IEC 60794-4-10

Edition 2.0 2014-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Optical fibre cables –
Part 4-10: Family specification – Optical ground wires (OPGW) along electrical power lines

Câbles à fibres optiques –
Partie 4-10: Spécification de famille – Câbles de garde à fibres optiques le long des lignes électriques de puissance

IEC 60794-4-10:2014-10(en-fr)

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OPTICAL FIBRE CABLES –

Part 4-10: Family specification – Optical ground wires (OPGW) along electrical power lines

FOREWORD

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International Standard IEC 60794-4-10 has been prepared by subcommittee 86A: Fibres and Cables, of IEC technical committee 86. Fibre optics

This bilingual version (2019-05) corresponds to the monolingual English version, published in 2014-10.

This second edition cancels and replaces the first edition published in 2006 and constitutes a technical revision.

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

a) galloping test (9.7) has been added to the type tests list;
b) update of definitions clause; maximum installation tension (MIT) defined and used in the sheave test description;

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c) definition of characterization of OPGW's mechanical behaviour in order to provide information useful for electrical power transmission lines designers;

d) improved definition of lightning test parameters and conditions to improve reproducibility among different laboratories.

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

CDV	Report on voting
86A/1594/CDV	86A/1627/RVC

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

The French version of this standard has not been voted upon.

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

- reconfirmed,
- withdrawn,
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OPTICAL FIBRE CABLES –

Part 4-10: Family specification – Optical ground wires (OPGW) along electrical power lines

1 Scope

This part of IEC 60794-4, which is a family specification, covers cable construction, test methods and optical, mechanical, environmental and electrical performance requirements for OPGW (optical ground wire) which is used for the protection of electrical power lines against atmospheric discharges or short-circuits and, at the same time, as a high bandwidth transport media for communications-and-control optical signals. The corresponding environmental declaration may be built according to IEC TR 62839-1.

The OPGW is a substitute for a conventional ground-/shield-wire containing optical fibres for control and/or telecommunication purposes. Usually the fibres are embedded loosely in protective buffer tubes. To fulfil mechanical and electrical requirements; an armouring of one or more layers with aluminium, aluminium alloy, and aluminium clad steel, galvanized steel or a mixture of them is helically stranded. If the construction contains an aluminium tube or an aluminium slotted core, this cross section is considered as a conductive part.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

IEC 60793 (all parts), *Optical fibres*

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 – Polarizationn mode dispersion*

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

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

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

IEC 60794-1-22:2012, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures –Environmental test methods*

IEC 60794-1-24:2014, *Optical fibre cables – Part 1-24: Generic specification – Basic optical cable test procedures – Electrical testmethods*

IEC 60794-4:2003, *Optical fibre cables – Part 4: Sectional specification – Aerial optical cables along electrical power lines*

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

IEC 60889, *Hard-drawn aluminium wire for overherad 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 – Characteristics of greases for aluminium, aluminium alloy and steel bare conductors*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 Cables

3.1.1
optical ground wire
OPGW
metallic optical cable that has the dual performance functions of a conventional ground wire with telecommunication capabilities

3.2 Other definitions

3.2.1
rated tensile strength
RTS
summation of the product of nominal cross-sectional area, nominal tensile strength and stranding factor (minimum 0,9) for each load bearing material in the cable construction

Note 1 to entry: See Annex A of IEC 60794-4:2003 for details of the recommended method to calculate rated tensile strength of OPGW.

3.2.2
creep test
test designed to determine the long-term tensile creep characteristics of metallic aerial installed cables

[1] To be published.

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Note 1 to entry: The information derived from this test is used in the sag-tension calculations during the design layout of the OPGW in the electrical system.

3.2.3
fittings
hardware used for stringing and clipping of OPGW to the structures at the end of the installation procedure

Note 1 to entry: Suspension, dead end, vibration damper and bonding clamps hardware are designed for a specific size and/or type of OPGW cable.

3.2.4
optical fibre unit
cable element designed to house and to protect the optical fibres from damage due to mechanical, thermal and electrical influences and moisture penetration

Note 1 to entry: Further details are given in Clause 6.

3.2.5
maximum allowable ovality
MAOC
unit or its component that does not exceed the specified value when calculated as $(d_1 - d_2)/(d_1 + d_2)$ in %

where

d_1 is the maximum measured diameter of the cable or the component;

d_2 is the minimum diameter of the cable or the component at the same cross-section as d_1.

3.2.6
maximum allowable tension
MAT
maximum tensile load that may be applied to the cable without detriment to the tensile performance requirement

Note 1 to entry: Such performances requirements may be optical, fibre strain and mechanical.

3.2.7
maximum installation tension
MIT
maximum recommended stringing tension during installation

3.2.8
strain margin
commonly referred to as 30 % of proof test level and the basis for defining the MIT and MAT of the optical cable

Note 1 to entry: The strain margin (%) is directly related to the amount of mechanical tension, in N, a specific cable design can sustain without strain on the optical fibres due to cable elongation.

4 Optical fibre

4.1 General

Single-mode optical fibres shall be used which meet the requirements of the relevant part of IEC 60793. Fibres other than those specified above can be used, if mutually agreed between the customer and supplier.

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4.2 Attenuation

4.2.1 Attenuation coefficient

The typical maximum attenuation coefficient of the cabled fibres shall meet the requirements of the relevant part of IEC 60793.

Particular values shall be agreed between customer and supplier.

The attenuation coefficient shall be measured in accordance with IEC 60793-1-40.

4.2.2 Attenuation uniformity and attenuation discontinuities

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

Any reflective discontinuity shall be specified with the optical return loss measurement which shall be ≥55 dB.

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

4.3 Cut-off wavelength of cabled fibre

The cabled fibre cut-off wavelength λ_{CC} shall be lower than the operational wavelength when measured in accordance with IEC 60793-1-44.

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 at 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.

4.5 Polarization mode dispersion (PMD)

When mutually agreed between customer and supplier, PMD shall be measured in accordance with IEC 60793-1-48. The individual PMD and link PMD value of optical fibres shall meet the limit values indicated in the IEC 60793-2-50 specific table corresponding to the type of fibre used in the OPGW.

5 Cable element

The material(s) used for a cable element shall be selected so that they are compatible with the other elements that are in contact with it. Refer to the relevant parts of the sectional specification IEC 60794-4. The following requirements apply specifically to OPGW:

a) Optical elements (buffer tubes containing optical fibres, bundles, etc) and each fibre within a cable optical element shall be uniquely identified, for example, by colours, by a positional scheme, by markings or as agreed between customer and supplier.

b) The optical fibre unit(s) 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 caused by environmental variations or by atmospheric discharges.

c) For loose tube construction, one or more primary coated fibres or optical elements are packaged, loosely in a tube construction, with a suitable water-blocking system. Polymeric tubes may be reinforced with a composite wall as long as the cable complies with this specification.

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6 Cable construction

Refer to the relevant parts in Clause 6 of IEC 60794-4 2003. The following requirements apply specifically to OPGW cables:

a) 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 caused by environmental variations or by atmospheric discharges.

b) The stranded wires used for cable armouring may be round according to IEC 61089 or other cross-sectional shapes, i.e. trapezoidal or z-form.

c) The wire types composing the external armour can be from one or more of the following standards and their mechanical properties shall comply, before stranding, with the requirements of the specification indicated.

- aluminum alloy IEC 60104
- zinc coated steel IEC 60888
- aluminum IEC 60889
- aluminum-clad steel IEC 61232.

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

7 Cable design characteristics

Table 1 is a summary of important cable characteristics which may be of relevance to both the customer and the supplier. Other characteristics may be mutually agreed by both customer and supplier.

Table 1 – Cable design characteristics

Ref	Design characteristics	Units
1	Number and type of fibres	
2	Detailed description of the cable design	
3	Overall diameter	mm
4	Calculated cross-sectional area of wires concerning calculation of RTS	mm^2
5	Calculated mass	kg/km
6	RTS	kN
7	Modulus of elasticity	MPa
8	Coefficient of linear expansion	10^{-6} K^{-1}
9	DC resistance at 20°C	Ω/km
10	Fault current capacity	$(kA)^2$ s
11	Lightning resistance	Coulomb
12	MAT – Maximum allowable tension	kN
13	MIT – Maximum Installation tension	kN
14	Allowable temperature range for storage, installation and operation	°C
15	Strain margin of OPGW	% length
16	Maximum tension for strain margin of OPGW	N
17	Lay direction of outer layer	
18	Minimum bending radius during installation	mm
19	Minimum bending radius installed	mm

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In order to reduce the risk of corrosion the external side of wires or the whole wires themselves on the strands and the tube protecting the fibre optic element(s) of cables should be composed of the same metal or be coated with grease. If used, the necessary type and the amount of grease to be applied shall be in accordance with IEC 61394 or shall be defined between the supplier and the customer.

The type of fittings shall be approved between the customer and the supplier and their compatibility shall be checked according to the customer or the supplier fitting specification.

8 Cable tests

8.1 General

The parameters specified in this standard may be affected by measurement uncertainty arising either from measurement errors or calibration errors. Acceptance criteria shall be interpreted with respect to this consideration. For some tests specified in this standard, the objective is “no change in attenuation”. The total uncertainty of measurement for this standard shall be less than or equal to 0,05 dB for attenuation or 0,05 dB/km for attenuation coefficient.

Any measured value within this range, either positive or negative, shall be considered as “no change in attenuation”. By agreement between customer and supplier, minor deviation from this limit may be accepted at some low frequency, e.g. less than 10 % of the fibres. However, for mechanical tests no deviation in excess of 0,20 dB shall be accepted.

The optical attenuation measurements may be performed by using an optical time domain reflectometer (OTDR) or a light source and a power meter, depending on the typology of the cable test. If, for a specific test, distribution damage is envisioned for the fibres, the attenuation shall be measured in terms of dB/km, while for localized damage the attenuation shall be measured in terms of dB. Nevertheless, uncertainty measurement issues due to short fibre length shall be considered when using OTDR.

The number of fibres tested shall be representative of the cable design according to fibre sampling indicated in IEC 60794-1-1. Different sampling can be agreed between customer and supplier.

The acceptance criteria are part of the manufacturer’s quality plan and his technical description.

Specimens for the tests shall be taken from the supplier in advance to the tests.

8.2 Classification of tests

8.2.1 Type tests

A full verification of an OPGW design includes all type tests and characteristics specified in Table 1. Type tests are required to be made before supplying a type of cable covered by this standard on a general commercial basis in order to demonstrate satisfactory performance characteristics to meet the intended application and 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 do not be repeated unless significant changes are made in the cable material, design or type of manufacturing process which might change the performance characteristics.

If some tests are to be repeated, they shall be agreed between the customer and the supplier.

8.2.2 Factory acceptance tests

Factory acceptance 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.

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Scope and incidence of sample tests if required shall be agreed between the customer and the supplier.

Failure of a test specimen to comply with any one of the requirements of this standard shall constitute grounds for rejection of the lot represented by the specimen. If any lot is so rejected, the supplier shall have the right to test, only once, all individual drums of cables in the lot and submit those which meet the requirements for acceptance.

8.2.3 Routine tests

Routine tests are made on all production cable lengths to demonstrate their integrity.

Failure of a test specimen to comply with any one of the requirements of this standard shall constitute grounds for rejection of the lot represented by the specimen. If any lot is so rejected, the supplier shall have the right to test, only once, all individual drums of cables in the lot and submit those which meet the requirements for acceptance.

8.3 Type tests

8.3.1 General

For all tests under load conditions, the fibres shall be terminated at both ends prior to strain in a manner such that the optical fibre ends cannot move relative to the cable ends.

The test results shall meet the requirements as stated in the supplier's written specification and the following general optical requirement.

If optical attenuation is monitored during the test, a permanent or temporary increase in optical attenuation greater than 0,2 dB or 0,2 dB/km of test fibre, at 1550 nm nominal wavelength for single-mode fibres, shall constitute failure. Attenuation measurement procedure should be in accordance to IEC 60793-1-40. Different monitoring wavelength can be used if agreed between customer and supplier.

8.3.2 Tensile performance

The cable and fibre strain shall be evaluated in accordance with IEC 60794-1-21, with the following precisions:

The cable shall be terminated with suitable fittings relevant to the type of cable.

The tensile performance test shall be performed in order to determine the optical behaviour of the OPGW under tensile load conditions with regard to the following:

a) optical performance (optical attenuation change);

b) fibre strain;

c) strain margin;

d) minimum length of cable under tension shall be 25 m.

The optical fibre test length shall be at least 100 m for attenuation measurement and 100m for fibre strain measurement. Tension shall be steadily increased to 70 % RTS and released back to initial load. Higher values may be used if mutually agreed between customer and manufacturer.

On completion of the test the following criteria shall be considered:

a) increase in optical attenuation greater than the limit stated in 8.3.1, before reaching MAT loading shall constitute failure;

b) a strain margin less than the specified value up to MAT shall constitute failure;

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