10-SDMS-03

Rev.0

SPECIFICATION FOR OPTICAL FIBER GROUND WIRES (OPGW)

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1. SCOPE

SEC Distribution Material Specification (SDMS) specifies the minimum standard & technical requirements for design, engineering, manufacture, inspection, testing and performance of composite Overhead Optical Fiber-Ground Wire (OPGW) intended for the installation along Overhead Medium Voltage (MV) and Overhead Low Voltage (LV) Power Lines within the Distribution Network System of Saudi Electricity Company, Saudi Arabia.

2. CROSS REFERENCES TO OTHER SEC STANDARDS

This Material Standard Specification shall always be read in conjunction with latest revision of SEC General Specification No. 01-SDMS-01, titled "General Requirements for All Equipment/Materials", which shall be considered as an integral part of this SDMS.

This SDMS shall also be read in conjunction with SEC Purchase Order or Contract Schedules and scope of work/technical specifications for projects, as applicable.

3. APPLICABLE CODES & STANDARDS

The latest revision of the following codes and standards shall be applicable for the equipment/materials covered in this specification. In case of any deviation, the vendor/manufacturer may propose equipment/materials conforming to alternate Industry Codes and Standards. However, the provisions of SEC standards shall supersede the provisions of these alternate standards in case of any difference.

Standard #	Title
IEC 60794-1-1	Optical Fiber Cables-Part 1-1 : Generic Specification - General
IEC 60889	Hard-Drawn Aluminum Wire for Overhead Line Conductors
IEC 61089	Round Wire Concentric Lay Overhead Electrical Stranded Conductor
EIC 61232	Aluminum Clad-Steel Wire for Electrical Purposes
IEC 61394	Overhead lines – Requirements for greases for aluminum, aluminum alloy and steel bare conductors
ASTM B230M	Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes
ASTM B398M	Standard Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes
ASTM B415	Standard Specification for Hard-Drawn Aluminum-Clad Steel Wires
ASTM B416	Standard Specification for Concentric-Lay Standard Aluminum-Clad Steel Conductor
EIA/TIA-455	Standard Test Procedure for Fiber Optic Fiber, Cables, Transducer, Sensors, Connecting and Terminating Devices and other Fiber Optic Components
EIA 492A	Generic Specification for Optical Waveguide Fibers
EIA 472A	Sectional Specification for Fiber Optic Communication Cables for Outside Aerial Use

EIA 440A	Fiber Optic Terminology
ITU-TG.652	Characteristics of a Single-Mode Optical Fiber Cable
TIA-598-D	Color coding of optical fibers
ITU-TG.655	Characteristics of a Non-Zero Dispersion-Shifted Single-Mode Optical Fiber and Cable
IEEE 1138	IEEE Standard for Testing and Performance for Optical Ground Wire (OPGW) for Use on Electric Utility Power Lines
IEEE 1222	Testing and Performance for All-Dielectric Self-Supporting (ADSS) Fiber Optic Cable for Use on Electric Utility Power Lines

Table 1: List of Applicable Standards

4. MATERIAL, DESIGN AND CONSTRUCTION REQUIREMENTS

4.1 General Requirements

4.1.1 The composite Overhead Optical Fiber-Ground Wire (OPGW) shall be of Manufacturer's Standard Design and shall meet or exceed the requirements of this Specification in all respects and it shall be manufacture and test in conformance with relevant international standards.

4.1.2 Manufacturer's Drawings, as required in 01-SDMS-01 shall show the outline of the composite Overhead Optical Fiber-Ground Wire together with all pertinent dimensions. Tolerances of any variations in dimensions shall be according to relevant standards.

4.1.3 Sample of the proposed composite Overhead Optical Fiber-Ground Wire OPGW shall be provided to SEC for evaluation and approval.

4.1.4 Stress-Strain data and diagrams along with Sag Chart No. etc. and sag- tension calculations shall be submitted for the proposed OPGW.

4.1.5 The general construction of OPTICAL GROUND WIRE (OPGW) cable is indicated in Clause 9: Drawing- Figure 1.

4.2 Design Requirements

4.2.1 The maximum ambient outdoor temperature specified in the latest revision of 01-SDMS-01 shall be regarded as the basic temperature.

4.2.2 The composite OPGW shall be designed in which the integral optical fibers are used for transmission of optical signals, and in which the metallic materials are used for conduction of surge currents attributed to lightning and electrical faults.

4.2.3 All Fiber Optic Cable shall have a minimum service life span of 30 years within the intended operating environment.

4.2.4 The Manufacturer shall submit documentary evidence to support the service life requirements for both the cables and optical fibers.

4.3 Materials

4.3.1 Stranded Metallic Wire

The type of stranded metallic wires shall be hard drawn aluminum wire, aluminum alloy wire, hard drawn aluminum-clad steel wire, or any combination of these types, for general use for electrical purposes.

a. When aluminum and aluminum-alloy wires are used, the wires shall be made in accordance with the requirements specified in ASTM B230M and ASTM B398M or IEC 61089, respectively.

b. When aluminum-clad steel wires are used, the thickness of aluminum at any points shall not be less than 10% of the nominal wire radius. The aluminum-clad shall be smooth, continuous and of reasonably uniform thickness.

c. The base metal of aluminum-clad steel wires shall be steel made by the open-hearth, basic-oxygen or electric-furnace process.

4.3.2 There shall be no joints of any kind made in the finished wires composing the strand. There shall be no joints or splices in any length of the completed OPGW cable.

4.3.3 The rated breaking strength of the completed OPGW shall be taken as 90% of the sum of the rated breaking strength of the individual wires, calculated from their nominal diameter and the approximate specified minimum tensile strength. The central fiber optical unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite OPGW.

4.3.4 The basic construction shall have bare concentric-lay stranded metallic wires with the outer layer having right hand-lay and wound around the metallic or non-metallic pipe or channeled rod. The stranded wires must be of multiple layers when use in the high contamination area or in the proximity of the sea (Coastal Regions Operating Area) and shall be Grease (Type of Grease: Type –A) as per IEC 61394 and IEC 61089 Annexure C (figure C.5) respectively.

The manufacturer shall guarantee the corrosion protection of OPGW for minimum of (30) years. The format of the guarantee shall be mutually decided between Saudi Electricity Company (SEC) Distribution Network and the Manufacturer.

4.3.5 The preferred length of lay of the various layers of wires is 13.5 times the outside diameter of that layer, but the length of lay shall be neither less than 10 nor more than 16 times this diameter.

4.3.6 Stranding shall be close to ensure no significant reduction in diameter or compression on metallic or non-metallic channeled rod or spacer when stressed to 10% of minimum rated tensile strength.

4.3.7 All wires shall lie naturally in their true positions in the completed composite OPGW. The wires shall be so stranded that when the composite OPGW is cut at any point the individual wires can be readily regrouped and then held in place by one hand.

4.4 Central Fiber Optical Unit

4.4.1 The central fiber optical unit shall be designed to encase and protect the optical fibers from damage due to forces such as crushing, bending, twisting, tensile stress and moisture.

4.4.2 The central fiber optical unit, including the outer stranded metallic wires, shall protect the optical fibers from degradation due to vibration, wind loading, wide temperature variations, lightning and fault currents as well as any other effects that may produce hydrogen.

4.4.3 The central fiber optical unit may include a metallic or non-metallic tube, and/or channeled rod or spacers, but shall not be limited to these designs. The metallic tube may be of aluminum, stainless steel, or aluminum coated stainless steel. All tube designs, having similar or dissimilar materials, shall pass the qualification test requirements (salt spray corrosion test) specified in Clause 6.1.1. There shall be no galvanic corrosion between stainless steel tubes and the surrounding aluminum or aluminum alloy or aluminum-clad steel wires. In order to qualify and accept the tube design, the manufacturer shall submit salt spray test results during bid stage.

a. Metallic Tube

The central fiber optical unit may include a tube such as stainless steel or aluminum to house the fibers. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

The central fiber optical unit may include a stainless steel tube with an aluminum protective coating to house the fibers. The coating shall completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc., with the surrounding stranded wires described in 4.3.1.

The grade and type of material for stainless steel tube and aluminum coated stainless steel tube shall be SS 316L (steel designation X2CrNiMo 17-12-2,

material No. 1.4404 per DIN/BS-EN 10088-2 standard or per other equivalent standard).

b. Channeled Rod or Spacer

An aluminum or non-metallic material may be used with channels or grooves and formed into a helix to house the fibers. The fibers may be contained inside a tube placed in the groove(s). An outer protective shield may be applied around the channeled rod or spacer such as a tube or a helically applied overlapping tape to provide an additional mechanical and environmental barrier.

4.4.4 Filling Compound

4.4.4.1 The interstices of the central fiber optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any longitudinal water migration within the fiber optic unit or along the fiber optic cable.

4.4.4.2 The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, anti-hygroscopic, electrically nonconductive and chemically and biologically inert.

4.4.4.3 The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

4.4.4.4 The filling compound shall be able to withstand normal service conditions specified in 01-SDMS-01 and shall remain stable for ambient temperature up to +70°C and shall not drip, flow or leak through age or at change of temperature.

4.4.4.5 Reference method to measure drip point shall be as per IEC 60811-5-1 and drip point shall not be lower than +70°C.

4.4.4.6 The water tightness of the cable shall meet or exceed the test performance criteria as per IEC60794-1-2-F5.

4.4.5 The fiber shall be stress free in the central metallic tube under all environment conditions.

4.4.6 The central fiber optical unit shall withstand maximum fault current as specified in Data Schedule without degradation to the physical and mechanical characteristics and properties of the fibers.

4.5 Single Mode Optical Fibers

4.5.1 Optical fiber shall be made of germanium doped silica glass or pure silica glass. Index profile shall be step index.

4.5.2 The mode field eccentricity shall be less than 1µm.

4.5.3 The cladding of the optical fiber shall be made of silica glass having lower refractive index. The outside diameter of the cladded fiber shall be 125 µm with tolerance of +2.0 µm.

4.5.4 The non-circularity of cladding surface shall be 2%maximum.

4.5.5 The nominal total fiber coating diameter shall be in the range of 245-400 µm.

4.5.6 There shall be no joints or splices in any optical fiber in any reel length of the complete optical cable.

4.5.7 Maximum optical loss variation at temperature range of -5°C to the temperature reached during fault at worst environmental condition shall not exceed +0.05dB/km.

4.5.8 Optical Fibers shall be free of material and manufacturing defects, which would prevent them from meeting the requirements of this Specification.

4.5.9 Each group of fiber shall be enclosed in a loose buffer tube or wrapped by a heat resistance tape in a helical fashion to provide mechanical and environmental protection.

4.5.10 The buffer shall be easily removed. If the manufacturer recommends special tools, these shall be provided.

4.6 Specification of Single Mode Optical Fibers

4.6.1 Dispersion Un-Shifted Single Mode Optical Fiber G.652D

Dispersion Un-Shifted Single Mode Optical Fiber G.652D shall meet the requirements of Table 2, unless otherwise specified in the Data Schedule.

Table 2: Characteristics of Single Mode G.652D Fiber

Operating Wavelength	Maximum Attenuation	Maximum Chromatic Dispersion	Zero Dispersion Wavelength (nm)	Nominal Mode Field Diameter (MFD)
1310 nm	≤0.37dB/km@1310nm	≤3.5ps/nm.km at 1285-1330nm	1300-1324 nm	9-10 µm ±5% at 1300 nm Operating Wavelength
1550 nm	0.235dB/km at 1550 nm	<18ps/nm.km at 1550 nm	1300-1324 nm	10-11 µm ±10% at 1550 nm Operating Wavelength

4.6.2 Non-Zero Dispersion-Shifted Single Mode Optical Fiber G.655

The Non-Zero Dispersion-Shifted Single-Mode Optical Fiber G.655 shall meet the requirements of Table III, unless otherwise specified in the data schedule.

Table 3: Characteristics of Non-Zero Dispersion Shifted Single Mode (G.655) Fiber

Operating Wavelength	Maximum Attenuation	Maximum Chromatic Dispersion	Cable cut-off Wavelength (nm)	Nominal Mode Field Diameter (MFD)
1530-1565 nm	0.24 dB/km	2.0-6.0 ps/nm.km	≤1450nm	8-11 µm ±0.7 µm at a Nominal Operating Wavelength of 1550 nm
1565-1625nm	0.25 dB/km	4.5-12.4ps/nm.km		

4.7 Color Coding and Identification

4.7.1 The individual color and group color-coding scheme of optical fibers shall be as specified in Table 4 and in accordance with international standard for fiber optic color coding scheme.

4.7.2 The scheme applies to optical fiber cable where fibers are physically separated.

4.7.3 Fibers within a cable shall be grouped and each group shall contain Twelve (12) Fibers.

4.7.4 When a number of fibers form a group, the group shall be uniquely identified as specified in Table 4.

4.7.5 All fibers within a group shall be discernible throughout the design life of the optical fibers and uniquely color coded as shown in Table 4.

4.7.6 When groups are defined by means of tubes, binder tapes, ribbons, threads, etc., such means shall be discernible and uniquely color-coded as shown in Table IV.

4.7.7 Each fiber shall be traceable back to the manufacturers' production batch and the results of any production tests relevant to that batch.

Table 4 - Individual Fiber and Group Identification

FIBER CORE NUMBER	FIBER BASE COLOR	GROUP BASE COLOR
1	Blue	Group # 1 "Blue"
2	Yellow	
3	Green	
4	Red	
5	Violet	
6	White	
7	Orange	
8	Brown	
9	Gray	
10	Black	
11	Pink	
12	Aqua	
13	Blue	
14	Yellow	
15	Green	
16	Red	

17 18 19 20 21 22 23 24	Violet White Orange Brown Gray Black Pink Aqua	Group # 2 "Yellow"
25 26 27 28 29 30 31 32 33 34 35 36	Blue Yellow Green Red Violet White Orange Brown Gray Black Pink Aqua	Group # 3 "Green"
37 38 39 40 41 42 43 44 45 46 47 48	Blue Yellow Green Red Violet White Orange Brown Gray Black Pink Aqua	Group # 4 "Red"
49 50 51 52 53 54 55 56 57 58 59 60	Blue Yellow Green Red Violet White Orange Brown Gray Black Pink Aqua	Group # 5 "Violet"
61 62 63 64 65	Blue Yellow Green Red Violet	

66 67 68 69 70 71 72	White Orange Brown Gray Black Pink Aqua	Group # 6 "White"
73 74 75 76 77 78 79 80 81 82 83 84	Blue Yellow Green Red Violet White Orange Brown Gray Black Pink Aqua	Group # 7 "Orange"
85 86 87 88 89 90 91 92 93 94 95 96	Blue Yellow Green Red Violet White Orange Brown Gray Black Pink Aqua	Group # 8 "Brown"

Table 4.a-Fiber Base Color Identification.

Number	1	2	3	4	**5**	6
Color	Blue	Yellow	Green	Red	Violet	White
Number	7	8	9	10	11	12
Color	Orange	Brown	Grey	Black	Pink	Aqua

Table 4.b-Binder (Group Base Color Identification.

Number	1	2	3	4	5	6	7	8
Color	Blue	Yellow	Green	Red	Violet	White	Orange	Brown

4.8 Composite OPGW

The composite OPGW shall have the following minimum dimensions and ratings, which are equivalent to the combined characteristics of stranded wires and metallic or non-metallic channeled rod or pipe.

4.8.1 The composite OPGW shall not experience any optical or mechanical degradation when subjected to maximum 40% of the OPGW rated tensile strength (RTS).

4.8.2 The manufacturer shall indicate the maximum permissible temperature rise reached during fault occurrence without any adverse effect on the fiber and RTS of wire.

a. This maximum temperature rise shall be used in calculating the theoretical fault current capacity of the OPGW.

b. OPGW hardware and fittings shall be able to withstand this maximum temperature rise.

c. OPGW manufacturer shall recommend the sag and tension calculations for various spans under the limiting conditions specified.

4.8.3 The minimum bending radius that can be applied without optical degradation shall be ≥ 15 times the diameter of OPGW.

4.8.4 The required diameter and characteristics of composite OPGW shall be as specified in Table V and other than that shall be specified in the data schedule.

4.8.5 For retrofitting projects, the characteristics of the OPGW such as diameter, rated tensile strength, fault current rating, weight and DC resistance (at 20°C) etc. different from those given in Table V could be specified on a case-to-case basis provided the proposed OPGW shall have:

a. Diameter equal to or less than that of the existing OPGW.

b. Rated tensile strength equal to or higher than that of the existing OPGW.

c. Fault current rating equal to or higher than that of the existing OPGW.

d. Weight equal to or less than that of the existing OPGW.

e. DC resistance (at 20°C) equal to or less than that of the existing OPGW.

4.8.6 The required rating of the composite overhead optical fiber-ground wire shall be as specified in the Data Schedule.

4.8.7 The completed OPGW shall be free from imperfections not consistent with good manufacturing practices.

Table 5-Diameter & Composite OPGW

Nominal Diameter	Minimum Rated Tensile Strength (kN)	Minimum Fault Current for 1 Second @ 55°C Initial Temperature (kA)	Maximum Weight (kg/m)
14.9	70	13.0	0.518
17.9	120	24.0	0.932

5. FABRICATION

OPGW shall be free of material and manufacturing defects that would prevent it from meeting the requirements of this specification.

5.1 Reel Design

5.1.1 Reel shall be of non-returnable wood.

5.1.2 The length of OPGW per reel shall be 4000 m with a permissible variation of ±5%, unless otherwise different lengths are required as per actual site requirements or as agreed between SEC and the Manufacturer.

5.2 Markings

5.2.1 Each end of the Composite OPGW in the reel shall have a non-corroding tag identifying the following:

a. Type of stranded metallic wire
b. Size of stranded metallic wires
c. Cross-sectional area of the composite OPGW
d. Type of Optical Fiber
e. Number of Optical Fiber

f. Manufacturer's Name or Trademark
g. Year of Manufacture

5.2.2 Composite OPGW reel shall be marked in legible and indelible letters providing the following particulars:

a. Manufacturer's Name and Country of Origin.
b. Year of Manufacture in English and Arabic.
c. Size and material of stranded metallic wire/number and type of optical fiber.
d. Serial number.
e. Length and Weight of Composite OPGW on reel
f. Gross Weight
g. Dimensions of reel
h. Directions of rolling of reel
i. SEC Stock No. / JO No. / Contract No.
j. SEC Address and Purchase Order Number
k. 10-SDMS-03, Rev.0

5.2.3 All markings shall appear on both sides of the reel. See Figure-3 for reel marking location.

5.2.4 Composite OPGW reel identification shall include any additional information as required by the SEC shipping instructions.

6.0 TESTING & INSPECTION

The Composite Overhead Optical Fiber-Ground Wire (OPGW) shall be tested in conformance the term 'relevant standards' referred hereunder relates to the group of standards listed in clause 3.0 to which the optical fiber is being supplied by the manufacturer. SEC reserves all the rights to attend and witness the tests. Supplier/Manufacturer shall provide all test results for review, approval and acceptance by SEC.

6.1 Composite OPGW Tests

6.1.1 Type (Design) Tests

All type (design) tests prescribed in the relevant IEC, EIA/TIA, ASTM or IEEE standards to which the material is being supplied shall be performed on the representative unit or on the first unit of every new design or rating to be supplied to SEC.

In lieu of the actual type (design) tests, certified test reports of type (design) tests performed on an identical unit shall submit to SEC for review and approval during the bidding stage.

The type (design) tests are as follows:

a. Cable Cut-off Wavelength Tests

The cut-off wavelength of the cabled fiber shall be less than or equal to 1250 nm and 1450 nm for dispersion un-shifted single-mode fiber and non-zero dispersion-shifted single-mode fiber, respectively. Measurement shall be as specified in the relevant standard or in accordance with EIA/TIA-455-170.

The cable sample shall be 20 m long with additional 1 m fiber ends, each having one 76 mm loop to simulate the splice organizer. (The total fiber length is 22 m including the two 1 m ends.)

b. Fluid Penetration Test

Water ingress tests 1 m (one meter) sample cable designed for water blocking shall be performed as specified in the relevant standard or in accordance with EIA/TIA-455-82B. No water shall leak through the open end of 1 m sample. If the first sample fails, one additional 1 m sample, taken from a section of cable adjacent to the first sample may be tested for acceptance. Water leaks from second sample shall constitute failure.

c. Compound Flow (Drip) Test

A 0.3 m sample of OPGW shall be tested. The sample shall be prepared as specified in the relevant standard or in accordance with EIA/TIA-455-81A.

The filling and flooding compound shall not flow (drip or leak) at 65°C.

d. Short Circuit Test

Short circuit test on OPGW shall be perform in accordance with IEEE 1138. The maximum fault current shall pass through the 10 m cable sample for at least 0.30-second fault duration while continuously monitoring the optical attenuation of the test fibers from at least 2 minutes before to at least 5 minutes after each current pulse. The testing ambient temperature shall be at least 55°C.

The acceptance criteria shall be as per IEEE 1138.

e. Aeolian Vibration Test

Aeolian vibration test shall be carried out on OPGW as specified in the relevant standard or in accordance with IEEE 1138.

The acceptance criteria shall be as per IEEE 1138.

f. Sheave Test

A sheave test shall be carried out as specified in the relevant standard or in accordance with IEEE 1138.

The acceptance criteria shall be as per IEEE 1138.

g. Crush Test and Impact Test

A crush and an impact tests shall be performed as specified in the relevant standard or in accordance with EIA-455-25A and EIA-455- 41A.

A permanent or temporary increase in optical attenuation value greater than 0.1 dB change in sample at 1300 nm or 1550 nm for single-mode fibers shall constitute failure.

h. Creep Test

A creep test shall be perform on an OPGW sample approximately 10 m long in accordance with IEEE 1138. The cable shall be terminate at each end and a tension of at least 30% of UTS shall be applied for duration of at least 1000 h.

The elongation of the composite OPGW versus time shall be measure at suitable intervals and recorded. Elongation with time shall be in accordance with the requirements as specified in the relevant standard or in accordance with ASTM B398M or ASTM B415. Any permanent or temporary increase in optical attenuation greater than 0.2 dB/km at 1300 nm or 1550 nm for single-mode fibers shall constitute failure.

i. Stress-Strain Test

A stress-strain test shall be perform on cable sample as specified in the relevant standard or in accordance with IEEE 1138.
Any visual damage to the conductor strands or permanent or temporary increase in optical attenuation greater than 0.2 dB/km at 1300 nm or 1550 nm for single-mode fibers shall constitute failure.

j. Temperature Cycling

Temperature cycling measurements shall be made as specified in the relevant standard or in accordance with EIA/TIA-455-3A, using a modified version of Test Condition B, -45°C to +85°C, two cycles.

The change in attenuation between extreme operational temperatures for un-shifted single-mode fibers shall not be greater than 0.2 dB/km. The attenuation change measurements shall be made at 1310 nm and 1550 nm.

k. Rated Strength Tests on Completed OPGW

The breaking strength of the completed OPGW shall not be less than the specified rated breaking strength of the OPGW unless the failure occurs in the gripping device. If the failure occurs in the grip, the test value must not be less than 90% of the specified rated breaking strength.

l. Salt Spray Corrosion Test

This test will be a 1000 hours salt spray test to be performed in accordance with the requirements of IEEE 1138 (latest edition). The test procedure shall be as per ASTM B117 or equivalent. In addition to the acceptance criteria of IEEE 1138, there shall be no signs of exposure of the base metal, pitting and porosity of the finish, cracking or delamination of components, abnormal nicks, cracks or scratches on surfaces.

m. Grease Test

Type Test shall be as per IEC 61394; (Drop Point shall not be less than 150°C).

All the conductor is greased except the outer surface of the wires in the outer layer as per IEC 61089 Annexure C (Figure C.5).

This International Standard specifies the requirements and tests of greases designed for corrosion protection of bare overhead conductors.

Type of Grease shall be Type-A.

6.1.2 Routine (Production) Tests

All routine (production) tests prescribed in the relevant IEC, EIA/TIA, ASTM or IEEE standards to which the material is being supplied shall be performed on all units prior to delivery to SEC.

Tests for mechanical and physical properties of concentric-lay stranded metallic wires shall be made before stranding.

a. Tests for aluminum-alloy wires shall be shown below.

i. All aluminum-alloy wires shall be capable of meeting the bending properties as specified in the relevant standard or in accordance with ASTM B398M after stranding.

ii. The minimum tensile strengths shall not be less than 95% of the tensile strengths specified for individual tests as specified in the relevant standard or in accordance with Table 1 of ASTM B398M.

b. Tests for aluminum-clad steel wires shall be as shown below.

i. The aluminum-clad steel wire shall withstand without fracture not less than 20 twists in a length equivalent to 100 times the nominal diameter of the wire. The specimen shall be twisted by rotating on the wires at a rate of approximately 15 twists per minute in the same direction until fracture occurs.

ii. The aluminum-clad steel wires after twisting to destruction shall not reveal any seams, pits, slivers or surface imperfections of sufficient magnitude to indicate inherent defects in the wire. Examination of the wire at the break shall show no separation of the aluminum from the steel.

Other required tests shall be performed as specified in the relevant standard or in accordance with ASTM B415.

Tests for mechanical and physical properties of Central Fiber Optic unit shall be made before assembly.

d. Optical Acceptance Tests

Attenuation test shall be performed on each fiber of each individual reel as specified in the relevant standard or in accordance with EIA/TIA 455-61, Measurement of Cable Attenuation using an Optical Time Domain Reflectometer (OTDR).

Measurement shall be made from both directions and the results shall be averaged. Attenuation loss values exceeding those specified shall constitute failure.

6.2 Fiber Tests

6.2.1 Type (Design) Tests

All type (design) tests prescribed in the relevant IEC, EIA/TIA, ASTM or IEEE standards to which the material is being supplied shall be performed on the representative unit or on the first unit of every new design or rating to be supplied to SEC.

In lieu of the actual type (design) tests, certified tests reports of type (design) tests performed on an identical unit shall be submitted, or the cable manufacturer shall submit reports in the form of batch test reports furnished by the core manufacturer, provided that the core supplied to SEC is out of

the same batch and the core manufacturer is listed in the SEC approved list. All the required test reports shall be submitted to SEC for review and approval during the bidding stage.

The type (design) tests are as follows:

a. Attenuation Variation with Wavelength
The measurement shall be made as specified in the relevant standard or in accordance with EIA/TIA 455-78A. The spectral width of the source shall be less than 10 nm.

The attenuation coefficient of un-shifted single-mode fibers for wavelengths between 1285 nm and 1300 nm shall not exceed the attenuation coefficient at 1300 nm by more than 0.1 dB/km.

6.2.2 Attenuation with Bending

Attenuation with bending measurements shall be made as specified in relevant standard or in accordance with Macro bending Sensitivity Technique at 1550 nm as per IEC 60793-1-C11. The two attenuation with bending requirements are measured by winding 100 turns of fiber on a collapsible reel or removable mandrel of 75 nm ±2 mm diameter and by wrapping a single turn of fiber around a 32 ± 0.5 mm diameter mandrel. Attenuation shall not exceed 0.5 dB at 1300 nm or 1550 nm.

c. Temperature Cycling Test

Temperature cycling measurement shall be made as specified in the relevant standard or in accordance with EIA/TIA 455-3A, using Test Condition A, -45°C to +85°C, 2 cycles.

The change in attenuation between extreme operational temperatures for single-mode fibers shall not be greater than 0.05 dB/km at 1300 nm and 1550 nm.

d. Attenuation at the Water Peak

For un-shifted single-mode fiber, the attenuation coefficient at the water peak shall be as specified in ITU-G.652.

e. Chromatic Dispersion

Dispersion measurements shall be made as specified in the relevant standard or in accordance with EIA/TIA 455-168A.

For dispersion un-shifted single-mode fibers refer to Table II.

f. Mode Field Diameter

Mode field diameter shall be measured as specified in the relevant standards or in accordance with EIA-455-174. The measurement wavelength as a minimum shall be 1310 ± 20 nm for dispersion un- shifted single mode fibers.

The nominal mode field diameter (MFD) for dispersion un-shifted single-mode fibers shall be in accordance with Table I.

g. Concentric Error

Core-to-Clad Concentricity Error measurements shall be made as specified in the relevant standard or in accordance with EIA/TIA 455-45B.

Concentricity error – the offset between the center of the core and the center of the cladding shall be < 1.0 micron.

h. Cladding Diameter and Non-Circularity Error Measurements shall be as specified in the relevant standard or in accordance with EIA/TIA 455-45B.

Cladding Diameter – the cladding outside diameter shall be 125.0 microns ± 2.0% microns.

Cladding Non-Circularity – the cladding non-circularity shall be ≤ 2%.

i. Coating Diameter

Coating diameter measurements shall be made as specified in the relevant standard or in accordance with EIA/TIA 455-55B.

Coating Diameter – the nominal coating diameter for loose buffer shall be 250 microns.

j. Fiber Tensile Proof Test

Individual fibers shall be proof tested as specified in the relevant standard or in accordance with EIA/TIA 455-31B.

All fibers shall be subjected to a minimum proof stress of 0.35GN/m² for one-second equivalent by the fiber manufacturer (100% testing).

6.2.3 Routine (Production) Tests

All routine (production) tests prescribed in the relevant IEC, EIA/TIA, ASTM

or IEEE standards to which the material is being supplied shall be performed on all units prior to delivery to SEC.

a. Attenuation Coefficient

The attenuation coefficient for un-shifted single-mode fiber shall be 0.45 dB/km or less at 1300 nm and 0.25 dB/km or less at 1550 nm wavelength and all measurements shall be made bi-directionally if accessible and the results shall be averaged.

All the traces (hard copies) must provide at least the following information other than the standard data provided by the OTDR.

i. For the graphical representation of the trace, sufficient acquisition time shall be set on ODTR for the straight line of the graph. Hazy lines due to insufficient acquisition time shall constitute failure.

ii. All traces shall clearly identify fiber number, binder-color (group identifier) and fiber color.

iii. All traces shall be furnished with the fiber-ID and the drum/reel number and physical length of the cable ordered for cross reference.

b. Fiber Point Defects

Attenuation uniformity shall be measured as specified in the relevant standard or in accordance with EIA/TIA 455-59. Measurement shall be made bi-directionally if accessible and the results shall be averaged.

The attenuation of the fiber shall be distributed uniformly throughout its length such that there are no discontinuities in excess of 0.1 dB for single-mode fiber.

6.3 Field Acceptance Testing

Upon receipt of the composite OPGW from the manufacturer, the purchaser shall at his option, perform acceptance test in order to verify that the optical characteristics of the fiber meet the order requirements and to determine if or not optical fibers have been damaged during shipment. The results of these tests and the manufacturer's certified quality control information, which is attached to each reel, shall be compared to the fiber requirements specified in the purchase order.

The tests shall be performed and documented by the use of Optical Time Domain Reflectometer (OTDR). The end of the cable shall be sealed after completion of these tests in order to prevent entry of moisture into the optical

fiber. Test shall be performed from both ends and results shall be averaged.

The following tests shall be performed as specified in the relevant standard or in accordance with EIA/TIA-455.

6.3.1 Fiber Continuity

Continuity checks of each fiber may be made to determine if or not any fiber is broken or any attenuation irregularities exist.

6.3.2 Attenuation

Total attenuation for the entire reel length and attenuation per kilometer should be measured on each fiber. Attenuation uniformity shall meet the requirements of clause 5.2.2.b of this standard.

6.3.3 Fiber Length

The fiber length may be measured using the OTDR. The index factor to be used in this measurement should be furnished by the fiber manufacturer. A check should be made to verify received reel numbers and lengths correspond to ordered quantities.

6.4 Sample Test

Sample tests is generally performed on each type of cable to verify supplier/manufacturer's compliance with this specification, and actual confirmation of the values proposed in the submitted technical data schedules.
SEC shall randomly select samples from the available packing list or by actual on-site selection.

7.0 PACKING AND SHIPPING

Packing and shipping requirement shall generally be as per latest revision of SEC General Requirements for Equipment/Materials, 01-SDMS-01 or as per purchase order requirements.

7.1 OPGW shall be tightly and uniformly wound onto reel(s) in layers. Reel lengths shall be as specified in Clause 5.0 above.

7.2 Reels shall be either wooden non-returnable or steel returnable type, which conform to ANSI/AA 53-1981, or equal. Unless specified otherwise by the purchaser, the manufacturer will determine the size and type reel, which will withstand normal shipping, handling, storage, and stringing operations without damage to the OPGW.

7.3 The drum and inside flanges shall be such that damage will not occur to the OPGW during shipping, handling, storage, and stringing. A layer of suitable

material, which is water resistant and will not absorb moisture, may provide for this.

The outer layer of the OPGW shall be protected by a water resistance wrapping over the exposed surface to prevent dirt and gritty material from coming in contact with the OPGW during shipment and storage.

7.4 Reels shall have wooden lagging attached to the flanges unless specified otherwise by the purchaser. Wood lagging should be similar to a Grade 3, cured and dressed, 50 x 100 mm Southern Pine lumber or equal. Lagging shall be attached to reels in such a manner where individual lagging strips will remain in place during normal shipment, handling, and storage.

7.5 The outer end of the OPGW shall be fastened to the inner surface of the reel flange a minimum of 25 mm below the wood lagging.

The cable end shall be securely fastened to prevent the cable from becoming loose during shipment. Minimum of 4 meter of the inner end of the OPGW shall be accessible for connection to optical measuring equipment without removing wood lagging or outer layer of protection. This length of cable shall be securely fastened and protected during shipment.

7.6 A seal shall be applied to each end of the OPGW to prevent the entrance of moisture into the optical fibers or the escape of filling compound during shipment and storage. Two (2) extra seals shall be shipped with each reel and should be accessible without removing lagging.

7.7 The manufacturer shall furnish at the time of shipment, a certified record of final quality control measured values for each fiber on each reel. This certification shall be attached to the outside flange of the reel in a weatherproof package or submitted by the vendor, separately.

7.8 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.

8.0 GUARANTEE

The supplier/manufacturer shall guarantee the products against all defects arising out of faulty design or manufacturing defects or defective materials for a period of five (5) years from the date of delivery. Special additional guarantee will be mentioned in the relative material specification/description.

The supplier/manufacturer shall guarantee the corrosion protection of OPGW for minimum of (30) years. The format of the guarantee shall be mutually decided between Saudi Electricity Company (SEC) Distribution Network.

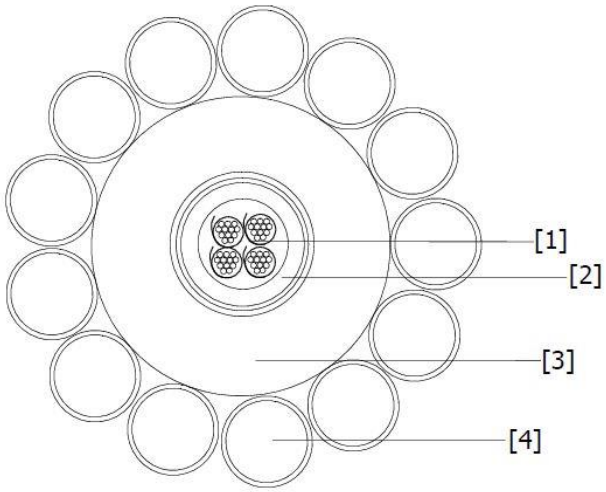
All Fiber Optic Cable shall have a minimum Service Life Span of 30 years within the intended operating environment.

9.0 DRAWING

Figure 1: General Construction of OPTICAL GROUND WIRE (OPGW)

The OPGW must be designed to the ultimate requirements from optical, electrical, mechanical, quality and cost point of view, optimizing diameter, weight, breaking load and short circuit capacity.

CABLE STRUCTURE:



OPTICAL CORE

[1] Optical Fibers
[2] Loose Buffer Tube
[3] Aluminum Extruded Tube
[4] Armour (Aluminum Clad Steel Wires)

Figure 2: OPTICAL GROUND WIRE (OPGW) Grease as per IEC 61394 and IEC 61089 Annexure C (figure C.5), Type A Grease.

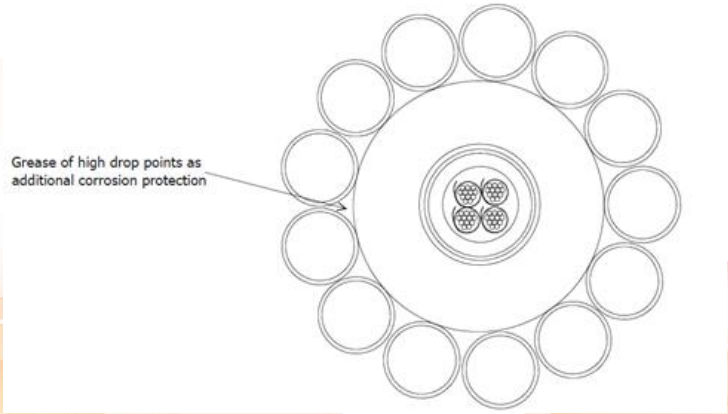
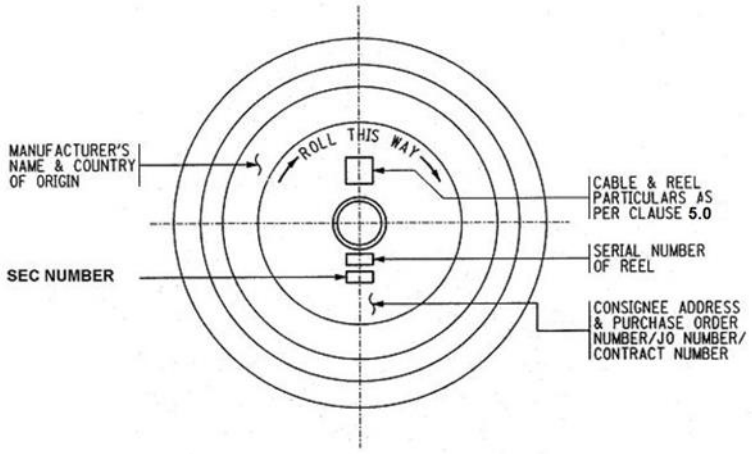


Figure 3: OPTICAL GROUND WIRE (OPGW) Reel Marking Locations



10. SUBMITTALS

Submittals shall be in hard and soft copy and in electronic formats. Unless otherwise specified, e-copies of the files should be in PDF format.

10.1 Submittals Required With Tender/Inquiry

10.1.1. Summary in table form with the following information: list of items offered, manufacturer, origin, catalogue number, and quantity.

10.1.2. Clause-by-clause compliance with the latest revision of SEC specification 10-SDMS-03 Rev.0 & 01-SDMS-01, latest Revision.

10.1.3. Manufacturer's Catalogue.

10.1.4. Certificate stating that the raw material has been sampled, tested and inspected in accordance with relevant standard specifications.

10.1.5. Product type test reports and certificates carried out from SEC approved laboratories.

10.1.6. Filled-up technical data schedule on each of the items offered, e-copy in Excel (*.xlsx) format.

10.1.7. Manufacturer CAD/Micro Station Drawings, e-copy in AutoCAD 2010/Micro Station (*.dwg) format, for each of the items offered showing the dimensions and cross-sectional views of each cables and its associated shipping reel/drum.

10.1.8. E-copy of all the documents mentioned above.

10.2. Submittals Required Following Award of Contract

10.2.1. Manufacturing and Routine Test Schedules

10.2.2. Quality Assurance Tests

10.2.3. Factory Test Reports

10.2.4. Special Tests, if applicable

10.2.5. E-copies of all the documents mentioned above.

11.0 TECHNICAL DATA SCHEDULE

Table 6: OPTICAL GROUND WIRE (OPGW) Design and Construction Requirements (SEC Ref: 4.0)

SEC Inquiry No: _____ Item No: _____

Ref. No.	Description	Unit	Specified Values	Vendor Proposed Values
3.0	**APPLICABLE CODES AND STANDARD**			
	Applicable Industry Codes & Standards		*	
4.0	**MATERIAL DESIGN AND CONSTRUCTION**			
4.1	**General Requirements**		*	
	Manufacturers drawings with dimensions		*	
	Samples of proposed material		*	
	Stress/Strain data and diagrams		*	
	Sag and tension calculations		*	
4.2	**Design Requirements**			
	Operating temperature range	°C	-10 to +75	
	Rated maximum wind speed	km/h	150	
	Design Service Life	Years	30	
4.3	**Materials**			
4.3.1	**Stranded Metallic Wires**			
	Number of Layers			
	Inner Layers:			
	Type of Metallic Wires	mm	*	
	Nominal Size of Wire	mm	*	
	Thickness of Aluminum-Cladding	mm	*	
	Nominal Diameter of the Wire	mm	*	

Ref. No.	Description	Unit	Specified Values	Vendor Proposed Values
	Minimum Breaking Strength of the Wire	kN	*	
	Nominal Diameter of Strand	mm	*	
	Directional of Lay Stranding		*	
	Nominal Length of Lay	mm	*	
	Type of Grease		Type A	
	Manufacturer Corrosion Protection Guarantee	Years	30	
	Outer Layers:			
	Type of Metallic Wires			
	Nominal Size of Wire	mm	*	
	Thickness of Aluminum Coati	mm	*	
	Nominal Diameter of the Wire	mm	*	
	Minimum Breaking Strength of the Wire	kN	*	
	Nominal Diameter of Strand	mm	*	
	Directional of Lay Stranding		*	
	Nominal Length of Lay	mm	*	
4.4	**Central Fiber Optical Unit**			
	Material Type		*	
4.4.3 (a)	Tube:		*	
	Thickness	mm	*	
4.4.3 (b)	Channel Rod or Spacer	mm	*	
	Diameter		*	
	Number of Grooves		*	
	Thermo-Resistant Type		*	
	Nominal Length of Lay	mm	*	
4.4.4	Filling Compound Type/Material		*	
	Structural Member Materials		*	

Ref. No.	Description	Unit	Specified Values	Vendor Proposed Values
4.5	**Single Mode Optical Fiber**			
	Type of Optical Fiber			
	Optical Fiber Operational:			
	Wavelength 1300/1550 nm for G.652D/G.655	nm	*	
	Wavelength 1383/1625 nm for G.652D/G.655	nm	*	
	Optical Fiber Material:			
	1. Germanium Doped Silica		*	
	2. Glass/Pure Silica Glass		*	
	Optical Fiber Material:			
	1. Silica/Doped Silica		*	
	Optical Fiber Mode Field Diameter	µm	*	
	Mode Field Eccentricity, Maximum	µm	*	
	Optical Fiber Cladding Material		*	
	Non-Circularity of Cladding	%	≤ 1	
4.6	**Specification of Single Mode Optical Fibers**			
	Optical Fiber Coating Material:		*	
	Primary Coat	mm	*	
	Secondary Coat	mm		
	Optical Fiber Coating Nominal Wall Thickness:			
	Primary Coat	mm	*	
	Secondary Coat	mm	*	
	Optical Fiber Coating Diameter (mm)	mm	*	
	Over Primary Coat	mm	*	
	Over Secondary Coat	mm	*	
	Optical Characteristics:			

Ref. No.	Description	Unit	Specified Values	Vendor Proposed Values
4.6.1	Maximum Optical Attenuation for G.652.D:			
	@ 1310 nm Wavelength (dB/km)	dB/km	*	
	@ 1383 nm Wavelength (dB/km)	dB/km	*	
	@ 1550 nm Wavelength (dB/km)	dB/km	*	
4.6.2	Maximum Optical Attenuation for G.655:			
	@ 1550 nm Wavelength (dB/km)	dB/km	*	
	@ 1625 nm Wavelength (dB/km)	dB/km	*	
	Polarization Mode Dispersion Coefficient (ps/√km)	ps/√km	≤ 0.2	
	Maximum Chromatic Dispersion:			
	@ 1310 nm	ps/nm/km	*	
	@ 1550 nm	ps/nm/km	*	
	Maximum Chromatic Dispersion:			
	@ 1550 nm	ps/nm/km	*	
	@ 1625 nm	ps/nm/km	*	
	Cut-off Wavelength	mm	*	
	Operational Characteristics:			
	Temperature Requirements w/o Optical Degradation		*	
	Nominal Operating Temperature (°C)	°C	*	
	Maximum Temperature Reached at Specified Fault Current Condition Inside the Optical Unit	°C	*	
	Maximum Temperature w/o Optical or Mechanical Degradation for 1 second minimum	°C	*	
	Maximum Optical Loss Variation at Temperature Range of -5°C to +150°C (dB/km).	°C	*	

Ref. No.	Description	Unit	Specified Values	Vendor Proposed Values
4.7	**Color Coding & Identification**			
	Color Coding of Each Fiber for a Group of Twelve (12) Fibers [additional group of twelve (12) fibers has the same sequence]			
	Fiber #1		Blue	
	Fiber #2		Yellow	
	Fiber #3		Green	
	Fiber #4		Red	
	Fiber #5		Violet	
	Fiber #6		White	
	Fiber #7		Orange	
	Fiber #8		Brown	
	Fiber #9		Gray	
	Fiber #10		Black	
	Fiber #11		Pink	
	Fiber #12		Aqua	
	Color Coding Group Identification/Ring Marking Group Identification		Color Coding/Ring Marking	
	Group # 1		Blue/1 Ring Mark (50mm apart)	
	Group # 2		Yellow/2 Ring Marks (50mm apart)	
	Group # 3		Green/3 Ring Marks (50mm apart)	
	Group # 4		Red/4 Ring Marks (50mm apart)	

Ref. No.	Description	Unit	Specified Values	Vendor Proposed Values
	Group # 5		Violet/1 Ring Mark (100mm apart)	
	Group # 6		White/2 Ring Marks (100mm apart)	
	Group # 7		Orange/3 Ring Marks (100mm apart)	
	Group # 8		Brown/4 Ring Marks (100mm apart)	
4.8	**Composite OPGW**			
	Maximum Tension that can be applied on Composite OPGW w/o Optical or Mechanical Degradation	kN	28/48	
	Minimum Bending Radius of Composite OPGW	mm	*	
	Cross Sectional Area of Metallic Part	mm^2	*	
	Maximum Nominal Diameter of Composite OPGW (mm)	mm	14.9/17.9	
	Minimum Rated Tensile Strength	kN	70/120	
	Fault Current for 1 second at 55°C Initial Conductor Temperature	kA	*	
	Maximum Temperature Attained Following a Rated Short Circuit Current for 0.30 second Fault Duration:		*	
	a. Strand (°C)	°C	*	
	b. Optical Unit (°C)	°C	*	
	c. Resistance (Ω)	Ohm(Ω)	*	
6.0	**TESTS**		*	
	Optional or Special Test requirements (If any)		*	
7.0	**PACKING AND SHIPPING**			

Ref. No.	Description	Unit	Specified Values	Vendor Proposed Values
	Drum Type		Non-Returnable	
	Length of OPGW	m	4,000 m, ±5%	
	Dimensions	m	*	
	Gross Weight	kg	*	
	Net Weight	kg	*	
	Marking as per the Specification		Yes	
	Sag-Tension and Stress-Strain Data along with Sag Chart No.		*	
8.0	**OTHERS**			
	Product is Type Tested		Yes	
	SEC Approved Laboratory		*	
	Date Tested		*	
	Manufacturer		*	
	Country of Origin		*	
	All submittals as per the Specification		Yes	

(*) – Values to be provided/proposed by the Vendor.

(**) – Please provide explanation for deviations, if any.

11.0 TECHNICAL DATA SCHEDULE

Table 6: OPTICAL GROUND WIRE (OPGW)

SEC Inquiry No: _____ Item No: _____

A. ADDITIONAL TECHNICAL INFORMATION FEATURE TO BE FURNISHED BY SEC:

B. ADDITIONAL SUPPLEMENTARY DATA OR FEATURES PROPOSED BY BIDDERS/SUPPLIER/CONTRACTOR:

C. OTHER PARTICULARS TO BE FILLED UP BY BIDDER/VENDOR/SUPPLIER/CONTRACTOR:

D. LIST OF DEVIATIONS AND CLAUSES TO WHICH EXCEPTION IS TAKEN BY THE BIDDER/VENDOR/SUPPLIER (USE SEPARATE SHEET, IF NECESSARY)

Description	Manufacturer of Material/Equipment	Vendor/Supplier
Name Of Company		
Location and Office Address		
Name & Signature of Authorized Representative with Date		
Official Seal/Stamp with Date		