IEC 60793-2-40

Edition 5.0 2021-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Optical fibres –
Part 2-40: Product specifications – Sectional specification for category A4 multimode fibres

Fibres optiques –
Partie 2-40: Spécifications de produits – Spécification intermédiaire pour les fibres multimodales de catégorie A4

IEC 60793-2-40:2021-02(en-fr)

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Full document details: IEC 60793-2-40-2021

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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Part 2-40: Product specifications – Sectional specification for category A4 multimode fibres

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International Standard IEC 60793-2-40 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 2015. This edition constitutes a technical revision.

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

a) revision of NA range of A4a.2;
b) addition of a new subcategory A4i;
c) deletion of the subcategory A4f and of Annex F.

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

CDV	Report on voting
86A/1943/CDV	86A/1981/RVC

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

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

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OPTICAL FIBRES –

Part 2-40: Product specifications – Sectional specification for category A4 multimode fibres

1 Scope

This part of IEC 60793 is applicable to category A4 optical multimode fibres and the related subcategories A4a, A4b, A4c, A4d, A4e, A4g, A4h and A4i. These fibres have a plastic core and plastic cladding and may have step-index, multi-step index or graded-index profiles. The fibres are used in information transmission equipment and other applications employing similar light transmitting techniques, and in fibre optic cables. Table 1 summarizes some of the salient characteristics and applications of these fibres.

Table 1 – Characteristics and applications of category A4 fibres

Sub-category	A4a		A4b	A4c	A4d	A4e	A4f	A4g	A4h	A4i
	A4a.1	A4a.2								
Core diameter (µm)	a		a	a	a	≥ 500	c	120	62,5	55
Cladding diameter (µm)	1 000		750	500	1 000	750	c	490	245[d]	490
Numerical aperture Na_{ff} [e]	0,50	0,53	0,50	0,50	0,30	0,25	c	0,190	0,190	0,24
Operating wave-length(s) (nm)	650[b]		650	650	650	650	c	650 850 1 300	850 1 300	850
Applications	Digital audio interface, automobile, industrial, sensor and data transmission		Industrial and sensor	Sensor	Digital audio-visual interface and data trans-mission	Digital audio-visual interface and data trans-mission	c	Data trans-mission	Data trans-mission; primarily used in ribbon structures	Industrial data trans-mission

[a] Typically 15 µm to 35 µm smaller than the cladding diameter.

[b] Other potential wavelengths for A4a fibre are described in Annex K.

[c] This sub-category is outdated and therefore no more specified.

[d] Cladding diameters of 490 µm and 750 µm are also possible.

[e] Na_{ff} is numerical aperture measured by far field pattern method.

In addition to the applications shown in Table 1, other applications for A4 fibres include, but are not restricted to, the following: support for short reach, high bit-rate systems in telephony, distribution and local networks, carrying data, voice and/or video services and on-premises intrabuilding and interbuilding fibre installations, including local area networks (LANs), private branch exchanges (PBXs), video, various multiplexing uses and miscellaneous related uses, such as consumer electronics and industrial and mobile networks.

Three types of requirements apply to A4 fibres:

- general requirements, as defined in IEC 60793-2;
- specific requirements common to category A4 multimode fibres covered in this document and which are given in Clause 4;

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- particular requirements applicable to individual fibre sub-categories and implementations or specific applications which are defined in this document, in the normative family specification annexes.

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 60068-1, *Environmental testing – Part 1: General and guidance*

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

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

IEC 60793-1-40:2019, *Optical fibres – Part 1-40: Attenuation measurement methods*

IEC 60793-1-41, *Optical fibres – Part 1-41: Measurement methods and test procedures – Bandwidth*

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

IEC 60793-1-43, *Optical fibres – Part 1-43: Measurement methods and test procedures – Numerical aperture measurement*

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 60793-1-50, *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*

3 Terms and definitions

No terms and definitions are listed in this document.

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4 Specifications

4.1 Dimensional requirements

Relevant dimensional attributes and measurement methods are given in Table 2.

Requirements common to all category A4 fibres are indicated in Table 3.

Additional attributes that shall be specified in the family specifications for subcategories A4g through A4i are given in Table 4.

Table 2 – Dimensional attributes and measurement methods

Attribute	Measurement method
Cladding diameter	IEC 60793-1-20 [a]
Cladding non-circularity	IEC 60793-1-20 [a]
Core diameter [b]	IEC 60793-1-20
Fibre length	IEC 60793-1-22
Core-cladding concentricity error	IEC 60793-1-20
Core non-circularity	IEC 60793-1-20

[a] Mechanical methods are also applicable to cladding diameter and cladding non-circularity measurements if they provide the same measurement uncertainty.

[b] Core diameter is specified at 650 nm ± 10 nm with a test specimen length of 2,0 m ± 0,2 m and a threshold value k_{CORE} of 2,5 % (IEC 60793-1-20, method B) for A4 fibres.

Table 3 – Requirements common to all category A4 fibres

Attribute	Unit	Limit
Cladding diameter	µm	[a]
Cladding non-circularity	%	≤ 6 [b]
Core diameter	µm	[c]
Fibre length	km	[d]

[a] The cladding diameter varies and is listed in the family specification.

[b] Unless otherwise specified in the family specification.

[c] For A4a, A4b, A4c and A4d fibre, the core diameter is typically 15 µm to 35 µm smaller than the cladding diameter. For A4e, A4g, A4h and A4i fibre, the core diameter varies and is listed in the relevant family specification (in the annexes to this document).

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

Table 4 – Additional attributes required in A4g through A4i family specifications

Attribute
Core non-circularity
Core-cladding concentricity error

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4.2 Mechanical requirements

4.2.1 General

Mechanical attributes, test methods, and requirements for buffered fibres can be found in IEC 60794-2-41.

Relevant mechanical attributes and test methods are given in Table 5.

Requirements common to all category A4 fibres are indicated in Table 6.

Additional attributes that shall be specified in the family specifications for subcategories A4g through A4i are given in Table 7.

Table 5 – Mechanical attributes and test methods

Attribute	Test method
Tensile performance	4.2.2

Table 6 – Requirements common to category A4 fibres

Attribute	Unit	Limit
Elongation at yield peak	%	≥ 4,0
Tensile load at yield peak	N	[a]
[a] Tensile load at yield peak varies and is listed in the family specification (see annexes to this document).		

Table 7 – Additional attributes required in family specification for subcategory A4g through A4i fibres

Attribute
Tensile load to induce 4 % elongation

4.2.2 Tensile load test

4.2.2.1 Object

The purpose of this test is to characterize the ability of the fibre to support a load during handling. Its purpose is to obtain values of the fibre's tensile strength.

The test shall be carried out at the standard test conditions in compliance with IEC 60068-1.

4.2.2.2 Definition of yield peak

Figure 1 shows a typical load versus elongation curve for a plastic optical fibre. The curve exhibits an initial monotonic increase in tensile load with applied elongation that goes through a load peak. The peak is followed by a decrease in load as the sample begins to undergo a ductile, irreversible elongation. Localized necking and drawing of the sample may accompany the process. This phenomenon is known as yielding and the peak is termed a yield peak.

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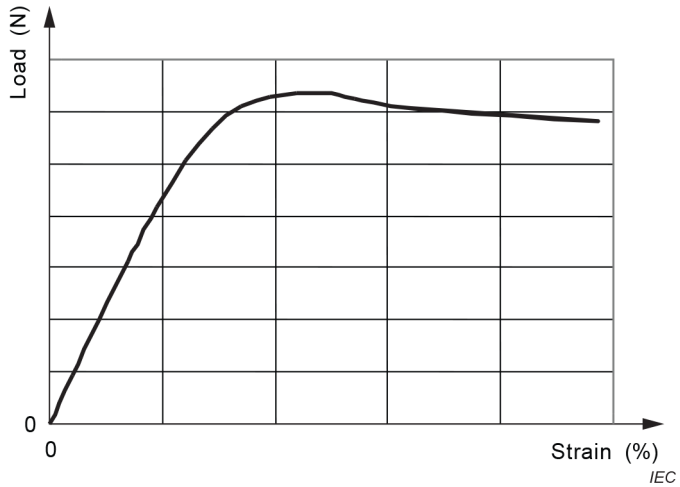

Figure 1 – Tensile load versus elongation for a plastic optical fibre

4.2.2.3 Test apparatus

The length of the sample between two clamping devices shall be between 100 mm and 200 mm.

The tensile strength measuring apparatus shall be a device, for example a vertical tensile tester, which provides relative motion to the test fibre. The apparatus shall be capable of imparting constant motion without jerking the fibre under test. The apparatus shall have the ability to simultaneously measure and record the resulting tensile force or load. To prevent fibre breakage, the means used to secure the fibre ends at the clamping points shall not stress the fibre excessively.

4.2.2.4 Procedure

The tensile speed shall be 100 mm/min ± 10 %. Yield strength and yield elongation are obtained from the load-elongation curve described in 4.2.2.2. Unless otherwise specified, tensile load at the yield peak and tensile load to induce 4 % elongation shall be recorded.

NOTE Elongation to breaking point is not applicable to category A4 fibres.

4.2.2.5 Requirements

The requirements are stated in the family specifications found in Annex A to Annex J. If the fibre sample breaks at a clamping point, the test shall be regarded as invalid and another test shall be carried out. The number of samples tested shall be sufficient to allow for a statistical analysis.

4.3 Transmission requirements

Relevant transmission attributes and measurement methods are given in Table 8.

Additional attributes required in the family specifications are indicated in Table 9.

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Table 8 – Transmission attributes and measurement methods

Attribute	Measurement method
Attenuation [a]	IEC 60793-1-40
Modal bandwidth [a]	IEC 60793-1-41
Modal bandwidth with RML	IEC 60793-1-41
Numerical aperture [b,c,d]	IEC 60793-1-43
Chromatic dispersion	IEC 60793-1-42
Macrobending loss	IEC 60793-1-47, method B

[a] When measuring attenuation and modal bandwidth, the appropriate launching conditions should be applied as specified in IEC 60793-1-40 and IEC 60793-1-41 or as stated in the family specification. Bandwidth is not necessarily linear with regard to length. The value of bandwidth is referenced to 100 m of fibre.

[b] Numerical aperture is specified at 650 nm ± 10 nm with a test specimen length of 2,0 m ± 0,2 m and a threshold value k_{NA} of 50 % for A4a to A4c and A4e fibres.

[c] Numerical aperture is specified at 650 nm ± 10 nm with a test specimen length of 2,0 m ± 0,2 m and by the local minimums and related angles in the farfield intensity pattern for A4d fibres (IEC 60793-1-43, Technique 4, inverse far-field measurement).

[d] Numerical aperture is specified at 850 nm ± 10 nm with a test specimen length of 6,0 m ± 0,6 m and a threshold value k_{NA} of 5 % for A4g to A4i fibres.

Table 9 – Attributes required in family specifications

Attribute
Attenuation
Modal bandwidth
Numerical aperture
Chromatic dispersion
Macrobending loss

4.4 Environmental requirements

4.4.1 General

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

- relevant environmental attributes, test methods and test conditions given in Table 10;
- measurements of a particular mechanical and transmission attribute that may change during exposure to the environmental test listed in Table 11.

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Table 10 – Environmental exposure tests

Test condition [a]	Environment	Test method [b]	Test condition [c]
A	Damp heat	IEC 60793-1-50	+75 °C, 85 % RH, 30 days
	Dry heat	IEC 60793-1-51	+85 °C, 30 days
	Change of temperature	IEC 60793-1-52	T_A:−40 °C, T_B:+85 °C
B	Damp heat	IEC 60793-1-50	+60 °C, 85 % RH, 30 days
	Dry heat	IEC 60793-1-51	+70 °C, 30 days
	Change of temperature	IEC 60793-1-52	T_A:−20 °C, T_B:+70 °C

[a] Test condition A or B should be agreed between supplier and customer.

[b] Although these test methods do not specifically mention their applicability to A4 fibres, the test methods should be used. The test specimen length shall be agreed between supplier and customer.

[c] These test conditions supersede any that might be specified in the indicated test methods.

Table 11 – Attributes measured

Attribute	Measurement method
Change in optical transmission	IEC 60793-1-46
Tensile load	4.2.2

These tests are normally conducted periodically as type-tests for a fibre design. Unless otherwise specified:

- the specimen shall be pre-conditioned by keeping it at standard atmospheric conditions for at least 24 h, and
- the recovery period allowed between the completion of the environmental exposure and measuring the attributes shall be as stated in the particular environmental test method.

Environmental exposure testing of subcategory A4a to A4e fibres are usually performed after the fibres are buffered (refer to IEC 60794-2-41 for environmental requirements on buffered fibres). Environmental exposure testing of unbuffered fibre is only required when the fibres are sold in unbuffered form.

4.4.2 Mechanical environmental requirements

Tensile strength shall be verified according to Table 12 following removal of the fibre from the environment but only after cooling down the specimen at standard atmospheric conditions.

Table 12 – Requirement for tensile strength

Environment	Elongation at yield peak
Damp heat	≥ 4,0 %

4.4.3 Transmission environmental requirements

Change in attenuation from the initial value shall be less than the values in Table 13 and Table 14. The requirements differ for the two groups of fibres because of their different application environments.

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Table 13 – Requirement for change in attenuation for A4a through A4e fibre

Environment	Attribute	Unit	Limits
Damp heat	Attenuation increase at 650 nm	dB/100 m	≤ 5 (includes attenuation due to water absorption)
Dry heat	Attenuation increase at 650 nm	dB/100 m	≤ 2
Change of temperature	Attenuation increase at 650 nm	dB/100 m	≤ 2

Table 14 – Requirement for change in attenuation for A4g through A4i fibre

Environment	Attribute	Unit	Limits
Damp heat	Attenuation increase at 650 nm, 850 nm and/or 1 300 nm [a]	dB/100 m	≤ 1,0 (includes attenuation due to water absorption)
Dry heat	Attenuation increase at 650 nm, 850 nm and/or 1 300 nm	dB/100 m	≤ 0,5
Change of temperature	Attenuation increase at 650 nm, 850 nm and/or 1 300 nm	dB/100 m	≤ 0,5

[a] Because the effect of absorbed water can be significant at 1 300 nm, attenuation increase is specified only after the sample has recovered for at least 24 h under standard room temperature atmospheric conditions.

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Annex A
(normative)

Family specifications for subcategory A4a multimode fibres

A.1 General

The clauses and tables in this Annex A contain particular requirements applicable to subcategory A4a fibres. Common requirements, from the main body text of this document and repeated here for ease of reference, are noted by an entry in the "Reference" column.

Subcategory A4a fibre is a 1 000 µm cladding diameter step-index fibre.

A.2 Dimensional requirements

Table A.1 contains dimensional requirements specific to A4a fibres.

Table A.1 – Dimensional requirements specific to A4a fibres

Attribute	Unit	Limit	Reference
Cladding diameter	µm	1 000 ± 60	4.1
Cladding non-circularity	%	≤ 6	4.1
Core diameter	µm	See 4.1	4.1 Table 2
Fibre length	km	See 4.1	4.1

A.3 Mechanical requirements

Table A.2 contains mechanical requirements specific to A4a fibres.

Table A.2 – Mechanical requirements specific to A4a fibres

Attribute	Unit	Limit	Reference
Tensile load at yield peak	N	≥ 56	4.2.2
Elongation at yield peak	%	≥ 4,0	4.2.2

A.4 Transmission requirements

Table A.3 contains transmission requirements specific to A4a fibres.

Implementation A4a.1 corresponds to subcategory A4a fibre specified in the second edition of this document, IEC 60793-2-40:2006. Implementation A4a.2 is a higher grade of subcategory A4a fibre in terms of attenuation and bandwidth, to achieve longer distance transmission than implementation A4a.1 (see Annex J for information about 520 nm transmission over A4a.2 fibres).

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Table A.3 – Transmission requirements specific to A4a fibres

Attribute	Unit	Limit		Reference
		A4a.1	A4a.2	
Attenuation at 650 nm when using an overfilled launch	dB/100 m [a]	≤ 40	≤ 40	4.3
Attenuation at 650 nm when using an equilibrium mode distribution launch [c]	dB/100 m [a]	≤ 30	≤ 18	4.3
Minimum modal bandwidth at 650 nm	MHz over 100 m [b]	10	–	4.3
Minimum modal bandwidth at 650 nm using RML	MHz over 100 m [b]	–	40	4.3
Numerical aperture	Unitless	0,50 ± 0,15	0,53 ± 0,07	4.3 Table 8
Macrobending loss at 650 nm (10 turns around a 25 mm radius quarter circle)	dB	≤ 0,5	≤ 0,5	4.3

[a] The unit of 100 m is used because this is typical of the fibre length actually used. Attenuation values expressed in dB/100 m can be approximately compared to values stated in dB/km by multiplying the dB/100 m values by 10.

[b] The unit of MHz over 100 m is used because this is typical of the fibre length actually used. Bandwidth values expressed in MHz over 100 m can be approximately compared to values stated in MHz·km by dividing the MHz over 100 m values by 10.

[c] See Annex J.

A.5 Environmental requirements

The requirements of 4.4 shall be met.

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Annex B
(normative)

Family specifications for subcategory A4b multimode fibres

B.1 General

The clauses and tables in this Annex B contain particular requirements applicable to subcategory A4b fibres. Common requirements, from the main body text of this document and repeated here for ease of reference, are noted by an entry in the "Reference" column.

Subcategory A4b fibre is a 750 µm cladding diameter step-index fibre.

B.2 Dimensional requirements

Table B.1 contains dimensional requirements specific to A4b fibres.

Table B.1 – Dimensional requirements specific to A4b fibres

Attribute	Unit	Limit	Reference
Cladding diameter	µm	750 ± 45	4.1
Cladding non-circularity	%	≤ 6	4.1
Core diameter	µm	See 4.1	4.1 Table 2
Fibre length	km	See 4.1	4.1

B.3 Mechanical requirements

Table B.2 contains mechanical requirements specific to A4b fibres.

Table B.2 – Mechanical requirements specific to A4b fibres

Attribute	Unit	Limit	Reference
Tensile load at yield peak	N	≥ 32	4.2.2
Elongation at yield peak	%	≥ 4,0	4.2.2

B.4 Transmission requirements

Table B.3 contains transmission requirements specific to A4b fibres.

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Table B.3 – Transmission requirements specific to A4b fibres

Attribute	Unit	Limit	Reference
Attenuation at 650 nm when using an overfilled launch	dB/100 m [a]	≤ 40	4.3
Attenuation at 650 nm when using an equilibrium mode distribution launch [c]	dB/100 m [a]	≤ 30	4.3
Minimum modal bandwidth at 650 nm	MHz over 100 m [b]	10	4.3
Numerical aperture	Unitless	0,50 ± 0,15	4.3 Table 8
Macrobending loss at 650 nm (10 turns around a 25 mm radius quarter circle)	dB	≤ 0,5	4.3

[a] The unit of 100 m is used because this is typical of the fibre length actually used. Attenuation values expressed in dB/100 m can be approximately compared to values stated in dB/km by multiplying the dB/100 m values by 10.

[b] The unit of MHz over 100 m is used because this is typical of the fibre length actually used. Bandwidth values expressed in MHz over 100 m can be approximately compared to values stated in MHz·km by dividing the MHz over 100 m values by 10.

[c] See Annex J.

B.5 Environmental requirements

The requirements of 4.4 shall be met.

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Annex C
(normative)

Family specifications for subcategory A4c multimode fibres

C.1 General

The clauses and tables in this Annex C contain particular requirements applicable to subcategory A4c fibres. Common requirements, from the main body text of this document and repeated here for ease of reference, are noted by an entry in the "Reference" column.

Sub-category A4c fibre is a 500 µm cladding diameter step-index fibre.

C.2 Dimensional requirements

Table C.1 contains dimensional requirements specific to A4c fibres.

Table C.1 – Dimensional requirements specific to A4c fibres

Attribute	Unit	Limit	Reference
Cladding diameter	µm	500 ± 30	4.1
Cladding non-circularity	%	≤ 6	4.1
Core diameter	µm	See 4.1	4.1 Table 2
Fibre length	km	See 4.1	4.1

C.3 Mechanical requirements

Table C.2 contains mechanical requirements specific to A4c fibres.

Table C.2 – Mechanical requirements specific to A4c fibres

Attribute	Unit	Limit	Reference
Tensile load at yield peak	N	≥ 14	4.2.2
Elongation at yield peak	%	≥ 4,0	4.2.2

C.4 Transmission requirements

Table C.3 contains transmission requirements specific to A4c fibres.

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Table C.3 – Transmission requirements specific to A4c fibres

Attribute	Unit	Limit	Reference
Attenuation at 650 nm when using an overfilled launch	dB/100 m [a]	≤ 40	4.3
Attenuation at 650 nm when using an equilibrium mode distribution launch [c]	dB/100 m [a]	≤ 30	4.3
Minimum modal bandwidth at 650 nm	MHz over 100 m [b]	10	4.3
Numerical aperture	Unitless	0,50 ± 0,15	4.3 Table 8
Macrobending loss at 650 nm (10 turns around a 25 mm radius quarter circle)	dB	≤ 0,5	4.3

[a] The unit of 100 m is used because this is typical of the fibre length actually used. Attenuation values expressed in dB/100 m can be approximately compared to values stated in dB/km by multiplying the dB/100 m values by 10.

[b] The unit of MHz over 100 m is used because this is typical of the fibre length actually used. Bandwidth values expressed in MHz over 100 m can be approximately compared to values stated in MHz·km by dividing the MHz over 100 m values by 10.

[c] See Annex J.

C.5 Environmental requirements

The requirements of 4.4 shall be met.

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