

**TECHNICAL SPECIFICATION
FOR OPTICAL GROUND WIRE
ON TRANSMISSION LINES**

OPTICAL GROUND WIRE ON 400 kV AND 150kV TRANSMISSIONS LINES

1. SCOPE

This technical description covers the requirements for design, construction and testing of:

- OPGW (Optical Ground Wire) on 400kV and 150kV transmission lines.

2. KEY - WORDS

OPGW

3. TECHNOLOGY

All supplied material and equipment must be of the latest technology and a relative declaration-certificate must be provided by the manufacturers.

The manufacturers of the supplied materials and equipment must have previous experience on the production of similar products for at least four-year time.

Similar products must have been supplied to other large electricity companies.

The contractor must guarantee the quality of the installation for at least three years.

4. SPECIFICATIONS FOR OPGW

4.1 Specifications

- 4.1.1 This specification covers the manufacturing and testing of Optical Ground Wire (OPGW), composed of aluminum clad steel concentric-lay stranded wires, which shall be used as overhead shield wire at electric power transmission lines and for the telecommunication between substations.
- 4.1.2 The technical data of OPGW are specified in Annex A for 400 kV T.L. and Annex B for 150 kV T.L. and have to be confirmed by the manufacturer.
- 4.1.3 In order to determine the physical characteristics of OPGW, as well as, the cable installation and the cable behavior in operation, bidders have to submit with their offer all tests, which have already carried out and to propose any other test necessary for the quality acceptance of the product.
Bids must include, but not by way of limitation, following type tests.

- Stress – strain test
- Breaking tensile load test
- Tensile performance test
- Short time current test.
- Sheave test
- Aeolian vibration test
- Temperature cycling test
- Water penetration test
- Lightning test

4.1.4 The OPGW shall be in accordance with the requirements of the IEC 60794-4-1. The selection of samples for the testing of OPGW as well as, all other type, routine & acceptance tests where applicable will be made according to the corresponding specifications EN 187200, IEC 61089, IEC 60794-4-1, IEEE 1138.

4.1.5 All material shall be subject to inspection and shall not released for shipping without the approval of Corporation's representative. The approval for shipping of material shall not relieve manufacturer from responsibility, for furnishing material conforming to the specified requirements, nor invalidate any claim, which Corporation may make because of defective or unsatisfactory material. The manufacturer shall provide adequate facilities to the Corporation's representative to test and inspect the manufacture and packing of all materials.

The manufacturer shall inform the Corporation on the progress of the work and shall give advance notice of the expected dates of completion, so that the progress of work shall be clearly indicated, and the inspection of the material and the witnessing of the tests may be scheduled without delay.

The manufacturer shall be also responsible for the behavior of the conductor during its installation on the line.

Copies of manufacturer's test reports shall be submitted to Corporation as requested. These reports shall be certified as correct by a responsible representative of the manufacturer.

4.1.6 Cable shall be shipped on substantial wooden reels. Reel heads shall be firmly bolted to the drum and shall be equipped with a cast iron hub bushing with a hole at the center of the head. Reels shall be lagged with wooden lagging, so that the outer layer of the conductor will be protected.

In addition the reels shall have a layer of waterproof paper around the drum and around the cable inside the lagging and also on the inner surface of the reel heads. Manufacturer shall furnish a drawing of the reels showing essential details and dimensions.

Special care shall be taken during the conductor's wrapping on the drum, such as to limit any movement of the conductor which may cause friction during conductor's transportation. Also the use of nails which may wound the conductor shall be avoided.

Reels must be designed, according to the minimum acceptable bending radius of the conductors.

- 4.1.7 On each reel has to be attached a tag in which shall be marked the name of material, the length, the size the stranding, the number of the order, the manufacturer's serial number (if any) the type of fiber and shipping marks. All the previous data shall appear on the outside of the package.

4.2 Specification for fiber optics

Fiber optics should conform to the attached specification "TECHNICAL DESCRIPTION OF OPTICAL FIBRES".

ANNEX

OPGW DATA For 400 kV T.L.

Overall diameter approx.	(mm)	13
Short time Current 0,5 sec	(kA)	9
Maximum Temperature after short time current according to IEC 865 (Temp 20 °C)	(° C)	200
Temperature during operation	(° C)	−40÷80
Minimum Breaking Load	(kN)	110
Modulus of Elasticity	(kN/mm ²)	160
Approx. weight of wire (max.)	(kgr/m)	~0.75
Number/type of fibers	36/G–652.B and 12/G–655.B	
Type of fibers according to	ITU-T	G–652.B/G–655.B
Max. Tension at NESC Heavy (+κ) condition κ=0,432kg/m	(kN)	37,3
Sag at everyday condition (20°C) for 350m span	(m)	7,00(±6%)
Sag at everyday condition (20°C) for 500m span	(m)	16,40(±6%)

TECHNICAL DESCRIPTION OF OPTICAL FIBRES

Optical Fibres characteristics

In each of the optical cables standardisation table optical fibres type and number are indicated.

The optical fibres must guarantee an average life of ≥ 20 years with a constant maximum working temperature of 90°C and must have a constant softening temperature all over the entire supply.

The optical fibres must have the building, dimensional, mechanical and transmitting characteristics shown in tables 1, 2, 3 and 4. These characteristics must be in keeping with IEC recommendations shown in the above mentioned tables.

Table 1 – Building characteristics

Fibre type	single mode	IEC 60793-1
Fibre component	silica / doped silica	IEC 60793-2
Fibre primary protection	double acrylic layer	IEC 60793-2

Table 2 – Dimensional characteristics

Primary protection diameter (uncoloured)		$245 \pm 10 \mu\text{m}$	IEC 60793-2
Mantle	diameter	$125 \pm 1 \mu\text{m}$	IEC 60793-2
	circularity error	$\leq 2\%$	IEC 60793-2
Mantle / Modal field concentricity error		$\leq 0.8 \mu\text{m}$	IEC 60793-2
Coating-cladding concentricity error		$\leq 12.5 \mu\text{m}$	IEC 60793-2

Table 3 – Mechanical characteristics

The optical fibres must have undergone a traction for about 1 second which has caused a minimum extension of 1%	IEC 60793-2 (par 34)
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Table 4 Transmitting characteristics of the in-cable optical fibres (Single Mode Reduced SM-R)

Loss 1	$\lambda = 1310 \text{ nm}$	$\leq 0.40 \text{ dB/km}$	IEC 60793-2
	$\lambda = 1550 \text{ nm}$	$\leq 0.30 \text{ dB/km}$	
Scattering centres		None	
Maximum number of concentrated loss centres (single fibre / lot)		1	IEC 60794-3
Maximum value for concentrated loss centres	$\lambda = 1310 \text{ nm}$	0.1 dB	
	$\lambda = 1550 \text{ nm}$	0.05 dB	
Linearity of characteristic loss	$\lambda = 1310 \text{ nm}$	$\pm 0.05 \text{ dB}$	IEC 60794-3
	$\lambda = 1550 \text{ nm}$	$\pm 0.05 \text{ dB}$	
Modal field diameter	$\lambda = 1310 \text{ nm}$	$9.3 \pm 0.5 \mu\text{m}$	IEC 60793-2
	$\lambda = 1550 \text{ nm}$		
Chromatic dispersion	$\lambda = 1285\text{-}1330 \text{ nm}$	$\leq 3.5 \text{ ps/nm*km}$	IEC 60793-2
	$\lambda = 1525\text{-}1575 \text{ nm}$	$\leq 20 \text{ ps/nm*km}$	
Wavelength on edge (λ_{cc})		$\leq 1280 \text{ nm}$	IEC 60794-3

Fibre optic

The fibre optic to be consider are the ITU-T G652 fibre and ITU-T G655 fibre. The main characteristics are reported hereafter. In presence of fibre characteristics mismatching between IEC and ITU-T, please refer to ITU-T.

The supplier shall be compliant with the requirements here specified.

ITU-T G.652: Subcategory B (G.652.B)

The subcategory is suitable for the transmission systems up to STM-64.

Fibre attributes

Attribute	Detail	Value
Mode field diameter	Wavelength	1310 nm
	Range of nominal values	8.6-9.5 μm
	Tolerance	$\pm 0.7 \mu\text{m}$
Cladding Diameter	Nominal	125.0 μm
	Tolerance	$\pm 1 \mu\text{m}$
Core concentricity error	Maximum	0.8 μm
Cladding noncircularity	Maximum	2.0%
Cable cut-off wavelength	Maximum	1260 nm
Macrobend loss	Radius	37.5 mm
	Number of turns	100
	Maximum at 1550 nm	0.50 dB
	Maximum at 1605 nm	0.50 dB
Proof stress	Minimum	0.69 GPa
Chromatic dispersion coefficient	$\lambda_{0\text{min}}$	1 300 nm
	$\lambda_{0\text{max}}$	1 324 nm
	$S_{0\text{max}}$	0.093 ps/nm ² •km
PMD coefficient	M	20 cables
	Q	0.01%
	Maximum PMD _Q	0.5 ps/ $\sqrt{\text{km}}$

ITU-T G.655: Subcategory B (G.655.B)

The subcategory is subcategory provides 100 GHz channel spacing.

Fibre attributes

Attribute	Detail	Value
Mode field diameter	Wavelength	1550 nm
	Range of nominal values	8-11 μm
	Tolerance	$\pm 0.7 \mu\text{m}$
Cladding Diameter	Nominal	125.0 μm
	Tolerance	$\pm 1 \mu\text{m}$
Core concentricity error	Maximum	0.8 μm
Cladding noncircularity	Maximum	2.0%
Cable cut-off wavelength	Maximum	1 480 nm
Macrobend loss	Radius	37.5 mm
	Number of turns	100
	Maximum at 1 550 nm	0.50 dB
	Maximum at 1605 nm	0.50 dB
Proof stress	Minimum	0.69 GPa
Chromatic dispersion coefficient Band: 1530-1565 nm	λ_{min} & λ_{max}	1530 nm & 1565 nm
	Minimum value of D_{min}	1.0 ps/nm•km
	Maximum value of D_{max}	10.0 ps/nm•km
	Sign	Positive or negative
	$D_{\text{max}} - D_{\text{min}}$	≤ 5.0 ps/nm•km
PMD coefficient	M	20 cables
	Q	0.01%
	Maximum PMD _Q	0.5 ps/ $\sqrt{\text{km}}$

Reference data for design (at 1550 nm)

Design with G.652 (Subcategory G.652.B) 2 fibre		
Maximum loss of fibre	0.26	dB/km
Chromatic dispersion	<20	Ps/nm km
Average individual splice connection loss (#splices ≥ 16)	0.04	dB
Maximum individual splice connection loss (#splices < 16)	0.1	dB
Termination loss	0.6	dB
Extent length	2500	m
Lengthening factor (catenary, wrapping, etc.)	1.03	
Dielectric cable pigtail lengthening	0.5	Km
Maximum PMD _Q	0.5	ps/ $\sqrt{\text{km}}$

Design with G.655 (Subcategory G.655.B)3 fibre		
Maximum loss of fibre	0.28	dB/km
Chromatic dispersion	<5	Ps/nm km
Average individual splice connection loss (#splices ≥ 16)	0.04	dB
Maximum individual splice connection loss (#splices < 16)	0.1	dB
Termination loss	0.6	dB
Extent length	2500	m
Lengthening factor (catenary, wrapping, etc.)	1.03	
Dielectric cable pigtail lengthening	0.5	km
Maximum PMD _Q	0.5	ps/ $\sqrt{\text{km}}$

2 This subcategory is suitable for the transmission systems up to STM-64.

3 This subcategory provides 100 GHz channel spacing.

TABLE – 5

FIBERS COLOURS

FIBER TUBE	FIBER COLOURS	FIBER NO
	1	RED
	2	YELLOW
	3	GREEN
	4	BLUE
	5	VIOLET
	6	BROWN
	7	BLACK
	8	ORANGE
	9	PINK
	10	GREY
	11	LIGHT GREEN
	12	NATURAL

TABLE – 6

YARN COLOUR CODING

GROUP	COLOUR
1	BLUE
2	ORANGE
3	GREEN
4	BROWN