IEC 60794-4-30

Edition 1.0 2021-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Optical fibre cables –
Part 4-30: Aerial optical cables along electrical power lines – Family specification for optical phase conductor (OPPC) optical cables

Câbles à fibres optiques –
Partie 4-30: Câbles optiques aériens le long des lignes électriques de puissance – Spécification de famille pour les conducteurs de phase à fibres optiques (OPPC)

IEC 60794-4-30:2021-04(en-fr)

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CONTENTS

FOREWORD 4
1 Scope 6
2 Normative references 6
3 Terms and definitions 7
4 Symbols and abbreviated terms 8
5 Optical fibre 8
6 Cable elements 8
7 Cable construction 8
7.1 General 8
7.2 Anti-corrosion 9
8 Main installation requirements 9
8.1 General 9
8.2 Installation methods and conditions of OPPC 9
8.3 Installation methods and conditions of the fittings 10
8.4 Anti-twist 10
8.5 Installation methods and conditions of the closure 10
9 Cable design characteristics 10
10 Cable tests 11
10.1 General 11
10.2 Classification of tests 12
10.2.1 Type test 12
10.2.2 Factory acceptance tests 12
10.2.3 Routine tests 12
10.3 Tensile performance 12
10.4 Aeolian vibration 13
10.5 Creep 13
10.6 Sheave test 13
10.7 Stress-strain test 14
10.8 Breaking strength 14
10.9 Twist 14
10.9.1 General 14
10.9.2 Set up 14
10.9.3 Procedure 15
10.10 Temperature cycling 15
10.11 Water penetration (applicable to optical unit only) 15
10.12 Compound flow (drip) (applicable to optical unit only) 15
10.13 Fibre coating compatibility 15
10.14 Salt spray corrosion test 16
10.15 DC resistance test 16
10.16 Short-circuit 16
10.17 Lightning test 17
10.18 Current-temperature test 17
10.19 Fitting compatibility 17
11 Packaging and marking 18
12 Quality assurance 18
Annex A (informative) Typical OPPC structures 19

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Annex B (informative) Installation example 20
Annex C (informative) Packaging and marking 22
Bibliography 23

Figure A.1 – OPPC example structures 19
Figure B.1 – OPPC's closure installation example with support method 20
Figure B.2 – OPPC's closure installation example with suspension method 20
Figure B.3 – Closure installation example with dead-end 21
Figure B.4 – Closure installation example with a suspension clamp 21

Table 1 – Cable design characteristics 10
Table 2 – Lightning test conditions and parameters to be informed in the test report 17

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OPTICAL FIBRE CABLES –

Part 4-30: Aerial optical cables along electrical power lines – Family specification for optical phase conductor (OPPC) optical cables

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

FDIS	Report on voting
86A/2079/FDIS	86A/2088/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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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.

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OPTICAL FIBRE CABLES –

Part 4-30: Aerial optical cables along electrical power lines – Family specification for optical phase conductor (OPPC) optical cables

1 Scope

This part of IEC 60794, which is a family specification, specifies the optical fibre, cable elements, cable construction requirements, main requirements for installation and operating conditions, cable design characteristics and test for OPPC (optical phase conductor), used for carrying current as well as communication and data transmission. The corresponding environmental declaration can be built according to IEC TR 62839-1.

The OPPC is a substitute for a conventional phase bare conductor containing optical fibres. 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.

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 60468, *Method of measurement of resistivity of metallic materials*

IEC 60793-1-40, *Optical fibres – Part 1-40: Attenuation measurement methods*

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*

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

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

IEC 60794-1-219, *Optical fibre cables – Part 1-219: Generic specification – Basic optical cable test procedures – Material compatibility test, method F19*[1]

[1] Under preparation. Stage at the time of publication: IEC/CCDV 60794-1-219:2020.

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

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

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

IEC 61089, *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*

IEC 62219, *Overhead electrical conductors – Formed wire, concentric lay, stranded conductors*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60794-1-1, IEC 60794-4 and the following 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
optical phase conductor
OPPC
metallic hybrid optical cable that has the dual performance functions of a conventional phase conductor with telecommunication capabilities

3.2
current-carrying capacity
calculated value for the maximum continuous current carrying capacity without degradation of of any element of the cable under specific conditions

Note 1 to entry: The value depends on various parameters (e.g. solar, wind speed, ambient temperature).

Note 2 to entry: If the construction contains an aluminium tube or aluminium slotted core, these elements are considered conductive parts.

3.3
operation temperature
steady state temperature the OPPC cable will reach during standard operation at the current carrying capacity, without degradation of any element's performance requirements under specific conditions

3.4
emergency condition temperature
maximum temperature the OPPC cable will reach during emergency operation for a limited period of time during cable's lifetime without degradation of any element's performance requirements

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3.5
emergency condition duration
OPPC cable's accumulated period running in emergency temperature mode within its lifetime

4 Symbols and abbreviated terms

For the purpose of this document, the abbreviated terms given in IEC 60794-1-1 apply.

5 Optical fibre

Single-mode optical fibres which comply with the relevant part of IEC 60793-2-50 shall be used. Fibres other than those specified above can be used, if agreed between the customer and supplier. The cabled fibre shall conform to IEC 60794-4.

Any reflective discontinuity specified with the optical return loss measurement shall be greater than 55,0 dB.

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

6 Cable elements

Refer to the relevant parts of the IEC 60794-4 series.

a) 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.

b) For loose tube constructions, one or more primary coated fibres or optical elements are packaged loosely in a tube construction, with a suitable water-blocking system. The tube(s) may be fabricated from stainless steel, aluminium, aluminium alloy, or a heat-resistant non-metallic material. The tube diameter shall be agreed between the customer and the supplier.

c) When used in the tube, the filling compound shall not flow at the cable maximum operation temperature or freeze at its lowest operation temperature.

d) The wire types can be from one or more of the following standards and their mechanical properties shall comply, before stranding, with the requirements of the standards indicated:
   - aluminium alloy according to IEC 60104;
   - zinc-coated steel according to IEC 60888;
   - hard-drawn aluminum according to IEC 60889;
   - aluminum-clad steel according to IEC 61232.

   Other wire types can be considered; the requirements shall be agreed between customer and manufacturer.

e) Each cable element shall be compatible.

7 Cable construction

7.1 General

Refer to the relevant parts of the IEC 60794-4 series.

An OPPC consists of bearing elements, conductor elements and optical fibre units. Usually, optical fibre units are within the bearing elements.

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If the OPPC includes several tubes with fibres, it shall be possible to identify each individual fibre and tube throughout the length of the cable. Use of an appropriate colour code is an accepted methodology.

The stranded wires may be round according to IEC 61089 or have other cross-sectional shapes, i.e. trapezoidal or z-form according to IEC 62219. Unless other requirements are mutually agreed between the customer and the supplier, after stranding, the OPPC shall comply with IEC 61089 or IEC 62219.

Typical OPPC structures with outer round wires are shown in Annex A. Formed wires can also be used.

7.2 Anti-corrosion

In order to reduce the risk of corrosion, the wires on the strands and the tube protecting the fibre optic cable element(s) should be composed of the same metal or be coated with grease. If used, the 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.

8 Main installation requirements

8.1 General

Installation and operating conditions shall be agreed between customer and supplier. It is recommended that a detailed study of the field conditions and technical information/support is provided by the supplier or third party expert prior to the agreement. Installation of OPPC shall match with its fittings and closures. Annex B gives some typical installation examples.

8.2 Installation methods and conditions of OPPC

Installation of OPPC is generally the same as that of overhead power lines conductors by tension method and according to the manufacturer's recommended procedure, slack stringing is forbidden. Bending radius of OPPC for installation should be specified, and MIT shall be according to Table 1. Installation mainly include how to

a) pay off and string OPPC;

b) install the fittings and adjust the sag of OPPC.

OPPC shall be extended from the cable reel by towing rope when deploying, and kept a loosen arc all during the whole process. Special fixture or strained preformed line should be used when the line is tightened. The sag and tension should be calculated according to the type, span and weather condition of OPPC. The maximum pay off tension should not exceed MIT, and no extra bending of the fibre which would damage or lower performance is allowed. The tensile force should be less than 20 % of RTS when stringing, and the diameter of pay off guide wheels should be at least 40 times of the OPPC diameter. V-groove type bull wheels should not be used. The conductor reel should be placed in a straight line with tensioner to avoid conductor binding. The use of neoprene, urethane lined dollies, sheaves, rollers or blocks, etc. is preferred.

Installation shall not be in bad weather such as wind and thunderstorm, and the installation temperature should not be lower than −10 °C. OPPC installation should avoid surface friction or damage. When replacing the OPPC, the new line should be connected with the old line and anti-twisting measures taken. The old line should be used as a traction line, and the old fittings should be removed after installation.

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8.3 Installation methods and conditions of the fittings

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

The fittings used on OPPC shall be matched mechanically and electrically. Factors affecting the interaction between fitting and OPPC are as follows.

a) If the fittings are too small, the contact pressure of the fitting will exceed the designed compression limit of OPPC.

b) If the fittings are too large, there will not be enough contact area, and the fitting will not have enough tension and grip strength. Also, the contact current transmission capacity between fittings and OPPC will be deficient affecting the current transmission capacity.

After fittings installation, the OPPC should be jointed, and the end of the OPPC should be sealed properly if not equipped with closure immediately.

The type of fittings shall be approved between the customer and the supplier. The fittings compatibility shall comply with 10.19.

8.4 Anti-twist

An anti-twist device can be used during installation. When a supplier does not recommend an anti-rotation device to be used during installation, they shall provide the maximum stringing tension.

8.5 Installation methods and conditions of the closure

Installation shall not be in bad weather such as strong wind and high humidity and thunderstorm, and the installation temperature should not be lower than −10 °C. If the closure is fixed by pillar insulators, the fixture should be specially designed and processed according to the structure of the connecting rod. If the closure is suspended by hanging insulators, the fitting type and specification of the connecting with the tower pole should be specified.

The electrical connection of the closure should use a jumper connection. The closure fibre count capacity should match that of the OPPC cable. Appropriate robust fixings should be used to install the closure, and proper sealing measures should be taken to prevent moisture or water from entering the closure.

9 Cable design characteristics

Table 1 is a summary of important cable characteristics. Other characteristics may be agreed between customer and supplier.

Table 1 – Cable design characteristics

Ref	Design characteristic	Units
1	Number and type of fibres	—
2	Conductor type	—
3	Construction	—
4	Overall diameter	mm
5	Calculated cross-sectional area of wires concerning calculation of RTS	mm^2
6	Calculated mass	kg/km
7	RTS (rated tensile strength)	kN
8	Modulus of elasticity	MPa
9	Coefficient of linear expansion	K^{-1}

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Ref	Design characteristic	Units
10	DC resistance at 20°C	Ω/km
11	Current-carrying capacity at specific condition	A
12	Fault-current capacity I^2t	$kA^2 \cdot s$
13	Lightning resistance	Coulomb
14	MAT (maximum allowable tension)	kN
15	MIT (maximum installation tension)	kN
16	Allowable temperature range for storage and installation	°C
17	Operation temperature	°C
18	Emergency condition temperature	°C
19	Emergency condition duration	hours or days
20	Maximum long term strain	% length
21	MAOC (maximum allowable ovality)	%

10 Cable tests

10.1 General

The parameters specified in this document 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 document, the objective is "no change in attenuation". The total uncertainty of measurement for this document shall be less than or equal to 0,05 dB for attenuation or 0,05 dB/km for attenuation coefficient.

By agreement between customer and supplier, minor deviation from this limit may be accepted at some low frequency, for example less than 10 % of the fibres. However, for mechanical tests, no deviation in excess of 0,15 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 localised 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.

If optical attenuation is monitored during the test, a permanent or temporary increase in optical attenuation greater than 0,15 dB or 0,15 dB/km of test fibre, at 1 550 nm nominal wavelength, shall constitute failure. Attenuation measurement procedure should be in accordance with IEC 60793-1-40. Different monitoring wavelength can be used if agreed between customer and supplier.

Specimens for the tests shall be taken from the supplier in advance of the tests. 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. Whenever possible, an equal number of fibres shall be selected from each optical fibre unit.

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10.2 Classification of tests

10.2.1 Type test

A full verification of an OPPC design includes all type tests and characteristics specified in Table 1 except for creep and salt spray corrosion which are optional, unless required by customers. Type tests are required to be made before supplying a type of cable covered by this document 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 do not need 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.

10.2.2 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 document 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.

10.2.3 Routine tests

Routine tests are made on 10 % of all production cable lengths to demonstrate their integrity in Table 1. Failure of a test specimen to comply with any one of the requirements of this document 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.

10.3 Tensile performance

The cable shall be tested in accordance with IEC 60794-1-21, method E1, with the following conditions:

– the cable shall be terminated with end fittings relevant to the type of cable considered;
– minimum length of cable under tension shall be 25 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);
– tension shall be steadily increased to MAT and released back to initial load. Higher values may be used if mutually agreed between customer and supplier.

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

– the attenuation increase shall comply with the general optical requirements stated in 10.1 up to reaching MAT; exceeding the values shall constitute failure;
– fibre strain;
– a strain margin lower than the specified value up to MAT shall constitute failure.

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10.4 Aeolian vibration

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

– mechanical tension on cable during the test shall be maintained at 20 % ± 5 % of its RTS value;
– the total cable length shall be enough to permit extension of the ends and for the equipment to be attached for optical measurements;
– the optical attenuation shall be monitored along the whole test and attenuation of the optical link shall be registered at regular intervals;
– suspension and dead end fittings approved for the OPPC cable shall be used to attach the sample to the test equipment;
– number of vibration cycles to apply shall be minimum 10 000 000;
– the maximum allowable ovality (MAOC) of the optical unit shall be 10 % of the measured diameter of the optical unit.

Any visible damage to the cable or to any of the cable elements shall be considered as a test failure.

The change in attenuation of monitored optical fibres shall comply with the general optical requirements stated in 10.1. The baseline for optical attenuation measurement shall be taken at the beginning of test and after tensioning the cable.

10.5 Creep

If requested, this test is carried out according to IEC 61395, with the following conditions:

– OPPC shall be tensioned to 20 % 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 % up to 25 % RTS.

The cable shall be terminated with fittings approved for the type of cable. Optionally, all wires can be held together with epoxy resin in order to lock all elements during the test. 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.

10.6 Sheave test

The test shall be performed to verify that the installation of the OPPC 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 conditions:

– the minimum length of cable shall be 15 m; minimum length of cable bent under tension shall be 2 m;
– the diameter of sheave shall not be larger than 40 times the cable diameter, but if agreed with the cable manufacturer, smaller pulleys can be used;
– 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.

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