IEC 60794-3-11

Edition 1.0 2007-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Withdrawn

Optical fibre cables –
Part 3-11: Outdoor cables – Detailed specification for duct and directly buried single-mode optical fibre telecommunication cables

Câbles à fibres optiques –
Partie 3-11: Câbles extérieurs – Spécification particulière pour les câbles de télécommunication à fibres optiques unimodales destinés à être installés dans des conduites ou à être directement enterrés

IEC 60794-3-11:2007

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OPTICAL FIBRE CABLES

Part 3-11: Outdoor cables – Detailed specification for duct and directly buried single-mode optical fibre telecommunication cables

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International Standard IEC 60794-3-11 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

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

FDIS	Report on voting
86A/1147/FDIS	86A/1165/RVD

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 ISO/IEC Directives, Part 2.

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

This standard shall be used in conjunction with IEC 60794-3 and IEC 60794-3-10.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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

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OPTICAL FIBRE CABLES

Part 3-11: Outdoor cables – Detailed specification for duct and directly buried single-mode optical fibre telecommunication cables

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1 Scope

This part of IEC 60794 sets forth technical requirements and characteristics of single-mode optical fibre cables for duct and direct buried installation.

This specification includes functional mechanical, environmental and optical requirements, recommended features and test methods for assessing the product against the stated requirements.

The specified test methods, where applicable, are those referenced in IEC 60794-1-1 and described in detail in IEC 60794-1-2.

The requirements of this specification are used in conjunction with IEC 60794-3 and IEC 60794-3-10.

Multimode fibre requirements are not addressed in this document; see IEC 60794-3-12[1)].

2 Normative references

The following referenced documents are indispensable for the application 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 Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

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

IEC 60708, *Low-frequency cables with polyolefin insulation and moisture barrier polyolefin sheath*

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

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

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1) IEC 60794-3-12, *Optical fibre cables - Part 3-12: Outdoor cables - Detailed specification for duct and directly buried optical telecommunication cables for use in premises cabling*

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

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

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

IEC 60794 (all parts), *Optical fibre cables*

IEC 60794-1-1, *Optical fibre cables – Part 1-1: Generic specification – General*

IEC 60794-1-2, *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures*

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

IEC 60794-3-10, *Optical fibre cables – Part 3-10: Outdoor cables – Family specification for duct and directly buried optical telecommunication cables*

IEC 60811-1-1, *Common test methods for insulating and sheathing materials of electric cables and optical cables – Part 1-1: Methods for general application – Measurement of thickness and overall dimensions – Tests for determining the mechanical properties*

IEC 62305 (all parts), *Protection against lightning*

IEC/TR 61931, *Fibre optic – Terminology*

IEC/TR 62000, *Single-mode fibre compatibility guidelines*

ITU-T G.652, *Characteristics of a single-mode optical fibre and cable*

3 Terms and definitions

For the purposes of this document, unless otherwise specified, the terms and definitions given in IEC/TR 61931 apply.

4 Symbols

The following symbols are used in this document.

λ_{cc} cable cut-off wavelength

d outer cable diameter

SZ technique in which the lay reverses direction periodically

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5 General information

5.1 Overview

Single-mode optical fibres are widely used for telecommunication purposes and are cabled to satisfy the functional requirements of the installation environment. Further, cables placed into ducts and sub-ducts may be installed using solely, or a combination of, pushing, pulling, and air-assisted installation techniques. For duct installations, the environment and infrastructure can be varied and may also involve the use of single and multiple sub-ducts. Directly buried cables may be installed by a variety of methods such as ploughing and trenching with different environments and infrastructure. This may require specific cable design solutions based on multiple layers of armours and sheaths. It is recognised that certain designs of cable for direct buried applications involving such solutions may also be suitable for duct installation. The functional requirements and test methods featured in this specification are based upon adherence to established and recognised installation techniques such as those highlighted in Annex A (Guide to the installation of optical fibre cable) of IEC 60794-1-1.

5.2 General cable description

5.2.1 Characteristics of optical fibre

Single-mode optical fibres are classified according to their operational wavelength and dispersion characteristics. The fibres covered by this specification are categorised as type B and described in IEC 60793-2-50. The fibre types featured in this specification include dispersion unshifted (B1.1, B1.3), dispersion shifted (B2), cut-off shifted (B1.2), non-zero dispersion (B4), and anticipated fibre category for wide-band non-zero dispersion-shifted (B5). (See Annex A for ITU-T cabled optical fibre references). While cut-off shifted B1.2 fibre can be used in terrestrial applications, it is mainly used in submarine applications.

5.2.2 Characteristics of optical fibre cable elements

Optical fibre cable elements such as loose buffer tubes, slotted core, fibre ribbons, fibre bundles and central/core tubes shall be suitably designed to provide adequate means of fibre location, identification, modularity, protection during cable manufacture, installation and termination. The structure of these elements and the materials used in their manufacture shall not have any long-term detrimental effects on fibre performance during the service life of the cable, splice enclosure and/or cabinet. To satisfy these functional requirements, the different elements shall comply with the requirements of IEC 60794-3 as well as those outlined in Clause 7 of this standard.

5.2.3 Characteristics of optical fibre cables

Optical fibre cables, for the intent of this document, are completed cable products as shipped by the manufacturer typically on disposable reels. Such products do not require additional assembly, or the use of additional materials or protection to meet the requirements contained herein. Some assembly or added protection is usually required only where the cables are terminated to other cables or equipment, and typically involve the use of an optical fibre closure or other hardware to protect cable splice or connectorization points. The required levels of protection for the fibre can be achieved by laying up or assembling the cable elements in association with suitable strength and/or anti buckling members. These can be either metallic in nature or non-metallic and positioned at the centre of the cable core or as peripheral members in or underneath the outer cable sheath. The cable may also contain moisture barrier tapes, metallic or non-metallic tapes, and water blocking or swellable materials.

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5.2.4 Environmental and product safety requirements

IEC Guide 104 should be taken into account as far as possible. The materials of the cables in contact with the environment shall not be hazardous to the environment and personnel.

It should be noted that the cable types specified by this standard are rarely accessible once installed. Therefore, the risk of exposure to hazardous materials, if any, is mostly a concern in the handling of the cable during manufacturing and installation. Additionally, the type of outer sheath specified herein is generally considered to be non-toxic, therefore the risk to the environment or personnel is minimal once properly installed.

This standard does not address the use of all types of cable materials that may be utilized in various cable designs to support meeting the requirements unique to a specific type of special application (e.g., very high temperatures or resistance to specific chemical attack). In such cases, it is incumbent on the customer and supplier to agree on the requirements applicable to such materials and cable designs, and to determine any special handling precautions or instructions needed as a result of their use.

5.3 Optical fibre spliceability

All of the single-mode fibre types covered in this specification can readily achieve very low splice loss levels using a range of commercially available techniques.

Typical bi-directional splice losses at 1 550 nm should be below 0,1 dB, with an average of 0,05 dB for fusion splices between fibres of the same category (B1-B1, or B2-B2, etc.) performed by skilled operators according to the current best practices. Additional fibre compatibility guidelines are provided in IEC/TR 62000.

NOTE 1 Higher maximum splice losses may occur without affecting the link transmission capability.

NOTE 2 Splices of fibres of the same category but different manufacturers and/or different production processes do generally not exceed the above values.

NOTE 3 If fibres of different categories (B1-B2, B1-B4, etc.) are spliced, typically the splice loss is slightly higher than with splices between fibres of the same category.

5.4 Testing

For all test procedures, the test conditions shall be the standard atmospheric conditions (23° C ± 5 °C, and 20 % - 70 % relative humidity), unless otherwise specified. All measured and computed values are to be rounded to the number of decimal places given in the corresponding acceptance criteria for each requirement.

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The parameters specified in this standard may be affected by measurement uncertainty arising either from measurement errors or calibration errors due to a lack of suitable standards. Acceptance criteria shall be interpreted with respect to this consideration. The total uncertainty of measurement for this standard shall be less than or equal to 0,05 dB for attenuation or 0,05 dB/km for attenuation coefficient. Any measured value within this range, either positive or negative, shall be considered as “no change in attenuation”.

Some of the mechanical and environmental tests in 8.5 and 8.6 can be performed on a short sample length of cable, which is still an integral part of a longer length. Thus it becomes possible to detect permanent changes in attenuation.

6 Requirements for cabled single-mode optical fibres

6.1 Fibre materials

Use optical fibre as specified in IEC 60793-2-50.

The coating surface shall be cleaned (e.g. from cable filling compounds) with only those cleaning agents recommended by the fibre manufacturer. In any case, chlorine-based cleaning agents shall not be used because of the health hazards involved.

6.2 Optical requirements

All optical fibre transmission attributes shall comply with the “transmission requirements” in IEC 60793-2-50. Attributes of the cabled fibre (attenuation, point defects, polarization mode dispersion, cable cut-off wavelength and group index) are specified in the following subclauses. Other fibre attributes in IEC 60793-2-50 are summarized in Annex B.

6.2.1 Attenuation coefficient

The cabled fibre attenuation coefficients for the fibre types covered by this specification shall meet the following requirements in Table 1, or as otherwise agreed upon between customer and supplier.

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Table 1 — Attenuation coefficient

	Fibre type (maximum attenuation in dB/km)					
Wavelength	B1.1	B1.2	B1.3	B2	B4	B5
1 310 nm	0,40	Not applicable	0,40	0,50	See Note 1	Not applicable
1 383 nm	Not applicable	Not applicable	0,40 (Note 2)	Not applicable	Not applicable	Not applicable
1 550 nm	0,35	0,30	0,30	0,35	0,35	0,35
1 625 nm	0,40 See Note 3	0,40 See Note 3	0,40 See Note 3	0,40 See Note 3	0,40 See Note 3	0,40 See Note 3

NOTE 1 1 310 nm is not specified unless agreed otherwise between customer and supplier.

NOTE 2 1 383 nm attenuation is specified after hydrogen ageing as per IEC 60793-2-50.

NOTE 3 1 625 nm attenuation values are optionally specified by the customer.

Fibre type definitions are provided in IEC 60793-2-50 for single-mode fibre. For informative purposes, they are described below:

B1.1: Single-mode fibre with a zero dispersion between 1 300 nm to 1 324 nm, which is optimised for use in the 1 310 nm region and is compatible in the 1 550 nm region.

B1.2: Dispersion unshifted single-mode fibre that is optimised for 1 550 nm transmission with a cable cut-off wavelength <1 530 nm.

B1.3: Single-mode fibre similar to B1.1 but has a low loss at 1 383 nm to provide additional compatibility between 1 360 nm to 1 460 nm.

B2: Dispersion shifted single-mode fibre with a zero dispersion in the 1 525 nm to 1 575 nm region.

B4: A non-zero dispersion shifted single-mode fibre (NZDSF) that is optimised for 1 550 nm transmission with the zero dispersion outside the 1 530 nm to 1 565 nm region.

B5: A non-zero dispersion shifted single-mode fibre (NZDSF) that is optimised for 1 460 nm to 1 625 nm transmission with the zero dispersion region below 1 460 nm.

Test procedure:

Measurements shall be made in accordance with IEC 60793-1-40 at room temperature (23 °C ± 5 °C).

6.2.2 Attenuation discontinuities

Point discontinuities / local variations representing non-reflective events shall be: ≤ 0,10 dB.

Test procedure:

Measurements shall be made in accordance with IEC 60793-1-40, method C (back scattering technique).

Measurement variables:

Wavelength: 1 310 nm and/or 1 550 nm.

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6.2.3 Cable cut-off wavelength

Cable cut-off wavelength λ_{cc} shall be:

$\lambda_{cc} \leq$ 1 260 nm for fibre types B1.1 and B1.3

$\lambda_{cc} \leq$ 1 260 nm for fibre type B2

$\lambda_{cc} \leq$ 1 450 nm for fibre type B4 and B5

$\lambda_{cc} \leq$ 1 530 nm for fibre type B1.2

Test procedure:

Cut-off wavelength measurements shall be made in accordance with IEC 60793-1-44.

6.2.4 Polarization mode dispersion (PMD)

Polarization mode dispersion (PMD) is usually described in terms of a differential group delay (DGD), which is the propagation time difference between the principal states of polarization of an optical signal. PMD in cabled fibres and optical components causes an optical pulse to spread in the time domain, which may impair the performance of a long length and high bit rate (e.g. 10 Gbit/s transport over 400 km) optical fibre system. For these systems, only the following evaluation may be useful.

Concerning the statistical nature of PMD in installed cable links, reference is made to Annex A of IEC 60794-3.

The appropriate test method shall be selected from IEC 60793-1-48, which also describes the statistical nature of PMD (see introduction):

– For links > 400 km, the link design value (PMD_Q) shall be less than or equal to 0,20 ps/km^{0,5}. Note, from ITU-T Recommendation G.652 Table I.2/, this maximum link design value should allow the possibility of 3 000 km links at 10 Gbit/s and 80 km (to 200 km) at 40 Gbit/s.
– For links ≤ 400 km, the link design value (PMD_Q) shall be less than or equal to 0,50 ps/km^{0,5}. Note from ITU-T Recommendation G.652 Table I.2 /, this maximum link design value should allow the possibility of 400 km links at 10 Gbit/s.

6.2.5 Group index

This parameter is used to determine the fibre length within cables or cable lengths (taking construction into account) using IEC 60793-1-22, method B. The group index shall be given at 1 310 nm for B1.1, B1.3, and B2 fibres and at 1 550 nm for all fibres. The group index shall be given at 1 625 nm for any cable specified for operation at 1 625 nm.

7 Requirements for cable elements

7.1 Element design

An optical fibre cable element is an assembly of optical fibres arranged in such a way to maintain its structure both inside the cable and once the sheath is removed.

The design intent of a fibre optic cable element is to organize fibres so as to facilitate fibre identification and to improve handling.

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Current cable designs may include the following fibre optic cable elements:

– tube(s);
– slotted core(s);
– fibre bundle(s);
– fibre ribbon(s);
– central / core tube.

7.1.1 Modularity

The most common modularities are: 1, 2, 4, 6, 8, 10, 12, 24.

7.1.2 Fibre and element identification

7.1.2.1 Fibre identification

The coated fibre or buffer shall be distinguishable by means of colour coding or positioning. Fibre and cable units shall be distinguishable by means of numbering or colour coding. Cable units are defined as structures within the cable that combines the fibres into groups. For example, this can be accomplished by placing fibres inside a tube, wrapping them with a thread, placing them in a ribbon, placing them inside a slot, or any other method that combines a group of fibres into an identifiable unit. Standard colours listed below alphabetically in Table 2 shall be used, as near as possible (reasonable match) to IEC 60304.

The colour code system is to be agreed upon between the customer and supplier.

Table 2 – Colour for individual fibres or units (listed alphabetically)

Colour
Black
Blue
Brown
Green
Grey
Orange
Pink
Red
Turquoise
Violet
White
Yellow
NOTE For units containing more than 12 fibres, fibres should be identified by combining the above sequence with an added identification (e.g. ring marking, dashed mark, tracer or coloured unit binders).

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7.1.2.2 Element identification

The optical fibre cable elements shall be identified uniquely. One method is by the same colour code as for the fibre identification. The first twelve elements (1-12) are identical to the first twelve fibre colours. The next groups of twelve elements shall be identified by combining the twelve colour sequence with an added identification.

Further alternatives are

– printing the sequential number on the element,
– marker/reference system (e.g. first element blue, second element yellow, followed by other elements uncoloured),
– marking of the slots or the ribs in slotted core construction,
– block-bar numbering.

7.2 Element characteristics

7.2.1 Ribbon

Optical fibre ribbons shall comply with IEC 60794-3.

7.2.2 Tube kinking

The resistance of stranded loose tube elements to kinking shall be tested in accordance with IEC 60794-1-2, method G7.

Test conditions:

Number of cycles: 5

Length L = 100 mm for tube diameter: d < 2,0 mm

Length L = 70 mm for tube diameter: 2,0 mm < d < 2,8 mm

Length L = 50 mm for tube diameter: d > 2,8 mm

Length $L1$ = 350 mm

Length $L2$ = 100 mm

The sample may be smoothed using a hot air fan.

8 Requirements for optical cables

8.1 Cable construction

The cable construction shall ensure protection of fibres from damage during shipping, storage, installation and use. It shall further ensure to maintain the optical characteristics of the fibres within the specified limits during the entire lifetime of the cable.

The features and characteristics given in the following paragraphs are for all general applications of the cables covered by this standard. Special applications may require deviations from these characteristics, to be agreed between customer and supplier.

The cable manufacturer shall give a description of the cable and particularly the arrangements of cable elements and the location and material of the strength members. The description may include a schematic cross-sectional drawing.

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8.1.1 Cable core

Unless otherwise agreed, the cable core shall be longitudinally water-blocked which may be achieved by gel, water swellable materials or other suitable materials.

8.1.2 Anti-buckling and strength element splicing

Splices are allowed in anti-buckling or strength elements if the mechanical requirements of the cable are fulfilled (e.g. tensile strength and bending requirements).

Every anti-buckling and strength element splice shall have a strength of at least 80 % the nominal strength of the relevant anti-buckling and strength elements. The diameter of a spliced anti-buckling element shall not be greater than the nominal anti-buckling element diameter.

8.1.3 Cable element stranding

Optical fibre cable elements as described in Clause 7 may be laid up according to the following configurations:

– single optical element(s) without a stranding lay;
– multiple homogeneous optical elements using helical or reverse oscillating (SZ) lay method;
– a number of hybrid configurations in loose tube(s), slotted core(s) or central core tube(s) such as fibre bundles, ribbons or loose tubes.

Fillers, insulated copper wires such as pairs or quads may be laid up with the optical elements, if required.

NOTE The intent of this requirement is that sufficient fibre length be available in to accomplish fibre routing and splicing in mid-span access. SZ and single central elements are obvious solutions, but any construction meeting this intent is acceptable.

8.1.4 Spliced fibres

Spliced fibres in the factory length are not allowed, unless agreed between customer and supplier.

8.1.5 Spare fibres

Optical fibre cables shall not contain spare fibres unless agreed between the customer and supplier.

NOTE A spare fibre is a fibre which is added to a cable element in extension of the nominal fibre content of this element.

8.1.6 Cable sheath removal

The supplier shall provide an appropriate method for sheath removal, such as the provision of one or two ripcords under the sheath.

8.1.7 Armouring

For direct burial, armouring (metallic or non-metallic) may be required, depending on mechanical and environmental conditions as agreed between customer and supplier including adapted mechanical cable requirements (see 8.5). Additional cable mechanical testing can be agreed upon by the customer and supplier.

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8.2 Marking

8.2.1 Sheath marking

The cable shall be marked by one of the following methods: sintering, embossing, hot foil, ink-jet, indent or imprinting.

The abrasion resistance of the sheath markings shall comply with IEC 60794-1-2, method E2B.

Depending on the cable marking method used, one of the following test methods shall be used:

Method 1: Steel needle diameter d = 1,0 mm
Load: 4 N
Number of cycles: 100 to 300 cycles depending on customer requirement.

or

Method 2: Felt pad to consist of either 1) water soaked wool felt or 2) rayon felt with ≤ 30 % wool
Weight: ≥ 450 g
Number of cycles: 3

8.2.2 Identification marking

The markings on each length of cable shall be printed in accordance with customer and supplier requirements. Unless specified otherwise, the print shall contain, at minimum, the following:

– designation, e.g. words or graphic identifying cable as an “optical cable”;
– number of fibres;
– type of fibres (e.g. B1, etc.);
– name of the supplier or product brand name;
– year of manufacture.

8.2.3 Cable length marking

Unless otherwise agreed, the difference between the length printed by the length marker and the actual length shall not be more than $\frac{-1}{0}$ % of the actual length. Other tolerances can be allowed provided the cable length is assured by other means.

The cable shall have sequentially numbered length markings printed on the sheath at 1 m intervals. Alternate length marking is also acceptable. The length marking shall not be reset to zero for the entire length of cable. The length marking can start with a value different from zero.

If agreed between customer and supplier, cables may be re-marked in accordance with the following.

Defective marking may be removed and the cable re-marked with the same colour.

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