification, the coloured coating shall be readily identifiable throughout the lifetime of the cable and shall be a reasonable match to IEC 60304. Refer to 7.2 for the specification of fibre colour coding.

6.1.6 Polarization mode dispersion (PMD)

Cabled single-mode fibre PMD shall be characterized on a statistical basis, not on an individual fibre basis, as described in IEC TR 61282-3. Measurements on individual cabled fibres shall be performed in accordance with IEC 60793-1-48. Measurements on uncabled fibre can be used to generate cabled fibre statistics when the design and processes are stable and the relationship between the PMD coefficients of uncabled and cabled fibre are known.

The manufacturer shall supply a PMD link design value, PMD_Q, that serves as a statistical upper bound PMD coefficient of the concatenated optical fibre cables within a possible optical link. Unless otherwise specified in the detail specification, the PMD_Q value shall be less than 0,5 ps/√km with a probability of 10^{-4} that this value be exceeded for a numerical concatenation of at least 20 cables.

6.2 Electrical conductors

The characteristics of any electrical conductors shall be in accordance with the relevant IEC standards.

6.3 Other materials

Material used in the construction of optical fibre cables shall be compatible with the physical and optical properties of the fibres and shall be in accordance with the relevant IEC standards.

6.4 Environmental requirements

When requested, information shall be provided on the overall environmental impact of the cable and cable material. This information should include manufacturing, cable handling and environmental impact during the lifetime of the cable. Examples of relevant information are the minimisation or replacement of harmful materials and improvements in waste disposal. Relevant standards include ISO 14001 and ISO 14064-1.

7 Cable construction

7.1 General

The construction, dimensions, weight, mechanical, optical, electrical and climatic properties of each type of optical fibre cable shall be as stated in the relevant specification.

7.2 Colour coding

7.2.1 Overview

Coding is essential to uniquely identify each fibre in a cable. Coding of fibres almost universally involves colouring of the fibre coating or buffer (see 6.1.5). The coding scheme employed will usually require inclusion of coding of fibre, subunits, and units within the cable.

Coding schemes shall be agreed between manufacturer and customer. The specific scheme is often the subject of regional norms. IEC 60304 identifies the colours to be used in fibre colouring, but does not address the coding.

Sheath colour coding may be used for a variety of purposes, and is most commonly used in indoor cables. Such sheath coding is used to identify the categories of fibre in the cable or the application of the cable, amongst a number of other possibilities.

Unless otherwise specified, fibres shall be uniquely identified by a scheme agreed between manufacturer and customer.

As per 6.1.5, colours shall be a reasonable match to IEC 60304. Other colours or schemes may be used, as agreed.

7.2.2 Unit colour coding

If required as a part of the unique fibre identification scheme, units shall be uniquely identified.

If colours are used, they shall be a reasonable match to IEC 60304. If other methods, such as a print string, positional identification, threads, etc. are used, they shall conform to the intent of the identification scheme.

7.2.3 Sheath colour coding

Sheath colour coding, if used, shall be as agreed between manufacturer and customer.

8 Measuring methods

8.1 General

Not all tests are applicable to all cables.

Intrinsic characteristics of optical fibres are not normally measured by cable manufacturers. The relevant values are provided by optical fibre manufacturers, available as unitary or statistical values. For practical reasons, the core diameter of single-mode fibres is not specified. Mode field diameter is the relevant specification parameter.

Test results shall follow the rule of “rounding half away from zero”, when the results recorded display more than the significant number of digits required in the acceptance criteria (see 3.18).

Guidance on selecting fibres for testing is given in Annex B.

8.2 Measuring methods for dimensions

The dimensions of the optical fibres, electrical conductors and cables shall be determined by subjecting samples to tests selected from Table 1. The tests applied, acceptance criteria and number of samples shall be as specified in the relevant specification.

Table 1 – Measuring methods for dimensions

Test method	Test	Characteristics covered by test method
IEC 60793-1-21	Coating geometry measurement	Diameter of primary coating Diameter of coloured fibre Diameter of secondary or “buffer” coating Non-circularities of secondary or “buffer” coating Primary coating-clading concentricity error
IEC 60793-1-22 Method A	Delay of transmitted and/or reflected pulse	Length of fibre
IEC 60793-1-22 Method B	Backscattering technique	Length of fibre
IEC 60189-1	Mechanical	Diameter of electrical conductor
IEC 60811-201 IEC 60811-202 IEC 60811-203	Mechanical	Thickness of insulation – electrical conductors Thickness of sheaths Overall dimensions

8.3 Measuring methods for mechanical characteristics

The mechanical characteristics of optical fibre cables shall be verified by subjecting samples to tests selected from IEC 60794-1-21. The acceptance criteria shall be as specified in the relevant specification.

8.4 Measuring methods for electrical characteristics

When electrical conductors or other metallic elements are incorporated in an optical fibre cable, verification of various electrical characteristics may be necessary. Typical tests are shown in Table 2, in addition to those given in IEC 60794-1-24. The tests applied and the acceptance criteria shall be as laid down in the relevant specification.

Table 2 – Measuring methods for electrical characteristics

Test method	Test	Characteristics covered by test method
IEC 60189-1	Conductor resistance	Characteristics of insulated electrical conductors
	Dielectric strength of insulation Insulation resistance	The insulation properties of conductors within optical fibre cables are normally just specified for the incoming material, pre-cabling.

For cables installed along overhead power lines, specialised tests are given in IEC 60794-1-24 (Method H1: Short circuit test and Method H2: Lightning test method) and in IEC 60794-4-20:2012, Annex C (Electrical test (tracking)).

8.5 Measuring methods for transmission and optical characteristics

The transmission and optical characteristics of optical fibre in cables shall be verified by carrying out selected tests from those shown in Table 3. The tests applied and acceptance criteria shall be as specified in the relevant specification.

Table 3 – Measuring methods for transmission and optical characteristics of cabled optical fibres

Test method	Test	Characteristics covered by the test method
Test methods for multimode and single-mode fibre cables		
IEC 60793-1-40 method B	Insertion loss technique	Attenuation
IEC 60793-1-40 method C	Backscattering technique	Attenuation
IEC 60793-1-40 method C	Backscattering technique	Point defects
IEC 60793-1-46 method A IEC 60793-1-46 method B	Transmitted power monitoring Backscattering monitoring	Change of optical transmittance during mechanical and environmental tests
Test methods for single-mode fibres		
IEC 60793-1-48	Polarization mode dispersion	Polarization mode dispersion

NOTE Bandwidth, chromatic dispersion and cable cut-off wavelength are not measured on cabled optical fibre.

8.6 Measuring methods for environmental characteristics

The environmental characteristics of optical fibre cables shall be verified by subjecting samples to tests selected from IEC 60794-1-22. The tests applied and acceptance criteria shall be as specified in the relevant specification.

8.7 Measuring methods for cable element characterisation

Tests to characterise the different types of cable elements for handling purposes are given in IEC 60794-1-23.

9 Related Technical Reports

Guidance to assist the user and installer with regard to the general aspects of the installation of optical fibre cables is covered by IEC TR 62691 [2] [1].

IEC TR 62222 [1] gives guidance on tests for assessing the fire performance of communication cables installed in buildings.

IEC TR 62362 [4] gives guidance on the selection of optical fibre cable specifications relative to mechanical, ingress, climatic or electromagnetic characteristics, as classified in ISO/IEC 24702 [9].

An evaluation of hydrogen induced effects within optical fibre cables is relevant for certain specialised designs, such as those for lakes, rivers, coastal and OPGW applications and those containing metallic tubes. More details on when detailed consideration may be warranted are given in IEC TR 62690 [3].

Guidelines on considerations that should be taken into account when testing optical fibres which are exposed to nuclear radiation are given in IEC TR 62283 [5].

Guidelines on considerations that should be taken into account when planning to connect different types of singlemode fibre are given in IEC/TR 62000 [6].

Guidance on techniques for the measurement of the coefficient of friction between cables and ducts is given in IEC TR 62470 [7].

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1 Numbers in square brackets refer to the Bibliography.

Annex A
(informative)

Guidelines for specific defined applications and cabled fibre performance

A.1 General

The fibre category should be agreed between customer and supplier.

Applications of optical fibre cables are defined by many different standards organisations including IEC, ISO, IEEE and ITU.

A.2 Cabled fibre attenuation requirements

Cabled fibre attenuation requirements are given in Table A.1, Table A.2 and Table A.3.

Table A.1 – Maximum cabled fibre attenuation coefficient (dB/km), as given by ITU-T

Fibre category	Maximum attenuation coefficient (dB/km) at wavelengths (nm)			
	1 310 nm	1 383 nm	1 550 nm	1 625 nm
IEC 60793-2-50, B1.1 (dispersion unshifted) – ITU-T G.652.A	0,5	n/a	0,4	n/a
IEC 60793-2-50, B1.1 (dispersion unshifted) – ITU-T G.652.B	0,4	n/a	0,35	0,4
IEC 60793-2-50, B1.2 (cut-off shifted) – ITU-T G.654.A/B/C	n/a	n/a	0,22	n/a
IEC 60793-2-50, B1.3 (extended band) – ITU-T G.652.C	0,4	0,4 (1 310 to 1 625)	0,3	0,4
IEC 60793-2-50, B1.3 (extended band) – ITU-T G.652.D	0,4	0,4 (1 310 to 1 625)	0,3	0,4
IEC 60793-2-50, B2 (dispersion shifted) – ITU-T G.653.C/D	n/a	n/a	0,35	n/a
IEC 60793-2-50, B4 (non-zero dispersion shifted) – ITU-T G.655.C/D/E	n/a	n/a	0,35	0,4
IEC 60793-2-50, B5 (wideband non-zero dispersion shifted) – ITU-T G.656	n/a	0,4 (1 460)	0,35	0,4
IEC 60793-2-50, B6_a1, B6_a2 (bending loss insensitive) – ITU-T G.657.A1/A2	0,4	0,4 (1 310 to 1 625)	0,3	0,4
IEC 60793-2-50, B6_b2, B6_b3 (bending loss insensitive) – ITU-T G.657.B2/B3	0,5	0,4	0,3	0,4
n/a = not applicable				

These values are more applicable to cables in the IEC 60794-3 [10] and IEC 60794-4 series, where used for long system applications (as defined by ITU-T). The introduction of link design attenuation (LDA) values is under consideration for certain fibre category. Different attenuation values may be agreed between the customer and the supplier for certain cable constructions.

1 625 nm attenuation values are optionally specified by the customer.

A list of applications supported by A1 multimode optical fibre for multimode optical cables can be found in IEC 60793-2-10.

ISO/IEC 11801 provides information on applications for single-mode and multimode optical cables. It has simplified the requirements for cable attenuation by defining performance categories of cabled optical fibre. The categories can then be used in channels, defined by distance, which support applications.

Table A.2 –Category A1 multimode fibre maximum cable attenuation coefficient (dB/km)

Fibre category	Attenuation coefficient at 850 nm	Attenuation coefficient at 1 300 nm	Performance category
IEC 60793-2-10, A1a.1 category	3,5	1,5	OM1, OM2
IEC 60793-2-10, A1a.2 category	3,5	1,5	OM3
IEC 60793-2-10, A1a.3 category	3,5	1,5	OM4
IEC 60793-2-10, A1b category	3,5	1,5	OM1, OM2

Table A.3 – Single-mode maximum cable attenuation coefficient (dB/km)

Fibre category	Wavelength (nm)	Maximum attenuation coefficient	Performance category
IEC 60793-2-50, B1.1, B1.3, or B6_a	1 310, 1 550	1,0	OS1[a]
IEC 60793-2-50, B1.3, or B6_a	1 310, 1 383, 1 550	0,4	OS2
[a] For OS1, the maximum attenuation of 1,0 dB is specified at 1 310 nm and 1 550 nm			

A.3 Cabled fibre bandwidth requirements

There are no bandwidth requirements on single-mode fibre.

For cables containing multimode fibres, the fibre should be specified at one of the performance levels defined in Table A.4 in terms of minimum bandwidth (MHz·km), wavelength, and type of measurement. The value for bandwidth is normally as given by the fibre supplier, rather than measured on cabled fibre.

The fibre category and performance level should be agreed between customer and supplier.

Table A.4 – Category A1 multimode cabled fibre bandwidth (MHz·km)

Fibre category	Nominal core diameter (µm)	Overfilled bandwidth at 850 nm	Overfilled bandwidth at 1300 nm	Effective modal bandwidth at 850 nm	Performance category
IEC 60793-2-10, A1a.1 category	50	200	500	n/a	OM1
IEC 60793-2-10, A1a.1 category	50	500	500	n/a	OM2
IEC 60793-2-10, A1a.2 category	50	1 500	500	2 000	OM3
IEC 60793-2-10, A1a.3 category	50	3 500	500	4 700	OM4
IEC 60793-2-10, A1b category	62,5	200	500	n/a	OM1
IEC 60793-2-10, A1b category	62,5	500	500	n/a	OM2
n/a = not applicable					

A.4 Type testing at 1 625 nm

When specifically requested by the customer specification, cables that are intended for use in systems operating in the L-Band (1 565 nm to 1 625 nm) may be tested at 1 625 nm. Table A.5 below gives some guidance on possible pass/fail criteria. Actual requirements should be established by agreement between the customer and supplier, based on the particular cable application.

Table A.5 – Guidance values for 1 625 nm type test acceptance criteria

Test	Wavelength (nm)	Acceptance criteria[a,b]	
Attenuation – Point discontinuities	1 625	0,2 dB	
Temperature cycling	1 625	0,3 dB/km	
All other tests in the IEC 60794-1-2x series	1 625	0,3 dB	

[a] Results at 1 625 nm may be used to demonstrate compliance at 1 550 nm, using 1 550 nm acceptance criteria.

[b] Results at 1 550 nm shall not be used to demonstrate compliance at 1 625 nm.

Annex B
(informative)

Guidelines for qualification sampling

B.1 General

Typically, a wide range of fibre counts can be accommodated by a small range of generic optical fibre cables. For example, considering loose tube designs with 12 fibres per tube, a 6 element cable could be produced in 12, 24, 36, 48, 60 or 72 fibre versions just by varying the number of tubes and dummy filler elements, within the same basic design. Similarly, cables with 6, 8, 12 and 24 elements could provide options for 12 cables covering from 12 to 288 fibres, within just 4 generic cable designs. This concept can be applied to different fibre counts. For qualification purposes, it should only be necessary to test a subset of the fibre counts and element counts that represent the product range (e.g. the smallest and the largest element count designs). In the previous example, it could be considered appropriate to test just one 6 element design and one 24 element design in order to prove a manufacturer's design and manufacturing capability.

This philosophy can equally be applied to other designs of optical cable such as central tube cable designs or buffered optical fibre cable designs. For example, the smallest and the largest fibre count designs could be tested.

B.2 Fibre selection for cable testing

The cable being tested may contain a full complement of working fibres or may contain working and dummy/scrap fibres. The tested fibres should be dispersed throughout the working units. For cables with multiple tube designs, non-working tubes or filler rods may be deployed but they should be used in such a manner that they do not affect the performance of the test. The manufacturer should position the working units within a cable such that they will be subjected to the full force of the test.

Stranded loose tube cable designs with more than one active tube should be tested as follows:

In a single layer cable design at least one fibre from a minimum of 2 tubes should be tested. In a multi-layer design at least one fibre from a minimum of 2 tubes of each layer should be tested. The selected tubes should not be located next to each other and should be fully populated with fibre although some may be scrap/dummy fibres.

Ribbon cables with a layered ribbon structure should contain working fibres in the first, last, and central ribbon position. The working fibre being tested should be located at both edges and in the middle of each of these ribbons.

If agreed by customer and supplier, optical fibres within a tube may be spliced to each other, for example, in cases where a test requires that no fibres should break. This is a convenient way to check all fibres under test.

When a change in the design occurs, then only the tests that are affected by the design change need to be performed.

B.3 Pass/fail criteria

The acceptance criteria will depend on the application, but would typically include no fibre break or a combination of "no change" (see Clause 3) and permissible change in performance. These differences arise due to varying requirements before, during and after a test, as given in the relevant specification.

Bibliography

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[2] IEC TR 62691, *Guide to the installation of optical fibre cables*

[3] IEC TR 62690, *Hydrogen effects in optical fibre cables – Guidelines*

[4] IEC TR 62362, *Selection of optical fibre cable specifications relative to mechanical, ingress, climatic or electromagnetic characteristics – Guidance*

[5] IEC TR 62283, *Optical fibres – Guidance fo nuclear radiation tests*

[6] IEC TR 62000, *Guidance for combining different single-mode fibres types*

[7] IEC TR 62470, *Guidance on techniques for the measurement of the coefficient of friction (COF) between cables and ducts*

[8] ISO/IEC 11801, *Information technology – Generic cabling for customer premises*

[9] ISO/IEC 24702, *Information technology – Generic cabling – Industrial premises*

[10] IEC 60794-3, *Optical fibre cables – Part 3: Outdoor cables – Sectional specification*

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IEC 60793-2-10, *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres*

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