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Part 2-60: Product specifications - Sectional specification for class C single-mode interconnection fibres

Fibres optiques -
Partie 2-60: Spécifications de produits - Spécification intermédiaire pour les fibres d'interconnexion unimodales de classe C

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Optical fibres - Part 2-60: Product specifications - Sectional specification for class C single-mode interconnection fibres

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IEC 60793-2-60 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics. It is an International Standard.

This second edition cancels and replaces the first edition published in 2008. This edition constitutes a technical revision.

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

a) replacement of "intraconnection" with "interconnection" and addition of the definition of "interconnection fibres";
b) modification of the nominal MFD limit of C1 fibres;
c) addition of "Primary coating diameter-coloured" limits for class C fibres and change of "Primary coating diameter-uncoloured" limits for class C_80 fibres;

d) change of coating strip force limits for class C1, class C2, and class C3 fibres;

e) replacement of "Fibre cut-off wavelength" with "Cable cut-off wavelength" and revision of "Note b" in Table 6;

f) replacement of "Fibre cut-off wavelength" with "Cable cut-off wavelength" and deletion of the "Note" in Table 8;

g) addition of 200 µm coating diameter requirements for C1_125 fibres and change of coating diameters limits for C1_80 fibres in Table A.1;

h) addition of 200 µm coating diameter requirements for C1_125 fibres and change of coating strip force limits in Table A.2 and in Table A.5;

i) replacement of "Fibre cut-off wavelength" with "Cable cut-off wavelength", modification of the "Cable cut-off wavelength" limit and addition of a new "Note" in Table A.3;

j) addition of a transmission requirements at 1 625 nm and deletion of 1 310 nm for C1 fibres in Table A.4;

k) modification of "Fibre cut-off wavelength" limits of C3 fibres in Table C.3;

l) replacement of "Fibre cut-off wavelength" with "Cable cut-off wavelength" for C4 fibres in Table D.3.

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

Draft	Report on voting
86A/2599/FDIS	86A/2617/RVD

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

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

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

A list of all parts in the IEC 60793 series, published under the general title *Optical fibres* can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

1 Scope

This part of IEC 60793 is applicable to optical fibre types C1, C2, C3, and C4, as described in Table 1. These fibres are used for the interconnections within or between optical components systems and are optimized to support dense optical connectivity. While the fibres can be overcoated or buffered for the purpose of making protected pigtails, they can be used without overcoating. They can, however, be colour coded.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60793-1-20, *Optical fibres - Part 1-20: Measurement methods and test procedures - Fibre geometry*

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

IEC 60793-1-22, *Optical fibres - Part 1-22: Measurement methods and test procedures - Length measurement*

IEC 60793-1-30, *Optical fibres - Part 1-30: Measurement methods and test procedures - Fibre proof test*

IEC 60793-1-31, *Optical fibres - Part 1-31: Measurement methods and test procedures - Tensile strength*

IEC 60793-1-32, *Optical fibres - Part 1-32: Measurement methods and test procedures - Coating strippability*

IEC 60793-1-33, *Optical fibres - Part 1-33: Measurement methods and test procedures - Stress corrosion susceptibility*

IEC 60793-1-40, *Optical fibres - Part 1-40: Attenuation measurement methods*

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

IEC 60793-1-45, *Optical fibres - Part 1-45: Measurement methods and test procedures - Mode field diameter*

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

IEC 60793-1-47, *Optical fibres - Part 1-47: Measurement methods and test procedures - Macrobending loss*

IEC 60793-1-50, *Optical fibres - Part 1-50: Measurement methods and test procedures - Damp heat (steady state) tests*

IEC 60793-1-51, *Optical fibres - Part 1-51: Measurement methods and test procedures - Dry heat (steady state) tests*

IEC 60793-1-52, *Optical fibres - Part 1-52: Measurement methods and test procedures - Change of temperature tests*

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

3 Terms, definitions, symbols, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60793-2 and the following apply. Moreover, the definitions of the specified attributes are contained in the test methods.

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

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

3.1.1
interconnection fibre
fibre up to 1 km long that is used within or between optical components or systems to support dense connectivity

3.2 Symbols and abbreviated terms

The following symbols and abbreviated terms are used in this document:

F_{avg}	average strip force
F_{peak}	peak strip force
MFD	mode field diameter
n_d	stress corrosion parameter – dynamic

4 Specifications

4.1 General

The general requirements defined in IEC 60793-2 apply to these fibres. Specific requirements that are common to these fibres are found in the body of this text. Particular requirements for individual fibre types or applications are defined in Annex A, Annex B, Annex C and Annex D, which refer to normative family specifications. These family specifications are distinguished based on optimum transmission wavelengths and nominal mode field diameter (MFD), which affects splice loss.

For each family specification, there are two sub-categories that are distinguished on the basis of the cladding diameter and other related attributes. The conventional nominal cladding diameter of 125 µm is augmented by the reduced cladding type product with a nominal diameter of 80 µm. These are distinguished with suffixes "_125" or "_80". For example, the C1 fibre can be selected as "C1_125" or "C1_80". The transmission characteristics of both the cladding diameter choices should be the same.

For each family specification except C1, there are two sub-categories that are distinguished on the basis of transmission characteristics that relate to MFD. To denote these sub-categories, suffix "_a" or "_b" is added, for lower or higher MFD. In general, the fibres can be optimised for either splice loss or macro-bend loss or both using MFD as a main variable. A C2 fibre with an 80 µm cladding diameter and lower MFD is designated as C2_80_a.

Fibres for the C1_125 family specification can be selected from category B-652.B or B-652.D or B-657 single-mode fibres and are suitable for use with any class B single-mode fibre at wavelengths from 1 260 nm to 1 625 nm. Fibres for the C2 and C3 family specifications are optimized at nominal wavelengths of 1 310 nm and 1 550 nm respectively for connection to any class B single-mode fibre. Fibres for the C4 family specification are optimized for transporting optical amplifier pump light at 980 nm or higher.

Table 1 – List of families and main differences

Families	Nominal transmission wavelengths nm	Nominal MFDs
C1	1 260, 1 310,1 550 and 1 625	8,6 to 9,2 µm at 1 310 nm
C2	1 310	5,0 to 7,0 µm at 1 310 nm
C3	1 550 and 1 625	5,5 to 7,5 µm at 1 550 nm
C4	980	4,0 to 7,0 µm at 980 nm

The fibre shall consist of a glass core, a glass cladding, and a coating in accordance with 5.3 of IEC 60793-2:2019.

4.2 Dimensional requirements

Table 2 specifies both the dimensional attributes and the corresponding measurement methods that shall be applied. Minimum dimensional requirements, common to all Class C fibres, shall be as specified in Table 3. Some family specification requirements can be stricter.

Table 2 – Dimensional attributes and measurement methods

Attributes	Measurement methods
Cladding diameter	IEC 60793-1-20
Cladding non-circularity	IEC 60793-1-20
Core concentricity error	IEC 60793-1-20
Coating diameter	IEC 60793-1-21
Coating non-circularity	IEC 60793-1-21
Cladding-coating concentricity error	IEC 60793-1-21
Fibre length	IEC 60793-1-22

Table 3 – Requirements common to class C fibres

Attributes	Units	_125 Limits	_80 Limits
Cladding diameter	µm	125 ± 1,0	80 ± 1,0
Cladding non-circularity	%	≤ 1,0	≤ 1,0
Core concentricity error	µm	≤ 0,5	≤ 0,5
Primary coating diameter – uncoloured [a c]	µm	235 to 255	150 to 170
Primary coating diameter – coloured [a c]	µm	235 to 265	150 to 180
Fibre length	km	[b]	[b]

[a] Tolerance applies to the entire length of fibre.

[b] Length requirements vary and should be agreed between customer and supplier.

[c] These limits on primary coating diameters are most commonly used. Other coating diameters shall be specified in the family specifications.

4.3 Mechanical requirements

Table 4 specifies both the mechanical attributes and the corresponding measurement methods that shall be applied. Minimum mechanical requirements, common to all fibres in class C, are given in Table 5. Some family specification values can be stricter.

Table 4 – Mechanical attributes and measurement methods

Attributes	Measurement methods
Proof test	IEC 60793-1-30
Tensile strength	IEC 60793-1-31
Coating strippability	IEC 60793-1-32
Stress corrosion susceptibility	IEC 60793-1-33

Table 5 – Mechanical requirements common to class C fibres

Attributes	Units	Limits
Proof stress level	GPa	≥ 0,69
Coating strip force [a]		
Tensile strength (median) for a 0,5 m specimen length	GPa	≥ 3,8

[a] The coating strip force is a common requirement for all Class C fibres. Refer to the Annexes of this document for detailed specifications.

4.4 Transmission requirements

Table 6 specifies both the transmission attributes and the corresponding measurement methods that shall be applied. Some family specifications can have additional attributes or test methods. Minimum transmission requirements, common to all class C fibres, shall be as specified in Table 7. Some family specifications can be stricter. Requirements that shall be specified in the family specifications are listed in Table 8.

Table 6 – Transmission attributes and measurement methods

Attributes	Measurement methods
Attenuation coefficient	IEC 60793-1-40 [a]
Cable cut-off wavelength	IEC 60793-1-44 [b]
Mode field diameter	IEC 60793-1-45
Macrobending loss	IEC 60793-1-47

[a] The attenuation coefficient at various wavelengths can be calculated using the measured values at a few wavelengths using a spectral model such as the one given in IEC 60793-1-40. For example, the attenuation at 1 480 nm can be calculated and used for design of systems that employ remote pumping of optical amplifiers.

[b] Cut-off wavelength intrinsically contains length or bending dependence. In the case of a short length deployment condition (e.g. a piece length shorter than 22 m without specific bending), cut-off wavelength under the expected condition should be ensured to have negligible influence on system performance.

Table 7 – Transmission requirements common to class C fibres

Attributes	Units	Limits
This table is empty, but retained in case of some common minimum requirement.		

Table 8 – Transmission attributes required in family specifications

Attributes required in family specifications
Maximum attenuation coefficient at operating wavelengths
Nominal mode field diameter, tolerance, and wavelength
Maximum macro-bending loss, wavelength, bend radius, and number of turns
Maximum cable cut-off wavelength

4.5 Environmental requirements

4.5.1 General

Environmental attribute tests and measurement methods are documented in two forms:

– environmental attributes and the corresponding measurement methods shall be as specified in Table 9;

– Environment-dependent mechanical or transmission attributes and their corresponding measurement methods shall be as specified in Table 10.

Table 9 – Environmental attributes and test methods

Environmental exposures	Measurement methods
Damp heat tests	IEC 60793-1-50
Dry heat tests	IEC 60793-1-51
Change of temperature tests	IEC 60793-1-52

Table 10 – Environment-dependent mechanical or transmission attributes and test methods

Attributes	Measurement methods
Change in attenuation	IEC 60793-1-46
Attenuation	IEC 60793-1-40
Coating strip force	IEC 60793-1-32
Tensile strength	IEC 60793-1-31
Stress corrosion sensitivity	IEC 60793-1-33

These tests are normally conducted periodically as type-tests for a fibre and coating design. The recovery period allowed between completing the environmental exposure and performing the attribute measurements shall be as specified in the particular environmental conditioning test standards listed in Table 9.

4.5.2 Transmission requirements

Change in attenuation from the initial value shall be less than the values specified in the relevant family specification.

4.5.3 Mechanical requirements

4.5.3.1 General

These tests are, in practice, the most severe requirements amongst the environment exposures defined in Table 9.

4.5.3.2 Coating strip force

In addition to the un-aged strip force requirements in 4.3, coating strip force after damp heat ageing shall be specified in the family specifications. The ageing options are also specified.

4.5.3.3 Tensile strength

The attributes given in Table 11 shall be verified following removal of the fibre from the test environment.

Table 11 – Tensile strength requirements common to class C fibres

Environment	Median tensile strength (GPa), specimen length: 0,5 m	15 % of the tensile strength distribution (GPa), specimen length: 0,5 m
Damp heat	≥ 3,03	≥ 2,76

The requirements given in Table 11 do not apply to hermetically coated fibres or to fibres that are intended for sole use within hermetically sealed enclosures.

4.5.3.4 Stress corrosion susceptibility

The attributes given in Table 12 shall be verified following removal of the fibres from the test environment.

Table 12 – Stress corrosion susceptibility requirements common to class C fibres

Environment	Stress corrosion Susceptibility constant, n_d
Damp heat	≥ 18

The requirements given in Table 12 do not apply to hermetically coated fibres or to fibres that are intended for sole use within hermetically sealed enclosures.

Annex A
(normative)

Family specification for C1 single-mode fibres

A.1 General

The C1 single-mode fibre is a single-mode interconnection fibre that is suitable for use with any category B single-mode fibre at wavelengths from 1 260 nm to 1 625 nm. It is optimised for precision glass geometry and improved macro-bending, and generally have lower fibre cut-off wavelength compared to that of B-652 fibres.

Clause A.2 to Clause A.5 contain the requirements for C1 fibres. Common requirements, copied for ease of reference from the sectional specification, are noted by an entry in the “Ref.” column. Relevant notes from the sectional specification are not repeated but indicated with a superscript.

A.2 Dimensional requirements

Table A.1 contains dimensional requirements for C1 fibres.

Table A.1 – Dimensional requirements for C1 fibres

Attributes	Units	_125 limits (250 µm coating)	_125 limits (200 µm coating)	_80 limits	Ref.
Cladding diameter	µm	125,0 ± 0,7	125,0 ± 0,7	80 ± 1,0	4.2
Cladding non-circularity	%	≤ 0,7	≤ 0,7	≤ 1,0	4.2
Core concentricity error	µm	≤ 0,5	≤ 0,5	≤ 0,5	4.2
Primary coating diameter – uncoloured	µm	235 to 255	180 to 210[a]	150 to 170	4.2
Primary coating diameter – coloured	µm	235 to 265	180 to 220[a]	150 to 180	4.2
Fibre length	km	(See 4.2)	(See 4.2)	(See 4.2)	4.2
[a] These limits on primary coating diameters are most commonly used. There are other applications, such as fibres for use within optical sub-systems, pigtails, or specialty applications, which use other primary coating diameters such as 150 µm to 170 µm uncoloured and 150 µm to 180 µm coloured					

A.3 Mechanical requirements

Table A.2 contains mechanical requirements for C1 fibres.

Table A.2 – Mechanical requirements for C1 fibres

Attributes	Units	_125 limits (250 µm coating)	_125 limits (200 µm coating)	_80 limits	Ref.
Proof stress level	GPa	≥ 0,69			4.3
Coating strip force (average)	N	$1,0 \leq F_{avg} \leq 5,0$	$0,4 \leq F_{avg} \leq 5,0$	$0,4 \leq F_{avg} \leq 5,0$	4.3
Coating strip force (peak)	N	$1,0 \leq F_{peak} \leq 8,9$	$0,4 \leq F_{peak} \leq 8,9$	$0,4 \leq F_{peak} \leq 8,9$	4.3
Tensile strength (median) for 0,5 m specimen length	GPa	≥ 3,8			4.3

A.4 Transmission requirements

Table A.3 contains transmission requirements for C1 fibres. The specified limits apply to both _125 and _80 fibres.

Table A.3 – Transmission requirements for C1 fibres

Attributes	Units	Limits	Ref.
Attenuation coefficient from 1 260 nm to 1 625 nm	dB/km	≤ 0,7	4.4
Mode field diameter range of nominal values at 1 310 nm	μm	8,6 to 9,2	4.4
Mode field diameter tolerance	μm	± 0,4	4.4
Cable cut-off wavelength	nm	≤ 1 260	4.4
Macro-bending loss at 1 625 nm, 5 turns on a 16 mm radius mandrel	dB	≤ 1,0	4.4
[a] Cut-off wavelength intrinsically contains length or bending dependence. In the case of a short length deployment condition (e.g. a piece length shorter than 22 m without specific bending), cut-off wavelength under the expected condition should be ensured to have negligible influence on system performance.			

A.5 Environmental requirements

A.5.1 General

Subclause A.5.2 and A.5.3 contain requirements specific to C1 fibres. The specified limits apply to all sub-categories.

A.5.2 Transmission requirements

Change in attenuation from the initial value shall be less than the values specified in Table A.4. Attenuation shall be measured periodically during the entire exposure to each environment and after removal.

Table A.4 – Environment-dependent transmission requirements for C1 fibres

Environment	Wavelengths nm	Maximum attenuation increase dB/km
Damp heat	1 550	≤ 0,10
	1 625	≤ 0,10
Dry heat	1 550	≤ 0,10
	1 625	≤ 0,10
Change of temperature	1 550	≤ 0,10
	1 625	≤ 0,10