IEC 60794-4

Edition 2.0 2018-06
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Optical fibre cables –
Part 4: Sectional specification – Aerial optical cables along electrical power lines

IEC 60794-4:2018-06 RLV(en)

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

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

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC 60794-4

Edition 2.0 2018-06
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Optical fibre cables –
Part 4: Sectional specification – Aerial optical cables along electrical power lines

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.180.10

ISBN 978-2-8322-5850-7

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

OPTICAL FIBRE CABLES –

Part 4: Sectional specification – Aerial optical cables along electrical power lines

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60794-4 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee TC 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2003. This edition constitutes a technical revision.

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

a) the specification has been streamlined by cross-referencing IEC 60794-1-1;
b) the classification as type tests or routine tests has been deleted;
c) cable kink test has been deleted;
d) creep test for ADSS is referred to IEC 60794-4-20.

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

FDIS	Report on voting
86A/1862/FDIS	86A/1868/RVD

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 60794 series, published under the general title *Optical fibre cables*, 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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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 publication using a colour printer.

OPTICAL FIBRE CABLES –

Part 4: Sectional specification – Aerial optical cables along electrical power lines

1 Scope

~~This part of IEC 60794 specifies the electrical, mechanical and optical requirements and test methods for aerial optical cables including OPGW (optical ground wire), OPPC (optical phase conductor), MASS (metallic aerial self-supported cable), ADSS (all-dielectric self-supporting cable) and OPAC (optical attached cable).~~

This part of IEC 60794 covers cable construction, test methods, optical, mechanical, environmental and electrical performance requirements for aerial optical fibre cables and cable elements which are intended to be used along power lines (OCEPL) as a high bandwidth transport media for communications and control optical signals, including optical ground wires (OPGW), optical phase conductors (OPPC), metallic aerial self-supported cables (MASS), all-dielectric self-supporting cables (ADSS) and optical attached cables (OPAC).

This document excludes figure-8 optical cables to be used on telephone utility poles.

The IEC TR 62839-1 gives recommendations to provide the customer with the environmental declaration on request.

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.

~~They complete the normative references already listed in the generic specification (IEC 60794-1-1, Clause 2, and IEC 60794-1-2, Clause 2) and in the sectional specification (IEC 60794-3, Clause 2).~~

IEC 60104~~:1987~~, *Aluminium-magnesium-silicon alloy wire for overhead line conductors*

IEC 60304~~:1982~~, *Standard colours for insulation for low-frequency cables and wires*

~~IEC 60708-1:1981, *Low-frequency cables with polyolefin insulation and moisture barrier polyolefin sheath – Part 1: General design details and requirements*~~

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

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

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

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, *Optical fibres – Part 2: Product specifications – General*

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

IEC 60794-1-21, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods*

IEC 60794-1-22, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental tests methods*

IEC 60794-1-23, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures – Cable element test methods*

IEC 60794-1-24, *Optical fibre cables – Part 1-24: Generic specification – Basic optical cable test procedures – Electrical test methods*

IEC 60794-3~~:2001~~, *Optical fibre cables – Part 3: Outdoor cables – Sectional specification*

IEC 60794-4-20:2012, *Optical fibre cables – Part 4-20: Aerial optical cables along power lines – Family specification for ADSS (All Dielectric Self Supported) optical cables*

~~*IEC 60811-4-2:1990, Common test methods for insulating and sheathing materials of electric cables – Part 4: Methods specific to polyethylene and polypropylene compounds – Section Two: Elongation at break after pre-conditioning – Wrapping test after pre-conditioning – Wrapping test after thermal ageing in air – Measurement of mass increase – Long term stability test (Appendix A) – Test method for copper-catalysed oxidative degradation (Appendix B)*~~

~~*IEC 60811-5-1:1990, Common test methods for insulating and sheathing materials of electric cables – Part 5: Methods specific to filling compounds – Section one: Drop point – Separation of oil – Lower temperature brittleness – Total acid number – Absence of corrosive components – Permittivity at 23 °C – DC resistivity at 23 °C and 100 °C*~~

IEC 60811-202, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*

IEC 60811-203, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*

IEC 60811-401, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*

IEC 60811-406, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 406: Miscellaneous tests – Resistance to stress cracking of polyethylene and polypropylene compounds*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

IEC 60811-604:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 604: Physical tests – Measurement of absence of corrosive components in filling compounds*

IEC 60811-607, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 607: Physical tests – Test for the assessment of carbon black dispersion in polyethylene and polypropylene*

IEC 60888~~:1987~~, *Zinc-coated steel wires for stranded conductors*

IEC 60889~~:1987~~, *Hard-drawn aluminium wire for overhead line conductors*

IEC 61089:1991, *Round wire concentric lay overhead electrical stranded conductors*

IEC 61232~~:1993~~, *Aluminium-clad steel wires for electrical purposes*

IEC 61394~~:1997~~, *Overhead lines – ~~Characteristics of~~ Requirements for greases for aluminium, aluminium alloy and steel bare conductors*

IEC 61395~~:1998~~, *Overhead electrical conductors – Creep test procedures for stranded conductors*

3 Terms, definitions, symbols and ~~abbreviations of cables~~ abbreviated terms

For the purposes of this document, the ~~following~~ terms, definitions, symbols and ~~abbreviations of cables~~ abbreviated terms given in IEC 60794-1-1 apply.

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

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

~~**3.1 Definitions**~~

~~**3.1.1**~~
~~**MAT**~~
~~**maximum allowable tension**~~
~~maximum tensile load that may be applied to the cable without detriment to the tensile performance requirement (optical performance, fibre strain)~~

~~**3.1.2**~~
~~**RTS**~~
~~**rated tensile strength**~~
~~summation of the product of nominal cross-sectional area, minimum tensile strength and stranding factor for each load bearing material in the cable construction (refer to Annex A in the case of OPGW)~~

~~**3.1.3**~~
~~**strain margin**~~
~~amount of strain the OCEPL can sustain without strain on the fibres due to the OCEPL's elongation~~

~~**3.2 Abbreviations of cables**~~

~~ADSS all-dielectric self-supporting cable~~

~~MASS metallic aerial self-supported cable which is not designed to have ground or phase capability~~

~~OCEPL optical cable to be used along electrical power lines~~

~~OPAC optical attached cable consisting of the following three attachment methods:~~

- ~~**wrapped:** all-dielectric (wrap). Using special machinery, a lightweight flexible non-metallic cable can be wrapped helically around either the earth wire or the phase conductor.~~
- ~~**lashed:** non-metallic cables that are installed longitudinally alongside the earth wire, the phase conductor or on a separate catenary (on a pole route) and are held in position with a binder or adhesive cord.~~
- ~~**preform attached:** similar to the lashed cables except that the method of attachment involves the use of special preformed spiral attachment clips.~~

~~OPGW optical ground wire. An OPGW has the dual performance functions of a conventional ground wire with telecommunication capabilities.~~

~~OPPC optical phase conductor. An OPPC has the dual performance functions of a phase conductor with telecommunication capabilities.~~

4 Optical fibre

4.1 General

Single-mode optical fibre which meets the requirements of IEC 60793-2 shall be used. Fibres other than those specified above can be used, if mutually agreed between the ~~customer~~ user and the supplier.

4.2 Attenuation

4.2.1 Attenuation coefficient

The typical maximum cable attenuation coefficient ~~of a cable at 1 310 nm is 0,45 dB/km and/or at 1 550 nm it is 0,30 dB/km~~ shall conform to IEC 60794-1-1.

Particular values ~~shall~~ may be agreed between the customer and supplier. The attenuation coefficient shall be measured in accordance with IEC 60793-1-40.

4.2.2 Attenuation uniformity-attenuation discontinuities

~~**4.2.2.1 Attenuation discontinuities**~~

~~The local attenuation shall not have point discontinuities in excess of 0,10 dB.~~

~~The test method best suited to provide the functional requirements is in accordance with IEC 60793-1-40.~~

~~**4.2.2.2 Attenuation linearity**~~

~~The functional requirements are under consideration.~~

Point discontinuities shall be measured in accordance with IEC 60793-1-40, method C, and conform to IEC 60794-1-1.

4.3 Cut-off wavelength of cabled fibre

For single mode fibre, the cabled fibre cut-off wavelength, λ_{cc}, shall be less than the operational wavelength, when measured in accordance with IEC 60793-1-44, and conform to IEC 60794-1-1.

4.4 Fibre colouring

If the primary coated fibres are coloured for identification, the coloured coating shall be readily identifiable throughout the lifetime of the cable and shall be a reasonable match to IEC 60304. ~~If required, the colouring shall permit sufficient light to be transmitted through the primary coating to allow local light injection and detection. Alternatively, the colour may be removable.~~

4.5 Polarization mode dispersion (PMD)

~~Refer to 5.5 of IEC 60794-3.~~

Cabled single-mode fibre PMD shall be measured in accordance with IEC 60793-1-48 and conform to IEC 60794-1-1.

5 Cable element

5.1 General

Generally, optical cables comprise several elements or individual constituents, depending on the cable design, which take into account the cable application, operating environment and manufacturing processes, as well as the need to protect the fibre during handling and cabling.

The material(s) used for a cable element shall be selected to be compatible with the other elements in contact with it. An appropriate compatibility test method shall be defined in the family or ~~product~~ detail specification.

When the fibres are in contact with a filling compound, the compatibility of the filling compound with the fibre coating shall be demonstrated by testing coating stripping force stability after accelerated ageing in accordance with IEC 60794-1-21, method E5. Alternative ageing conditions and tests may be agreed between the customer and supplier.

Optical elements are cable elements containing optical fibres and are designed to be a primary functional unit of the cable core. They may comprise any of the cable elements described below. Optical elements and each fibre within a cable element shall be uniquely identified, for example, by colours, a positional scheme, markings, tapes, threads or specified in the ~~product~~ detail specification.

Tests may be performed on cable elements either in uncabled form or in finished cable. Unless otherwise specified, testing shall be performed on cable elements in a finished cable. This means that testing shall be performed only on a finished cable if the cable element manufacturing operation is done by the same manufacturer as the cabling operation. Testing shall be performed on cable elements only if the cable element is supplied by a third party; this does not exclude testing of the finished cable.

Different types of optical elements are described below.

5.2 Slotted core

~~The slotted core is either a metallic (for example, aluminium alloy) or non-metallic (for example, polyethylene or polypropylene) material with a defined number of slots, with longitudinal, helical or SZ configuration along the core. One or more primary coated fibres or optical element is located in each slot which shall be filled, if necessary, with a suitable water blocking system.~~

~~If metallic, it shall be electrically bonded with the other metallic elements of the cable. If non-metallic, the slotted core usually contains a central element which shall be non-metallic. In this case, there shall be adequate adhesion between the central element and the extruded~~

~~core in order to obtain the required temperature stability and tensile behaviour for the slotted core element.~~

The slotted core is obtained by extruding a suitable material (for example polyethylene or polypropylene) with a defined number of slots, providing helical or SZ configuration along the core. One or more primary coated fibres or optical element is located in each slot which may be filled.

The slotted core usually contains a central element which may be either metallic or non-metallic. In this case, there shall be adequate adhesion between the central element and the extruded core in order to obtain the required temperature stability and tensile behaviour for the slotted core element.

The profile of the slot shall be uniform and shall ensure the optical and mechanical performance required for the optical cable.

5.3 ~~Plastic~~ Polymeric tube

One or more primary coated fibres or optical elements are packaged (loosely or not) in a tube construction which shall be filled, ~~if necessary, with a suitable water~~ use dry-blocking ~~system~~ methods or be otherwise water blocked. The plastic tube may be reinforced with a composite wall.

If required, the suitability of the tube shall be determined by an evaluation of its kink resistance in accordance with IEC 60794-1-23, method G7.

If used, the filling compound in the tube shall comply with ~~IEC 60794-1-2, Method E14 (compound flow (drip)) or Method E15 (bleeding and evaporation)~~ the evaporation test in accordance with IEC 60794-1-21, method E15. The filled tube shall comply with drip test in accordance with IEC 60794-1-22, method F16, when tested in tube or cabled form.

NOTE Method E15 of IEC 60794-1-21 will be transferred in IEC 60794-1-23:—[1] as method G9.

5.4 Ribbon

Optical fibre ribbons are assembled optical fibres; they shall be in accordance with IEC 60794-3.

NOTE The technical content of IEC 60794-3 regarding optical fibre ribbons will be moved to IEC 60794-1-31:—[2]. Users are directed to that document when it is issued.

5.5 Metallic tube

5.5.1 General

Constructions having fibres within a hermetically sealed tube shall consider the possibility of evolution of hydrogen gas. See 9.9 for guidance.

5.5.2 Metallic tube on the optical core

A metallic tube (for example, aluminium tube) may be applied over the optical core (for example, aluminium spacer or stranded tube).

---

1 This second edition is under preparation. Stage at the time of publication: IEC/NFDIS 60794-1-23:2018.

2 Under preparation. Stage at the time of publication: IEC/APUB 60794-1-31:2018.

5.5.3 Fibres directly located in a metallic tube

One or more primary coated and coloured fibres are packaged in a metallic hermetically sealed tube, which shall be filled with a suitable compound if necessary to avoid water penetration.

The inside surface of the tube should be smooth without any defects.

6 Optical fibre cable construction

6.1 General

The intent is that the cable ~~shall~~ be designed and manufactured for a predicted operating lifetime of at least 20 years ~~depending on the type of cable~~. In this context, the attenuation of the installed cable at the operational wavelength(s) shall not exceed values agreed between the customer and supplier. The tests of this document are intended to assess the performance of cables as manufactured and under agreed ageing and performance-limit tests. These tests are not intended to define end-of-life performance, but may be used as agreed between manufacturer and customer to predict such performance. The materials in the cable shall not present a health hazard within its intended use.

The fibres in the cables are usually of the same type, but some cables may contain multiple specified fibre types, and fibres of the same type may have different origins.

There shall be no fibre splice in a delivery length, unless otherwise agreed by the customer and supplier.

It shall be possible to identify each individual fibre throughout the length of the cable.

If mutually agreed between ~~customer~~ purchaser and ~~supplier~~ manufacturer to avoid excess fibre strain induced by the environmental conditions, such as wind or ice loading, the cable construction and particularly the strength members shall be selected to avoid any long-term detrimental effects on fibres up to the specified MAT.

The optical fibre unit shall house the optical fibres and protect them from damage due to environmental or mechanical forces such as longitudinal compression, crushing, bending, twisting, tensile stress, long- and short-term heat effects.

The aerial cable types covered by this document can be divided into the following groups:

a) optical ground wire or optical phase conductor (OPGW or OPPC);

b) all-dielectric self-supporting cable (ADSS);

c) optical attached cables (OPAC);

d) metallic aerial self-supported cables (MASS).

These aerial cables have different constructions, environmental and electrical operating conditions for use on high-voltage lines.

6.2 Lay-up of the cable elements

Optical unit elements as described in Clause 5 may be laid up as follows:

a) optical element(s) without a stranding lay, such as a single optical unit in the cable centre~~, which may contain one or more optical elements~~;

b) a number of homogeneous optical elements using helical or SZ stranding configurations (ribbon elements may be laid up by stacking two or more elements);

c) a number of ~~hybrid~~ different configurations in slotted core such as ribbon or plastic tube~~, which may contain one or more optical elements~~;

d) for OPGW, if required, insulated copper conductors in single, pair or quad construction may be laid up with the optical elements.

6.3 Cable core filling

~~If specified, the element(s) and in addition the cable core shall be continuously filled with water-blocking material. Alternatively, water blocks may be applied at regular intervals. The material shall be easily removed without the use of materials considered to be hazardous or dangerous.~~

~~The blocking material used shall be compatible with the other relevant cable elements. Where a filling compound is used, its suitability shall be demonstrated by the use of the following test methods:~~

~~d) The amount of oil separation from the filling compound shall meet the requirements of Clause 5 of IEC 60811-5-1; alternatively, the filling compound shall be tested in accordance with IEC 60794-1-2, Method E15.~~

~~e) For cables containing metallic elements, the filling compound shall be tested for the presence of corrosive compounds in accordance with IEC 60811-5-1, Clause 8.~~

~~f) The filling compound shall not be liquid at temperatures lower than a specified value. The determination of the drop point shall be in accordance with IEC 60811-5-1, Clause 4.~~

~~g) Increase in weight shall be tested as specified in IEC 60811-4-2, Clause 11. The increase in weight shall not exceed the value specified for the particular material.~~

~~h) Where the blocking material is water swellable, suitability tests are under consideration.~~

If specified, the element(s) and in addition the cable core shall contain water blocking material, such as grease-like and/or dry-block materials, to prevent longitudinal water penetration in accordance with IEC 60794-1-22, method F5. The material shall be easily removed without the use of substances considered to be hazardous or dangerous. The grease-like compound shall comply with IEC 60794-1-21, method E15. The cable shall pass the compound flow test of IEC 60794-1-21, method E14.

The blocking material used shall be compatible with the other relevant cable elements. Where a grease-like filling compound is used in cables containing metallic elements, it shall be tested for the presence of corrosive compounds in accordance with IEC 60811-604:2012, Clause 4.

6.4 Strength members

6.4.1 General

The type of materials used as strength members shall fulfil the mechanical and thermal requirements of the overhead lines.

6.4.2 OPGW, OPPC and MASS

The stranded wires used for armouring may be round according to IEC 61089 or other cross-sectional shapes, i.e. trapezoidal or z-form and can be of the following materials:

– aluminium alloy IEC 60104;
– galvanized steel IEC 60888;
– aluminium IEC 60889;
– aluminium-clad steel IEC 61232.

These standards give requirements on wire before stranding.

Unless other requirements are mutually agreed between the ~~customer~~ purchaser and the ~~supplier~~ manufacturer, after stranding, the wires shall meet the requirements of IEC 61089.

Materials other than those specified can be used if mutually agreed between the ~~customer~~ purchaser and the ~~supplier~~ manufacturer.

In order to reduce the risk of corrosion, it ~~may~~ can be necessary for the armouring to be greased (see 9.13).

6.4.3 ADSS and OPAC

The strength member elements shall consist of aramid yarns, glass-reinforced materials or equivalent dielectric strength members.

6.5 Cable sheath (ADSS and OPAC)

6.5.1 Inner sheath

A cable inner sheath may be applied by agreement between the ~~customer~~ purchaser and the supplier. When required for a specific construction, or for manufacturing purposes, cable cores or sub-units within the core, or both, may be covered by inner sheaths. Unless otherwise specified, the inner sheath shall be made of polyethylene.

6.5.2 Outer sheath

6.5.2.1 General requirements

~~If the aerial cable has an outer sheath, this shall be made of UV-stabilized weather-resistant material in accordance with IEC 60708-1, Clause 22, unless otherwise agreed between the customer and the supplier. In the case of ADSS and OPAC, in certain conditions it shall be necessary to consider the use of a tracking-resistant sheath.~~

ADSS and OPAC cables shall have a seamless sheath made of UV-stabilized weather resistant polyethylene, containing 2,0 % minimum well-dispersed carbon black in accordance with IEC 60811-607, unless otherwise agreed between the customer and supplier. Under certain conditions, it shall be necessary to consider the use of a tracking-resistant sheath.

The sheath thickness (tested in accordance with IEC 60811-202) and cable overall diameter (tested in accordance with IEC 60811-203) and its variations shall take into account the installation conditions and shall be determined by the relevant specification or by agreement between the customer and supplier.

6.5.2.2 Tensile strength and elongation

When tested in accordance with IEC 60811-501, the measured values of tensile strength shall be not less than:

a) 10 MPa for low- or linear low-density polyethylene;

b) 12,0 MPa for medium-density polyethylene;

c) 16,5 MPa for high-density polyethylene.

The measured values of elongation at break shall be not less than 300 %.

6.5.2.3 Elongation at break after ageing

The mechanical characteristics of the sheath shall remain sufficiently constant during normal use. This is checked by determining the elongation at break according to IEC 60811-501 after an ageing test at 100 °C ± 2 °C for 10 × 24 h according to IEC 60811-401. The median of the values of elongation at break shall be not less than 300 %.

6.5.2.4 Resistance to environmental stress cracking

The resistance to environmental stress cracking shall comply with the requirements of IEC 60811-406. Method B of IEC 60811-406 shall be applied.

6.6 Sheath marking

If required for non-metallic aerial cable, the sheath ~~may~~ shall be marked by a method agreed between the customer and supplier. Common methods of marking are embossing, sintering, imprinting, hot foil and surface printing.

The information given in the marking text may include cable length, the number of fibres, fibre type, manufacturer's name and the date of manufacture.

The characters shall be spaced at intervals of not more than 1 m. The actual length of the cable shall be within +1 %, –0 % of the length indicated by the length marking. For example, 1 000 m of cable, if the starting sheath length mark was 0, should have a final sheath mark in the range 990 m to 1 000 m. Occasional illegible markings are permitted, provided that a legible mark is located within 5 m of the illegible mark. Cables may be remarked in a second contrasting colour, if the first marking process is unsuccessful.

Marking may be provided as a single or double line of marking. A single line of marking shall be provided by marking longitudinally along the length of the cable. A double line of marking shall be provided with the two lines diametrically opposite each other, longitudinally along the length of the cable.

The abrasion resistance of the sheath markings shall be demonstrated in accordance with IEC 60794-1-21, method E2B.

For a double line of marking, the abrasion resistance test only needs be carried out on one line of marking.

If there is a risk due to high-voltage tracking effects, then sheath marking may be omitted.

7 ~~Main requirements for installation and operating conditions~~ Characterization of cable elements

~~7.1 General~~

~~Installation and operating conditions shall be agreed upon between the customer and the supplier. Operating conditions are particularly important for aerial cables.~~

~~7.2 Characterization of optical units for splicing purpose~~

~~For characterization of the different types of cable elements for splicing purposes, refer to IEC 60794-3.~~

The tests in Table 1 are intended to characterize the different types of cable elements.

Table 1 – Characteristics of different types of cable elements

Characteristics	Family requirements	Test methods	Remarks
Dimensions	5.0	IEC 60793-1-21	Secondary coating
Dimensions	6.1, 6.2, 6.4, 6.6	IEC 60811-202 and IEC 60811-203	Loose tube, slotted core and ruggedized elements

Dimensions	6.3	IEC 60794-1-23 Methods G2, G3	Ribbons
Bend	5.0, 6.2	IEC 60794-1-23 Method G1	Secondary coating, loose tube
Kink	6.4	IEC 60794-1-23 Method G7	Tube
Strippability	5.0	IEC 60793-1-32	Fibre coatings
Compound flow	6.4	IEC 60794-1-22 Method F16	Tube

8 Design characteristics

Table 2 is a summary of important OCEPL characteristics which may be of relevance to both the ~~customer~~ purchaser and the ~~supplier~~ manufacturer. Other characteristics may be mutually agreed upon by both ~~the customer~~ purchaser and ~~the supplier~~ manufacturer.

Table 2 – Design characteristics

~~Reference~~	Design characteristics	OPGW	OPPC	MASS	ADSS	OPAC
~~(1)~~	Number and type of fibres	X	X	X	X	X
~~(2)~~	Detailed description of the cable design	X	X	X	X	X
~~(3)~~	Overall diameter (mm)	X	X	X	X	X
~~(4)~~	Calculated cross-sectional area concerning calculation of rated tensile strength (RTS) (mm^2) ~~(μm^2)~~	X	X	X	~~X~~ –	–
~~(5)~~	Calculated mass (kg/km)	X	X	X	X	X
~~(6)~~	RTS ~~– Rated tensile strength~~ (kN)	X	X	X	~~X~~ –	~~X~~ –
~~(7)~~	Modulus of elasticity (N/mm^2)	X	X	X	X	X
~~(8)~~	Coefficient of thermal expansion (K^{-1})	X	X	X	X	X
~~(9)~~	DC resistance (Ω/km)	X	X	–	–	–
~~(10)~~	Fault-current capacity I^2t ($kA^2 \times s$)	X	X	–	–	[a]
~~(11)~~	MAT – Maximum allowable tension (kN)	X	X	X	X	X
~~(12)~~	Allowable temperature range for storage, installation and operation (°C)	X	X	X	X	X
~~(13)~~	Strain margin (according to IEC 60794-1-2) (%)	X	X	X	X	X
~~(14)~~	Lay direction of outer layer	X	X	X	–	–
~~(15)~~	Tracking resistant sheath (if applicable)	–	–	–	X	X

[a] Maximum operating current of the cable under short-circuit shall be specified by the manufacturer.

9 Optical fibre cable tests

9.1 General

Compliance with specification requirements shall be verified by carrying out tests as required by the relevant family or detail specification. Suitable tests are detailed in Table 3. It is not intended that all tests shall be carried out: the frequency of testing shall be agreed between the customer and supplier.

Guidance on qualification sampling and interpretation of test results are given in IEC 60794-1-1. The number of fibres tested shall be representative of the cable design and shall be agreed between the customer and supplier.

The parameters specified in this document may be affected by measurement uncertainty arising either from measurement errors or calibration errors due to the lack of suitable standards. Acceptance criteria shall be interpreted with respect to this consideration. The total uncertainty of measurement for this document shall be less than, or equal to, 0,05 dB for attenuation.

The expression of no change in attenuation means that any change in measurement value, either positive or negative, within the uncertainty of measurement shall be ignored.

The number of fibres tested shall be representative of the cable design and shall be agreed between the ~~customer~~ purchaser and the ~~supplier~~ manufacturer.

The tests applicable for aerial cables are listed below. The minimum acceptance criteria for the different types of cables are given in the relevant family specifications.

Table 3 – Mechanical and environmental applicable tests

Characteristics	Family requirements	Test methods	Remarks
Tensile performance	9.2	IEC 60794-1-21 Method E1	
Sheave test	9.4	IEC 60794-1-21 Method E18B	OPGW, OPPC, MASS and ADSS
Crush	Family specification	IEC 60794-1-21 Method E3	
Impact	Family specification	IEC 60794-1-21 Method E4	
Short-circuit	9.5	IEC 69794-1-24 Method H1	OPGW, OPPC, OPAC
Lightning	9.6	IEC 60794-1-24 Method H2	OPGW, OPPC
Fitting compatibility	9.12 and family specification		OPGW, ADSS, OPPC
Tracking and erosion	9.15	IEC 60794-4-20:2012 Annex B	ADSS, OPAC
Repeated bending	Family specification	IEC 60794-1-21 Method E6	
Torsion	Family specification	IEC 60794-1-21 Method E7	
Bend	Family specification	IEC 60794-1-21 Method E11	
Shotgun resistance	9.17	IEC 60794-1-21 Method E13	Aerial cables specified for shotgun protection
Aeolian vibration	9.10	IEC 60794-1-21 Method E19	OPGW, OPPC, ADSS, MASS
Low frequency vibration (galloping)	Family specification	IEC 60794-1-21 Method E26	OPGW, OPPC, ADSS, MASS
Creep	Family specification	IEC 61395	OPGW, OPPC, MASS
Stress-strain test on metallic cables	Family specification	IEC 61089	OPGW, OPPC, MASS
Temperature cycling	Family specification	IEC 60794-1-22 Method F1	

Characteristics	Family requirements	Test methods	Remarks
Water penetration	Family specification	IEC 60794-1-22 Method F5B or F5C	
Sheath abrasion resistance	Family specification	IEC 60794-1-21 Method E2A	ADSS, OPAC
Ageing	9.7	IEC 60794-1-22 Method F9	
Ribbon stripping	Family specification	IEC 60794-1-21 Method E5B	Ribbon cables

~~**9.3 Classification of tests**~~

~~**9.3.1 Type tests**~~

~~Tests required to be made before supplying a type of cable covered by this part of IEC 60794 on a general commercial basis in order to demonstrate satisfactory performance characteristics to meet the intended application. These tests shall be carried out on a cable length which meets the requirements of the relevant routine tests. These tests are of such a nature that, after they have been made, they need not be repeated unless significant changes are made in the cable material, design or type of manufacturing process which might change the performance characteristics.~~

~~The tests to be repeated shall be agreed between the customer and the supplier.~~

~~**9.3.2 Sample tests**~~

~~Tests are made on samples of completed cable or components taken from a completed cable adequate to verify that the finished product meets the design specifications. Scope and incidence of sample tests, if required, shall be agreed between the customer and the supplier.~~

~~**9.3.3 Routine tests**~~

~~Tests are made on all production cable lengths to demonstrate their integrity.~~

9.2 Tensile performance

The cable shall be tested in accordance with IEC 60794-1-21, method E1. Under this test, the cables shall meet the specified MAT value.

If required by the product specification, the cable shall be terminated with end fittings relevant to the type of cable considered.

~~In addition to the test detailed in 9.2,~~ OPAC cables should undergo an additional tensile test having been attached to a messenger cable at the defined installation tension, which is agreed between the ~~customer~~ user and the ~~supplier~~ manufacturer. This test is to ensure that lengthening and retraction of the messenger wire in service will not cause the OPAC to festoon.

9.3 Stress-strain test on metallic cables

Stress-strain tests shall be performed to determine the behaviour of the cable under load conditions and shall be in accordance with IEC 61089:1991, Annex B. Sample length shall be in accordance with IEC 61089 (other sample lengths may be used if mutually agreed between the ~~customer~~ user and the ~~supplier~~ manufacturer).End fittings such as the helically preformed fittings, cone type, compression, epoxy type, bolted or solder type relevant to the cable type considered shall be used. During the test, there shall be no visual damage to the cable

strands. All stress and strain values obtained during the test and agreed upon by the ~~supplier~~ manufacturer and the ~~customer~~ purchaser shall be recorded.

If required, the test of tensile performance may be carried out simultaneously with this test.

The Young's modulus should be calculated during the second cycle.

When the test for the breaking strength of the OPGW is required, the OPGW shall withstand without fracture of any wire, not less than 95 % of its RTS.

~~**9.4 Installation capability**~~

~~Compatibility with particular installation conditions may be demonstrated by selecting from the following tests.~~

9.4 Sheave test

The sheave test shall be performed to verify that the installation of the OPGW, OPPC, MASS and ADSS will not damage or degrade their performance. The cable shall be tested in accordance with ~~IEC 60794-1-2, Method E9~~ IEC 60794-1-21, method E18B.

~~**9.4.2 Repeated bending**~~

~~The cable shall be tested in accordance with the method specified in IEC 60794-1-2, Method E6.~~

~~**9.4.3 Impact**~~

~~The cable construction shall be tested in accordance with the method specified in IEC 60794-1-2, Method E4.~~

~~**9.4.4 Crush**~~

~~The cable shall be tested in accordance with the method specified in IEC 60794-1-2, Method E3.~~

~~**9.4.5 Kink**~~

~~The cable shall be tested in accordance with the method specified in IEC 60794-1-2, Method E10. The minimum diameter shall be agreed between the customer and the supplier.~~

~~**9.4.6 Torsion**~~

~~The cable shall be tested in accordance with the method specified in IEC 60794-1-2, Method E7.~~

~~NOTE Subclauses 9.4.2 to 9.4.6 are applicable for ADSS and OPAC only.~~

~~**9.5 Temperature cycling**~~

~~Unless otherwise specified in the family specification, the cable shall be tested in accordance with the combined test procedure of the method specified in IEC 60794-1-2, Method F1.~~

9.5 Short-circuit

The short-circuit test shall assess the performance of the OPGW, OPPC or OPAC cable and the optical characteristics of the fibres under typical short-circuit and has to be tested in accordance with the method specified in ~~IEC 60794-1-2, Method H1~~ IEC 60794-1-24, method H1.

When agreed between the ~~customer~~ purchaser and ~~supplier~~ manufacturer, the test procedure may be replaced by an adequate theoretical calculation method.

9.6 Lightning test

The cable construction shall be tested in accordance with IEC 60794-1-24, method H2.

9.7 Ageing

~~Under consideration.~~

The resistance of the cable to ageing shall be tested in accordance with IEC 60794-1-22, method F9.

9.8 Fibre coating compatibility

When the fibres are in contact with a filling compound, the compatibility of the filling compound with the fibre coating shall be demonstrated by testing, after accelerated ageing, either the cabled fibre or the fibre in filling compound for

e) stripping force stability in accordance with ~~IEC 60794-1-2, Method E5~~ IEC 60794-1-21, method E13B,

f) stability of the colour of the coating for fibre identification (test method is under consideration),

and, if required, for

g) dimensional stability, and

h) coating transmissivity.

Test methods are under consideration.

~~9.8.2 Finished cable~~

~~Under consideration.~~

9.9 Hydrogen gas

~~Under consideration.~~

An informative guideline is given in IEC TR 62690.

9.10 Aeolian vibration

The resistance of the cable to aeolian vibration shall be tested in accordance with IEC 60794-1-21, method E19.

9.11 Creep

If requested, this test is carried out ~~on metallic~~ for OPGW, OPPC, MASS cables according to IEC 61395.

~~Under consideration for non-metallic cables.~~

IEC 60794-4-20 indicates adequate evaluation methods for ADSS.

9.12 Fitting compatibility

The type of fittings shall be approved between the ~~customer~~ purchaser and the ~~supplier~~ manufacturer, and their compatibility has to be checked according to the ~~customer's~~ purchaser's or the ~~supplier's~~ manufacturer's fitting specification.

~~**9.13 Water penetration (for filled cables only)**~~

~~The cable shall be tested in accordance with IEC 60794-1-2, Method F5B. Other acceptance criteria may be applied in accordance with particular customer requirements.~~

~~**9.14 Bleeding (for filled cables only)**~~

~~The bleeding performance of the filling compound of the unit fibre element shall comply with IEC 60794-1-2, Method E15.~~

9.13 Grease

In order to reduce the risk of corrosion, it ~~may~~ can be necessary for the strands of OPGW, OPPC and MASS to be coated with grease. The type of grease to be applied shall be in accordance with IEC 61394 or shall be defined between the ~~supplier~~ manufacturer and the ~~customer~~ purchaser.

9.14 Attenuation

The attenuation coefficient shall conform to IEC 60794-1-1. It shall be measured in accordance with IEC 60793-1-40.

9.15 Tracking and erosion resistance test on ADSS and OPAC

~~Under~~ Family specification for ADSS, IEC 60794-4-20, provides guidance for tracking consideration.

9.16 ~~Weathering~~ UV resistance test on ADSS and OPAC

~~Under consideration.~~

The outer sheath shall be made of UV-stabilized weather-resistant material in accordance with IEC 60794-1-22, method F14.

9.17 Shotgun resistance test on ADSS and OPAC

If ~~requested~~ required, this test will be performed according to IEC 60794-1-21, method E13B.

9.18 Conductor access trolley for OPAC

Under consideration.

10 Quality assurance

~~Under consideration.~~

The supplier shall establish, introduce and maintain a quality management system in accordance with ISO 9001 or equivalent.

11 Packaging

According to IEC 61089, if applicable, and to the following additional requirements,

a) packaging of the cable shall allow access to one or both ends of the cable in order to perform quality checks,

b) ends of the cable shall be sealed by a suitable method in order to prevent moisture ingress, and

c) delivery lengths and tolerance shall be determined in accordance with agreement between the ~~customer~~ purchaser and the ~~supplier~~ manufacturer.

Annex A
(~~informative~~ normative)

Recommended methods of calculating rated tensile strength, cross-section of a layer of trapezoidal shaped wires, modulus of elasticity, linear expansion and DC resistance for OPGW, OPPC and MASS

A.1 Calculation of rated tensile strength (RTS)

This calculation should be based on the tensile strength of the armouring and optical unit materials (where applicable) before stranding.

If the OPGW is of type Ax, Ax/Syz or Ax/Ax, the RTS ~~is~~ shall be calculated in accordance with IEC 61089. In cases where the load-bearing elements are homogenous steel or aluminium-clad steel, the RTS is 90 % of the summation of the tensile strength of the individual wires.

A.2 Calculation of the cross-sectional area of a layer of trapezoidal or Z-shaped wires ~~(A)~~

The value should be calculated from the formula:

$$A = (D_o^2 - D_i^2)\,(\pi/4)\,f$$

where

A is the total cross-sectional area of the shaped wire (mm^2);

D_o is the outer diameter of the shaped layer (mm)

D_i is the inner diameter of the shaped layer (mm);

f is the space factor.

Typical values:

– aluminium-clad steel/zinc-coated steel wires, f = 0,90;

– aluminium, aluminium alloy wires, f = 0,92.

A.3 Calculation of the final modulus of elasticity (E)

The value should be calculated from the following formula:

$$E = \frac{\Sigma(E_n A_n)}{\Sigma A_n}$$

where

E_n is the value of the modulus for each material (N/mm^2);

A_n is the cross-sectional area for the corresponding material (mm^2).

This formula gives a constant modulus corresponding to a linear stress-strain graph and forms a straight line. This is an approximation of the real modulus of elasticity as achieved from the test given in 9.3.

A.4 Calculation of coefficient of linear expansion (β)

The value should be calculated from the following formula:

$$\beta = \frac{\Sigma(\beta_n . E_n . A_n)}{\sum(E_n . A_n)}$$

where

E_n is the value of the modulus for each material (N/mm^2);

A_n is the cross-sectional area for the corresponding material (mm^2);

β_n is the value of the coefficient of linear expansion for each material (K^{-1}).

A.5 Calculation of DC resistance ~~(*R*)~~

The value should be calculated from the following formula:

$$R = \frac{1}{\sum_n \frac{1}{R_n}}$$

where

R is the linear DC resistance of the completed OPGW (Ω/km);

R_n is the linear DC resistance of each material (Ω/km);

with

$$R_n = \frac{P}{\sum_i \frac{A_i}{F_i}}$$

where

P is the resistivity of material (Ω × mm^2/km);

A_i is the area of a given material in the ith layer (mm^2);

F_i is the lay ratio of the ith layer.

NOTE F_i = 1 when the optical element is the central carrier of the OPGW.

Bibliography

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

IEC 60794-1-23:—, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures - Cable element test methods*[3]

IEC 60794-1-31:—, *Optical fibre cables – Part 1-31: Generic specification – Basic optical cable test procedures – Optical fibre ribbon*[4]

IEC TR 62690, *Hydrogen effects in optical fibre cables – Guidelines*

IEC TR 62839-1, *Environmental declaration – Part 1: Wires, cables and accessory products – Specific rules*

3 This second edition is under preparation. Stage at the time of publication: IEC/NFDIS 60794-1-23:2018.

4 Under preparation. Stage at the time of publication: IEC/APUB 60794-1-31:2018.

IEC 60794-4

Edition 2.0 2018-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Optical fibre cables –
Part 4: Sectional specification – Aerial optical cables along electrical power lines

Câbles à fibres optiques –
Partie 4: Spécification intermédiaire – Câbles optiques aériens le long des lignes électriques de transport d'énergie

IEC 60794-4:2018-06(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

OPTICAL FIBRE CABLES –

Part 4: Sectional specification – Aerial optical cables along electrical power lines

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60794-4 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee TC 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2003. This edition constitutes a technical revision.

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

a) the specification has been streamlined by cross-referencing IEC 60794-1-1;
b) the classification as type tests or routine tests has been deleted;
c) cable kink test has been deleted;
d) creep test for ADSS is referred to IEC 60794-4-20.

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

FDIS	Report on voting
86A/1862/FDIS	86A/1868/RVD

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 60794 series, published under the general title *Optical fibre cables*, 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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

OPTICAL FIBRE CABLES –

Part 4: Sectional specification – Aerial optical cables along electrical power lines

1 Scope

This part of IEC 60794 covers cable construction, test methods, optical, mechanical, environmental and electrical performance requirements for aerial optical fibre cables and cable elements which are intended to be used along power lines (OCEPL) as a high bandwidth transport media for communications and control optical signals, including optical ground wires (OPGW), optical phase conductors (OPPC), metallic aerial self-supported cables (MASS), all-dielectric self-supporting cables (ADSS) and optical attached cables (OPAC).

This document excludes figure-8 optical cables to be used on telephone utility poles.

The IEC TR 62839-1 gives recommendations to provide the customer with the environmental declaration on request.

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 60104, *Aluminium-magnesium-silicon alloy wire for overhead line conductors*

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

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

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

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

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, *Optical fibres – Part 2: Product specifications – General*

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

IEC 60794-1-21, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods*

IEC 60794-1-22, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental tests methods*

IEC 60794-1-23, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures – Cable element test methods*

IEC 60794-1-24, *Optical fibre cables – Part 1-24: Generic specification – Basic optical cable test procedures – Electrical test methods*

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

IEC 60794-4-20:2012, *Optical fibre cables – Part 4-20: Aerial optical cables along power lines – Family specification for ADSS (All Dielectric Self Supported) optical cables*

IEC 60811-202, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*

IEC 60811-203, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*

IEC 60811-401, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*

IEC 60811-406, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 406: Miscellaneous tests – Resistance to stress cracking of polyethylene and polypropylene compounds*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

IEC 60811-604:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 604: Physical tests – Measurement of absence of corrosive components in filling compounds*

IEC 60811-607, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 607: Physical tests – Test for the assessment of carbon black dispersion in polyethylene and polypropylene*

IEC 60888, *Zinc-coated steel wires for stranded conductors*

IEC 60889, *Hard-drawn aluminium wire for overhead line conductors*

IEC 61089:1991, *Round wire concentric lay overhead electrical stranded conductors*

IEC 61232, *Aluminium-clad steel wires for electrical purposes*

IEC 61394, *Overhead lines – Requirements for greases for aluminium, aluminium alloy and steel bare conductors*

IEC 61395, *Overhead electrical conductors – Creep test procedures for stranded conductors*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the terms, definitions, symbols and abbreviated terms given in IEC 60794-1-1 apply.

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

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

4 Optical fibre

4.1 General

Single-mode optical fibre which meets the requirements of IEC 60793-2 shall be used. Fibres other than those specified above can be used, if mutually agreed between the user and the supplier.

4.2 Attenuation

4.2.1 Attenuation coefficient

The typical maximum cable attenuation coefficient shall conform to IEC 60794-1-1.

Particular values may be agreed between the customer and supplier. The attenuation coefficient shall be measured in accordance with IEC 60793-1-40.

4.2.2 Attenuation uniformity-attenuation discontinuities

Point discontinuities shall be measured in accordance with IEC 60793-1-40, method C, and conform to IEC 60794-1-1.

4.3 Cut-off wavelength of cabled fibre

For single mode fibre, the cabled fibre cut-off wavelength, λ_{cc}, shall be less than the operational wavelength, when measured in accordance with IEC 60793-1-44, and conform to IEC 60794-1-1.

4.4 Fibre colouring

If the primary coated fibres are coloured for identification, the coloured coating shall be readily identifiable throughout the lifetime of the cable and shall be a reasonable match to IEC 60304.

4.5 Polarization mode dispersion (PMD)

Cabled single-mode fibre PMD shall be measured in accordance with IEC 60793-1-48 and conform to IEC 60794-1-1.

5 Cable element

5.1 General

Generally, optical cables comprise several elements or individual constituents, depending on the cable design, which take into account the cable application, operating environment and manufacturing processes, as well as the need to protect the fibre during handling and cabling.

The material(s) used for a cable element shall be selected to be compatible with the other elements in contact with it. An appropriate compatibility test method shall be defined in the family or detail specification.

When the fibres are in contact with a filling compound, the compatibility of the filling compound with the fibre coating shall be demonstrated by testing coating stripping force stability after accelerated ageing in accordance with IEC 60794-1-21, method E5. Alternative ageing conditions and tests may be agreed between the customer and supplier.

Optical elements are cable elements containing optical fibres and are designed to be a primary functional unit of the cable core. They may comprise any of the cable elements described below. Optical elements and each fibre within a cable element shall be uniquely identified, for example, by colours, a positional scheme, markings, tapes, threads or specified in the detail specification.

Tests may be performed on cable elements either in uncabled form or in finished cable. Unless otherwise specified, testing shall be performed on cable elements in a finished cable. This means that testing shall be performed only on a finished cable if the cable element manufacturing operation is done by the same manufacturer as the cabling operation. Testing shall be performed on cable elements only if the cable element is supplied by a third party; this does not exclude testing of the finished cable.

Different types of optical elements are described below.

5.2 Slotted core

The slotted core is obtained by extruding a suitable material (for example polyethylene or polypropylene) with a defined number of slots, providing helical or SZ configuration along the core. One or more primary coated fibres or optical element is located in each slot which may be filled.

The slotted core usually contains a central element which may be either metallic or non-metallic. In this case, there shall be adequate adhesion between the central element and the extruded core in order to obtain the required temperature stability and tensile behaviour for the slotted core element.

The profile of the slot shall be uniform and shall ensure the optical and mechanical performance required for the optical cable.

5.3 Polymeric tube

One or more primary coated fibres or optical elements are packaged (loosely or not) in a tube construction which shall be filled, use dry-blocking methods or be otherwise water blocked. The plastic tube may be reinforced with a composite wall.

If required, the suitability of the tube shall be determined by an evaluation of its kink resistance in accordance with IEC 60794-1-23, method G7.

If used, the filling compound in the tube shall comply with the evaporation test in accordance with IEC 60794-1-21, method E15. The filled tube shall comply with drip test in accordance with IEC 60794-1-22, method F16, when tested in tube or cabled form.

NOTE Method E15 of IEC 60794-1-21 will be transferred in IEC 60794-1-23:—[1] as method G9.

[1] This second edition is under preparation. Stage at the time of publication: IEC/NFDIS 60794-1-23:2018.

5.4 Ribbon

Optical fibre ribbons are assembled optical fibres; they shall be in accordance with IEC 60794-3.

NOTE The technical content of IEC 60794-3 regarding optical fibre ribbons will be moved to IEC 60794-1-31:—[2]. Users are directed to that document when it is issued.

5.5 Metallic tube

5.5.1 General

Constructions having fibres within a hermetically sealed tube shall consider the possibility of evolution of hydrogen gas. See 9.9 for guidance.

5.5.2 Metallic tube on the optical core

A metallic tube (for example, aluminium tube) may be applied over the optical core (for example, aluminium spacer or stranded tube).

5.5.3 Fibres directly located in a metallic tube

One or more primary coated and coloured fibres are packaged in a metallic hermetically sealed tube, which shall be filled with a suitable compound if necessary to avoid water penetration.

The inside surface of the tube should be smooth without any defects.

6 Optical fibre cable construction

6.1 General

The intent is that the cable be designed and manufactured for a predicted operating lifetime of at least 20 years. In this context, the attenuation of the installed cable at the operational wavelength(s) shall not exceed values agreed between the customer and supplier. The tests of this document are intended to assess the performance of cables as manufactured and under agreed ageing and performance-limit tests. These tests are not intended to define end-of-life performance, but may be used as agreed between manufacturer and customer to predict such performance. The materials in the cable shall not present a health hazard within its intended use.

The fibres in the cables are usually of the same type, but some cables may contain multiple specified fibre types, and fibres of the same type may have different origins.

There shall be no fibre splice in a delivery length, unless otherwise agreed by the customer and supplier.

It shall be possible to identify each individual fibre throughout the length of the cable.

If mutually agreed between purchaser and manufacturer to avoid excess fibre strain induced by the environmental conditions, such as wind or ice loading, the cable construction and particularly the strength members shall be selected to avoid any long-term detrimental effects on fibres up to the specified MAT.

2 Under preparation. Stage at the time of publication: IEC/APUB 60794-1-31:2018.

The optical fibre unit shall house the optical fibres and protect them from damage due to environmental or mechanical forces such as longitudinal compression, crushing, bending, twisting, tensile stress, long- and short-term heat effects.

The aerial cable types covered by this document can be divided into the following groups:

a) optical ground wire or optical phase conductor (OPGW or OPPC);
b) all-dielectric self-supporting cable (ADSS);
c) optical attached cables (OPAC);
d) metallic aerial self-supported cables (MASS).

These aerial cables have different constructions, environmental and electrical operating conditions for use on high-voltage lines.

6.2 Lay-up of the cable elements

Optical unit elements as described in Clause 5 may be laid up as follows:

a) optical element(s) without a stranding lay, such as a single optical unit in the cable centre;
b) a number of homogeneous optical elements using helical or SZ stranding configurations (ribbon elements may be laid up by stacking two or more elements);
c) a number of different configurations in slotted core such as ribbon or plastic tube;
d) for OPGW, if required, insulated copper conductors in single, pair or quad construction may be laid up with the optical elements.

6.3 Cable core filling

If specified, the element(s) and in addition the cable core shall contain water blocking material, such as grease-like and/or dry-block materials, to prevent longitudinal water penetration in accordance with IEC 60794-1-22, method F5. The material shall be easily removed without the use of substances considered to be hazardous or dangerous. The grease-like compound shall comply with IEC 60794-1-21, method E15. The cable shall pass the compound flow test of IEC 60794-1-21, method E14.

The blocking material used shall be compatible with the other relevant cable elements. Where a grease-like filling compound is used in cables containing metallic elements, it shall be tested for the presence of corrosive compounds in accordance with IEC 60811-604:2012, Clause 4.

6.4 Strength members

6.4.1 General

The type of materials used as strength members shall fulfil the mechanical and thermal requirements of the overhead lines.

6.4.2 OPGW, OPPC and MASS

The stranded wires used for armouring may be round according to IEC 61089 or other cross-sectional shapes, i.e. trapezoidal or z-form and can be of the following materials:

– aluminium alloy IEC 60104;
– galvanized steel IEC 60888;
– aluminium IEC 60889;
– aluminium-clad steel IEC 61232.

These standards give requirements on wire before stranding.

Unless other requirements are mutually agreed between the purchaser and the manufacturer, after stranding, the wires shall meet the requirements of IEC 61089.

Materials other than those specified can be used if mutually agreed between the purchaser and the manufacturer.

In order to reduce the risk of corrosion, it can be necessary for the armouring to be greased (see 9.13).

6.4.3 ADSS and OPAC

The strength member elements shall consist of aramid yarns, glass-reinforced materials or equivalent dielectric strength members.

6.5 Cable sheath (ADSS and OPAC)

6.5.1 Inner sheath

A cable inner sheath may be applied by agreement between the purchaser and the supplier. When required for a specific construction, or for manufacturing purposes, cable cores or sub-units within the core, or both, may be covered by inner sheaths. Unless otherwise specified, the inner sheath shall be made of polyethylene.

6.5.2 Outer sheath

6.5.2.1 General requirements

ADSS and OPAC cables shall have a seamless sheath made of UV-stabilized weather resistant polyethylene, containing 2,0 % minimum well-dispersed carbon black in accordance with IEC 60811-607, unless otherwise agreed between the customer and supplier. Under certain conditions, it shall be necessary to consider the use of a tracking-resistant sheath.

The sheath thickness (tested in accordance with IEC 60811-202) and cable overall diameter (tested in accordance with IEC 60811-203) and its variations shall take into account the installation conditions and shall be determined by the relevant specification or by agreement between the customer and supplier.

6.5.2.2 Tensile strength and elongation

When tested in accordance with IEC 60811-501, the measured values of tensile strength shall be not less than:

a) 10 MPa for low- or linear low-density polyethylene;

b) 12,0 MPa for medium-density polyethylene;

c) 16,5 MPa for high-density polyethylene.

The measured values of elongation at break shall be not less than 300 %.

6.5.2.3 Elongation at break after ageing

The mechanical characteristics of the sheath shall remain sufficiently constant during normal use. This is checked by determining the elongation at break according to IEC 60811-501 after an ageing test at 100 °C ± 2 °C for 10 × 24 h according to IEC 60811-401. The median of the values of elongation at break shall be not less than 300 %.

6.5.2.4 Resistance to environmental stress cracking

The resistance to environmental stress cracking shall comply with the requirements of IEC 60811-406. Method B of IEC 60811-406 shall be applied.

6.6 Sheath marking

If required for non-metallic aerial cable, the sheath shall be marked by a method agreed between the customer and supplier. Common methods of marking are embossing, sintering, imprinting, hot foil and surface printing.

The information given in the marking text may include cable length, the number of fibres, fibre type, manufacturer's name and the date of manufacture.

The characters shall be spaced at intervals of not more than 1 m. The actual length of the cable shall be within +1 %, –0 % of the length indicated by the length marking. For example, 1 000 m of cable, if the starting sheath length mark was 0, should have a final sheath mark in the range 990 m to 1 000 m. Occasional illegible markings are permitted, provided that a legible mark is located within 5 m of the illegible mark. Cables may be remarked in a second contrasting colour, if the first marking process is unsuccessful.

Marking may be provided as a single or double line of marking. A single line of marking shall be provided by marking longitudinally along the length of the cable. A double line of marking shall be provided with the two lines diametrically opposite each other, longitudinally along the length of the cable.

The abrasion resistance of the sheath markings shall be demonstrated in accordance with IEC 60794-1-21, method E2B.

For a double line of marking, the abrasion resistance test only needs be carried out on one line of marking.

If there is a risk due to high-voltage tracking effects, then sheath marking may be omitted.

7 Characterization of cable elements

The tests in Table 1 are intended to characterize the different types of cable elements.

Table 1 – Characteristics of different types of cable elements

Characteristics	Family requirements	Test methods	Remarks
Dimensions	5.0	IEC 60793-1-21	Secondary coating
Dimensions	6.1, 6.2, 6.4, 6.6	IEC 60811-202 and IEC 60811-203	Loose tube, slotted core and ruggedized elements
Dimensions	6.3	IEC 60794-1-23 Methods G2, G3	Ribbons
Bend	5.0, 6.2	IEC 60794-1-23 Method G1	Secondary coating, loose tube
Kink	6.4	IEC 60794-1-23 Method G7	Tube
Strippability	5.0	IEC 60793-1-32	Fibre coatings
Compound flow	6.4	IEC 60794-1-22 Method F16	Tube

8 Design characteristics

Table 2 is a summary of important OCEPL characteristics which may be of relevance to both the purchaser and the manufacturer. Other characteristics may be mutually agreed upon by both purchaser and manufacturer.

Table 2 – Design characteristics

Design characteristics		OPGW	OPPC	MASS	ADSS	OPAC
Number and type of fibres		X	X	X	X	X
Detailed description of the cable design		X	X	X	X	X
Overall diameter	(mm)	X	X	X	X	X
Calculated cross-sectional area concerning calculation of rated tensile strength (RTS)	(mm^2)	X	X	X	–	–
Calculated mass	(kg/km)	X	X	X	X	X
RTS	(kN)	X	X	X	–	–
Modulus of elasticity	(N/mm^2)	X	X	X	X	X
Coefficient of thermal expansion	(K^{-1})	X	X	X	X	X
DC resistance	(Ω/km)	X	X	–	–	–
Fault-current capacity I^2t	($kA^2 \times s$)	X	X	–	–	[a]
MAT – Maximum allowable tension	(kN)	X	X	X	X	X
Allowable temperature range for storage, installation and operation	(°C)	X	X	X	X	X
Strain margin (according to IEC 60794-1-2)	(%)	X	X	X	X	X
Lay direction of outer layer		X	X	X	–	–
Tracking resistant sheath (if applicable)		–	–	–	X	X

[a] Maximum operating current of the cable under short-circuit shall be specified by the manufacturer.

9 Optical fibre cable tests

9.1 General

Compliance with specification requirements shall be verified by carrying out tests as required by the relevant family or detail specification. Suitable tests are detailed in Table 3. It is not intended that all tests shall be carried out: the frequency of testing shall be agreed between the customer and supplier.

Guidance on qualification sampling and interpretation of test results are given in IEC 60794-1-1. The number of fibres tested shall be representative of the cable design and shall be agreed between the customer and supplier.

The parameters specified in this document may be affected by measurement uncertainty arising either from measurement errors or calibration errors due to the lack of suitable standards. Acceptance criteria shall be interpreted with respect to this consideration. The total uncertainty of measurement for this document shall be less than, or equal to, 0,05 dB for attenuation.

The expression of no change in attenuation means that any change in measurement value, either positive or negative, within the uncertainty of measurement shall be ignored.

The number of fibres tested shall be representative of the cable design and shall be agreed between the purchaser and the manufacturer.

The tests applicable for aerial cables are listed below. The minimum acceptance criteria for the different types of cables are given in the relevant family specifications.

Table 3 – Mechanical and environmental applicable tests

Characteristics	Family requirements	Test methods	Remarks
Tensile performance	9.2	IEC 60794-1-21 Method E1	
Sheave test	9.4	IEC 60794-1-21 Method E18B	OPGW, OPPC, MASS and ADSS
Crush	Family specification	IEC 60794-1-21 Method E3	
Impact	Family specification	IEC 60794-1-21 Method E4	
Short-circuit	9.5	IEC 69794-1-24 Method H1	OPGW, OPPC, OPAC
Lightning	9.6	IEC 60794-1-24 Method H2	OPGW, OPPC
Fitting compatibility	9.12 and family specification		OPGW, ADSS, OPPC
Tracking and erosion	9.15	IEC 60794-4-20:2012 Annex B	ADSS, OPAC
Repeated bending	Family specification	IEC 60794-1-21 Method E6	
Torsion	Family specification	IEC 60794-1-21 Method E7	
Bend	Family specification	IEC 60794-1-21 Method E11	
Shotgun resistance	9.17	IEC 60794-1-21 Method E13	Aerial cables specified for shotgun protection
Aeolian vibration	9.10	IEC 60794-1-21 Method E19	OPGW, OPPC, ADSS, MASS
Low frequency vibration (galloping)	Family specification	IEC 60794-1-21 Method E26	OPGW, OPPC, ADSS, MASS
Creep	Family specification	IEC 61395	OPGW, OPPC, MASS
Stress-strain test on metallic cables	Family specification	IEC 61089	OPGW, OPPC, MASS
Temperature cycling	Family specification	IEC 60794-1-22 Method F1	
Water penetration	Family specification	IEC 60794-1-22 Method F5B or F5C	
Sheath abrasion resistance	Family specification	IEC 60794-1-21 Method E2A	ADSS, OPAC
Ageing	9.7	IEC 60794-1-22 Method F9	
Ribbon stripping	Family specification	IEC 60794-1-21 Method E5B	Ribbon cables

9.2 Tensile performance

The cable shall be tested in accordance with IEC 60794-1-21, method E1. Under this test, the cables shall meet the specified MAT value.

If required by the product specification, the cable shall be terminated with end fittings relevant to the type of cable considered.

OPAC cables should undergo an additional tensile test having been attached to a messenger cable at the defined installation tension, which is agreed between the user and the manufacturer. This test is to ensure that lengthening and retraction of the messenger wire in service will not cause the OPAC to festoon.

9.3 Stress-strain test on metallic cables

Stress-strain tests shall be performed to determine the behaviour of the cable under load conditions and shall be in accordance with IEC 61089:1991, Annex B. Sample length shall be in accordance with IEC 61089 (other sample lengths may be used if mutually agreed between the user and the manufacturer).

End fittings such as the helically preformed fittings, cone type, compression, epoxy type, bolted or solder type relevant to the cable type considered shall be used. During the test, there shall be no visual damage to the cable strands. All stress and strain values obtained during the test and agreed upon by the manufacturer and the purchaser shall be recorded.

If required, the test of tensile performance may be carried out simultaneously with this test.

The Young's modulus should be calculated during the second cycle.

When the test for the breaking strength of the OPGW is required, the OPGW shall withstand without fracture of any wire, not less than 95 % of its RTS.

9.4 Sheave test

The sheave test shall be performed to verify that the installation of the OPGW, OPPC, MASS and ADSS will not damage or degrade their performance. The cable shall be tested in accordance with IEC 60794-1-21, method E18B.

9.5 Short-circuit

The short-circuit test shall assess the performance of the OPGW, OPPC or OPAC cable and the optical characteristics of the fibres under typical short-circuit and has to be tested in accordance with the method specified in IEC 60794-1-24, method H1.

When agreed between the purchaser and manufacturer, the test procedure may be replaced by an adequate theoretical calculation method.

9.6 Lightning test

The cable construction shall be tested in accordance with IEC 60794-1-24, method H2.

9.7 Ageing

The resistance of the cable to ageing shall be tested in accordance with IEC 60794-1-22, method F9.

9.8 Fibre coating compatibility

When the fibres are in contact with a filling compound, the compatibility of the filling compound with the fibre coating shall be demonstrated by testing, after accelerated ageing, either the cabled fibre or the fibre in filling compound for

a) stripping force stability in accordance with IEC 60794-1-21, method E13B,
b) stability of the colour of the coating for fibre identification (test method is under consideration),

and, if required, for

c) dimensional stability, and
d) coating transmissivity.

Test methods are under consideration.

9.9 Hydrogen gas

An informative guideline is given in IEC TR 62690.

9.10 Aeolian vibration

The resistance of the cable to aeolian vibration shall be tested in accordance with IEC 60794-1-21, method E19.

9.11 Creep

If requested, this test is carried out for OPGW, OPPC, MASS cables according to IEC 61395.

IEC 60794-4-20 indicates adequate evaluation methods for ADSS.

9.12 Fitting compatibility

The type of fittings shall be approved between the purchaser and the manufacturer, and their compatibility has to be checked according to the purchaser's or the manufacturer's fitting specification.

9.13 Grease

In order to reduce the risk of corrosion, it can be necessary for the strands of OPGW, OPPC and MASS to be coated with grease. The type of grease to be applied shall be in accordance with IEC 61394 or shall be defined between the manufacturer and the purchaser.

9.14 Attenuation

The attenuation coefficient shall conform to IEC 60794-1-1. It shall be measured in accordance with IEC 60793-1-40.

9.15 Tracking and erosion resistance test on ADSS and OPAC

Family specification for ADSS, IEC 60794-4-20, provides guidance for tracking consideration.

9.16 UV resistance test on ADSS and OPAC

The outer sheath shall be made of UV-stabilized weather-resistant material in accordance with IEC 60794-1-22, method F14.

9.17 Shotgun resistance test on ADSS and OPAC

If required, this test will be performed according to IEC 60794-1-21, method E13B.

9.18 Conductor access trolley for OPAC

Under consideration.

10 Quality assurance

The supplier shall establish, introduce and maintain a quality management system in accordance with ISO 9001 or equivalent.

11 Packaging

According to IEC 61089, if applicable, and to the following additional requirements,

a) packaging of the cable shall allow access to one or both ends of the cable in order to perform quality checks,

b) ends of the cable shall be sealed by a suitable method in order to prevent moisture ingress, and

c) delivery lengths and tolerance shall be determined in accordance with agreement between the purchaser and the manufacturer.

Annex A
(normative)

Recommended methods of calculating rated tensile strength, cross-section of a layer of trapezoidal shaped wires, modulus of elasticity, linear expansion and DC resistance for OPGW, OPPC and MASS

A.1 Calculation of rated tensile strength (RTS)

This calculation should be based on the tensile strength of the armouring and optical unit materials (where applicable) before stranding.

If the OPGW is of type Ax, Ax/Syz or Ax/Ax, the RTS shall be calculated in accordance with IEC 61089. In cases where the load-bearing elements are homogenous steel or aluminium-clad steel, the RTS is 90 % of the summation of the tensile strength of the individual wires.

A.2 Calculation of the cross-sectional area of a layer of trapezoidal or Z-shaped wires

The value should be calculated from the formula:

$$A = (D_o^2 - D_i^2)\,(\pi/4)\,f$$

where

A is the total cross-sectional area of the shaped wire (mm^2);

D_o is the outer diameter of the shaped layer (mm)

D_i is the inner diameter of the shaped layer (mm);

f is the space factor.

Typical values:

– aluminium-clad steel/zinc-coated steel wires, f = 0,90;

– aluminium, aluminium alloy wires, f = 0,92.

A.3 Calculation of the final modulus of elasticity (E)

The value should be calculated from the following formula:

$$E = \frac{\Sigma(E_n A_n)}{\Sigma A_n}$$

where

E_n is the value of the modulus for each material (N/mm^2);

A_n is the cross-sectional area for the corresponding material (mm^2).

This formula gives a constant modulus corresponding to a linear stress-strain graph and forms a straight line. This is an approximation of the real modulus of elasticity as achieved from the test given in 9.3.

A.4 Calculation of coefficient of linear expansion (β)

The value should be calculated from the following formula:

$$\beta = \frac{\Sigma(\beta_n . E_n . A_n)}{\sum(E_n . A_n)}$$

where

E_n is the value of the modulus for each material (N/mm^2);

A_n is the cross-sectional area for the corresponding material (mm^2);

β_n is the value of the coefficient of linear expansion for each material (K^{-1}).

A.5 Calculation of DC resistance

The value should be calculated from the following formula:

$$R = \frac{1}{\sum_n \frac{1}{R_n}}$$

where

R is the linear DC resistance of the completed OPGW (Ω/km);

R_n is the linear DC resistance of each material (Ω/km);

with

$$R_n = \frac{P}{\sum_i \frac{A_i}{F_i}}$$

where

P is the resistivity of material (Ω × mm^2/km);

A_i is the area of a given material in the ith layer (mm^2);

F_i is the lay ratio of the ith layer.

NOTE F_i = 1 when the optical element is the central carrier of the OPGW.

Bibliography

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

IEC 60794-1-23:—, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures - Cable element test methods*[3]

IEC 60794-1-31:—, *Optical fibre cables – Part 1-31: Generic specification – Basic optical cable test procedures – Optical fibre ribbon*[4]

IEC TR 62690, *Hydrogen effects in optical fibre cables – Guidelines*

IEC TR 62839-1, *Environmental declaration – Part 1: Wires, cables and accessory products – Specific rules*

3 This second edition is under preparation. Stage at the time of publication: IEC/NFDIS 60794-1-23:2018.

4 Under preparation. Stage at the time of publication: IEC/APUB 60794-1-31:2018.

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

_____

CÂBLES À FIBRES OPTIQUES –

Partie 4: Spécification intermédiaire – Câbles optiques aériens le long des lignes électriques de transport d'énergie

AVANT-PROPOS

1) La Commission Electrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. A cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de l'IEC peuvent faire l'objet de droits de brevet. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

La Norme internationale IEC 60794-4 a été établie par le sous-comité 86A: Fibres et câbles, du comité d'études 86 de l'IEC: Fibres optiques.

Cette deuxième édition annule et remplace la première édition parue en 2003 dont elle constitue une révision technique.

La présente édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) la spécification a été simplifiée par des références croisées avec l'IEC 60794-1-1;
b) la classification en essais de type ou en essais individuels de série a été supprimée;
c) l'essai de pliure des câbles a été supprimé;

d) l'essai de fluage pour les câbles autoporteurs entièrement diélectriques fait référence à l'IEC 60794-4-20.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
86A/1862/FDIS	86A/1868/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60794, publiées sous le titre général *Câbles à fibres optiques*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

CÂBLES À FIBRES OPTIQUES –

Partie 4: Spécification intermédiaire – Câbles optiques aériens le long des lignes électriques de transport d'énergie

1 Domaine d'application

La présente partie de l'IEC 60794 couvre les exigences relatives à la construction de câbles, aux méthodes d'essai et aux performances optiques, mécaniques environnementales et électriques pour des câbles et des éléments de câbles optiques aériens destinés à être utilisés le long des lignes électriques de transport d'énergie (OCEPL: *optical cable to be used along electrical power lines*) comme support de transport à très large bande pour les signaux optiques de communication et de commande, comprenant les câbles de garde à fibres optiques (OPGW: *optical ground wire*), les conducteurs de phase à fibres optiques (OPPC: *optical phase conductor*), les câbles aériens métalliques autoporteurs (MASS: *metallic aerial self-supported cable*), les câbles autoporteurs entièrement diélectriques (ADSS: *all-dielectric self-supporting cable*) et les câbles optiques attachés (OPAC: *optical attached cable*).

Le présent document exclut les câbles optiques en forme de "8" utilisés sur les poteaux téléphoniques.

L'IEC TR 62839-1 donne des recommandations pour fournir une déclaration environnementale au client à sa demande.

2 Références normatives

Les documents ci-après, dans leur intégralité ou non, sont des références normatives indispensables à l'application du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60104, *Fils en alliage d'aluminium-magnésium-silicium pour conducteurs de lignes aériennes*

IEC 60304, *Couleurs de référence de l'enveloppe isolante pour câbles et fils pour basses fréquences*

IEC 60793-1-21, *Fibres optiques – Partie 1-21: Méthodes de mesure et procédures d'essai – Géométrie du revêtement*

IEC 60793-1-32, *Fibres optiques – Partie 1-32: Mesures de mesure et procédures d'essai – Dénudabilité du revêtement*

IEC 60793-1-40, *Fibres optiques – Partie 1-40: Méthodes de mesure et procédures d'essai – Affaiblissement*

IEC 60793-1-44, *Fibres optiques – Partie 1-44: Méthodes de mesure et procédures d'essai – Longueur d'onde de coupure*

IEC 60793-1-48, *Fibres optiques – Partie 1-48: Méthodes de mesure et procédures d'essai – Dispersion de mode de polarisation*

IEC 60793-2, *Fibres optiques – Partie 2: Spécifications de produits – Généralités*

IEC 60794-1-1, *Câbles à fibres optiques – Partie 1-1: Spécification générique – Généralités*

IEC 60794-1-21, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods* (disponible en anglais seulement)

IEC 60794-1-22, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental tests methods* (disponible en anglais seulement)

IEC 60794-1-23, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures – Cable element test methods* (disponible en anglais seulement)

IEC 60794-1-24, *Câbles à fibres optiques – Partie 1-24: Spécification générique – Méthodes fondamentales d'essais applicables aux câbles optiques – Méthodes d'essais électriques*

IEC 60794-3, *Câbles à fibres optiques – Partie 3: Câbles extérieurs – Spécification intermédiaire*

IEC 60794-4-20:2012, *Optical fibre cables – Part 4-20: Aerial optical cables along power lines – Family specification for ADSS (All Dielectric Self Supported) optical cables* (disponible en anglais seulement)

IEC 60811-202, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non métalliques – Partie 202: Essais généraux – Mesure de l'épaisseur des gaines non métalliques*

IEC 60811-203, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non métalliques – Partie 203: Essais généraux – Mesure des dimensions extérieures*

IEC 60811-401, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non métalliques – Partie 401: Essais divers – Méthodes de vieillissement thermique – Vieillissement en étuve à air*

IEC 60811-406, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non métalliques – Partie 406: Essais divers – Résistance des mélanges polyéthylène et polypropylène aux craquelures*

IEC 60811-501, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non métalliques – Partie 501: Essais mécaniques – Détermination des propriétés mécaniques des mélanges pour les enveloppes isolantes et les gaines*

IEC 60811-604:2012, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non métalliques – Partie 604: Essais physiques – Mesure de l'absence de composants corrosifs dans les matières de remplissage*

IEC 60811-607, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non métalliques – Partie 607: Essais physiques – Essai pour l'évaluation de la dispersion du noir de carbone dans le polyéthylène et le polypropylène*

IEC 60888, *Fils en acier zingué pour conducteurs câblés*

IEC 60889, *Fil d'aluminium écroui dur pour conducteurs de lignes aériennes*

IEC 61089:1991, *Conducteurs pour lignes aériennes à brins circulaires, câblés en couches concentriques*

IEC 61232, *Fils d'acier revêtus d'aluminium pour usages électriques*

IEC 61394, *Overhead lines – Requirements for greases for aluminium, aluminium alloy and steel bare conductors* (disponible en anglais seulement)

IEC 61395, *Conducteurs pour lignes électriques aériennes – Procédures d'essai de fluage pour conducteurs câblés*

3 Termes, définitions, symboles et termes abrégés

Pour les besoins du présent document, les termes, définitions, symboles et termes abrégés de l'IEC 60794-1-1 s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

4 Fibres optiques

4.1 Généralités

Une fibre optique unimodale conforme aux exigences de l'IEC 60793-2 doit être utilisée. Des fibres autres que celles spécifiées ci-dessus peuvent être utilisées sous réserve d'un accord entre l'utilisateur et le fournisseur.

4.2 Affaiblissement

4.2.1 Affaiblissement linéique

L'affaiblissement linéique maximal typique d'un câble doit être conforme à l'IEC 60794-1-1.

Des valeurs particulières peuvent faire l'objet d'un accord entre le client et le fournisseur. L'affaiblissement linéique doit être mesuré conformément à l'IEC 60793-1-40.

4.2.2 Uniformité de l'affaiblissement-discontinuité de l'affaiblissement

Les discontinuités doivent être mesurées conformément à la méthode C de l'IEC 60793-1-40 et être conformes à l'IEC 60794-1-1.

4.3 Longueur d'onde de coupure de fibre câblée

Pour les fibres unimodales, la longueur d'onde de coupure d'une fibre câblée, λ_{cc}, doit être inférieure à la longueur d'onde de fonctionnement lorsqu'elle est mesurée conformément à l'IEC 60793-1-44 et être conforme à l'IEC 60794-1-1.

4.4 Couleurs des fibres

Si le revêtement primaire des fibres est coloré à des fins d'identification, le revêtement coloré doit être facilement identifiable tout au long de la durée de vie du câble et doit correspondre, dans la mesure du possible, à l'IEC 60304.

4.5 Dispersion de mode de polarisation

La dispersion de mode de polarisation de fibres optiques unimodales câblées doit être mesurée conformément à l'IEC 60793-1-48 et être conforme à l'IEC 60794-1-1.

5 Elément de câble

5.1 Généralités

Généralement, les câbles optiques comportent plusieurs éléments ou constituants individuels, selon la conception du câble, élaborée en fonction de l'application, de l'environnement opérationnel, des procédés de fabrication et du besoin de protéger la fibre au cours des manipulations et pendant le câblage.

Les matériaux entrant dans la composition d'un élément de câble doivent être choisis de manière à être compatibles avec les autres éléments en contact avec eux. Une méthode d'essai de compatibilité appropriée doit être définie dans la spécification de famille ou particulière.

Lorsque les fibres sont en contact avec un matériau de remplissage, la compatibilité du matériau de remplissage avec le revêtement de la fibre doit être démontrée en effectuant un essai de stabilité de la force de dénudage du revêtement, après un vieillissement accéléré conformément à la méthode E5 de l'IEC 60794-1-21. D'autres essais et conditions de vieillissement peuvent faire l'objet d'un accord entre le client et le fournisseur.

Les éléments optiques sont des éléments de câble comportant des fibres optiques et sont conçus pour être une unité fonctionnelle primaire du cœur du câble. Ils peuvent comprendre n'importe lesquels des éléments de câble décrits ci-dessous. Les éléments optiques, ainsi que chaque fibre, contenus dans un élément de câble doivent être identifiés de manière unique, par exemple par des couleurs, par un schéma de positionnement, par des marquages, par des rubans, par des fils ou selon les indications données dans la spécification particulière.

Les essais peuvent être effectués sur des éléments de câble soit sous la forme du câble non terminé soit sous la forme du câble terminé. Sauf spécification contraire, les essais doivent être effectués sur des éléments de câble inclus dans un câble terminé. Ceci signifie que les essais doivent être effectués uniquement sur le câble terminé, lorsque le même fabricant réalise les éléments de câble et l'assemblage de ceux-ci, pour constituer le câble définitif. Les essais ne doivent être effectués sur des éléments de câble, que si ces derniers sont fournis par une tierce partie; ils n'excluent pas les essais sur le câble terminé.

Différents types d'éléments optiques sont décrits ci-dessous.

5.2 Jonc rainuré

Le jonc rainuré s'obtient en extrudant un matériau adapté (par exemple du polyéthylène ou du polypropylène) avec un certain nombre d'encoches longitudinales, présentant la forme d'une hélice ou d'un SZ. Chaque encoche peut être remplie d'une ou plusieurs fibres sous revêtement primaire ou éléments optiques.

Le jonc rainuré comporte habituellement un élément central qui peut être métallique ou non métallique. Dans ce cas, il doit y avoir une adhérence adaptée entre l'élément central et le jonc extrudé, afin d'obtenir la stabilité en température et le comportement à la traction exigés pour l'élément à jonc rainuré.

Le profil de l'encoche doit être uniforme et doit garantir les performances optiques et mécaniques exigées pour le câble optique.

5.3 Tube polymère

Une ou plusieurs fibres sous revêtement primaire ou éléments optiques sont conditionnés (de manière lâche ou non) dans un tube, qui doit être rempli, en utilisant des méthodes d'étanchéité à sec, ou rendu étanche à l'eau d'une autre manière. Le tube plastique peut être renforcé par une paroi composite.