Rural Electrification and Renewable Energy Corporation. Specifications for Optic Ground Wire (OPGW) for Manda Island Ocean Strait Crossing

1.0 GENERAL

This specification lays down minimum requirements for cable termination and jointing kits.

It shall be the responsibility of the manufacturer to ensure adequacy of the design and good engineering practice in the manufacture of the cable termination and jointing kits. The manufacturer shall submit information which confirms satisfactory service experience with products which fall within the scope of this specification

The telecommunication media shall provide the means for transportation of information from points of origin to various destinations. The information to be carried by the telecommunication media for the power transmission network shall comprise:

- Data Communication between RTUs and SCADA/EMS at NPCC.
- Operational telephony.
- Tele-protection signaling.

This Specification covers the design, manufacture, factory testing, supply, installation, site testing, type testing and commissioning of OPGW needed to implement the above mentioned requirements.

The proposed OPGW optical cable shall be 48 core Single Mode fiber type in conformity with recommendations ITU-T G.655C to be installed on the 132kV transmission line in the coastal environment of Kenya. The cable shall be designed to withstand the varying operating and environmental conditions that the cable shall experience while in service. The exact transmission line details shall be collected by the Contractor during survey.

The cable shall meet both the construction and performance requirements such that the ground wire function, the optical fiber integrity and optical transmission characteristics are suitable for the intended purpose and be in conformity with the requirements of International Standard IEEE 1138-2021 - IEEE Standard for Testing and Performance of Optical Ground Wire (OPGW) for use on Electric Utility Power Lines.

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The OPGW shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy/stainless steel with aluminium coating protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single buffer tube or directly in central fibre optic unit is NOT ACCEPTABLE. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fiber. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay.

2.0 STANDARDS

Standards included in this section shall in general conform to the following list. The bidder may propose alternative codes and standards provided it is proven that it gives an equivalent degree of quality as the referenced codes and standards.

2.1 OPGW and Fiber Optic Cable

Unless otherwise specified herein, the cable shall be designed and manufactured in accordance with the latest revisions of the following standards or equivalent as approved by the Engineer.

- IEC 61232 Aluminum-clad steel wires for electrical purposes.
- IEC 61089 Round wire concentric lay overhead electrical stranded conductors.
- IEC 60793-1 Part-1 Optical Fiber, generic specification, measurement and test.
- IEC 60793-2 Part-2 Optical Fiber Cable Product Specification.
- IEC 60793-4 Part-4 Sectional Specification-Aerial optical cables along electrical power lines.
- IEC 60793-4-10 Part 4-10 Aerial optical cables along electrical power lines – Family specification for OPGW (Optical Ground Wire).
- IEC 60794-2 Part-2 Optical Fiber Cable Product Specification.
- ITU-T G.655C Characteristics of a non-zero dispersion-shifted single-mode optical fiber and cable
- IEC 61328 Guidelines for installation of transmission line conductor and earth wires.

- ASTM B 415, B 416 Standard Specifications for Hard-Drawn Aluminum-Clad Steel Wires
- ASTM B 398 Standard Specification for Aluminum-Alloy6201-T81 Wire for Electrical Purposes
- IEEE Std 1138 Construction of Composite Fiber Optic Overhead Ground Wire (OPGW) for use on Electric Utility Power Lines
- IEC 68-2-14 Joint Boxes/Hardware Fittings
- IEC 61300-2-36 Fiber Optic Interconnection Devices &Passive component-Basic Test and Measurement Procedures – Part 2-36:Tests-Flammability (Fire Hazards)

3. Optical Fiber Ground Wire (OPGW)

3.1. Material and Workmanship

The material(s) used for the manufacture of the OPGW shall be of highest grade free from defects and imperfections conforming to the requirements of the latest issue of the relevant standards.

The materials used shall be:

- Aluminum clad steel (ACS) and/or,
- Aluminum alloy (AA) wires for outer conducting layer (armor) and inner conducting layer (if additional layer is used).
- Glass .
- Metallic buffer tubes.
- Moisture proof and hydrogen absorbent gel.

Proper arrangement shall be made for the provision of highly corrosion prevention material and suitable filling compounds as hydrogen absorbing gel in the offered OPGW. The bidder shall provide details in this regard as the material being procured for coastal area.

3.2. Construction

The OPGW shall comprise:-

- A fiber optic unit designed to house and protect the optical from damage to forces such as crushing, bending, twisting, tensile stress and moisture.
- An outer metallic part (armor) designed to function as the conventional shield wire and to protect additionally, the fiber optic unit.

The fiber optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibers from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault currents as well as environmental effects that may produce hydrogen.

3.3. Fiber optic unit

The optical fibers shall be comprise of buffer tube made of appropriate material to withstand temperatures of 200°C under short-circuit current without continuous degradation. The buffer tubes shall not be on the outer layer in order to be protected from external mechanical forces and electrical disturbances. Inside the buffer tube, these fibers shall be loosely housed in a waterproof gel to prevent water penetration and protection against friction.

OPGW comprising of single SS buffer tube with aluminum cladding and housing all required number of fibers; however more plastic buffer tube can be housed in the buffer tube surrounded with thermal barrier (if applicable). The maximum number of fibers in one Plastic tube shall not be more than eight (8). Each fiber in a tube shall be distinguishable from other fibers in the same tube by means of color coding in accordance with EIA-598A.

3.4. Stranded metallic wires (armor).

The OPGW shall be stranded with Aluminum-Clad Steel wires (ACS).However, if more than one layer is used, Aluminum-Alloy (AA) may be used in the outer layer.

The basic construction shall have bare concentric lay stranded metallic wires. The stranded wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay shall be reversed in successive layers.

The wires shall be stranded such that when the OPGW cable is cut the individual wires can be regrouped and held in place.

3.5. Sag and tension limits.

Physical design of the proposed OPGW for installation on new overhead transmission lines shall have sag and tension characteristics similar to the 9.15mm diameter, extra high strength, 7 strands, and galvanized steel overhead shield wire for the spans.

3.6. Cable characteristics

From the environmental point of view, the OPGW will be exposed to a harsh environment that needs to be taken into consideration:

Max. Outdoor summer temperature: +70°C
Max. Summer relative humidity: approaching 100%
Sand and wind storms.
The Contractor shall take these atmospheric constraints into account to guarantee 25-30 years of bservice life for OPGW cable. In this respect, the Contractor shall provide type test certificates proving that cable comply with IEC accelerated aging test in the above conditions.

The main features of the cable shall be:

Number of cores:	48
Outer diameter:	< 18mm nominal
Rated Tensile Strength:	> 85kN
Short circuit current for 1 sec:	> 25kA for temp. rise from 20-200 deg C
DC resistance at 20°C:	< 1.264 ohm/km
Minimum bending radius (without fiber damage):	< 200mm
Nominal weight:	<460kg/km

3.7. Fiber characteristics

The main features of the optical fiber shall be as follows:-

- fiber type: non-zero dispersion-shifted single mode according to ITU-T G.655

- wavelength: 1310nm and 1550nm
- max. attenuation: ≤ 0.35dB/km at 1310nm
- ≤ 0.20 dB/km at 1550nm
- max. splicing loss: 0.1 dB
- max. end-connector loss: 0.5dB
- Core diameter: 9/10μm ± 0.5μm
- cladding diameter: 125μm ± 2μm
- max. concentricity error: 1μm
- max. cladding non-circularity: 2%
- max. chromatic dispersion: 4ps/nm.km at 1310nm
- 20ps/nm.kmat 1550nm
- cut-off wavelength: < 1270nm
- mode field diameter: 8.6-9.5μm+ 0.6
- Operational temperature range. -10 to +70°C

Inside the buffer tube the reserve length of the cores shall be at least 0.45% against the linear length of the complete OPGW to prevent them from coming under stress. To prove this, a sample of at least 80m shall be pulled up to endurance tensile strength while a continuous optical measurement of fiber length and attenuation is done simultaneously.

4. Live Line Installation of OPGW

4.1.1. Installation

The live line installation of OPGW shall be accomplished by the following procedure if required:

Initial Preparation

Installation of supporting rollers/guide rope and mobile unit.

OPGW stringing

Turnover and sagging

Retrieval of support rollers, ropes, mobile unit and the existing ground wire.

Jointing and testing

The Contractor shall arrange all the installation equipment/material for the live line installation. This shall include but not be limited to;

Guide rope

Pulling rope

Recovery mechanism

Mobile unit

Tools and measuring equipment

The above materials shall be under the Contractor's ownership and maybe taken back after completion of the contract.

4.1.2. Safety and Security

The Contractor shall ensure that all arrangements for safety and security of personnel and equipment are in place before start of installation. In particular, the following measures shall be taken:

Working conditions on tower and ground shall be fully investigated.

Safety gadgets for the personnel shall be made available.

Warning flags shall be fixed.

Electrical grounding shall be ensured.

Clearance between live line and installation equipment shall be ensured at all times.

Safety evaluation shall be made by simulation of.

Electrostatic induction

Electromagnetic induction

Dry band arcing

Dynamic sag/tension during installation.

4.2. Joint Boxes

Joint boxes shall be provided to protect splices from all construction and working stresses likely to deteriorate their characteristics. Attachment of OPGW or Fiber optic approach cable (FOC) ends to joint box shall also be ensured. Operating temperature range shall be -10° to +70°C.

Weather-proof units of protection Class IP65 made of highly non corrosive Aluminum alloy or stainless steel shall be provided. The joint boxes shall include all necessary hardware to terminate, protect and fix the spliced. A name plate giving important information shall be attached to the joint box. This name shall have embossed characters and shall be made of weather proof material.

4.3. Types of joint boxes:-

Type A: Joint boxes on OHL used to connect two sections of OPGW anchored on a tower. These will be installed in about middle portion of towers or portal structure along their body. A spare fiber length (approx.1.5m) shall be left inside so as to be able to remake a faulty splice.

Type B: Terminal joint boxes on OHL used to connect the optical fiber of OPGW to underground approach fiber optic cable (FOC) within the substation.

Type C: Joint boxes on OHL used to connect two sections of OPGW fibers with provision for connection to two underground fiber optic cables (supplied by others). These will be installed at a suitable height of the support structure (tower/gantry). A spare fiber length (approx. 1.5m) shall be left inside so as to be able to remake a faulty splice.

Type D: Terminal joint boxes on OHL used to connect the optical fibers of OPGW to Fiber optic approach cable (FOC) (supplied by others) within the substation. These shall be similar to above type except for the connection arrangement shown in Annex TS-4.7.4.

The Contractor shall also design and supply the supporting devices made of galvanized steel to install joint boxes on the galvanized steel towers/terminal structures. For the purpose of designing the supporting devices the Employer, after award of Contract shall supply to the Contractor one copy of relevant drawings of steel towers/structures (where the devices are to be installed). Fasteners for installation of the supporting devices on the towers/terminal structures and the joint boxes on the supporting devices shall also be supplied by the Contractor. Design and materials of the supporting devices are subject to approval of the Engineer. Galvanizing on the structural steel shapes of supporting device shall conform to ASTM A123 latest edition with average weight of zinc coating as 610gm/m2 and on the fasteners shall conform to ASTM A153 (latest edition) with average weight of zinc coating as 305gm/m2. One supporting device for each joint box will be supplied.

5. Hardware and Fittings for OPGW

5.1. General

All hardware & fittings shall be designed in such a way that no degradation of the optical transmission of the wire will occur under all service conditions. The optical fiber shall be freely moveable in the wire under service load. Separable

5.2. Tension assembly.

The tension assembly shall consist of a line guard and a pre-formed dead end which is placed on the line guard. The line guard shall be laid in the opposite direction of the outer layer of the OPGW and the dead end must be laid in the opposite direction of the line guard. The length of line guard shall be sufficient to install vibration dampers, if necessary. It shall protect the OPGW against concentrated radial forces in the region of contact between the dead end and the OPGW. All helical rods shall be made of ACS.

The distance from the centre of the take-off hole to the edge of the plate will be 32mm. The thickness of the strain plate will be 16mm.The assembly shall have provisions for attachment of pulling fittings for erection and maintenance.

The assembly shall be free to swing so that the clevis will stay in line with the OPGW when the OPGW approaches the tower at any horizontal angle within $\pm 30°$ from the longitudinal

direction of the transmission line and at any vertical angle between the horizontal and 20° below the horizontal.

The general arrangement of tension assemblies for single and double tension set for OPGW are given in Annex TS-4.7.5 a) and b).

5.3. Suspension Assembly

At suspension points, armor grip suspensions must be used exclusively. The clamp body shall be of Aluminum alloy, which shall preferably be forged. The rod material shall be drawn Aluminum alloy.

The assembly of the suspension clamp and its hanger shall be able to swing freely in both the longitudinal and transverse directions up to an angle of 70° with the vertical.

The general arrangement for suspension set for OPGW is given in Annex TS-4.7.5 c).

5.4. Vibration dampers

The OPGW shall be protected from Aeolian vibrations. For this purpose the Contractor shall conduct a vibration study based on the self-damping measurements of offered OPGW, span length distribution, height of OPGW above ground level, local atmospheric condition (i.e. wind velocities, temperatures etc.), topography and design tension limits and shall calculate and recommend the number, type and locations of vibration dampers for different span sizes.

The vibration dampers shall be of the stock bridge type having clamp compressed or cast onto the steel messenger wire between the weights. Damper weights shall not be cast on the messenger strand. All ferrous components shall be protected by zinc coating and shall be according to ASTM A153 and ASTM A239 (latest edition). The damper clamp shall be designed in such a manner that moisture cannot accumulate anywhere in the damper. Each damper weight shall be provided with drain hole. Break away bolts shall be provided for the dampers.

5.5. OPGW attachment clamps

Attachment clamps to hold the OPGW to the tower at splicing locations shall be made of hot dip galvanized steel to standards of Saline environment with humidity reaching 100%.

6. Underground Fiber Optic Cable

6.1. General

The fiber optic cable shall be designed to withstand all prevalent environmental conditions including the effects of high electric and magnetic fields produced in proximity of live power cables.

A service life of at least 25 years is required, and test evidence to support Supplier's claim in this respect shall be submitted with the bid.

6.2. Cable type

The fiber optic cable shall be of the single mode type equipped with at least 48 complying with ITU-T recommendation G.655 and shall be suitable for underground installation and laying in trenches/cable trays.

6.3. Fiber optic cable requirements

Water-tightness.

The cable shall be fully moisture-resistant and meet the longitudinal water-tightness test requirements.

Electrical withstand

Considering there is a potential danger through fault or leakage currents, the cable must be non-metallic.

Mechanical withstand

The cable shall suitably withstand the mechanical radial stresses and shall be protected against rodents and termites. The crush resistance shall be at least 2kN/10cm.

Temperature withstand

The operating temperature range shall be 0 to +70°C and the cable shall be suitable for operation in tropical climate with humidity approaching 100%.

6.4. Fiber characteristics

Identical to those given in section g) "Cable characteristics"

6.5. Cable construction

A loose tube, minimum strain configuration, which provides protection from external forces and possesses high tensile strength/resistance to crushing, shall be supplied. The fibers shall lie loosely inside plastic tubes filled with a gel to protect the fibers from the ingress and propagation of moisture. The maximum number of fibers inside any one tube shall be 8. Each tube and fiber shall be color coded to be distinguishable from the other.

The cable construction shall comprise a dielectric central strength member surrounded by loose buffer tubes and fillers covered by moisture-resistant wrapping. The interstices among the loose tubes shall be filled with water blocking jelly compound. The wrapping shall be covered with thermoplastic sheath surrounded by aramid or glass yarn reinforcement. Anti-rodent protection shall be applied around the reinforcement layer by means of glass tape. The outer jacket of the cable shall be made of rugged non-metallic material of thickness not less than 1.5mm and covered with anti-termite coating.

Full constructional details of the cable offered shall be submitted with the bid.

6.6. Ending rules

After factory acceptance, the inner end of the cable shall be fitted with an end cap to ensure water-tightness; the outer end shall be fitted with a water-tight head compatible with cable pulling. Caps (material and implementation) shall comply with applicable standards. They shall not be removed until immediately prior to optical jointing.

6.7. Cable installation

The fiber optic cable shall be laid in a buried 100mm PVC duct from/to the terminal joint boxes. However within building premises it shall be laid in a flexible duct on cable trays. Drawings showing the installation details shall be submitted to the Engineer/Employer for approval.

Any damage to the cable which is laid and exposed but not protected and during installation shall be made good by the Contractor at his expense and to the satisfaction of the Engineer/Employer.

For buried PVC duct, a trench 0.5 m wide x 1m deep shall be excavated with provision of manholes at every 1km distance for cable pulling and future maintenance.

PVC duct shall be laid on a sand bed of at least 100mm thickness and shall be covered by sand layer of 300mm thick

A cable warning tape shall be placed on the top of sand layer. It shall be bright yellow in color and of plastic material 300 mm wide by 0.1mmthick shall be supplied. The tape shall be continuously and indelibly marked in English with the words:

CAUTION
FIBRE OPTIC CABLE 700 mm BELOW

The lettering shall be black on yellow.

The excavated material shall be used for the remaining back filling of the trench.

The openings to the ducts shall be closed with a suitable compound after the cable has been laid. A 10m loop shall be kept in manholes.

6.8. Cable Drums

Fiber optic cables shall be delivered on drums of wooden reels. The lengths of the cable drums shall be such that intermediate jointing is kept to a minimum on any of the cable routes. The minimum drum length shall be 3000m.

6.9. Labeling

All cables and cable ends should be labeled clearly in accordance with the specification. The meter run should be marked on the outer sheath. This speeds up localization of faults which are detected during calibration of cable.

Drums shall be fitted with securely attached, unalterable identification plate bearing the following information:
Employer's name,

- Supplier's name,
- Contract number,
- Content (including drum no.),
- Manufacturing date,
- Length of cable on drum,
- Direction of rotation of the drum,
- Position of the cable nose,
- Weight of drum.

6.10. Storage and Transport

The permissible mechanical stress values (tensile force, bending radius)shall be adhered to during transport and storage. The barrel diameter of the shipping drums shall be at least 30 times the outer diameter of the cable, but not less than 400 mm.

The transportation and storage shall not be done in conditions exceeding the permissible temperature limits.

6.11. Joint Box

Joint boxes shall be provided to protect the splices and shall be suitable for underground installation in harsh environment. The units shall be weather-proof type of protection Class IP65 made of non-corrosive Aluminum alloy or similar material. All necessary hardware to terminate, protect and fix 48 no. spliced shall be included. The cover shall be provided with a long life neoprene gasket to provide a seal against moisture and dust. The cable inlets shall be similarly sealed. Entry for four cables shall be available. A name plate giving important information shall be attached to the joint box. This name shall have embossed characters and shall be made of

weather proof material. Operating temperature range shall be 0 to + 70°C and relative humidity range 5-95%.

7. Factory Tests on OPGW

7.1. General:

Test for OPGW shall be mainly on functional basis and shall include factory and Sites Tests.

All Telecom equipment/component shall be tested in the manufacturer's works. The contractor shall be required to carry out any one or the entire test stated in this specification under witness of Engineer/Employer. Any other test that the Engineer/Employer desire to performed shall be added to the factory and Site Protocol

Testing of the OPGW stated herein shall be performed in line with this specification and in accordance with the relevant Standards. Where no appropriate standard is available, test shall be available, subject to the approval of Engineer /Employer.

Acceptance by Engineer/Employer of any equipment shall not relieve the Contractor/Manufacturer from any of his contractual obligations.

Engineer/Employer reserves the right to perform the checks during manufacturing process at any time. It shall be at the discretion of the Engineer/Employer to witness test on 100 %, or any percentage quantity of each lot for routine test, apart from the type test, wherever called for.

7.1.1. Type tests

OPGW shall successfully pass the following tests based on the requirements of IEEE 1138-1994, unless otherwise stated.

Short circuit test.

The cable shall be subjected to the short circuit test as described in IEEE 1138-1994. An increase in attenuation greater than 1.0dB/km at1550 nm shall constitute a failure. Bridging or breaking of the strands shall also constitute a failure. The maximum temperature attained during short circuit testing shall not exceed 200°C.

Aeolian vibration test

The cable shall be subject to the Aeolian vibration test described in IEEE 1138-1994. An increase in attenuation greater than 1.0dB/km at1550 nm shall constitute failure.

Galloping test

The cable shall be subjected to galloping test described in IEEE 1138-1994. An increase in attenuation greater than 1.0dB/km at 1550nm shall constitute failure.

Sheave wheel test

The cable shall be subjected to a sheave wheel test as described in IEEE1138-1994. Any significant damage to the OPGW core or strands in excess of 0.50mm shall constitute failure. An increase in attenuation greater than 1.0dB/km at 1550nm shall also constitute failure.

Crush test

The cable shall be subjected to a crush load of 1750N/cm without significant damage to the optical core. The cable shall be tested in accordance with IEEE 1138-1994. An increase in attenuation greater than 0.10dB/km at 1550nm shall constitute failure.

Impact test

The cable shall be subjected to an impact test as described in IEEE 1138-1994. An increase in attenuation greater than 0.10dB/km at1550nm shall constitute failure.

Creep test

The cable shall be subjected to creep test as described in IEEE 1138-1994.

Strain margin test

A strain margin test shall be conducted on the cable to determine the amount of strain that the cable can withstand without placing strain on the optical fiber. The test shall be conducted as described in IEEE 1138-1994. Any significant fiber strain below 50% of the cable's rated breaking strength shall constitute failure. The strain margin shall be above 50% of the cable's rated breaking strength. The strain margin is defined as the point at which the fiber strains at the same rate as the cable

Temperature cycling test

The cable shall be subjected to a temperature cycling test as described in IEEE 1138-1994. An attenuation change greater than 0.2dB/km at1310nm and 1550nm shall constitute failure.

The bidder shall submit certified copies of type test certificates/reports covering the above Telecom requirement from the NTDC approved International laboratories.

Type tests certificates/reports shall be considered acceptable if they are in compliance with the relevant Standards and the following:

- Type Tests conducted at an internationally recognized laboratory listed below.
- Type Tests conducted at the manufacturer's laboratory and witnessed by representatives from an internationally recognized laboratory listed below.

Failure to provide the certificates or if the presented type test reports are not in accordance with the above requirements, then the type tests shall be carried out with no additional cost in the Manufacturer's premises or at NTDC approved labs in the presence of Engineer/Employer and in the presence of a representative of NTDC approved labs which should issue the relevant type test certificates upon successful tests. No additional cost shall be paid for the type test in case of failure to provide the type test certificate.

7.1.2. Routine tests

The following tests shall at least be performed. The Contractor shall indicate the standards accordingly which shall be internationally acceptable (i.e. IEEE, IEC, ASTM, DIN, BS...). In case OPGW is of special design, the Contractor shall attach tests of similar design. The tests to be performed are:

Tensile test:

With indicated over length of fiber and simultaneously measured attenuation at 1310nm and 1550nm.

Bending test:

Similar to DIN VDE 0472 Teil 232; the bending radius shall be 25xouter diameter of OPGW and the test shall be carried out successfully if the attenuation of the straightened fiber is within the fiber standards limits.

Water penetration test (tube):

Similar to DIN VDE 0472 Teil 811test shall be successful, if no water is visible at the end of the tube after a period of 24 hours.

- Attenuation test using OTDR.
- Chromatic Dispersion test.
- Geometry tests.

In addition, the Contractor shall carry out tests of the single wires according to one of the above mentioned standards. For parts of the OPGW that are greased, the Contractor shall attach data sheets of the grease.

7.1.3. Site Tests for OPGW.

7.1.3.1. General

Testing of the OPGW on site will be carried out as per following schedule. Any micro bend, irregularity or any other defect found during testing shall constitute failure.

7.1.3.2. Testing of OPGW on receipt at Site.

The following test shall be carried out by the supplier/contractor for each individual fiber on each drum. Any defect found in the fiber shall constitute failure of the whole OPGW cable drum.

- OTDR test
- Attenuation test

The Contractor shall depute a competent person for carrying out the above tests . This testing shall also witness by the NTDC representative.

7.1.3.3. Testing of OPGW after installation

- OTDR test of each fiber for each of the individual section of OPGW laid before splicing of to join two sections.
- Splicing loss of all at the intermediate jointing locations.
- End to end testing of all (to be done from both ends)consisting of:

- OTDR test
- Attenuation loss measurement for all fibers.
- Measurement of length of OPGW/Continuity test.

7.1.4. Tests on Hardware Fittings.

7.1.4.1. Type Tests

Type tests are intended to verify and establish design characteristics. The tests shall be made once only on hardware identical in all essential details with those to be supplied.

The type tests to be performed on the OPGW hardware fittings shall include at least the following:

- Mechanical test; on each item of hardware.
- Resistance to conductor slippage test; on suspension clamps and tension sets.
- Vertical fatigue test; the stock bridge damper shall be installed on a shaker at the recommended torque and vibrated at the highest resonance frequency with an amplitude of ± 1mm. The test shall be continued for 10 million cycles. After the test no breakage of any part shall occur and the torque on the bolt is not less than 60% of the recommended value of the torque.

7.1.4.2. b) Routine Tests

Tests shall be made to verify the quality and workmanship. The routine tests to be performed shall be:

- On all items of hardware:
- Visual examination. Verification of dimensions.
- Mechanical tests.

  On suspension clamps and tension sets.
- Resistance to OPGW slippage test
- Galvanizing test - On all ferrous parts.

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8. TEST EQUIPMENT, INSTALLATION AND MAINTENANCE TOOLS.

The bidder shall provide details of all the test equipment, installation and maintenance tools being supplied that shall include, as a minimum, the following:

1. Optical Time Domain Reflect meter (OTDR), preferably having coverage range of at least 400 km with OTDR and OTS modules (1310/1550nm), colored screen, software and all accessories including AC cord/adapter, rechargeable batteries, battery charger, carrying case etc.

2. Fiber Optic Splicing Unit type Sumitomo FSM-50 or equivalent with alignment tools (fiber cleaver etc.) and all accessories including spare electrodes, AC cord/adapter, rechargeable batteries, battery charger, splice tray holder, work lamp, carrying case etc.

3. Fiber Optic Toolkit including:

- Stripper for 0.9 mm tight secondary coated and for 250 μm primary coated fibers. 1 pc
- Stripper for buffer tubes and cord-type fiber optic cables 1 pc
- Cutting tool for the core of OPGW 1 pc
- Fiber holder for stripping optical fibers 1 pc
- High-precision cleaving tool 1 pc
- Cleaning tissues, 200pcs/pack 1 pack
- Cotton sticks for cleaning the V-grooves of a fusion splicer, 100pcs/pack 1 pack
- Acetone, 300ml/bottle 1 pc
- Moistener bottle for acetone 1 pc
- Air blast, Dust-off 1 pc
- Tweezers for handling optical 1 pc
- Microscope 30X with universal connector adapter 1 pc
- Cleaning cassette for fiber optic connectors 1 pc
- Self-adhesive warning label "FIBRE OPTIC CABLE" Size 185mm
- x 15mm, 120pcs/pack 1 pack
- Number tape set with replacement rolls of numbers 0-9 1 set
- Rugged carrying case 1 pc

4. Instruction/specification manuals of tools and test equipment (in English language).

5. Service Engineer's tool kit for telecom equipment. 1 set.

6. Equipment for SDH, Multiplexer and Data Link Measurements including accessories.

7. Additional recommended tools shall be listed and described separately.