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INTERNATIONAL STANDARD

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

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FOREWORD

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International Standard IEC 60793-2-50 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This fifth edition cancels and replaces the fourth edition, published in 2012. This edition constitutes a technical revision.

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

a) aligns the requirements with the ITU-T Recommendations G.654 (2012-10) and G.657 (2012-10);
b) adds a new sub-category B1.2_d;
c) modifies B6 sub-categories in terms of attenuation and chromatic dispersion coefficient.

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

CDV	Report on voting
86A/1571/CDV	86A/1614/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.

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

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 publication will remain unchanged until the stability date indicated on the IEC web site 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- withdrawn,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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

OPTICAL FIBRES –

Part 2-50: Product specifications – Sectional specification for class B single-mode fibres

1 Scope

This part of IEC 60793 is applicable to optical fibre categories B1.1, B1.2, B1.3, B2, B4, B5 and B6. A map illustrating the connection of IEC designations to ITU-T designations is shown in Annex I. These fibres are used or can be incorporated in information transmission equipment and optical fibre cables.

Three types of requirements apply to these fibres:

– general requirements, as defined in IEC 60793-2;

– specific requirements common to the class B single-mode fibres covered in this standard and which are given in Clause 5;

– particular requirements applicable to individual fibre categories or specific applications, which are defined in Annexes A to G.

For some fibre categories (shown in the relevant family specifications), there are sub-categories that are distinguished on the basis of difference in transmission attribute specifications. The designations for these sub-categories are documented in the individual family specifications.

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 60793-1 (all parts), *Optical fibres – Measurement methods and test procedures*

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

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 60793-1-34, *Optical fibres – Part 1-34: Measurement methods and test procedures – Fibre curl*

IEC 60793-1-40:2001, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

IEC 60793-1-42, *Optical fibres – Part 1-42: Measurement methods and test procedures – Chromatic dispersion*

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 optical transmittance*

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

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

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 60793-1-53, *Optical fibres – Part 1-53: Measurement methods and test procedures – Water immersion tests*

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

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

IEC TR 62316, *Guidance for the interpretation of OTDR backscattering traces*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60793-2 and the IEC 60793-1 series apply.

NOTE General definitions for fibres are provided in IEC 60793-2. The definitions of the specified attributes are contained in the relevant test methods standard of the IEC 60793-1 series, while general definitions for testing are provided in IEC 60793-1-1.

4 Abbreviations and symbols

For the purposes of this document, the following abbreviations and symbols apply:

λ_0 zero dispersion wavelength
F_{avg} average strip force
F_{peak} peak strip force
MFD mode field diameter
n_d stress corrosion parameter – dynamic
PMD polarization mode dispersion
PMD_Q PMD link design value

5 Specifications

5.1 General

The fibre shall consist of a glass core and glass cladding in accordance with the construction of optical fibre class B – single-mode fibre – as given in IEC 60793-2.

The term “glass” usually refers to material consisting of non-metallic oxides. The composition of some fibres may be all glass, or glass and glass/hard polymeric composites.

5.2 Dimensional requirements

Relevant dimensional attributes and measurement methods are given in Table 1.

Requirements common to all categories of class B single-mode fibres are given in Table 2.

Cladding diameter, cladding non-circularity, and core concentricity error shall be specified in the family specifications.

Table 1 – Dimensional attributes and measurement methods

Attribute	Measurement method
Cladding diameter	IEC 60793-1-20
Cladding non-circularity	IEC 60793-1-20
Core-cladding concentricity error	IEC 60793-1-20
Primary coating diameter	IEC 60793-1-21
Primary coating non-circularity	IEC 60793-1-21
Primary coating-cladding concentricity error	IEC 60793-1-21
Fibre length	IEC 60793-1-22

Table 2 – Dimensional requirements common to all category B fibres

Attribute	Unit	Limit
Primary coating diameter – uncoloured	µm	235 to 255 [a]
Primary coating diameter – coloured	µm	235 to 265 [a]
Primary coating-cladding concentricity error	µm	≤ 12,5
Fibre length	km	[b]

[a] The above limits on primary coating diameter are most commonly used in telecommunications cables. There are other applications, such as fibre for use within optical sub-systems, pigtails, or specialty applications such as for submarines cables or for compact FTTH cables, which use other primary coating diameters, several of which are listed below.

Alternative nominal primary coating diameters and ranges:

200 µm ± 10 µm (uncoloured; 190 µm to 220 µm coloured)

400 µm ± 40 µm

500 µm ± 30 µm

700 µm ± 100 µm

900 µm ± 100 µm

The primary coating cladding concentricity error should be limited to a maximum 10 µm for 200 µm.

Alternative coating diameters may impact fibre connectivity such as ribbons, multi-fibre connectors, mechanical splices, and fusion splice protectors; they may also need adjustments to connectivity tools.

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

5.3 Mechanical requirements

Relevant mechanical attributes and test methods are given in Table 3. The relationship between some of these attributes and mechanical reliability are described in IEC TR 62048.

Requirements common to all categories of class B single-mode fibres are given in Table 4.

Table 3 – Mechanical attributes and test methods

Attribute	Test method
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
Fibre curl	IEC 60793-1-34

Table 4 – Mechanical requirements common to all class B fibres

Attribute	Unit	Limit
Proof stress level	GPa	≥ 0,69 [a]
Coating strip force (average) [b, c]	N	$1,0 \leq F_{ave} \leq 5,0$
Coating strip force (peak) [b, c]	N	$1,0 \leq F_{peak} \leq 8,9$
Fibre curl radius	m	≥ 2 [d]
Tensile strength (median) for 0,5 m specimen length	GPa	≥ 3,8
Stress corrosion susceptibility parameter, n_d	–	≥ 18

[a] The proof test value of 0,69 GPa equals about 1 % strain or about 8,8 N force. For the relation between these different units, see IEC TR 62048:2014, 7.4.

[b] Either average strip force or peak strip force, which are defined in the test procedure, may be specified with agreement between supplier and customer.

[c] In case of alternative nominal primary coating diameters (see Table 2), associated alternative coating strip force values need to be agreed between supplier and customer.

[d] Depending on splicing methods, a minimum of 4 m may be specified for fibre intended to be used in some cable constructions – such as ribbon cable.

5.4 Transmission requirements

Relevant transmission attributes and measurement methods are given in Table 5.

Requirements common to all categories of class B single-mode fibres are shown in Table 6.

Requirements that shall be specified in the family specifications are listed in Table 7.

Table 5 – Transmission attributes and measurement methods

Attribute	Measurement method
Attenuation coefficient	IEC 60793-1-40 [a]
Chromatic dispersion	IEC 60793-1-42
Cut-off wavelength [b]	IEC 60793-1-44
Mode field diameter	IEC 60793-1-45
Change of optical transmission	IEC 60793-1-46
Macrobending loss	IEC 60793-1-47
Polarization mode dispersion	IEC 60793-1-48

NOTE The indicated maximum attenuation values apply to uncabled optical fibres; for the maximum cabled attenuation values, reference is made to IEC 60794-2, which can be used in conjunction with this standard.

[a] The attenuation coefficient at various wavelengths can be calculated using the measured values at a few wavelengths using a spectral model such as that 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. When using Method C, OTDR, additional guidance information in IEC TR 62316 shall be taken into account. As reported in IEC 60793-1-40, the spectral attenuation model, to date, has only been demonstrated on B1 and B2 fibres

[b] There are two ways to measure cut-off wavelength, leading to: fibre cut-off wavelength λ_c and to cable cut-off wavelength λ_{cc}, respectively. The correlation of the measured values of λ_c and λ_{cc} depends on the specific fibre and cable design and the test conditions. While in general $\lambda_{cc} < \lambda_c$ a general quantitative relationship cannot be easily established, the importance of ensuring single-mode transmission in the minimum cable length between joints at the minimum operating wavelength is paramount. This may be performed by recommending the maximum cable cut-off wavelength λ_{cc} of a cabled single-mode fibre to be 1 260 nm or for worst case length and bends by recommending a maximum fibre cut-off wavelength λ_c to be 1 250 nm.

Table 6 – Transmission, requirements common to all class B fibres

Attribute	Unit	Limit
Polarization mode dispersion (PMD) coefficient link design value (PMD_Q)	ps/√km	[a]
[a] A maximum value of PMD_Q on uncabled fibre shall be agreed between supplier and customer to satisfy the primary requirement of cable PMD, given in IEC 60794-3.		

Table 7 – Additional transmission attributes required in the family specifications

Attribute
Attenuation coefficient and wavelengths
Chromatic dispersion characteristics
Nominal mode field diameter (MFD) range and wavelength
Mode field diameter tolerance
Cable cut-off wavelength
Macrobending loss including: wavelength, mandrel size, and number of turns
Cladding diameter
Cladding non-circularity
Core concentricity error

For category B4 fibre, information for system design is given in Annex H.

5.5 Environmental requirements

5.5.1 General

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

– relevant environmental attributes and test methods are given in Table 8;

– measurements of a particular mechanical or transmission attributes that may change on the application of the environment are listed in Table 9.

Table 8 – Environmental exposure tests

Attribute	Test method
Damp heat tests	IEC 60793-1-50
Dry heat tests	IEC 60793-1-51
Change of temperature tests	IEC 60793-1-52
Water immersion tests	IEC 60793-1-53

Table 9 – Attributes measured in environmental exposure tests

Attribute	Test method
Change in optical transmission	IEC 60793-1-46
Attenuation	IEC 60793-1-40
Coating strip force	IEC 60793-1-32
Tensile strength	IEC 60793-1-31
Stress corrosion susceptibility	IEC 60793-1-33

These tests are normally conducted periodically as type-tests for a fibre and coating design. Unless otherwise indicated, the recovery period allowed between the completion of the

environmental exposure and performing the attribute measurements shall be as stated in the particular environmental test method.

5.5.2 Optical environmental requirements – Attenuation

Change in attenuation from the initial value shall be less than the values in Table 10. Attenuation shall be measured periodically during the entire exposure to each environment and after removal.

Table 10 – Change in attenuation for environmental tests

Environment	Wavelength nm	Maximum attenuation increase dB/km
Damp heat	1 550, 1 625	≤ 0,05
Dry heat	1 550, 1 625	≤ 0,05
Change of temperature	1 550, 1 625	≤ 0,05
Water immersion	1 550, 1 625	≤ 0,05
NOTE Attenuation changes at wavelengths lower than the test wavelength are smaller than the attenuation change at the test wavelength.		

5.5.3 Mechanical environmental requirements

5.5.3.1 General

These tests are, in practice, the most severe requirements amongst the environments defined in Table 8.

5.5.3.2 Coating strip force

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

Table 11 – Coating strip force for environmental tests

Environment	Average strip force N	Peak strip force N
Damp heat	$1,0 \leq F_{avg} \leq 5,0$	$1,0 \leq F_{peak} \leq 8,9$
Water immersion	$1,0 \leq F_{avg} \leq 5,0$	$1,0 \leq F_{peak} \leq 8,9$
In case of alternative nominal primary coating diameters (see Table 2), associated alternative coating strip force values need to be agreed between supplier and customer.		

5.5.3.3 Tensile strength

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

Table 12 – Tensile strength for environmental tests

Environment	Median tensile strength (GPa), specimen length: 0,5 m	15 percentile of the tensile strength distribution (GPa), specimen length: 0,5 m
Damp heat	≥ 3,03	≥ 2,76
NOTE These requirements do not apply to hermetically coated fibre. (A hermetic coating is a protective layer that completely segregates the glass fibre from moisture, thereby ensuring a high level of stress corrosion resistance. Typical hermetic coating is a carbon layer of several microns thickness applied on the glass surface.)		

5.5.3.4 Stress corrosion susceptibility

The attribute given in Table 13 shall be verified following removal of the fibre from the environment indicated.

Table 13 – Stress corrosion susceptibility for environmental tests

Environment	Stress corrosion susceptibility parameter, n_d
Damp heat	≥ 18
NOTE This requirement does not apply to hermetically coated fibre (see definition for hermetic coating in Table 12).	

Annex A
(normative)

Family specification for category B1.1 single-mode fibres

A.1 General

This dispersion unshifted single-mode fibre is optimized for use in the 1 310 nm region but can be used in the 1 550 nm and 1 625 nm regions. Depending on link length and bit rates, dispersion may need accommodation in the 1 550 nm and 1 625 nm regions.

The clauses and tables in Annex A contain particular requirements applicable to category B1.1 fibres. Common requirements, repeated here for ease of reference from the sectional specification, are noted by an entry in the "Reference" column. Relevant notes from the sectional specification are not repeated but indicated with a superscript "SS".

A.2 Dimensional requirements

Table A.1 contains dimensional requirements specific to category B1.1 fibres.

Table A.1 – Dimensional requirements specific to category B1.1 fibres

Attribute	Unit	Limit	Reference
Cladding diameter	µm	125 ± 1	5.2
Cladding non-circularity	%	≤ 1,0	5.2
Core concentricity error	µm	≤ 0,6	5.2
Primary coating diameter – uncoloured [a]	µm	235 to 255	5.2
Primary coating diameter – coloured [a]	µm	235 to 265	5.2
Primary coating-cladding concentricity error	µm	≤ 12,5	5.2
Fibre length	km	See 5.1	5.2
[a] Alternative nominal primary coating diameters may be used (see Table 2), to be agreed between supplier and customer.			

A.3 Mechanical requirements

Table A.2 contains mechanical requirements specific to category B1.1 fibres.

Table A.2 – Mechanical requirements specific to category B1.1 fibres

Attribute	Unit	Limit	Reference
Proof stress level	GPa	≥ 0,69[SS]	5.3
Coating strip force (average) [SS]	N	$1{,}0 \leq F_{ave} \leq 5{,}0$	5.3
Coating strip force (peak) [SS]	N	$1{,}0 \leq F_{peak} \leq 8{,}9$	5.3
Fibre curl radius	m	≥ 2[a]	5.3
Tensile strength (median) for 0,5 m specimen length	GPa	≥ 3,8	5.3
Stress corrosion susceptibility parameter, n_d	–	≥ 18	5.3
[a] Depending on splicing methods, a minimum of 4 m may be specified for fibre intended to be used in some cable constructions – such as ribbon cable.			

A.4 Transmission requirements

Table A.3 contains transmission requirements specific to category B1.1 fibres.

Table A.3 – Transmission requirements specific to category B1.1 fibres

Attribute	Unit	Limit	Reference
Attenuation coefficient at 1 310 nm	dB/km	≤ 0,40	
Attenuation coefficient at 1 550 nm	dB/km	≤ 0,30	
Attenuation coefficient at 1 625 nm	dB/km	≤ 0,40	
Zero dispersion wavelength, λ_0	nm	$1\,300 \leq \lambda_0 \leq 1\,324$	
Zero dispersion slope	ps/nm^2 · km	≤ 0,092	
Nominal MFD range at 1 310 nm [a]	µm	8,6 to 9,5	
MFD tolerance	µm	± 0,6	
Cable cut-off wavelength	nm	≤ 1 260	
Macrobending loss at 1 625 nm, 100 turns on a 30 mm radius mandrel	dB	≤ 0,1	
Polarization mode dispersion (PMD) coefficient	ps/√km	See 5.4	
NOTE In the 1 550 nm region, the chromatic dispersion can be approximated as a linear function with wavelength. A typical value for the chromatic dispersion at 1 550 nm is 17 ps/nm · km with a typical slope at 1 550 nm of 0,056 ps/nm^2 · km.			
[a] The value of the nominal MFD shall be agreed between supplier and customer from within the range given. The tolerance shown is then applied around that nominal value.			

A.5 Environmental requirements

The requirements of 5.5 shall be met.

Annex B
(normative)

Family specification for category B1.2 single-mode fibres

B.1 General

This dispersion unshifted single-mode fibre is optimized for low loss in the 1 550 nm region, with cutoff wavelength shifted above the 1 310 nm region.

The clauses and tables in Annex B contain particular requirements applicable to category B1.2 fibres. Common requirements, repeated here for ease of reference from the sectional specification, are noted by an entry in the "Reference" column. Relevant notes from the sectional specification are not repeated but indicated with a superscript "SS".

There are three sub-categories which are designated as with suffixes, "_b", "_c" and "_d". These sub-categories are distinguished by the chromatic dispersion coefficient and mode field diameter attribute specifications.

B.2 Dimensional requirements

Table B.1 contains dimensional requirements specific to category B1.2 fibres.

Table B.1 – Dimensional requirements specific to category B1.2 fibres

Attribute	Unit	Limit	Reference
Cladding diameter	µm	125 ± 1	5.2
Cladding non-circularity	%	≤ 2,0	5.2
Core concentricity error	µm	≤ 0,8	5.2
Primary coating diameter – uncoloured [a]	µm	235 to 255	5.2
Primary coating diameter – coloured [a]	µm	235 to 265	5.2
Primary coating-cladding concentricity error	µm	≤ 12,5	5.2
Fibre length	km	See 5.2	5.2

[a] Alternative nominal primary coating diameters may be used, (see Table 2), to be agreed between supplier and customer.

B.3 Mechanical requirements

Table B.2 contains mechanical requirements specific to category B1.2 fibres.

Table B.2 – Mechanical requirements specific to category B1.2 fibres

Attribute	Unit	Limit	Reference
Proof stress level	GPa	≥ 0,69[SS]	5.3
Coating strip force (average) [SS]	N	$1,0 \leq F_{ave} \leq 5,0$	5.3
Coating strip force (peak) [SS]	N	$1,0 \leq F_{peak} \leq 8,9$	5.3
Fibre curl radius	m	≥ 2 [a]	5.3
Tensile strength (median) for 0,5 m specimen length	GPa	≥ 3,8	5.3
Stress corrosion susceptibility parameter, n_d	–	≥ 18	5.3

[a] Depending on splicing methods, a minimum of 4 m may be specified for fibre intended to be used in some cable constructions – such as ribbon cable.

B.4 Transmission requirements

Table B.3 contains transmission requirements specific to category B1.2 fibres. There are three sub-categories designated as "_b", "_c" and "_d".

Table B.3 – Transmission requirements specific to category B1.2 fibres

Attribute	Unit	_b Limit	_c Limit	_d Limit	Reference
Attenuation coefficient at 1 550 nm	dB/km	≤ 0,22	≤ 0,22	≤ 0,20	
Attenuation coefficient at 1 625 nm	dB/km	≤ 0,40	≤ 0,40	≤ 0,40	
Dispersion slope at 1 550 nm	ps/nm^2 · km	≤ 0,07	≤ 0,07	≤ 0,07	
Dispersion coefficient at 1 550 nm	ps/nm · km	≤ 22	≤ 20	≤ 23	
Nominal MFD range at 1 550 nm [a]	µm	9,5 to 13,0	9,5 to 10,5	11,5 to 15,0	
MFD tolerance	µm	±0,7	±0,7	±0,7	
Cable cut-off wavelength	nm	≤ 1 530	≤ 1 530	≤ 1 530	
Macrobending loss at 1 625 nm, 100 turns on a 30 mm radius mandrel	dB	≤ 0,50	≤ 0,50	≤ 2,0 [b]	
Polarization mode dispersion (PMD) coefficient	ps/√km	See 5.4	See 5.4	See 5.4	

[a] The value of the nominal MFD shall be agreed between supplier and customer from within the range given. The tolerance shown is then applied around that nominal value

[b] Other application specific test conditions and requirements (bending radius and number of turns) at 1 550 nm are under study.

B.5 Environmental requirements

The requirements of 5.5 shall be met.

Annex C
(normative)

Family specification for category B1.3 single-mode fibres

C.1 General

This dispersion unshifted single-mode fibre can be used from 1 260 nm up to 1 625 nm. Chromatic dispersion in this band may impose requirements either on the maximum link length or on the need for accommodation.

The clauses and tables in Annex C contain particular requirements applicable to category B1.3 fibres. Common requirements, repeated here for ease of reference from the sectional specification, are noted by an entry in the "Reference" column. Relevant notes from the sectional specification are not repeated but indicated with a superscript "SS".

C.2 Dimensional requirements

Table C.1 contains dimensional requirements specific to category B1.3 fibres.

Table C.1 – Dimensional requirements specific to category B1.3 fibres

Attribute	Unit	Limit	Reference
Cladding diameter	µm	125 ± 1	5.2
Cladding non-circularity	%	≤ 1,0	5.2
Core concentricity error	µm	≤ 0,6	5.2
Primary coating diameter – uncoloured [a]	µm	235 to 255	5.2
Primary coating diameter – coloured [a]	µm	235 to 265	5.2
Primary coating-cladding concentricity error	µm	≤ 12,5	5.2
Fibre length	km	See 5.2	5.2
[a] Alternative nominal primary coating diameters may be used, (see Table 2), to be agreed between supplier and customer.			

C.3 Mechanical requirements

Table C.2 contains mechanical requirements specific to category B1.3 fibres.

Table C.2 – Mechanical requirements specific to category B1.3 fibres

Attribute	Unit	Limit	Reference
Proof stress level	GPa	≥ 0,69 SS	5.3
Coating strip force (average)SS	N	$1,0 \leq F_{ave} \leq 5,0$	5.3
Coating strip force (peak)SS	N	$1,0 \leq F_{peak} \leq 8,9$	5.3
Fibre curl radius	m	≥ 2 [a]	5.3
Tensile strength (median) for 0,5 m specimen length	GPa	≥ 3,8	5.3
Stress corrosion susceptibility parameter, n_d	–	≥ 18	5.3
[a] Depending on splicing methods, a minimum of 4 m may be specified for fibre intended to be used in some cable constructions – such as ribbon cable.			

C.4 Transmission requirements

Table C.3 contains transmission requirements specific to category B1.3 fibres.

Table C.3 – Transmission requirements specific to category B1.3 fibres

Attribute	Unit	Limit	Reference
Attenuation coefficient from 1 310 nm [a] to 1 625 nm	dB/km	≤ 0,40	
Attenuation coefficient at 1 383 nm ± 3 nm	dB/km	≤ 0,40 [b]	
Attenuation coefficient at 1 550 nm	dB/km	≤ 0,30	
Zero dispersion wavelength, λ_0	nm	1 300 ≤ λ_0 ≤ 1 324	
Zero dispersion slope	ps/nm^2 · km	≤ 0,092	
Nominal MFD range at 1 310 nm [c]	µm	8,6 to 9,5	
MFD tolerance	µm	± 0,6	
Cable cut-off wavelength	nm	≤ 1 260	
Macrobending loss at 1 625 nm, 100 turns on a 30 mm radius mandrel	dB	≤ 0,1	
Polarization mode dispersion (PMD) coefficient	ps/√km	See 5.4	

NOTE In the 1 550 nm region, the chromatic dispersion can be approximated as a linear function with wavelength. A typical value for the chromatic dispersion at 1 550 nm is 17 ps/nm · km with a typical slope at 1 550 nm of 0,056 ps/nm^2 · km.

[a] This wavelength region can be extended to 1 260 nm by adding 0,07 dB/km induced Rayleigh scattering loss to the attenuation value at 1 310 nm.

[b] The average attenuation coefficient after ageing according to the test outlined in the following paragraph shall be less than the value specified for the range of 1 310 nm to 1 625 nm.

[c] The value of the nominal MFD shall be agreed between supplier and customer from within the range given. The tolerance shown is then applied around that nominal value.

C.5 Hydrogen ageing for category B1.3

Select a fibre specimen at least 1 km long. After spooling the fibre to a test configuration that minimizes the effect of winding on attenuation at 1 310 nm, measure the attenuation coefficient of the specimen at 1 240 nm and at 1 383 nm. This measurement gives the baseline attenuation for the specimen. Expose the fibre to 0,01 atmospheres of hydrogen at room temperature (reference test). For practical considerations, such as the availability of equipment and testing time, higher H_2 concentrations (e.g. 1 atm) can be used with proper care as mentioned in Note 4. During this exposure, monitor the attenuation coefficient of the specimen at 1 240 nm. This wavelength is indicative of the molecular hydrogen present in the specimen. Constructing the change in attenuation as the monitored results minus the baseline value, continue exposure until the 1 240 nm attenuation changes by ≥ 0,03 dB/km. At this time, the attenuation increase at 1 383 nm may be considered fully saturated, and the specimen may be removed from the hydrogen atmosphere. After at least 14 days in the normal laboratory environment, measure the attenuation coefficient of the fibre at 1 383 nm using methods A, B or C of IEC 60793-1-40:2001.

NOTE 1 This is a type test performed periodically to ensure that the manufacturing process reliably yields fibre with acceptable ageing characteristics. For example, 10 fibre samples can be tested every 6 months.

NOTE 2 This test is not appropriate for hermetically coated fibre (see definition for hermetic coating in Table 12).

NOTE 3 For non-hermetic fibres, typical hydrogen exposure is from 4 days to 6 days (see definition for hermetic coating in Table 12).

NOTE 4 To be useful, hydrogen ageing is performed in H_2 concentrations that produce results representative of the actual field conditions. Although increased H_2 concentration reduces testing time, it tends to produce slightly

higher values of added loss at equivalent exposure time (see threshold for increases at 1 240 nm). The 0,01 atmosphere test is a compromise between impractically long testing times and unrealistically high added loss. When testing with higher H_2 concentration, the reduced testing time can require increased safety measures.

C.6 Environmental requirements

The requirements of 5.5 shall be met.

Annex D
(normative)

Family specification for category B2 single-mode fibres

D.1 General

This dispersion-shifted single-mode fibre is optimized for single-channel transmission in the 1 550 nm region. Multiple channels can only be transmitted if care is taken to avoid the effects of four-wave mixing by, for example, moderating the power levels or appropriate spacing or placement of the channels.

The clauses and tables in Annex D contain particular requirements applicable to category B2 fibres. Common requirements, repeated here for ease of reference from the sectional specification, are noted by an entry in the "reference" column. Relevant notes from the sectional specification are not repeated but indicated with a superscript "SS".

There are two sub-categories which are designated as with suffixes, "_a" and "_b". These sub-categories are distinguished by the glass geometry tolerances, mode field diameter tolerance, and chromatic dispersion coefficient attribute specifications.

D.2 Dimensional requirements

Table D.1 contains dimensional requirements specific to category B2 fibres.

Table D.1 – Dimensional requirements specific to category B2 fibres

Attribute	Unit	_a Limit	_b Limit	Reference
Cladding diameter	µm	125 ± 1	125 ± 1	5.2
Cladding non-circularity	%	≤ 2,0	≤ 1,0	5.2
Core concentricity error	µm	≤ 0,8	≤ 0,6	5.2
Primary coating diameter – uncoloured [a]	µm	235 to 255	235 to 255	5.2
Primary coating diameter – coloured [a]	µm	235 to 265	235 to 265	5.2
Primary coating-cladding concentricity error	µm	≤ 12,5	≤ 12,5	5.2
Fibre length	km	See 5.2	See 5.2	5.2

[a] Alternative nominal primary coating diameters may be used, (see Table 2), to be agreed between supplier and customer.

D.3 Mechanical requirements

Table D.2 contains mechanical requirements specific to category B2 fibres.

Table D.2 – Mechanical requirements specific to category B2 fibres

Attribute	Unit	Limit	Reference
Proof stress level	GPa	≥ 0,69 SS	5.3
Coating strip force (average) SS	N	$1,0 \leq F_{ave} \leq 5,0$	5.3
Coating strip force (peak) SS	N	$1,0 \leq F_{peak} \leq 8,9$	5.3
Fibre curl radius	m	≥ 2 [a]	5.3
Tensile strength (median) for 0,5 m specimen length	GPa	≥ 3,8	5.3
Stress corrosion susceptibility parameter, n_d	–	≥ 18	5.3

[a] Depending on splicing methods, a minimum of 4 m may be specified for fibre intended to be used in some cable constructions – such as ribbon cable.

D.4 Transmission requirements

D.4.1 General

Table D.3 contains transmission requirements specific to category B2 fibres.

Table D.3 – Transmission requirements specific to category B2 fibres

Attribute	Unit	_a Limit	_b Limit	Reference
Attenuation coefficient at 1 310 nm	dB/km	≤ 0,50	≤ 0,50	
Attenuation coefficient at 1 550 nm	dB/km	≤ 0,30	≤ 0,30	
Attenuation coefficient at 1 625 nm	dB/km	≤ 0,40	≤ 0,40	
Chromatic dispersion coefficient	ps/nm · km	See D.4.2	See D.4.3	
Nominal MFD range at 1 550 nm [a]	µm	7,8 to 8,5	7,8 to 8,5	
MFD tolerance	µm	± 0,8	± 0,6	
Cable cut-off wavelength	nm	≤ 1 270	≤ 1 270	
Macrobending loss at 1 550 nm, 100 turns on a 30 mm radius mandrel	dB	≤ 0,5	≤ 0,1	
Polarization mode dispersion (PMD) coefficient	ps/√km	See 5.4	See 5.4	

[a] The value of the nominal MFD shall be agreed between supplier and customer from within the range given. The tolerance shown is then applied around that nominal value.

D.4.2 Chromatic dispersion coefficient requirement for sub-category B2_a fibres

The requirement is given as a combined requirement on the absolute value of the chromatic dispersion coefficient for a range of wavelength and a limit on the zero-dispersion wavelength, λ_0, and slope at λ_0, S_0.

$|D(\lambda)| \leq 3,5$ ps/nm · km for 1 525 nm $\leq \lambda \leq$ 1 575 nm

and

1 500 nm $\leq \lambda_0 \leq$ 1 600 nm

and

$S_0 \leq 0,085$ ps/nm^2 · km.

D.4.3 Chromatic dispersion coefficient requirement for sub-category B2_b fibres

The requirement is given as a series of bounding line segments versus wavelength. These line segment boundaries are equivalent to the requirements stated in D.4.2. The units of chromatic dispersion coefficient, $D(\lambda)$, are ps/nm · km and the units of wavelength, λ, are nm.

$0{,}085\ (\lambda - 1\ 525) - 3{,}5 \le D(\lambda)$ for 1 460 nm ≤ λ ≤1 525 nm

$\frac{3{,}5}{75}(\lambda - 1\ 600) \le D(\lambda)$ for 1 525 nm ≤ λ ≤1 625 nm

$D(\lambda) \le \frac{3{,}5}{75}(\lambda - 1\ 500)$ for 1 460 nm ≤ λ ≤1 575 nm

$D(\lambda) \le 0{,}85\ (\lambda - 1\ 575) + 3{,}5$ for 1 575 nm ≤ λ ≤1 625 nm

D.5 Environmental requirements

The requirements of 5.5 shall be met.

Annex E
(normative)

Family specification for category B4 single-mode fibres

E.1 General

This non-zero dispersion-shifted single-mode fibre is optimized for multiple channel transmission in the 1 550 nm region with a cut-off wavelength that may be shifted above the 1 310 nm region. The dispersion coefficient is required to be non-zero throughout the band from 1 530 nm to 1 565 nm, but may be either positive or negative. Depending on the dispersion characteristics, multiple channel transmission may be possible at bands either above or below the normal 1 550 nm region.

The clauses and tables in Annex E contain particular requirements applicable to category B4 fibres. Common requirements, repeated here for ease of reference from the sectional specification, are noted by an entry in the "reference" column. Relevant notes from the sectional specification are not repeated but indicated with a superscript "SS".

There are three sub-categories which are designated as with suffixes, "_c", "_d", and "_e". These sub-categories are distinguished by the chromatic dispersion coefficient attribute specifications. For sub-category B4_c, the traditional "box specification" is maintained. For sub-categories B4_d and B4_e fibres, the chromatic dispersion limits are in the form of a pair of curves versus wavelength. See Annex H for more information on these curves.

E.2 Dimensional requirements

Table E.1 contains dimensional requirements specific to category B4 fibres.

Table E.1 – Dimensional requirements specific to category B4 fibres

Attribute	Unit	Limit	Reference
Cladding diameter	µm	125 ± 1	5.2
Cladding non-circularity	%	≤ 1,0	5.2
Core concentricity error	µm	≤ 0,6	5.2
Primary coating diameter – uncoloured [a]	µm	235 to 255	5.2
Primary coating diameter – coloured [a]	µm	235 to 265	5.2
Primary coating-cladding concentricity error	µm	≤ 12,5	5.2
Fibre length	km	See 5.2	5.2

[a] Alternative nominal primary coating diameters may be used (see Table 2), to be agreed between supplier and customer.

E.3 Mechanical requirements

Table E.2 contains mechanical requirements specific to category B4 fibres.

Table E.2 – Mechanical requirements specific to category B4 fibres

Attribute	Unit	Limit	Reference
Proof stress level	GPa	≥ 0,69 SS	5.3
Coating strip force (average) SS	N	$1,0 \le F_{ave} \le 5,0$	5.3
Coating strip force (peak) SS	N	$1,0 \le F_{peak} \le 8,9$	5.3
Fibre curl radius	m	≥ 2 [a]	5.3
Tensile strength (median) for 0,5 m specimen length	GPa	≥ 3,8	5.3
Stress corrosion susceptibility parameter, n_d	–	≥ 18	5.3

[a] Depending on splicing methods, a minimum of 4 m may be specified for fibre intended to be used in some cable constructions – such as ribbon cable.

E.4 Transmission requirements

E.4.1 General

Table E.3 contains transmission requirements specific to category B4 fibres.

Table E.3 – Transmission requirements specific to category B4 fibres

Attribute	Unit	Limit	Reference
Attenuation coefficient at 1 550 nm	dB/km	≤ 0,30	
Attenuation coefficient at 1 625 nm	dB/km	≤ 0,40	
Chromatic dispersion coefficient	ps/nm · km	See E.4.2, E.4.3, and E.4.4	
Nominal MFD range at 1 550 nm [a]	µm	8,0 to 11,0	
MFD tolerance	µm	± 0,6	
Cable cut-off wavelength	nm	≤ 1 450	
Macrobending loss at 1 625 nm, 100 turns on a 30 mm radius mandrel	dB	≤ 0,1	
Polarization mode dispersion (PMD) coefficient	ps/√km	See 5.4	

[a] The value of the nominal MFD shall be agreed between supplier and customer from within the range given. The tolerance shown is then applied around that nominal value.

NOTE Annex H includes implementation examples that do not preclude any other possible implementations.

E.4.2 Chromatic dispersion coefficient limits for sub-category B4_c fibres

The chromatic dispersion coefficient, $D(\lambda)$, is given in ps/nm · km and varies with wavelength, λ. The following inequalities shall be met:

$$1,0 \text{ ps/nm} \cdot \text{km} \le D_{min} \le |D(\lambda)| \le D_{max} \le 10,0 \text{ ps/nm} \cdot \text{km}$$

for $1\,530 \text{ nm} \le \lambda \le 1\,565 \text{ nm}$

and $D_{max} - D_{min} \le 5,0 \text{ ps/nm} \cdot \text{km}$.

The sign of the chromatic dispersion coefficient may be positive or negative, but $D(\lambda)$ shall not cross zero in the range of wavelengths from 1 530 nm to 1 565 nm.

The values of D_{min} and D_{max} as well as the sign shall be agreed between customer and supplier.

E.4.3 Chromatic dispersion coefficient limits for sub-category B4_d fibres

The chromatic dispersion coefficient, $D(\lambda)$, is given in ps/nm · km and varies with wavelength, λ. The following inequalities shall be met:

$$\frac{7{,}00}{90}(\lambda - 1460) - 4{,}20 \le D(\lambda) \le \frac{2{,}91}{90}(\lambda - 1460) + 3{,}29$$

for $1\ 460\ \text{nm} \le \lambda \le 1\ 550\ \text{nm}$

and $\frac{2{,}97}{75}(\lambda - 1\ 550) + 2{,}80 \le D(\lambda) \le \frac{5{,}06}{75}(\lambda - 1\ 550) + 6{,}20$

for $1\ 550\ \text{nm} \le \lambda \le 1\ 625\ \text{nm}$

E.4.4 Chromatic dispersion coefficient limits for sub-category B4_e fibres

The chromatic dispersion coefficient, $D(\lambda)$, is given in ps/nm · km and varies with wavelength, λ. The following inequalities shall be met.

$$\frac{5{,}2}{90}(\lambda - 1460) + 0{,}64 \le D(\lambda) \le \frac{4{,}65}{90}(\lambda - 1460) + 4{,}66$$

for $1\ 460\ \text{nm} \le \lambda \le 1\ 550\ \text{nm}$

and $\frac{3{,}30}{75}(\lambda - 1\ 550) + 6{,}06 \le D(\lambda) \le \frac{4{,}12}{75}(\lambda - 1\ 550) + 9{,}31$

for $1\ 550\ \text{nm} \le \lambda \le 1\ 625\ \text{nm}$

E.5 Environmental requirements

The requirements of 5.5 shall be met.

Annex F
(normative)

Family specification for category B5 single-mode fibres

F.1 General

This non-zero dispersion-shifted single-mode fibre is optimized for multiple channel transmission in the wavelength range of 1 460 nm to 1 625 nm with the positive value of the chromatic dispersion coefficient that is greater than some non-zero value. This fibre can be used for both CWDM and DWDM systems throughout the wavelength region between 1 460 nm and 1 625 nm.

The clauses and tables in Annex F contain particular requirements applicable to category B5 fibres. Common requirements, repeated here for ease of reference from the sectional specification, are noted by an entry in the "reference" column. Relevant notes from the sectional specification are not repeated but indicated with a superscript "SS".

F.2 Dimensional requirements

Table F.1 contains dimensional requirements specific to category B5 fibres.

Table F.1 – Dimensional requirements specific to category B5 fibres

Attribute	Unit	Limit	Reference
Cladding diameter	µm	125 ± 1	5.2
Cladding non-circularity	%	≤ 2,0	5.2
Core concentricity error	µm	≤ 0,8	5.2
Primary coating diameter – uncoloured [a]	µm	235 to 255	5.2
Primary coating diameter – coloured [a]	µm	235 to 265	5.2
Primary coating-cladding concentricity error	µm	≤ 12,5	5.2
Fibre length	km	See 5.2	5.2

[a] Alternative nominal primary coating diameters may be used, (see Table 2), to be agreed between supplier and customer.

F.3 Mechanical requirements

Table F.2 contains mechanical requirements specific to category B5 fibres.

Table F.2 – Mechanical requirements specific to category B5 fibres

Attribute	Unit	Limit	Reference
Proof stress level	GPa	≥ 0,69 SS	5.3
Coating strip force (average) SS	N	$1,0 \le F_{ave} \le 5,0$	5.3
Coating strip force (peak) SS	N	$1,0 \le F_{peak} \le 8,9$	5.3
Fibre curl radius	m	≥ 2 [a]	5.3
Tensile strength (median) for 0,5 m specimen length	GPa	≥ 3,8	5.3
Stress corrosion susceptibility parameter, n_d	–	≥ 18	5.3

[a] Depending on splicing methods, a minimum of 4 m may be specified for fibre intended to be used in some cable constructions, such as ribbon cable.

F.4 Transmission requirements

F.4.1 General

Table F.3 contains transmission requirements specific to category B5 fibres.

Table F.3 – Transmission requirements specific to category B5 fibres

Attribute	Unit	Limit	Reference
Attenuation coefficient at 1 460 nm	dB/km	≤ 0,40	
Attenuation coefficient at 1 550 nm	dB/km	≤ 0,30	
Attenuation coefficient at 1 625 nm	dB/km	≤ 0,40	
Chromatic dispersion coefficient [a]	ps/nm · km	See F.4.2	
Nominal MFD range at 1 550 nm [b]	µm	7,0 to 11,0	
MFD tolerance	µm	± 0,7	
Cable cut-off wavelength	nm	≤ 1 450	
Macrobending loss at 1 625 nm, 100 turns on a 30 mm radius mandrel	dB	≤0,50	
Polarization mode dispersion (PMD) coefficient	ps/√km	See 5.4	

[a] If a Raman pump is used outside the wavelength region from 1 460 nm to 1 625 nm, fibre properties have to be suitable for accommodating this pump, for example λ_0 may need to be less than the pump wavelength.

[b] The value of nominal MFD shall be agreed between supplier and customer from within the range given. The tolerance shown is then applied around that nominal value.

F.4.2 Chromatic dispersion coefficient for category B5 fibres

The chromatic dispersion coefficient, $D(\lambda)$, is given in ps/nm · km and varies with wavelength, λ. The following inequalities shall be met:

$$\frac{2,60}{90}(\lambda - 1460) + 1,00 \le D(\lambda) \le \frac{4,68}{90}(\lambda - 1460) + 4,60$$

for $1460\ \text{nm} \le \lambda \le 1550\ \text{nm}$

and $$\frac{0,98}{75}(\lambda - 1550) + 3,60 \le D(\lambda) \le \frac{4,72}{75}(\lambda - 1550) + 9,28$$

for $1550\ \text{nm} \le \lambda \le 1625\ \text{nm}$

F.5 Environmental requirements

The requirements of 5.5 shall be met.

Annex G
(normative)

Family specification for category B6 single-mode fibres

G.1 General

This specification describes two main sub-category groups of bending loss insensitive single-mode optical fibre which are suitable for use in the access networks, including inside buildings at the end of these networks.

The clauses and tables in Annex G contain particular requirements applicable to category B6 fibres. Common requirements, repeated here for ease of reference from the sectional specification, are noted by an entry in the "reference" column. Relevant notes from the sectional specification are not repeated but indicated with a superscript "SS".

There are four sub-categories which are designated with suffixes "_a1", "_a2", "_b2" and "_b3". The fibres are suitable to be used in the O, E, S, C and L-band (i.e. throughout the 1 260 nm to 1 625 nm range). They have improved bending loss and tighter dimensional specifications compared to B1.3 fibres for improved connectivity.

Sub-categories B6_a1 and B6_a2 fibres are a subset of category B1.3 fibres and therefore are compliant with B1.3 fibres and have the same transmission properties.

NOTE 1 Compliance here means adherence to the referenced fibre category (B1.3) meeting or exceeding the values of the specified attributes.

Sub-category B6_a1 fibres are appropriate for a minimum bend radius of 10 mm; sub-category B6_a2 fibres for a minimum bend radius of 7,5 mm.

Sub-categories B6_b2 and B6_b3 fibres are intended to be used for restricted distances (less than 1 000 m) at the end of access networks, in particular inside buildings or near buildings (e.g. outside building riser cabling). Application length of B6_b fibre, however, depends on the deployment strategy of each network operator.

Sub-category B6_b fibres are not necessarily compliant with category B1.3 fibres in terms of chromatic dispersion coefficient specifications. These fibres, however, are system compatible with B6_a (and B1.3) fibres in Access networks.

NOTE 2 Compatibility here means that the product in this sub-category will introduce negligible system impairment or deployment issues but may not be compliant with the referenced fibre category (B1.3).

Sub-category B6_b2 fibres are appropriate for a minimum bend radius of 7,5 mm; sub-category B6_b3 fibres for a minimum bend radius of 5 mm.

NOTE 3 Most category B1.1 and B1.3 fibres deployed have macrobending losses of several dBs over ten turns at 1 625 nm with 15 mm bend radius.

G.2 Dimensional requirements

Table G.1 contains dimensional requirements specific to category B6 fibres.