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INTERNATIONAL STANDARD

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

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FOREWORD

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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 fourth edition cancels and replaces the third edition published in 2009. This edition constitutes a technical revision.

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

a) harmonization of terminology within the IEC 60793-2 series;

b) added measurement parameters for numerical aperture and fibre geometry.

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

CDV	Report on voting
86A/1587/CDV	86A/1618/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- withdrawn,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.

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OPTICAL FIBRES –

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

1 Scope

This part of IEC 60793-2 is applicable to category A4 optical multimode fibres and the related sub-categories A4a, A4b, A4c, A4d, A4e, A4f, A4g and A4h. 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 finally 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
Core diameter (μm)	See Note 1	See Note 1	See Note 1	See Note 1	≥ 500	200	120	62,5
Cladding diameter (μm)	1 000	750	500	1 000	750	490	490	245
Numerical aperture Na_{ff}	0,50	0,50	0,50	0,30	0,25	0,190	0,190	0,190
Operating wave-length (s) (nm)	650 See Note 2	650	650	650	650	650 850 1 300	650 850 1 300	850 1 300
Applica-tions	Digital audio interface, automobile, industrial, sensor and data transmis-sion	Indus-trial and sen-sor	Sen-sor	Digital audiovisual interface and data transmission	Digital audiovisual interface and data transmission	Industrial and mobile; compatible with A3 transmission equipment	Data transmission	Data transmission; primarily used in ribbon structures

NOTE 1 Typically 15 μm to 35 μm smaller than the cladding diameter.

NOTE 2 Other potential wavelengths for A4a fibre are described in Annex J.

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 LANs, 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 standard and which are given in Clause 3;

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

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

IEC 60793-1-20:2001, *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 60793-1-40:2001, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

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 60793-1-47:2009, *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 Specifications

3.1 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 sub-categories A4f through A4h 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 ± 10) nm with a test specimen length of 2,0 m ± 0,2 m and a threshold value k_{CORE} of 2,5 % (IEC 60793-1-20:2001, 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, A4f, A4g and A4h fibre, the core diameter varies and is listed in the family specification.

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

Table 4 – Additional attributes required in A4f through A4h family specifications

Attribute
Core non-circularity
Core-cladding concentricity error

3.2 Mechanical requirements

3.2.1 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 sub-categories A4f through A4h are given in Table 7.

Table 5 – Mechanical attributes and test methods

Attribute	Test method
Tensile performance	3.2.2

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.		

Table 7 – Additional attributes required in family specification for sub-category A4f through A4h fibres

Attribute
Tensile load to induce 4 % elongation

3.2.2 Tensile load test

3.2.2.1 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 fibre samples are subjected to a mechanical environment as specified below. The test shall be carried out at the standard test conditions in compliance with IEC 60068-1.

3.2.2.2 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.

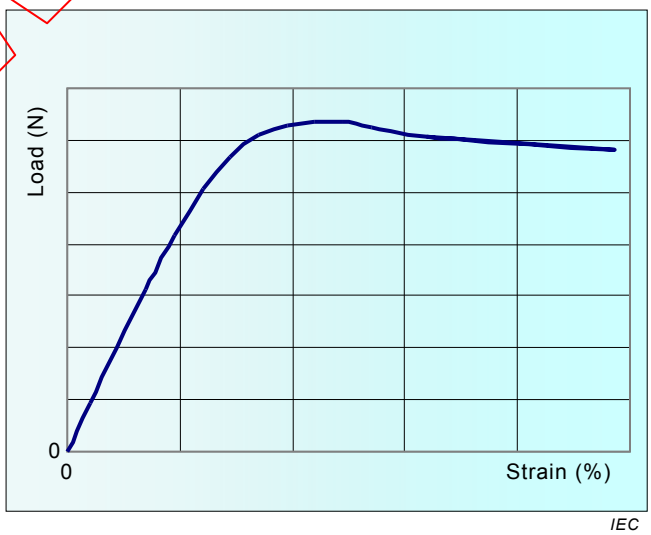

Figure 1 – Tensile load versus elongation for a plastic optical fibre

3.2.2.3 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.

3.2.2.4 Procedure

The tensile speed shall be 100 mm/min (±10 %). Yield strength and yield elongation are obtained from the load-elongation curve described in 3.2.2.2. 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.

3.2.2.5 Requirements

The requirements are stated in the family specifications found in the normative annexes to this specification. 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.

3.3 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.

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 60793-1-47:2009, 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 60793-1-43:2014 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 A4f to A4h fibres.

Table 9 – Attributes required in family specifications

Attribute
Attenuation
Modal bandwidth
Numerical aperture
Chromatic dispersion
Macrobending loss

3.4 Environmental requirements

3.4.1 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.

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	Subclause 3.2.2

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 sub-category 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.

3.4.2 Mechanical environmental requirements

Tensile strength shall be verified 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 %

3.4.3 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.

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 A4f through A4h fibre

Environment	Attribute	Unit	Limits
Damp heat	Attenuation increase at 650nm, 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.

Annex A
(normative)

Family specifications for sub-category A4a multimode fibres

A.1 General

The clauses and tables in Annex A contain particular requirements applicable to sub-category A4a fibres. Common requirements, repeated here for ease of reference from this sectional specification, are noted by an entry in the “Reference” column.

Sub-category 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	3.1
Cladding non-circularity	%	≤ 6	3.1
Core diameter	μm	See 3.1	3.1 Table 2
Fibre length	km	See 3.1	3.1

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	3.2.2
Elongation at yield peak	%	≥ 4,0	3.2.2

A.4 Transmission requirements

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

Implementation A4a.1 corresponds to sub-category A4a fibre specified in IEC 60793-2-40:2006. Implementation A4a.2 is a higher grade of sub-category 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.)

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	3.3
Attenuation at 650 nm when using an equilibrium mode distribution launch [c]	dB/100 m [a]	≤ 30	≤ 18	3.3
Minimum modal bandwidth at 650 nm	MHz over 100 m [b]	10	–	3.3
Minimum modal bandwidth at 650 nm using RML	MHz over 100 m [b]	–	40	3.3
Numerical aperture	Unitless	0,50 ± 0,15	0,485 ± 0,045	3.3 Table 8
Macrobending loss at 650 nm (10 turns around a 25 mm radius quarter circle)	dB	≤ 0,5	≤ 0,5	3.3

[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 I.

A.5 Environmental requirements

The requirements of 3.4 shall be met.

Annex B
(normative)

Family specifications for sub-category A4b multimode fibres

B.1 General

The clauses and tables in Annex B contain particular requirements applicable to sub-category A4b fibres. Common requirements, repeated here for ease of reference from this sectional specification, are noted by an entry in the “Reference” column.

Sub-category 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	3.1
Cladding non-circularity	%	≤ 6	3.1
Core diameter	μm	See 3.1	3.1 Table 2
Fibre length	km	See 3.1	3.1

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	3.2.2
Elongation at yield peak	%	≥ 4,0	3.2.2

B.4 Transmission requirements

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

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	3.3
Attenuation at 650 nm when using an equilibrium mode distribution launch [c]	dB/100 m[a]	≤ 30	3.3
Minimum modal bandwidth at 650 nm	MHz over 100 m[b]	10	3.3
Numerical aperture	Unitless	0,50 ± 0,15	3.3 Table 8
Macrobending loss at 650 nm (10 turns around a 25 mm radius quarter circle)	dB	≤ 0,5	3.3

[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 I.

B.5 Environmental requirements

The requirements of 3.4 shall be met.

Annex C
(normative)

Family specifications for sub-category A4c multimode fibres

C.1 General

The clauses and tables in Annex C contain particular requirements applicable to sub-category A4c fibres. Common requirements, repeated here for ease of reference from this sectional specification, 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	3.1
Cladding non-circularity	%	≤ 6	3.1
Core diameter	μm	See 3.1	3.1 Table 2
Fibre length	km	See 3.1	3.1

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	3.2.2
Elongation at yield peak	%	≥ 4,0	3.2.2

C.4 Transmission requirements

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

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	3.3
Attenuation at 650 nm when using an equilibrium mode distribution launch[c]	dB/100 m[a]	≤ 30	3.3
Minimum modal bandwidth at 650 nm	MHz over 100 m[b]	10	3.3
Numerical aperture	Unitless	0,50 ± 0,15	3.3 Table 8
Macrobending loss at 650 nm (10 turns around a 25 mm radius quarter circle)	dB	≤ 0,5	3.3

[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 I.

C.5 Environmental requirements

The requirements of 3.4 shall be met.

Annex D
(normative)

Family specifications for sub-category A4d multimode fibres

D.1 General

The clauses and tables in Annex D contain particular requirements applicable to sub-category A4d fibres. Common requirements, repeated here for ease of reference from this sectional specification, are noted by an entry in the “Reference” column.

Sub-category A4d fibre is a 1 000 μm cladding diameter double step-index fibre.

D.2 Dimensional requirements

Table D.1 contains dimensional requirements specific to A4d fibres.

Table D.1 – Dimensional requirements specific to A4d fibres

Attribute	Unit	Limit	Reference
Cladding diameter	μm	1 000 ± 60	3.1
Cladding non-circularity	%	≤ 6	3.1
Core diameter	μm	See 3.1	3.1
Fibre length	km	See 3.1	3.1

D.3 Mechanical requirements

Table D.2 contains mechanical requirements specific to A4d fibres.

Table D.2 – Mechanical requirements specific to A4d fibres

Attribute	Unit	Limit	Reference
Tensile load at yield peak	N	≥ 56	3.2.2
Elongation at yield peak	%	≥ 4,0	3.2.2

D.4 Transmission requirements

Table D.3 contains transmission requirements specific to A4d fibres.

Table D.3 – Transmission requirements specific to A4d fibres

Attribute	Unit	Limit	Reference
Attenuation at 650 nm when using an overfilled launch	dB/100 m[a]	≤ 40	3.3
Attenuation at 650 nm using a launch NA = 0,3	dB/100 m[a]	≤ 18	3.3
Minimum modal bandwidth at 650 nm using launch NA = 0,3 (RML)	MHz over 100 m[b]	100	3.3
Numerical aperture	Unitless	0,30 ± 0,05	3.3 Table 8
Macrobending loss at 650 nm (10 turns around a 25 mm radius quarter circle)	dB	≤ 0,5	3.3

[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.

D.5 Environmental requirements

The requirements of 3.4 shall be met.

Annex E
(normative)

Family specifications for sub-category A4e multimode fibres

E.1 General

The clauses and tables in Annex E contain particular requirements applicable to sub-category A4e fibres. Common requirements, repeated here for ease of reference from this sectional specification, are noted by an entry in the “Reference” column.

Sub-category A4e fibre is a 750 μm cladding diameter, either multi-step-index or graded-index fibre.

E.2 Dimensional requirements

Table E.1 contains dimensional requirements specific to A4e fibres.

Table E.1 – Dimensional requirements specific to A4e fibres

Attribute	Unit	Limit	Reference
Cladding diameter	μm	750 ± 45	3.1
Cladding non-circularity	%	≤ 6	3.1
Core diameter	μm	≥ 500	3.1
Length	km	See 3.1	3.1

E.3 Mechanical requirements

Table E.2 contains the mechanical requirements specific to A4e fibres.

Table E.2 – Mechanical requirements specific to A4e fibres

Attribute	Unit	Limit	Reference
Tensile load at yield peak	N	≥ 32	3.2.2
Elongation at yield peak	%	≥ 4,0	3.2.2

E.4 Transmission requirements

Table E.3 contains transmission requirements specific to A4e fibres.

Table E.3 – Transmission requirements specific to A4e fibres

Attribute	Unit	Limit	Reference
Attenuation coefficient at 650 nm using a launch NA = 0,3	dB/100m[a]	≤ 18	3.3
Minimum modal bandwidth at 650 nm using a launch NA = 0,3	MHz over 100 m[b]	200	3.3
Numerical aperture	Unitless	0,25 ± 0,07	3.3 Table 8
Macrobending loss at 650 nm (10 turns around a 25 mm radius quarter circle)	dB	≤ 0,5	3.3

[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.

E.5 Environmental requirements

The requirements of 3.4 shall be met.

Annex F
(normative)

Family specifications for sub-category A4f multimode fibres

F.1 General

The clauses and tables in Annex F contain particular requirements applicable to sub-category A4f fibres. Common requirements, repeated here for ease of reference from this sectional specification, are noted by an entry in the “Reference” column.

Sub-category A4f fibre is a 200/490 μm graded-index fibre.

F.2 Dimensional requirements

Table F.1 contains dimensional requirements specific to A4f fibres.

Table F.1 – Dimensional requirements specific to A4f fibres

Attribute	Unit	Limit	Reference
Cladding diameter	μm	490 ± 10	3.1
Cladding non-circularity	%	≤ 4	3.1
Core-cladding concentricity error	μm	≤ 6	3.1
Core diameter	μm	200 ± 10	3.1
Core non-circularity	%	≤ 6	3.1
Length	km	See 3.1	3.1

F.3 Mechanical requirements

Table F.2 contains the mechanical requirements specific to A4f fibres.

Table F.2 – Mechanical requirements specific to A4f fibres

Attribute	Unit	Limit	Reference
Tensile load at yield peak	N	≥ 7	3.2.2
Tensile load to induce 4 % elongation	N	≥ 7	3.2.2
Elongation at yield peak	%	≥ 4	3.2.2

F.4 Transmission requirements

Table F.3 contains transmission requirements specific to A4f fibres.

Table F.3 – Transmission requirements specific to A4f fibres

Attribute	Unit	Limit	Reference
Attenuation at 650 nm[a]	dB/100 m[f]	≤ 10	3.3
Attenuation at 850 nm[a]	dB/100 m[f]	≤ 4	3.3
Attenuation at 1300 nm[a]	dB/100 m[f]	≤ 4	3.3
Minimum modal bandwidth at 650 nm[b]	MHz over 100 m[c]	800	3.3
Minimum modal bandwidth at 850 nm[b]	MHz over 100 m[c]	≥ 1 500[d]	3.3
Minimum modal bandwidth at 1300 nm[b]	MHz over 100 m[c]	≥ 1 500[d]	3.3
Numerical aperture	Unitless	0,190 ± 0,015	3.3 Table 8
Macrobending loss at 850 nm (10 turns around a 25 mm radius quarter circle)[e]	dB	≤ 1,25	3.3
Zero dispersion wavelength, λ_0	nm	$1\,200 \leq \lambda_0 \leq 1\,650$	3.3
Zero dispersion slope, S_0	ps/(nm^2 · km)	≤ 0,06	3.3

[a] 60 mm is a common mandrel diameter when using Method A in IEC 60793-1-40:2001.

[b] Measured using the overfilled launch condition in IEC 60793-1-41 for A3 and A4 fibres.

[c] Measured on 100 through 500 m length. The method used to scale from the measurement length to the 100 m reference length should be available on request. 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.

[d] The specific value shall be agreed by the supplier and the customer.

[e] Measured with a 60 mm diameter mandrel launch.

[f] 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.

F.5 Environmental requirements

The requirements of 3.4 shall be met.

Annex G
(normative)

Family specifications for sub-category A4g multimode fibres

G.1 General

The clauses and tables in Annex G contain particular requirements applicable to sub-category A4g fibres. Common requirements, repeated here for ease of reference from this sectional specification, are noted by an entry in the “Reference” column.

Sub-category A4g fibre is a 120/490 μm graded-index fibre.

G.2 Dimensional requirements

Table G.1 contains dimensional requirements specific to A4g fibres.

Table G.1 – Dimensional requirements specific to A4g fibres

Attribute	Unit	Limit	Reference
Cladding diameter	μm	490 ± 10	3.1
Cladding non-circularity	%	≤ 4	3.1
Core-cladding concentricity error	μm	≤ 6	3.1
Core diameter	μm	120 ± 10	3.1
Core non-circularity	%	≤ 6	3.1
Length	km	See 3.1	3.1

G.3 Mechanical requirements

Table G.2 contains the mechanical requirements specific to A4g fibres.

Table G.2 – Mechanical requirements specific to A4g fibres

Attribute	Unit	Limit	Reference
Tensile load at yield peak	N	≥ 7	3.2.2
Tensile load to induce 4 % elongation	N	≥ 7	3.2.2
Elongation at yield peak	%	≥ 4	3.2.2

G.4 Transmission requirements

Table G.3 contains transmission requirements specific to A4g fibres.