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Edition 2.0 2014-10

INTERNATIONAL STANDARD

colour inside

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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 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;
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.

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

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OPTICAL 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*

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

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1 To be published.

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.

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.

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	

Ref	Design characteristics	Units
18	Minimum bending radius during installation	mm
19	Minimum bending radius installed	mm

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. 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;

c) any permanent increase in optical attenuation after test shall constitute failure.

8.3.3 Stress-strain test

Stress-strain tests shall be performed in order determine the behaviour of the cable under load conditions and shall be undertaken in accordance with Annex B of IEC 61089:1991. Sample length under tension shall be minimum 10 m and control length shall be in accordance with IEC 61089 (other sample control lengths may be used if mutually agreed between the customer and the supplier). The maximum load shall be 70 % of RTS or the value agreed between customer and manufacturer.

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

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

The modulus of elasticity, if required, can be calculated during the third cycle.

8.3.4 Breaking strength test

When a test for the breaking strength of the cable is required, the cable shall withstand without fracture of any wire, not less than 95 % of RTS. This value is 90 % of the summation of the nominal tensile strength of each wire. The cable shall be terminated with suitable fittings relevant to the type of cable.

This test shall be carried out without optical measurements.

8.3.5 Sheave test

The test shall be performed to verify that the installation of the OPGW will not damage or degrade their performance. The cable shall be tested in accordance with Method E18B of IEC 60794-1-21 with the following details:

– the minimum length of cable shall be 15 m; minimum length of cable bent under tension shall be 2m;

– the diameter of sheave shall be not larger than 40 times the cable diameter;

– the moving speed of cable during test shall be up to 0,6 m/s.

Subject the cable sample to a minimum of 20 moving cycles with a bending angle of 45° ±15°.

Mechanical tension on cable during the test shall be maintained at MIT or 15 % of RTS, whichever is larger. Inspect the tension level and adjust, if necessary, each 5 cycles during the test.

The total cable length shall be enough to permit optical measurements and shall be terminated with suitable fittings relevant to the OPGW cable.

The cable ends are prepared in order to allow transmitted optical power measurement in one or several fibres during the test. The minimum test length of the optical fibres shall be 100 m. If necessary, fibres shall have to be loop-spliced at the cable ends. Terminations should be positioned in such a way to assure that movement of cable during cycles doesn't affect optical

measurements. The baseline for optical attenuation measurement shall be taken before tensioning the cable.

The ovality of OPGW and the ovality of optical unit(s) shall be calculated after the test. The maximum allowable ovality (MAOC) of the cable and optical unit(s) shall be not greater than 20 %.

The change in attenuation of monitored optical fibres shall comply with the general optical requirements stated in 8.2.1.

Under visual inspection, the OPGW section subjected to sheave test shall not show cracking, bird caging, nor breaking of any element.

8.3.6 Aeolian vibration test

The resistance of the cable to aeolian vibration shall be tested in accordance with IEC 60794-1-21, Method E19 with the following precisions:

a) mechanical tension on cable during the test shall be maintained at 20 % ±5 % of its RTS value;

b) the total cable length shall be enough to permit extension of the ends and for the equipment to be attached for optical measurements;

c) the optical attenuation shall be monitored at 1 550 nm, along the whole test and attenuation of the optical link shall be registered at regular intervals;

d) suspension and dead end fittings relevant to the OPGW cable shall be used to attach the sample to the test equipment;

e) number of vibration cycles to apply shall be minimum 10 000 000;

f) any visible damage to the cable or to any of the cable elements shall be considered as a test failure;

g) the maximum allowable ovality (MAOC) of the optical unit shall be 20 % of the measured diameter of the optical unit.

The change in attenuation of monitored optical fibres shall comply with the general optical requirements stated in 8.2.1. The baseline for optical attenuation measurement shall be taken at the beginning of test and after tensioning the cable.

8.3.7 Creep

If required, this test shall be carried out on cables according to IEC 61395. The parameters of evaluation are:as follows

– OPGW shall be tensioned to 20 % RTS ±5 % RTS level and maintained within the limits specified in IEC 61395 during the test;

– temperature of evaluation: 20 °C.

Additional or different conditions of evaluation can be applied if agreed between customer and supplier. Test loads of interest for line designers could go from 10 % RTS up to 25 % RTS.

The sample shall be terminated with suitable fittings relevant to the OPGW. No optical measurements are required when performing this test. The predicted creep at one year and 10 years should be calculated using the equation fitted to the experimental 1 000 h creep results.

8.3.8 Low frequency vibration test (Galloping test)

8.3.8.1 General

Low frequency vibration shall be tested in accordance with E26 method of IEC 60794-1-21; this test applies for OPGW to be installed in areas where ice build-up and strong winds are envisaged.

8.3.8.2 Test conditions

The following test conditions apply:

a) Number of cycles: 100 000.

b) Peak to peak antinode amplitude/loop length ratio: 1/25.

c) Tension: The cable shall be tensioned to a level that permits induce galloping effect at the defined amplitude; 5 % to 10 % of MAT is considered an adequate tension level.

d) The overall span between dead-end assemblies shall be a minimum of 35 m. The end abutments are used to load and maintain tension in the OPGW. The test section is contained between the two intermediate abutments. End and intermediate abutments need not be separate units if the combined unit affords sufficient space for the apparatus specified below. The OPGW sample to be tested shall be of sufficient length beyond the intermediate abutments to allow removal of the cable outer coverings and to allow access to the optical fibres.

e) A suitable suspension assembly shall be located approximately midway between the two dead-end assemblies.

f) Means shall be provided for measuring and monitoring the mid-loop (antinode), single loop galloping amplitude. A suitable shaker shall be used to excite the cable in the vertical plane. The shaker armature shall be securely fastened to the cable in the vertical plane.

g) The test length of the optical fibre shall be a minimum of 100 m. To achieve this length several fibres may be spliced together. At least one fibre shall be tested from each buffer tube or fibre bundle. Splices should be made so the optical equipment can be located at the same end.

h) An initial optical measurement shall be taken when the span is pre-tensioned to approximately 5 % of maximum installation tension prior to final tensioning.

8.3.8.3 Requirements of galloping test

The change in attenuation of monitored optical fibres shall comply with the general optical requirements stated in 8.3.1.

The elements of OPGW shall have no cracks or splits.

8.3.9 Temperature cycling

The cable shall be tested in accordance with Method F1 of IEC 60794-1-22, with the following conditions:

- Minimum length of cable to test shall be 500 m;
- low temperature extreme –40 °C;
- high temperature extreme +75 °C;
- precondition the sample at 23 °C, before test, a minimum of 16 h;
- soak time at extreme temperatures shall be minimum 16 h;
- Number of cycles: 2
- Temperature change rate: ≤40 °C/h.

Different conditions of evaluation can be applied if agreed between customer and supplier.

Any permanent increase in attenuation in optical fibres after the test shall not exceed 0,10 dB/km when measured at 1 550 nm.

8.3.10 Water penetration (applicable to optical unit(s) only)

The cable shall be tested in accordance with Method F5B of IEC 60794-1-22:2012.

A 1 m sample of OPGW cable with all the armour wires removed shall be tested for water penetration only on the hermetic optical unit. Assure the ends of the uncovered optical unit are not collapsed in order to permit free flow of liquids at the entrance.

No water leak should be detected at the unsealed end of the sample after 1 h of 1 m height of water pressure is applied on one end of the sample.

8.3.11 Short-circuit

The short-circuit test shall assess the performance of the cables and the optical characteristics of the fibres under typical short-circuit and has to be tested in accordance with the method specified in Method H1 of IEC 60794-1-24.

The following conditions apply:

a) the initial sample temperature shall be 40 °C ± 5 °C, if not otherwise agreed between customer and manufacturer;

b) the sample shall be subjected to three short-circuit pulses;

c) apply each short-circuit pulse once the sample has stabilized at initial temperature;

d) for each short-circuit pulse, the fault current duration shall be between 0,25 s to 1,0 s;

e) the total short-circuit energy of each pulse to be impacted on the sample shall be equal to the value specified by the manufacturer and agreed with the customer;

f) the maximum temperature measured inside the optical unit of OPGW on each pulse shall not exceed 200 °C;

g) any permanent increase in attenuation in the monitored optical fibres 30 min after the test shall comply with the general optical requirements stated in 8.2.1;

h) any visible rupture or degradation on the OPGW elements, such as bird-caging effect on armour wires, during the test or after releasing the OPGW load, is considered a failure. The optical unit(s) of the tested sample shall be dissected and inspected visually for excessive wear, discoloration, deformation or breakdown.

8.3.12 Lightning test

The lightning test shall assess the performance of the cables and the optical characteristics of the fibres under typical lightning conditions and shall be tested in accordance with the method specified in Method HD of IEC 60794-1-24. Different conditions of evaluation can be applied if agreed between customer and supplier.

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

The change in attenuation of monitored optical fibres shall comply with the general optical requirements stated in 8.2.1.

If after the lightning impact, on any of the impact zones any wires are found to be broken, then the residual strength of the sample with broken wires shall be evaluated. If the residual strength in the sample is less than 75 % of the OPGW RTS, then this shall constitute a failure.

Any visible bird-caging effect on armour wires, during the test or after releasing the OPGW load, is considered a failure in this test.

The parameters and infomration on test conditions listed in Table 2 shall be provided in the lightning test report:

Table 2 – Lightning test conditions and parameters to be informed in the test report

No.	Description	Units
1	Mean direct current level of each applied electrical impact	A
2	Time of each applied electrical impact	s
3	Resultant calculated charge for each electrical impact	Coulomb
4	Polarity of discharge from electrode to cable sample	(+) if not otherwise agreed
5	Maximum observed current variation during electrical impact	% (average current)
6	Gap distance between electrode and cable sample	mm
7	Mechanical load applied on cable sample during test	N
8	Considerations for charge amount used for electrical fuse melting if considered as part of the results calculation.	Coulomb
9	Material and dimensions of electrode and electrical fuse	–
10	Minimum existing distance between electrical fuse and any point of the structure used to fix the electrode and cable sample.	mm
11	Environmental temperature under which the lightning test was performed	°C
12	Description of fittings used to fix the cable sample	–
13	Number and type of broken wires (if any) after each electrical impact	–

8.4 Factory acceptance tests

8.4.1 General

Sample tests and factory acceptance tests shall be carried out according to the quality plan of the supplier and, if required, in the presence of the customer or his representative.

The test methods and requirements are given by this standard. Additional tests may be agreed between customer and supplier.

8.4.2 Typical tests

- Design
- Visual inspection of the cable elements
- Lay length of armouring
- Diameter of cable
- Weight per unit length of cable
- DC resistance of cable
- Breaking strength test (one sample)
- Optical fibre attenuation coefficient at operational wavelength

8.5 Routine tests

8.5.1 General

Routine tests shall be carried out on all manufactured cables and in accordance to the quality plan of the supplier.

The test methods and requirements are given by this standard. Additional tests may be agreed between customer and supplier

8.5.2 Typical tests

- Inspection of incoming raw materials according to the manufacturer's quality plan
- Optical fibre attenuation coefficient at operational wavelength
- Cable design
- Quality of cable surface
- Lay length of armouring
- Diameter of cable
- Diameter of cable components
- Mechanical and electrical cable component characteristics

9 Quality assurance

The supplier shall establish, introduce and maintain a quality management system.

NOTE As example of such a system could be ISO 9001:or equivalent.

Annex A
(informative)

Packaging and marking

Packaging and marking shall be as follows:

- Cable shall be tightly and uniformly wound onto reel(s) in layers. Reel lengths may be either standard length or specified length. Standard lengths are reel lengths normally provided by a supplier. This length will be defined by the supplier. Specified lengths are reel lengths which are specified by the customer. A tolerance of $^{+2}_{0}$ % shall be maintained for specified lengths and standard lengths.
- Reels shall be either wooden/steel/ steel reinforced wooden non-returnable or returnable type. Unless specified otherwise by the customer, the supplier will determine the size and type reel that will withstand normal shipping, handling, storage, and stringing operations without damage to the cable.
- The reel and inside flanges shall be manufactured in a such a manner that damage will not occur to the cable during shipping, handling, storage, and stringing.
- Reels shall have wood lagging attached to the flanges unless specified otherwise by the supplier. Lagging shall be attached to reels in such a manner that individual lagging strips will remain in place during normal shipment, handling and storage.
- Reel numbers shall be identified in a clear and legible manner on the outside of each flange on two opposite locations.
- Each reel shall be tagged with two shipping tags. Tags shall be weather resistant. All essential information such as supplier's name, cable size and number of fibres, order number, reel number, cable number, cable lengths; and gross, tare, and net weight shall appear legibly on the tags. The tags should clearly indicate **Cable** in the description.
- The cable ends shall be securely fastened to prevent the cable from becoming loose during shipment. The inner end of the cable shall be accessible for connection to optical measuring equipment. This length of cable shall be securely fastened and protected during shipment.
- A seal shall be applied to each end of the cable to prevent the entrance of moisture into the optical fibres or the escape of filling compound during shipment and storage.
- Each reel shall be marked on the outside flange to indicate the direction the reel should be rolled during shipment in order to prevent loosening of the cable on the reel.

Bibliography

IEC 60794-1-20, *Optical fibre cables – Part 1-20: Generic specification – Basic optical cable test procedures – General and definitions*

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

IEC TR 62839-1, *Environmental declaration – Part 1: wires and cables and accessories products specific rules*

ISO 9001, *Quality management systems – Requirements*

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