

**POWER TRANSMISSION
CORPORATION OF UTTARAKHAND
LIMITED**

**TECHNICAL SPECIFICATIONS
FOR
*SUPPLY & ERECTION OF OPGW AND ASSOCIATED
HARDWARES***

SECTION-I SCOPE OF WORK

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Section 1

1.1 Scope

The scope of of this specification includes Design, engineering, manufacturing, testing, demonstration for acceptance, documentation, supply of OPGW and associated hardware & fittings and In-line Splices, loading, transportation, unloading, transit insurance and delivery at site and erection of the same on the following transmission line:

1	220KV Khodri-Rishikesh line	79.6 Km.
2	220KV Rishikesh-SIDCUL-Roorkee	51.3 Km.
3	220KV Kashipur-Berhani-Haldwani line	61.71 Km.
4	132KV Rishikesh-Srinagar	78.38 Km.
5	132KV Pantnagar-Rudrapur line	7.6 Km.
6	132KV Rudrapur-Kichha line	20.3 Km.
7	132KV Kichha-Sitarganj line	32.1 Km.
8	132KV Haldwani-Bhowali	14.05 Km.
9	132KV Bhowali-Almora line	31.04 Km.
10	132 KV Almora-Pithoragarh line	76.6 Km.
11	132 KV Kashipur-Bajpur line	15.6 Km.
	Total length	468.28 Km.

1.2 General Requirements

This specification defines the design, performance and testing requirements for supply of OPGW cable & its associated hardware & fittings.

The Contractor is encouraged to offer standard products and designs. However, the Contractor must conform to the requirements and provide any special equipment necessary to meet the requirements stated herein.

The Bidder's proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation in order to determine compliance with this specification without further necessity for inquiries.

The Bidder's proposal shall clearly identify all features described in the specifications or in any supporting reference material that will not be implemented; otherwise, those features shall become binding as part of the final contract.

An analysis of the functional and performance requirements of this specification and/or design, and engineering may lead the Contractor to conclude that additional items (hardware/software) are required that are not specifically mentioned in this specification. The Contractor shall be responsible for providing at no added cost to the Employer, all such additional items. Such materials shall be considered to be within the scope of the contract. To the extent possible, the Bidders shall identify and include all such additional

items (hardware/ software) in their proposal.

OPGW cable & associated hardware & fittings shall be designed to operate in varying environments. Adequate measures shall be taken to provide protection against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration and electro-magnetic interference etc.

The Contractor shall demonstrate a specified level of performance of the OPGW cable & associated hardware & fittings during well structured factory tests.

1.3 General Responsibilities And Obligations

This section describes the general responsibilities and obligations of the Contractor and the Employer.

1.3.1 Responsibilities for the Implementation Plan

The Bidder's technical proposal shall include a project implementation plan and schedule that is consistent with the implementation plan detailed in the technical specification . The Implementation plan shall include the activities of both the Contractor and the Employer, showing all key milestones and clearly identifying the nature of all information and project support expected from the Employer. The Employer and Contractor shall finalise the detailed Implementation plan following award of the contract.

The contractor shall be responsible for collecting the tower & the transmission line details for the proposed fibre optic links required for cable designing & tower structural analysis. A tower structural analysis shall be carried out by the Contractor to ensure that with the replacement of existing earth wire with the OPGW cable, the tower members remain within the statutory safety limits as per Indian Electricity rules and if required the Contractor shall carry out the tower strengthening as necessary. The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exception circumstances, and on Employer specific approval, cable may be terminated on Suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor.

1.3.2 Contractor Responsibilities and Obligations

The Contractor shall be responsible for design, engineering, manufacturing, testing, demonstration for acceptance, documentation, supply of OPGW and associated hardware & fittings and In-line Splices, loading, transportation, unloading, transit insurance, delivery at site for supply of OPGW cable & its associated hardware & fittings and erection .

The Contractor's obligations include, but are not limited to, the following:

(1)Provide OPGW cabling that meets the functional and performance requirements of this specification.

(2)Engineering and design specific to each location including review of, and conformance with local environmental and earthing requirements.

(3)Testing and documentation for OPGW cable & its associated hardware & fittings.

(4)Project management, project scheduling, including monthly project reports documenting progress during the contract period.

(5) Studies necessary to identify and provide OPGW cable.

(6) Suitability for OPGW cable for live line installation

(7)Design of the mechanical assemblies and accessories, including vibration dampers required for installation of all overhead fibre cable.

(8) Factory acceptance testing of all equipment provided.

(9)Conduct type tests and provide documented evidence of satisfactory Type Test performance to the Employer.

(10)Provide a Quality Assurance Plan ensuring the Employer access to the manufacturing process.

(11)Shipment of all equipment and documentation to the Employer designated locations and/or staging areas.

(12) All documentation and drawings as specified.

(13) Collection of tower and transmission line details for proposed fibre optic links required for cable designing and tower structural analysis.

(14) Sag tension calculation of OPGW to match with the sag tension characteristic of existing earth wire.

(15) Reanalysing and restrengthening of existing tower for fitment of OPGW if required.

(16) As the owner has no design available of existing towers, contractor has to check the loading of existing tower and accordingly strength the tower peak or increase the height of tower peak. All material and erection of tower will be in contractor's scope.

Detailed descriptions of the Contractor's obligations, in relation to individual items of hardware, software, functions and services, are delineated in other sections of this specification.

1.3.3 The Employer Responsibilities and Obligations

The Employer will provide the following items and services as part of the procurement Project:

(1)Review and approval of the Contractor's designs, drawings, and recommendations.

(2)Review and approval of test procedures.

(3) Participation in and approval of Type test and factory acceptance tests.

(4) Providing support and access to facilities at the sites.

1.4 General Bidding Requirements

The Bidder shall be responsive to the Employer's technical requirements as set forth in this specification. To be considered responsive, the Bidder's proposal shall include the following:

(1)The Technical Proposal including the documents listed in the table 1-1: Bid Documents Checklist shall be provided in the bid.

(2)A detailed project implementation plan and schedule that is consistent with the scope of the project and Employer's specified objectives. The plan shall include the activities of both the Contractor and Employer, show all key milestones, and clearly identify the nature of all information and project support to be provided by Employer. Manpower resources proposed to be deployed by the Contractor during the implementation shall be clearly indicated.

Table 1-1;

Bid Documents Checklist

S.No.	Description:	Enclosure Reference	
1	Type Test Certificates for OPGW cable & its associated hardware & fittings (As per relevant Sections of Technical Specs Volume II)	Page no. Ref no.	
2	Completed Data Requirement Sheets (As per relevant Sections of Technical Spec Volume II)	Page no. Ref no.	
3	Quality Assurance Program (As per relevant Sections of Technical Specs Volume II)	Page no. Ref no.	
4	Detailed Project Implementation Plan (As per relevant Sections of Technical Specs Volume II)	Page no. Ref no.	

1.5 Organization Of The Technical Specification Document

Sections 2 through 5 and appendices A through C provides the technical & implementation requirements of the Package.

Section 2 contains the hardware description and specifications for the fibre optic cable .

Section 3 contains the inspection and test requirements.

Section 4 contains the documentation requirements

Section 5 describes project management and implementation requirements.

Appendix A – General requirements, Implementation Schedule and BoQ
Appendix B – Type test/FAT procedure
Appendix C - Data Requirement Sheets

1.6 Applicable Standards

The following standards and codes shall be generally applicable to the equipment and works supplied under this Contract:

- (1) American Society for Testing and Materials ASTM-B415, ASTM-D1248, ASTM D 3349.
- (2) ITU-T/CCITT Recommendations G.650, G.652, G.653, G.655
- (3) Institute of Electrical and Electronics Engineers IEEE-812, 1138-1994, IEEE-524, IEEE-828 & 830.
- (4) Electronic Industries Association, EIA-455-3, 455-31B, 455-32, 455-91, 455-78, 455-59, 455-80, 455-169, 455-81, EIA RS 598
- (5) International Electrotechnical Commission standards, IEC -1396 and IEC - 1089.
- (6) International Electrotechnical Commission standards, IEC 793-1, 793-2, 794-1, 794-2, IEC-529, , IEC 60794-1-2 , IEC 60794-4-10

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer's written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

1.7 References

- (1) CIGRE Guide for Planning of Power Utility Digital Communications Networks
- (2) CIGRE Optical Fibre Planning Guide for Power Utilities
- (3) CIGRE New Opportunities For Optical Fibre Technology in Electricity Utilities
- (4) CIGRE guide to fittings for Optical Cables on Transmission Lines.

Details of towers

Sl. No.	Name of Transmission Line	Length in Kms	Type of Towers			
			A	B	C	D
1	220 KV Khodri - Rishikesh	79.6	160	34	39	
2	220 KV Rishikesh - SIDCUL - Roorkee	51.3	82	23	44	
3	132 KV Rishikesh - Srinagar	78.38	75	80	53	
4	132 KV Pantnagar - Rudrapur	7.6	14	8	9	
5	132 KV Rudrapur - Kichha	20.3	47	10	14	
6	132 KV Kichha - Sitarganj	32.1	38	24	13	
7	132 KV Haldwani - Bhanwali	14.05	23	23	1	
8	132 KV Bhanwali - Almora	31.04	35	36	25	
9	132 KV Almora - Pithoragarh	76.6		179	92	
10	220 KV Haldwani - Bhrani - Kashipur	61.71	110	25	9	20
11	132 KV Kashipur - Bajpur	15.6	23	13	6	
	Total Length	468.28	607	455	305	20

Total Suspension Tower	607
Total Tension Tower	780
Total Tower	1387

Section 2

Specifications and Functional Description of Fibre Optic Cable

This section describes the functional & technical specifications for supply of OPGW cable & its associated hardware & fittings.

2.1 Fibre Optic Cabling

2.1.1 General

The Contractor shall supply 24 fibre (DWSM) OPGW fibre optic cables. The cable length requirement is indicated in the appendices.

All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years.

2.1.2 Required Optical Fibre Characteristics

The characteristics of optical fibre to be provided under this specification are as follows.

2.1.2.1 Physical Characteristics

Dual-Window Single mode (DWSM), G.652 telecommunication grade optical fibres shall be provided in fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 2-1(a).

2.1.2.2 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm, shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fibre attenuation characteristics specified in Table 2-1(a) shall be “guaranteed” fibre attenuation of any & every fibre reel

Table 2-1(a)
DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 μm ($\pm 10\%$ of the nominal value)
Cladding Diameter:	125.0 $\mu\text{m} \pm 2 \mu\text{m}$
Mode field concentricity error	$\leq 1.0\mu\text{m}$ at 1310 nm
Cladding non-circularity	$\leq 2\%$
Cable Cut-off Wavelength λ_{cc}	≤ 1260 nm

Table 2-1(a)
DWSM Optical Fibre Characteristics

1550 nm loss performance	As per G.652
Proof Test Level	≥100 kpsi
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.23dB/km
Chromatic Dispersion; Maximum:	20 ps/(nm x km) 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm
Zero Dispersion Wavelength: Zero Dispersion Slope:	1300 to 1324nm -0.093 ps/(nm ² xkm) maximum
Polarization mode dispersion coefficient	≤0.5 ps/km ^{1/2}
Temperature Dependence:	Induced attenuation ≤ 0.05 dB (-60°C - +85 °C)
Bend Performance:	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB/km @ 1550 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.10 dB/km @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB/km
End of Table	

2.1.3 Fibre Optic Cable Construction

Overhead Fibre Optic Cables shall be OPGW (Optical Ground Wire). The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service.

2.1.3.1 EHV Transmission Line- Earthwire/Conductor Details

Details of maximum spans, voltage levels and the relevant characteristics of the earthwire/conductor required for design of OPGW cable will be provided by PTCUL

2.1.3.2 Optical Fibre Identification

Individual optical fibres within a fibre unit, and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme.

2.1.3.3 Buffer Tube

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Buffer tubes shall be filled with a water-blocking gel.

2.1.3.4 Optical Fibre Strain

The fibre optic cable shall be designed such that the optical fibres experience no strain under all loading conditions defined in IS 802. No fibre strain condition shall apply even after a 25 year cable creep.

For the purpose of these specifications, the following definitions shall apply:

- Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is *no fibre strain*.
- The no fibre strain condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ ETSI (FOTP) specified optical reflectometry techniques.
- The Cable strain margin is defined as the maximum cable strain at which there is no fibre strain.
- The cable Maximum Allowable Tension (MAT) is defined as the maximum tension experienced by the Cable under the worst case loading condition as defined in IS 802.
- The cable max strain is defined as the maximum strain experienced by the Cable under the worst case loading condition as defined in IS 802.
- The cable Every Day Tension (EDT) is defined as the maximum cable tension on any span under normal conditions viz at 32 °C and no wind.
- The Ultimate /Rated Tensile Strength (UTS/RTS/ breaking strength) is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:

- The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS of OPGW. However, Max Allowable Tension up to 0.5 times the UTS of OPGW may be accepted, subject to no fibre strain.
- The 25 year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25 year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.
- The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart indicating the maximum tension, cable strain and sag shall be calculated for the following conditions as specified in IS 802:1977/1995:

- a. 53 °C, no wind, no ice
- b. 32 °C, no wind, no ice
- c. 0 °C, no wind, no ice
- d. 32 °C, full wind, no ice
- e. 0 °C, 2/3rd / 36% of full wind (IS 802:1977/1995)

The above cases shall be considered for the spans from 100 m to max. span length in the range of 50 m spans. The full wind load shall be considered as the design wind load as per relevant IS 802 version and the sag-tension chart shall be submitted accordingly.

2.1.3.5 Cable Materials

The materials used for optical fibre cable construction, shall meet the following requirements:

2.1.3.5.1 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC-60794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, nonhygroscopic, electrically nonconductive and non-nutritive to fungus. 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.

The filling compound shall remain stable for ambient temp. between -20°C and +65°C and shall not drip, flow or leak with age or at high temperatures during short duration lightning strikes and short circuit currents. The filling compound shall meet the requirements of "Seepage of Filling Compound test" as per EIA/TIA 455-81.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

2.1.3.5.2 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

2.1.3. 5.3 Marking, Packaging and Shipping

This section describes the requirements for marking, packaging and shipping the overhead fibre optic cable.

- (a) Drum Markings: Each side of every reel of cable shall be permanently marked in a minimum of 1 cm high white lettering with the vendors' address, the Employer's destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number & segment no., factory inspection stamp and date.
- (b) Cable Drums: All optical fibre cabling shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during

shipment and handling. Spare cable caps shall be provided with each drum as required.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied by the contractor on each drum shall not be less than 2.5 kms. Same shall be discussed & finalised during the detailed engineering.

2.1.3.6 Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-P1138 and IEC publication 1396. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose.

The composite fibre optic overhead ground wire shall be made up of buffered optical fibre units embedded in a water tight aluminium/aluminium alloy/stainless steel protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. However, other material may be accepted subject to meeting the cable type-testing requirements as specified in the technical specifications. 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 fibre.

2.1.3.6.1 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen. The central fibre optic unit may include an aluminium tube and/or channelled aluminium rod.

2.1.3.6.2 Basic Construction

The cable construction shall conform to the applicable requirements of Technical Specification, applicable clauses of IEC 1089 related to stranded conductors and Table 2.2(a) OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed.

2.1.3.6.3 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

2.1.3.6.4 Electrical and Mechanical Requirements

Table 2-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to the electrical & mechanical characteristics of the earthwire being replaced such that there is no or minimal consequential increase in stresses on towers. The existing earthwire parameters are listed in appendices . For the purposes of determining the appropriate Max Working Tension limit for the OPGW cable, IS 802:1995 and IS 875: 1987 shall be applied. However the OPGW sag & tension charts shall be based on IS 802. For the OPGW cable design selection and preparation of sag tension charts, the limits specified in this section shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

**Table 2.2(a)
OPGW Electrical and Mechanical Requirements**

(1)	Everyday Tension at 32°C, no wind:	$\leq 20\%$ of UTS of OPGW
(2)	D.C. Resistance at 20°C:	< 1.0 ohm/Km
(3)	Short Circuit Current:	≥ 6.32 kA for 1.0 second

2.1.3.6.5 Operating conditions

Since OPGW shall be located at the top of the EHV transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be the same or similar as those required of conventional ground wire.

2.1.3.6.6 Live Line Installation Suitability

OPGW shall be suitable for installation under live line condition, i.e. with all circuits charged to the rated line voltage as specified in this section shall be generally in accordance with the IEEE guide to the installation of overhead transmission line conductor (IEE STD.524 with latest revisions), with additional instructions and precaution for live line working and fibre optic cable handling.

2.1.3.6.7 Installation Hardware

The scope of supply of the optical cable includes the assessment, supply and installation of all required fittings and hardware. The Contractor shall determine the exact requirements of all accessories required to install and secure the OPGW.

The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in §4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The Contractor shall provide the OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document for all the assemblies & components. However, DRS format of assemblies has been enclosed in the appendices. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

- (a) Suspension Assemblies: Preformed armour grip suspension clamps and aluminum alloy armour rods/ reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25 KN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured in accordance with type test procedures specified in appendix B, Vol IIC.

The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the centre point of the OPGW).

- (b) Dead End Clamp Assemblies: All dead end clamp assemblies shall preferably be of the performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.
- (c) Clamp Assembly Earthing Wire: Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.
- (d) Structure Attachment Clamp Assemblies: Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.
- (e) Vibration Dampers: Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth, shall

be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis as specified in appendices. Vibration damper clamps shall be made of aluminium or aluminium alloy shall support the dampers during installation and shall maintain the dampers in position without damage to the OPGW and without causing fatigue. Armour or patch rods made of aluminium or aluminium alloy shall be provided as required to reduce clamping stress on the OPGW. The vibration damper body shall be hot-dip galvanised mild steel/cast iron or shall be permanent mould cast zinc alloy.

2.1.4.3 In-Line Fibre Optic Splice Enclosures

All in-line splices shall be encased in In-Line Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. In line splice enclosures shall comply to ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of a minimum of 48/24 optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. In-line splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on EHV transmission towers above anti-climb guard levels at about 10 metres from the ground level and shall accommodate pass-through splicing.

-----**End of the Section**-----

SECTION 3

Inspection & testing requirements

This section describes the specific requirements for inspection & testing requirement for supply of OPGW cable & its associated hardware & fittings.

3.1 General

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

The entire cost of testing for factory acceptance test, routine tests, production tests and other test during manufacture specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The test shall be considered complete when (a) all variances have been resolved (b) all the test records have been submitted (c) Employer acknowledges in writing the successful completion of the test.

3.1.1 Inspection

Access to the Contractor's facilities while manufacturing and testing are taking place, and to any facility where systems/equipment are being produced/tested for Employer shall be available to Employer representatives. The Contractor shall provide to Employer representatives sufficient facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification. Inspection rights shall apply to the Contractor's facilities and to subcontractor facilities where equipment is being manufactured.

Inspections will be performed by Employer, which will include visual examination of hardware, enclosure cable dressings, and equipment and cable labeling. Contractor documentation will also be examined to verify that it adequately identifies and describes all wiring, hardware and spare parts. Access to inspect the Contractor's hardware quality assurance standards, procedures, and records that are applicable to the facilities shall be provided to Employer.

3.1.2 Inspection Certificate

The Contractor shall give the Employer two weeks in case of domestic supplies and six weeks in case of foreign supplies written notice of any material being ready for testing. Such tests shall be to the Contractor's account except for the expenses of the Inspector. The Employer, unless witnessing of the tests is waived, will attend such tests on the scheduled date for which Employer has been so notified or on a mutually agreed alternative date. If Employer fails to attend the testing on the mutually agreed date, Contractor may proceed with the test which shall be deemed to have been made in the Inspector's presence and Contractor shall forthwith forward to the Inspector, duly certified copies of the test results in triplicate.

The Employer shall, within fourteen (14) days from the date of inspection as defined herein, give notice in writing to the Contractor of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall make the modifications that may be necessary to meet said objections. When the factory tests have been completed successfully at the Contractor's or Sub-contractor's works, the Employer shall issue a certificate to this effect within fourteen (14) days after completion of tests but if the tests are not witnessed by the Employer, the certificate shall be issued within fourteen (14) days of receipt of the Contractor's Test Certificate by the Employer. The completion of these tests or the issue of the certificates shall not bind the Employer to accept the equipment should it, on further tests after erection, be found not to comply with the Contract.

In cases where the Contract provides for tests, whether at the premises or works of the Contractor or of any Sub-contractor, the Contractor except where otherwise specified shall provide free of charge items such as labour, materials, electricity, fuel, water stores, apparatus and instruments, as may be reasonably demanded by the Employer or his authorized representative to carry out effectively such tests of the equipment in accordance with the Contract and shall provide facilities to the Employer or his authorized representative to accomplish testing.

The inspection by Employer and issue of Inspection Certificate thereon, shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Program forming a part of the Contract.

The Contractor shall keep the Employer informed in advance of the time of starting of the progress of manufacture of material in its various stages so that arrangements can be made for inspection.

Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Employer's representative.

Certificates of manufacturing tests shall be maintained by the Contractor and produced for verification as and when desired by the Employer. No material shall be dispatched from its point of manufacture until it has been satisfactorily inspected and tested. Testing shall always be carried out while the inspection may be waived off by the Employer in writing only.

However, such inspection by the Employer's representative(s) shall not relieve the Contractor from the responsibility for furnishing material, software, and equipment to conform to the requirements of the Contract; nor invalidate any claim which the Employer may make because of defective or unsatisfactory material, software or equipment.

3.1.3 Reporting of Variance

A variance report shall be prepared by either Employer or Contractor personnel each time a deviation from specification requirements is detected during inspection or testing. All such variances shall be closed in mutually agreed manner.

However, at any stage if Employer feels that quality of variances calls for suspension of the testing the testing shall be halted till satisfactory resolution of variances, which may involve retesting also.

3.2 Test Plans and Procedures

Test plans for factory acceptance tests shall be provided by the Contractor to ensure that each test is comprehensive and verifies all the features of the equipment are tested. The test plans for factory tests shall be submitted for Employer approval before the start of testing.

The contractor shall prepare detail testing procedure in line to specification and submit for Employer's approval. The procedure shall be modular to the extent possible, which shall facilitate the completion of the testing in the least possible time.

3.2.1 Test Records

The complete record of all factory acceptance tests results shall be maintained by the Contractor. The records shall be maintained in a logical form and shall contain all the relevant information. The test reports shall be signed by the testing engineer and the engineer witnessing the tests.

3.3 Testing Requirements

Following are the requirements of testing for supply of OPGW Cable:

1. Type Testing
2. Factory Acceptance Testing

3.3.1 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

- (a) The Contractor shall submit, within 30 days of Contract Award, copies of test reports and certificates for all of the Type Tests that are specified in the specifications and that have previously been performed. These certificates may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at Internationally accredited labs and witnessed by third party / customer's representatives .
- (b) Type Tests shall be performed for all equipment types for which certification is not provided as required in (a) above, or if it is determined by the Employer that the certification provided is not acceptable. If any of the type tests are required to be carried out, the same shall be carried out by the Contractor. The bidder shall quote testing charges for each type test individually.
- (c) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as shown in Table 6-2 and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.
- (d) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.
- (e) Testing charges for all the type tests listed in the specifications shall be indicated separately for each item (excluding expenses of Inspector/ Employer's representative) in the prescribed schedule of the bidding document. The total amount of these charges will be considered in the bid evaluation process.
- (f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.
- (g) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type tests at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

3.3.1.1 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall

be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. For optical fibres/ Fibre Optic cables, at least three reels/ drums of each type of fibre/ cable proposed shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered of which at least three samples shall be selected by the Employer's representative. For In line Splice enclosures and other equipment at least three samples shall be offered, of which one sample shall be selected.

3.3.1.2 List of Type Tests

The list of required type tests is given in Appendix B.

3.3.2 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of a Fibre Optic Cable & associated hardware & accessories to be supplied. Factory acceptance testing shall be carried out on overhead fibre optic cable (OPGW) & FO cable hardware fittings & accessories, splice enclosures and all other items for which price has been identified separately in the Bid Price Schedules.

Equipment shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorized representatives unless waiver for witnessing by Employer's representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation in this Section by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the Fibre Optic cable & associated accessories in relation to this specifications and approved drawings and documents. List of factory acceptance tests for OPGW and FO cable hardware fittings & accessories are given in Appendix B. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance tests for the splice enclosures shall be proposed by the Contractor in accordance with technical specifications (mentioned in Appendix-B) and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program.

3.3.2.1 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be

performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected. Physical inspection shall be carried out on 100% basis for all the equipment/items offered.

For the FO cable hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

3.3.2.2 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), along with information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

-----**End of the Section**-----

SECTION 4

DOCUMENTATION and DELIVERABLES

This section describes the documentation requirements and provides a list of deliverable that the Contractor shall provide to Employer.

The Contractor shall submit a comprehensive list of the document as applicable for the offered system for Employer's approval immediately after signing of the Contract and the documents shall be finalised as per the approved list. The Schedule for submission/approval of documents shall be inline with overall project schedule.

4.1 Documentation

To ensure that the proposed systems conform to the specific provisions and general intent of the Specification, the Contractor shall submit documentation describing the systems to Employer for review and approval. Further the Contractor shall also submit the drawings/documents for testing of the system. The Contractor shall obtain approval of Employer for the relevant document at each stage before proceeding for purchase, manufacturing, factory testing etc.

Each document shall be identified by a Contractor document number, the Employer document number, and the Employer purchase order number. Where a document is revised for any reason, each revision shall be indicated by a number, date, and description in a revision block along with an indication of official approval by the Contractor's Project Manager. Each revision of a document shall highlight all changes made since the previous revision.

The Contractor shall submit three hard copies of each document/drawing for Employer's review and approval along with soft copy with each submission. After approval two set of all the documents/drawings shall be submitted as final documentation, however, for site specific documents two sets of documents shall be provided for each site. In addition to paper copies all the documents shall also be provided on electronic media in two copies. In case any documentation requirement is specified in the relevant section the same shall apply for the equipment /system defined in that section. The following document shall be submitted as applicable for the subsystem.

- (a) Data Requirement sheets
- (b) Sag tension charts
- (c) Bill of Quantity
- (d) Standard documents
- (e) Previous type test report
- (f) Manufacturing Quality Plan
- (g) Test Procedure (Type test & FAT)
- (h) Test report (Type test & FAT)
- (i) Test Schedule
- (j) Transportation & handling procedure
- (k) Numbering, Marking, labeling document

The documentation pertaining to third party or OEM products may be supplied in the format as available from the third party/OEM. If both formats (Paper/electronic) are available then

the above mentioned copies of documents shall be supplied in both the formats, however, in exceptional cases where the Contractor is not able to get more copies due to copyright laws restriction, the issue will be mutually agreed upon on case to case basis. The document to be submitted shall include the following:

4.1 System Functional Description Document

The document shall include an overview of the system configuration. This document shall be designed to serve as a complete introduction to the supplied system and to the more specific documents that are defined in this Section. The document shall be oriented to the Employer user's point of view and be subject to the Employer's review and approval. Users will include Employer operating personnel communication support staff and maintenance personnel.

4.2 Test Documentation

The Contractor shall provide documentation for all type tests and factory tests. The test documentation shall include the following:

- (a) Type test documents (Procedures & Reports)
- (b) Factory Acceptance Test Documents (Procedures & Reports)

4.3 Drawings

All drawings submitted by the Contractor shall indicate the type, size, arrangement, dimensions, material description, Bill of Materials, weight of each component, break-up for packing and shipment, shipping arrangement required, the dimensions required for installation and any other information specifically requested in the Specifications.

Each drawing submitted by the Contractor shall be clearly marked with the Employer name, the unit designation, the specification title, the specification number and the name of the Project. All titles, notes, markings and writings on the drawing shall be in English. All the dimensions should be to the scale and in metric units. The drawing revision level/ issue no, issue date shall be marked on each drawing and the drawing shall carry issue history information and appropriate signatures (e.g.: originator, checker and approving authority).

.....**End of the Section**.....

SECTION - 5

Project Management, Schedule and Implementation Plan

This section describes the project management, schedule, quality assurance, and implementation plan requirements for the supply of OPGW Cable & associated hardware and fittings.

5.1 Project Management

The Contractor shall assign a Project Manager with the authority to make commitments and decisions that are binding on the Contractor. The Project Manager's responsibility shall include interface and coordination with the Project Contractor. The Employer will designate a Project Manager to coordinate all the Employer project activities. All communications between the Employer and the Contractor shall be coordinated through the Project Managers.

5.2 Project Review Meetings

Progress meetings shall be scheduled by the Project Manager and attended by the Contractor and Employer each reporting period to review progress of the project. Progress meetings shall be used to review the progress report, written correspondence exchanged since the last meeting, and open action items.

The Contractor shall also attend technical meetings as required to discuss technical aspects of the project and to review Employer comments on approval documents. When appropriate, these technical meetings shall be conducted as extensions to the progress meetings. The consultant shall also attend the meeting as and when required by Employer.

The Project Manager shall schedule and attend Progress Meetings as deemed necessary but no less than once every months.

5.3 Progress Report

A progress report shall be prepared by the Contractor each month against the activities listed in the project schedule. The report shall be made available to Employer on a monthly basis, e.g., the 10th of each month. The progress report shall include all the completed, ongoing and scheduled activities and transmittals issued and received for the month.

5.4 Transmittals

Every document, letter, progress report, change order, and any other written exchanged between Contractors and the Employer shall be assigned a unique transmittal number. The Contractor shall maintain a correspondence index and assign transmittal numbers consecutively for all Contractor documents. The Employer will maintain a similar correspondence numbering scheme identifying documents and correspondence that the

Employer initiates.

5.5 Quality Assurance and Quality Control Program

All materials and parts of the system/sub-system to be supplied under the project shall be of current manufacture from a supplier regularly engaged in the production of such equipment.

The Contractor shall maintain a Quality Assurance/Quality Control (QA/QC) program that provides that equipment, materials and services under this specification whether manufactured, designed or performed within the Contractor's plant, in the field, or at any sub-contractor source shall be controlled at all points necessary to assure conformance to contractual requirements. The program shall provide for prevention and ready detection of discrepancies and for timely and positive corrective action. The Contractor shall make objective evidence of quality conformance readily available to the Employer. Instructions and records for quality assurance shall be controlled and maintained at the system levels. The Contractor shall describe his QA/QC program in the Technical Proposal, (along with samples from his QA/QC manual) and shall submit his QA/QC Manual for review and acceptance by the Employer.

Such QA/QC program shall be outlined by the Contractor and shall be finally accepted by Employer after discussions before the award of Contract. A Quality Assurance Program of the Contractor shall generally cover but not be limited to the following:

- (a) The organization structure for the management and implementation of the proposed Quality Assurance Program.
- (b) Documentation control system.
- (c) Qualification data for key personnel.
- (d) The procedure for purchase of materials, parts/components and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases, etc.
- (e) System for shop manufacturing including process controls.
- (f) Control of non-conforming items and system for corrective action.
- (g) Control of calibration and testing of measuring and testing equipments.
- (h) Inspection and test procedure for manufacture.
- (i) System for indication and appraisal of inspection status.
- (j) System for quality audits.
- (k) System for authorizing release of manufactured product to Employer.
- (l) System for maintenance of records.

- (m) System for handling, storage and delivery.
- (n) A Quality Plan detailing out the specific quality control procedure adopted for controlling the quality characteristics of the product.

The Quality Plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

Neither the enforcement of QA/QC procedures nor the correction of work mandated by those procedures shall be cause for an excusable delay. An effective Quality Assurance and Quality Control organization shall be maintained by the Contractor for at least the duration of this Contract. The personnel performing QA/QC functions shall have well-defined responsibility, authority, and organizational freedom to identify and evaluate quality problems and to initiate, recommend, or provide solutions during all phases of the Contract. The QA/QC organization of the Contractor shall be an independent administrative and functional structure reporting via its manager to the Contractor's top management. The QA/QC manager(s) shall have the authority within the delegated areas of responsibility to resolve all matters pertaining to quality to the satisfaction of Employer when actual quality deviates from that stated in the Work Statement.

The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employer's inspection of equipment/materials.

The Employer or his duly authorized representative reserves the right to carry out Quality Audit and Quality Surveillance of the systems and procedures of the Contractor's/his vendor's Quality Management and Control Activities.

The scope of the duties of the Employer, pursuant to the Contract, will include but not be limited to the following:

- (a) Review of all the Contractor's drawings, engineering data etc.
- (b) Witness or authorize his representative to witness tests at the manufacturer's works or at site, or at any place where work is performed under the Contract.
- (c) Inspect, accept or reject any equipment, material and work under the Contract in accordance with the specifications.
- (d) Issue certificate of acceptance and/or progressive payment and final payment certificate
- (e) Review and suggest modification and improvement in completion schedules from time to time; and
- (f) Monitor the Quality Assurance program implementation at all stages of the works.

5.6 Project Schedule

The project implementation plan is given in Appendix - A. Based upon this the bidder shall submit a preliminary project implementation schedule along with the bid. The detail project implementation schedule shall be submitted by the Contractor after award for Employer's approval, which shall include at least the following activities:

- (a) Documents, DRS, Drawing submission and approval
- (b) Type Testing Schedule
- (c) Manufacturing
- (d) Factory Testing Schedule
- (e) Dispatch Schedule
- (f) Receipt & Storage

The project implementation schedule shall include the estimated period for completion and its linkage with other activities. The Project implementation schedule shall also contain Employer activities required for the Contractor to complete the system.

5.7 Implementation Schedule

Appendix A of this Technical Specifications provides a implementation schedule for the supply of OPGW Cabling.

The Bidder shall submit a detailed project schedule showing the activities of both the Contractor and Employer and also including the documentation schedule and training schedule. The Employer and the Contractor shall finalise the detailed implementation plan following the award of the contract.

-----**End of the Section**-----

APPENDIX A

**GENERAL REQUIREMENTS, IMPLEMENTATION SCHEDULE & BILL OF
QUANTITIES**

Table-1
Details of Tower/Earthwire/Conductor

Sl.No.	Volt. (KV)	Every Day Temp. (as per design)(°C)		Details of Earthwire Conductor				Ground Fault Current (KA)
		Conductor	E/wire	Size (mm)	UTS (Kgf)	Weight (Kg/Km)	Overall dia (mm)	
1	220	32	32	7/3.66	6972	583	10.98	40
2	132	32	32	7/3.15	5710	428	9.45	31.5

Implementation Schedule

**Table 2: Implementation Schedule for Supply of OPGW
And Associated Hardwares for**

S.N.	Description of Work	Completion Period from Letter/ Notification of award
1	Design, engineering, manufacturing, testing, demonstration for acceptance, Documentation, supply and erection , loading, transportation, unloading, transit insurance, delivery at site for supply of OPGW cabling for Northern Region Transmission System-I	18 Months

Table 3: BOQ for OPGW & associated Hardwares

S.NO.	Item Description	Unit	Quantity
A.	OPGW cable & Accessories		
1	24 Fibre (DWDM) OPGW fibre optic cable	Km.	490
2	Installation Hardware set for 24 Fibre (DWDM) OPGW Fibre Optic cabling including all cable fittings & accessories	Set *	490

Note *

- 1) One set of installation hardware shall contain all installation hardware fittings as may be required for 1 km of OPGW cabling.
- 2) Hardwares set shall be supplied as per approved drawing during detailed engineering.

Table- 4
Type testing requirement

S.No.	Item Description	Unit
1	Type tests for Optical Fibres	1
2	Type tests for OPGW cable	1
3	Type tests for OPGW cable fittings	1
4	Type tests for in line splice enclosure	1

-----End of the Appendix-----

APPENDIX B
TYPE TESTING / FACTORY ACCEPTANCE TESTING
PROCEDURES / REQUIREMENTS

Appendix -B

TYPE TESTING/ FACTORY ACCEPTANCE TESTS REQUIREMENTS

Wherever the referenced test procedures or the technical specifications call for visual inspection for damage, the test report shall include a full description of observed status of the sample. (Visually inspected samples shall also be colour photographed and copies of colour photographs shall be included in type test report)

B-1 Type Tests for Optical Fibres

The type tests listed below in table B-1.1 shall be conducted on DWDM fibres. The tests specific to the cable type are listed in subsequent sections.

**Table B-1.1
Type Tests For Optical Fibres**

S.No.	Test Name	Acceptance Criteria	Test procedure	
1	Attenuation	AS per Section-02 of TS, Volume II	EIA/TIA 455- 78A	
2	Attenuation Variation with Wavelength	AS per Section-02 of TS, Volume II	EIA/TIA 455- 78A	
3	Attenuation at Water Peak	AS per Section-02 of TS, Volume II	EIA/TIA 455- 78A	
4	Temp. Cycling (Temp dependence of Attenuation)		EIA/TIA 455- 3A, 2 cycles	
5	Attenuation With Bending (Bend Performance)		EIA/TIA 455- 62A	
6	Mode Field dia.		EIA/TIA 455- 164A/167A/174	
7	Chromatic Dispersion		EIA/TIA 455- 168A/169A/175A	
8	Cladding Diameter		EIA/TIA 455-176	
9	Point Discontinuities of attenuation		EIA/TIA 455-59	
10	Core -Clad concentricity error		EIA/TIA 455-176	
11	Fibre Tensile Proof Testing		EIA/TIA 455-31B	
-End Of table-				

B-2 Type Tests For OPGW Cables

The type tests to be conducted on the OPGW cable are listed in table B-2.1: Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

**Table B-2.1
Type tests for OPGW Cable**

S.NO.	Test Name	Test Description	Test Procedure
1	Water Ingress Test	IEEE 1138 Section 4.1.1.1	IEEE 1138, Section 5.1.1.1 (IEC 794-1-F5 /EIA/TIA 455-82B) : Test duration : 24 hours
2	Seepage of filling compound	IEEE 1138 Section 4.1.1.2	Preconditioning period : 72 hours. Test duration : 24 hours.
3	Short Circuit Test	IEEE 1138 Section 4.1.1.3 Or	IEEE 1138 Section 5.1.1.2 (EIA/TIA 455-81B) IEEE 1138 Section 5.1.1.3 Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. A suitable temperature sensor such as thermocouple shall be used to monitor and record the temperature inside the OPGW tube in addition to monitoring & recording the temperatures between the strands and between optical tube and the strand as required by IEEE 1138. Test shall be conducted with the tension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
4	Aeolian Vibration Test	IEC 60794-1-2 (2003) Method H1 IEEE 1138 Section 4.1.1.4	Initial temperature during the test shall be greater than or equal to ambient field temperature. However, maximum temperature recorded on any component of OPGW cable shall not exceed the Short Circuit transient peak temperature guaranteed by the Contractor during design. Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The vibration frequency and amplitude shall be monitored and recorded continuously. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring. Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
5	Galloping test	IEEE 1138 Section 4.1.1.5	IEEE 1138 Section 5.1.1.5 Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and clamps shall be visually inspected for mechanical damage and photographed after the test. All fibres of the test

**Table B-2.1
Type tests for OPGW Cable**

S.NO.	Test Name	Test Description	Test Procedure
			cable sample shall be spliced together in serial for attenuation monitoring.
6	Cable Bend Test	Procedure 2 in IEC:794-1-E11	The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC:794-1-E11 to determine the minimum acceptable radius of bending without any increase in attenuation or any other damage to the fibre optic cable core such as bird caging, deformation, kinking and crimping.
7	Sheave Test	IEEE 1138 Section 4.1.1.6 Or IEC 60794-1-2 (2003) Method E18B	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The Sheave dia. Shall be based on the pulling angle and the minimum pulley dia employed during installation. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
8	Crush Test	IEEE 1138 Section 4.1.1.7	The crush test shall be carried out on a sample of approximately one (1) metre long in accordance with IEC:794-1-E3. A load equal to 1.3 times the weight of a 400-metre length of fibre optic cable shall be applied for a period of 10 minutes. A permanent or temporarily increase in optical attenuation value greater than 0.1 dB change in sample shall constitute failure. The load shall be further increased in small increments until the measured attenuation of the optical waveguide fibres increases and the failure load recorded along with results.
9	Impact Test	IEEE 1138 Section 4.1.1.7	The impact test shall be carried out in accordance with IEC:794-1-E4. Five separate impacts of 0.1-0.3kgm shall be applied. The radius of the intermediate piece shall be the reel drum radius \pm 10%. A permanent or temporary increase in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.
10	Creep Test	IEEE 1138 Section 4.1.1.8	As per Aluminium Association Method , the best-fit straight line shall be fitted to the recorded creep data and shall be extrapolated to 25 years. The strain margin of the cable at the end of 25 years shall be calculated. The time when the creep shall achieve the strain margin limits shall also be

Table B-2.1
Type tests for OPGW Cable

S.NO.	Test Name	Test Description	Test Procedure	
				calculated.
11	Fibre Strain Test	IEEE 1138 Section 4.1.1.9	IEEE 1138 Section 5.1.1.9	
12	Strain Margin Test	IEEE 1138 Section 4.1.1.10	IEEE 1138 Section 5.1.1.10	
13	Stress strain Test	IEEE 1138 Section 4.1.1.11	IEEE 1138 Section 5.1.1.11	
14	Cable Cut-off wavelength Test	IEEE 1138 Section 4.1.1.12	IEEE 1138 Section 5.1.1.12	
15	Temperature Cycling Test	IEEE 1138 Section 4.1.1.13	IEEE 1138 Section 5.1.1.13	
16	Corrosion (Salt Spray) Test	EIA/TIA 455-16A		
17	Tensile Performance Test	IEC 794-1-E1 / EIA/TIA 455-33A	The test shall be conducted on a sample of sufficient length in accordance with IEC:794-1-E1. The attenuation variation shall not exceed 0.05 dB/kM up to 90% of RTS of fibre optic cable. The load shall be increased at a steady rate up to rated tensile strength and held for one (1) minute. The fibre optic cable sample shall not fail during the period. The applied load shall then be increased until the failing load is reached and the value recorded.	

B-3 Type Test on OPGW Cable Fittings

The type tests to be conducted on the OPGW Cable fittings and accessories are listed below:

B-3.1 Mechanical Strength Test for Suspension/Tension Assembly

Applicable Standards : IS : 2486 / IEC : 61284 :1997.

Suspension Assembly

The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16°. This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Tension Assembly

The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then removed in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Tension Dead-End and associated components shall then be reassembled and

bolts tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of part 1 of Test.
- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

B-3.2 Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder 'zeroed'. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative position between clamp body and armour rods shall be marked on the other side. After the one minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm. or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

Acceptance Criteria :

The Suspension Clamp has passed the Slip Test if the following conditions are met :

- No slippage* shall occur at or below the specified minimum slip load.
 - * Definition of no slippage in accordance with IEC 61284:1997 :- Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.
- Slippage shall occur between the specified maximum and minimum slip load of 12 - 17 kN.

- There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.
- The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.
- The Armour Rods shall not be displaced from their original lay or damaged**.

** Definition of no damage in accordance with convention expressed in IEC 61284 : 1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

B-3.3 Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on a 8 m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load shall gradually be applied up to 20 % of the RTS of OPGW . Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods and Tension Dead -End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50 % of the UTS and the position scale of the recorder is zeroed. The load shall then gradually increased up to 95 % of the UTS and maintained for one minute. After one minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria :

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.
- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or OPGW.

* Definition of no movement as defined in IEC 61284 : Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage.

Any result outside these parameters shall constitute a failure.

B-3.4 Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the fibre optic cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 5.5 kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also the fibre optic cable shall be checked to ensure free

movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter as measured outside the clamped area.

B-3.5 Structure Mounting Clamp Strength Test

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

D-3.6 Type Test on Vibration Damper

D-3.6.1 Dynamic Characteristic Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for Critical Aeolian Vibration frequency band as determined through vibration analysis of undamped OPGW.. The damper assembly shall be vibrated vertically with a ± 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm to determine following characteristics with the help of suitable recording instruments.

- (a) Force Vs frequency
- (b) Phase angle Vs frequency
- (c) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the Aeolian vibration frequency-band between the lower and upper dangerous frequency limits determined by the vibration analysis of fibre optic cable without dampers.

The above dynamic characteristics test shall be conducted on five dampers. The variations between the samples tested shall conform to the sample test limits.

B-3.6.2 Vibration Analysis

The vibration analysis of the fibre optic cable shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

- (d) The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as max Permissible Every Day Tension (20% of

UTS), for a span ranging from 100 m to 1100 m.

- (e) The self damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.
- (f) Examine the Aeolian Vibration level of the fibre optic cable with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.
- (g) From vibration analysis of fibre optic cable without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.
- (h) From vibration analysis of fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the fibre optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment point, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

B-3.7 Vibration Damper Clamp Slip and Fatigue Tests

B-3.7.1 Test Set Up

The clamp slip and fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 15 kN and shall not be equipped with protective armour rods at any point.

Constant tension shall be maintained within the span by means of lever arm arrangement. After the fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the fibre optic cable. There shall be no loose parts, such as suspension clamps, U bolts, on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

B-3.7.2 Clamp Slip Test

The vibration damper shall be installed on the test span. The damper clamp, after tightening with the manufacturer's specified tightening torque, when subjected to a longitudinal pull of 2.5 kN parallel to the axis of fibre optic cable for a minimum duration of one minute shall not slip, i.e., the permanent displacement between fibre optic cable and clamp measured after removal of the load shall not exceed 1.0 mm. The load shall be further increased until the clamp starts slipping. The load at which the clamp slips shall not be more than 5 kN.

B-3.7.3 Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than $\pm 25/f$ mm where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the test, if resonance shift is observed, the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned herein above shall be repeated after fatigue tests without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from fibre optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The fibre optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

- (i) There shall not be any frequency shift by more than ± 2 Hz for frequencies lower than 15 Hz and ± 3 Hz for frequencies higher than 15 Hz.
- (j) The force response curve shall generally lie within guaranteed % variation in reactance after fatigue test in comparison with that before fatigue test by they Supplier.

- (k) The power dissipation of the damper shall not be less than guaranteed % variation in power dissipation before fatigue test by the Supplier. However, it shall not be less than minimum power dissipation which shall be governed by lower limits of reactance and phase angle indicated in the envelope.

B-4 Type Tests for In Line Splice Enclosures

Following Type tests shall be demonstrated on the In Line Splice Enclosure(s) (Splice Enclosure/Box) . For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 794-1 procedures).

B-4.1 Temperature Cycling Test

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40°C to +65°C with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20/ IEC 794-1-C10. The variation in attenuation shall be less than ± 0.05 dB. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

B-4.2 Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of +55°C ± 2 °C with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than ± 0.05 dB, and the internal humidity rate measured, less than 2% .

B-4.3 Rain Withstand Test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than ± 0.05 dB.

B-4.4 Vibration Test

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than ± 0.05 dB. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

B-4.5 Bending and Torsion test

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be

subjected to the following sequence of mechanical stresses on the cable:

- a) 3 torsion cycles of $\pm 180^\circ$ shall be exercised on the cable. Each cycle shall be less than one minute.
- b) 3 flexure cycles of the cable, of $\pm 180^\circ$ with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than $\pm 0.05\text{dB}$. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure

B-4.6 Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

B-4.7 Drop Test

With 2 lengths of 10 metres of cable fixed to the box, it shall be dropped five times from a height of 11 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test shall be carried out in accordance with procedure described in IEC-68-2-32.

B-5 Factory Acceptance Tests On Fibre Optic Cables

As specified in technical specifications, the Factory acceptance tests shall be conducted on random sampling of fibre optic cable to be supplied for the present procurement, prior to any shipment.

B-5.1 FAT On Fibre : Optical Acceptance Tests

The Optical acceptance tests listed in table B-5.1 below are applicable for the fibres of all types of Fibre Optic Cables i.e. OPGW and approach cable to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138 section 4.2.2.1 and section 5.2.2.1 . The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above mentioned IEEE standards unless specified otherwise in the technical specifications.

**Table B-5.1
Factory Acceptance Tests for Fibres of all FO cables: Optical Tests**

S.No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation Coefficient	AS per Section-02 of TS, Volume II	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	AS per Section-02 of TS, Volume II	EIA/TIA 455-59
3	Attenuation at Water Peak	AS per Section-02 of TS,	EIA/TIA 455- 78A

**Table B-5.1
Factory Acceptance Tests for Fibres of all FO cables: Optical Tests**

S.No.	Test Name	Acceptance Criteria	Test procedure
4	Chromatic Dispersion	Volume II	EIA/TIA 455-168A/169A/175A
5	Core – Clad Concentricity Error		EIA/TIA 455-/176
6	Cladding diameter		EIA/TIA 455-176
7	Fibre Tensile Proof Testing		EIA/TIA 455-31B
-End Of table-			

The test reports for the above tests for all types of the fibres carried out by the Fibre Manufacturer and used in the OPGW cables and approach cable shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

B-5.2 Factory Acceptance Test On OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table B-5.2 follow the requirements set forth in section 4.1.2 and section 5.1.2 of IEEE standard 1138. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

**Table B-5.2
Factory Acceptance Tests On OPGW
Applicable standard: IEEE 1138**

S. No.	Factory Acceptance Test on Manufactured OPGW
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Rated Tensile Strength
5	Lay Length Measurements

B-5.3 Factory Acceptance Test On OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table B-5.3. The sampling plan shall be as per IS 2486:

**Table B-5.3
Factory Acceptance Tests On OPGW Fittings**

S. No.	Factory Acceptance Test
Suspension Assembly	
1	UTS/Mechanical Strength of the assembly
2	Clamp Slip Test
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Mechanical strength of each component
Tension Assembly	
5	Clamp Slip Strength test
6	Visual Material verification and dimensional checks as per approved DRS/Drawings
7	Mechanical strength of each component
Vibration Damper	
8	Galvanising test on damper, masses and messenger wires
9	Damper response (resonant frequencies)
10	Clamp Slip test
11	Strength of messenger wires
12	Mass pull off test
13	Visual Material verification and dimensional checks as per approved DRS/Drawings
Structure Mounting Clamp	
14	Clamp fit test
15	Clamp Strength test
16	Visual Material verification and dimensional checks as per approved DRS/Drawings
End of Table	

B-5.4 Factory Acceptance Test on In Line Splice Enclosures

The factory acceptance tests for In Line Splice Enclosures as specified below in Table B-5.4:

**Table B-5.4
Factory Acceptance Tests on In Line Splice Enclosures**

S. No.	Factory Acceptance Test
1	Visual check Kit Quantities and Specific Component Number for each

component of In Line Splice Enclosure and dimensional checks against the approved drawings.

----- **End of the Appendix**-----

APPENDIX C

DATA REQUIREMENT SHEETS

The DRS forms have been included for the major items, however, the DRS for each item along with sufficient details shall be submitted.

Appendix C

Data Requirement Sheets

The following sets of Data Requirement Sheets are required to be filled up by the bidders to aid in the evaluation process. The response shall be brief and to the point and shall be supported by the printed product description and other literature. The same DRS format duly filled and the relevant drawings shall also be submitted during the detailed engineering along with the relevant technical brochures.

DRS Form 1

DATA REQUIREMENTS SHEETS for OVERHEAD FIBRE OPTIC CABLE

OPTICAL GROUND WIRE (OPGW):

Manufacturer: _____

Part #: _____

CABLE CONSTRUCTION			
Seq	Parameter:	Unit:	Particulars:
1	Fibre Manufacturer Dual Window Single-Mode:		
2	No. of Fibres Dual Window Single-Mode:	each	
3	Buffer Type:		
4	Buffer Tube Diameter:	mm	
5	Buffer Tube material		
6	No. of Buffer Tubes:	each	
7	No. of Fibers per Tube:	each	
8	Identification/numbering of individual tubes:		
9	No. of empty tubes (If any):	each	
10	Filling material:		
11	Filling material compliant with technical specifications?	Yes/No	
12.	Strength member(s):		
13.	Binding yarn/ tape:		
14	<u>Describe Central Core Design:</u>		

**DATA REQUIREMENTS SHEETS for
OVERHEAD FIBRE OPTIC CABLE**

OPTICAL GROUND WIRE (OPGW):

Seq	Parameter:	Unit:	Particulars:
14.	20% Aluminum Clad steel wire Diameter: Number:	mm each	
15.	Aluminum alloy wires Diameter: Number:	mm each	
16.	Aluminum tube inner diameter:	mm	
17.	Aluminum tube outside diameter:	mm	
18.	Cable Diameter: (nominal ± deviation)	mm	
19.	Cable cross-section area (Nominal):	mm ²	
20.	Cable cross-section area (Effective):	mm ²	
21.	Fully Compliant with IEEE P1138:	Yes/No	

Mechanical Properties of Cable

22.	Max. breaking load/ Ultimate Tensile Strength (UTS):	kN	
23.	Fibre strain margin:	%	
24.	Zero fibre strain up to load	kN	
25.	Weight:	kg/km	
26.	Crush strength:	kg/mm	
27.	Equivalent Modulus of elasticity:	KN/mm ²	

- Continued -

**DATA REQUIREMENTS SHEETS for
OVERHEAD FIBRE OPTIC CABLE**

OPTICAL GROUND WIRE (OPGW):

Seq	Parameter:	Unit:	Particulars:
28.	Minimum Bending Radius without microbending:	mm	
29.	Maximum Bending Radius: Short Term: Long Term (Continuous):	mm	
30.	Tensile proof test (Screening) level:	KN/mm ²	
31.	Maximum permissible tensile stress:	KN/mm ²	
32.	Permissible CTS. tensile stress:	KN/mm ²	
33.	Maximum sag at maximum temperature and design span with no wind:	mm	
34.	Everyday tension , no wind:	% of UTS	
35.	Maximum tension at Every day condition with full wind pressure ofKg/m ² on full projected are, 400 meter span:	Kg	

Thermal Properties of Cable

36.	Coefficient of linear expansion:	per °C	
37.	Coefficient of expansion Cladding: Core:	per °C per °C	
38.	Nominal operating temperature range:	°C	
39.	SC current transient peak temperature:	°C	
40.	Maximum allowable temperature for lightning strike:	°C	

- Continued -

**DATA REQUIREMENTS SHEETS for
OVERHEAD FIBRE OPTIC CABLE**

OPTICAL GROUND WIRE (OPGW):

CABLE SPOOL and DRUM			
Seq	Parameter:	Unit:	Particulars:
41.	Available length per spool Maximum: Nominal:	m	
42.	Size of drum:	m	
43.	Weight of empty drum:	kg	
44.	Weight of drum with cable: spooled	kg	
45.	Will drum length scheduling be practiced to match transmission line span lengths?	Yes/No	

46. Describe Drum materials:

47. Describe cable end capping and protection against abrasion etc.:

**DATA REQUIREMENTS SHEETS for
OVERHEAD FIBRE OPTIC CABLE**

OPTICAL GROUND WIRE (OPGW):

INSTALLATION			
Seq	Parameter:	Unit:	Particulars:
48.	Splice Loss: Maximum: Average:	dB dB	
49.	Operating Temperature Range:	°C	
50.	Rated Isoceraunic No.		
51.	Expected Cable Life:	Years	
52.	Installation rate per team:	km/day	
53.	No. of persons per team:	no.	
54.	Max. possible span for specified operating conditions:	m	
55.	Midspan sag at 0°C with no wind loading:	mm	
56.	Midspan sag at max temp. with no wind loading:	mm	
57.	Midspan sag at max temp. and wind loading	mm	
58.	Cable swing angles: Worst Case: Everyday:		
69	<u>Describe Installation method(s):</u>		

Sag tension chart parameters like sag and tension at various spans and applicable wind and ice load conditions shall be submitted along with the DRS. The cable parameters like coefficient of liner expansion, modulus of elasticity shall also be indicated.

DRS Form 2
DATA REQUIREMENTS SHEETS for OPTICAL FIBRE
 DUAL-WINDOW SINGLE MODE (DW-SM)

OPTICAL PARAMETERS			
Seq	Parameter:	Unit:	Particulars:
1.	Fiber manufacturer(s)/Type:		
2.	Fiber production method:		
3.	Attenuation Coefficient@ 1310 nm @ 1550 nm:	dB/km dB/km	
4.	Attenuation Variation with Wavelength (± 25 nm):	dB/km	
5.	Attenuation at water peak:	dB/km	
6.	Point discontinuity @ 1310nm: @ 1550nm:	dB dB	
7.	Temperature dependence (induced attenuation):	dB	
8.	Nominal Mode Field Diameter @ 1310 nm: @ 1550 nm:	μm	
9.	Mode Field Diameter Deviation @ 1310 nm: @ 1550 nm:	μm	
10.	Mode field non-circularity:	%	
11.	Chromatic Dispersion Coefficient @ 1310 (1288-1339) nm: @ 1310 (1271-1360) nm: @ 1550 nm:	ps/nm.km	
12.	Zero dispersion wavelength:	nm	
13.	Zero dispersion Slope:	ps/nm ² .km	
14.	Cutoff wavelength:	nm	
15.	Refractive Index:		
16.	Refractive Index profile:		
17.	Cladding Design:		
18.	Numerical aperture:		

DRS Form 2 (Continued)
DATA REQUIREMENTS SHEETS for OPTICAL FIBRE

DUAL-WINDOW SINGLE MODE (DW-SM)

PHYSICAL and MECHANICAL PROPERTIES			
Seq	Parameter:	Unit:	Particulars:
19.	Bend Performance: (37.5 mm radius, 100 turns) @1310 nm & @ 1550 nm	dB	
	(16mm radius, 1 turn) @1550 nm	dB	
20.	Core Diameter(nominal ± deviation)	µm	
21.	Core non-circularity:	%	
22.	Cladding Diameter (nominal ± deviation):	µm	
23.	Core- Clad concentricity Error:	µm	
24.	Cladding noncircularity:	%	
25.	Fibre cut-off wavelength	µm	
26.	Protective Coating type & material Primary: Secondary:		
27.	Protective Coating Diameter (nominal ± deviation):	µm	
28.	Protective Coating removal method:		
29.	Coating Concentricity	µm	
30.	Polarisation mode dispersion coefficient	ps/km ^{1/2}	
31.	Proof test level	kpsi	
32.	Colour coding scheme compliant with EIA/TIA 598 or IEC 60304 or Bellore GR-20.	Yes/No	
33.	Colouring material compliant with technical specs?	Yes/No	

DRS Form 3-A
DATA REQUIREMENTS SHEETS for
HARDWARE AND ACCESSORIES
 Suspension Clamp Assembly:

Manufacturer: _____
 Part #: _____

ITEM	DESCRIPTION	UNIT	PARTICULARS
1.	Minimum vertical Strength	kN	
2.	Maximum Slip Strength	kN	
3.	Minimum Slip Strength	kN	
4.	Length (nominal)	mm	
5.	Weight (nominal)	kg	
6.	Total Drop (maximum) including shackles	mm	
7.	Tightening torque (nominal)	Nm	
8.	Details of Armour Rod Set		
	a) No. of rods per clamp		
	b) Direction of Lay		
	c) Overall length	mm	
	d) Diameter of each Rod	mm	
	e) Tolerances (i) Diameter of each rod (ii) Length of each rod	±% ±%	
	f) Material of manufacture		
	g) UTS of each Rod	kN	
	h) Weight	kg	
9.	Details of Protection Splice Set (Reinforcing Rods)		
	i) No. of rods per clamp		
	j) Direction of Lay		
	k) Overall length	mm	
	l) Diameter of each Rod	mm	
	m) Tolerances		

	(i) Diameter of each rod (ii) Length of each	±% ±%	
	n) Material of manufacture		
	o) UTS of each Rod	kN	
	p) Weight	kg	

**DATA REQUIREMENTS SHEETS for
HARDWARE AND ACCESSORIES**

Dead End Clamp Assembly:

Manufacturer: _____
Part #: _____

ITEM	DESCRIPTION	UNIT	PARTICULARS
1.	Minimum Slip Load	kN	
2.	Length (nominal)		
	a) Reinforcing Rods	mm	
	b) Dead end	mm	
3.	Weight (nominal)		
	a) Reinforcing Rods	kg	
	b) Dead end	kg	
4.	Breaking strength (minimum)	kN	
5.	Wire Size		
	a) Reinforcing Rods	mm	
	b) Dead end	mm	

DRS Form 3-C
DATA REQUIREMENTS SHEETS for
HARDWARE AND ACCESSORIES

Vibration Damper:

Manufacturer: _____
 Part #: _____

ITEM	DESCRIPTION	UNIT	PARTICULARS
1.	Total Weight	Kg	
2.	Weight of each Damper	Kg	
3.	Material of Damper Weight		
4.	Clamp Material		
5.	Clamp bolt tightening torque	Nm	
6.	Clamp bolt material		
7.	Messenger Cable Material		
8.	No. of Strands in Messenger Cable		
9.	Breaking Strength of Messenger Cable	kN	
10.	Resonance Frequencies		
	a) First Frequency	Hz	
	b) Second Frequency	Hz	
	c) Third Frequency	Hz	
	d) Forth Frequency	Hz	
11.	Minimum Slip Strength of Damper Clamp		
	a) Before Fatigue Test	kN	
	b) After fatigue Test	kN	

**DATA REQUIREMENTS SHEETS for
OPGW HARDWARES and ACCESSORIES**

Down Lead Clamp /Fastening Clamp

Manufacturer: _____
Part #: _____

ITEM	DESCRIPTION	Unit:	Particulars:
1.	Material:		
2.	Suitable for OPGW (range):	mm	
3.	Tightening torques	Nm	
4.	Vertical load	kN	
5.	Filler details:		
(a)	Material		
(b)	diameter:	mm	
6.	Tower attachment arrangement		

DRS Form 4
DATA REQUIREMENTS SHEETS for
In Line Splice Enclosures

Manufacturer: _____

Model # _____

Seq	Parameter:	Unit:	Particulars:
1.	Dimensions H * W * D:	cm	
2.	Weight:	Kg	
3.	Colour and Finish:		
4.	Cable Glanding & Fixing:		
5.	Construction materials & Gauge:		
6.	Locking arrangements:		
7.	Installation Clearances: Front Access: Rear Access: Top * Bottom * Sides:	cm	
8.	IP Protection	Class	
9.	Total number of optical couplings:	ea	
10.	Provision of pass through splicing:	Yes/No	
11.	Whether filled with suitable encapsulant	Yes/No	
12.	Method(s) for mounting with the tower:		

Optical Fibre Cable Accommodations

13.	Cable Glanding:		
14.	Maximum number of cables that can be accommodated:	each	
15.	Diameter(s) of cables that can be accommodated:		

16. Describe Cable entries :

**DATA REQUIREMENTS SHEETS for
In Line Splice Enclosures**

Seq	Parameter:	Unit:	Particulars:
Cable Termination Splice Accomodations:			
17.	Details of Splice Trays:		
	Dimension:		
	Material/Gauge:		
	Weight:	kg	
	Colour & Finish:		
	Method of mounting:		
18.	Maximum number of splice trays:	ea	
19.	Number of splices per tray:	ea	
20.	Provision of Splice organisers:		
21.	Do splice trays require a separate enclosure? If so:	Yes/No	
	Manufacturer:		
	Dimensions H * W * D:	cm	
	Weight:	Kg	
	Colour and Finish:		
	Method(s) of Mounting:		
	Construction materials & Gauge:		
	Locking arrangements:		
22.	Installation Clearances Front Access: Rear Access: Top * Bottom * Sides:	m	
	Excess length of fibre service loops		

DATA REQUIREMENTS SHEETS for
Other Items/Materials being supplied under the Package and not covered in
DRS Forms

The following items shall be described as a minimum:

1. Name of item:
2. Make & Model Number:
3. All Major Parameters:
4. Different options available and the specific option proposed to be supplied:
5. Operation Temperature range:

However, the technical brochure from the Manufacturer must be submitted along with the above DRSs in support of the various parameters. The DRS shall also include the list of suppliers for all bought out items.

-----**End of the Appendix**-----

SUPPLY OF OPGW AND ASSOCIATED HARDWARE INCLUDING ERECTION

Price Break-up for Type Tests for Supply of OPGW and associated Hardware .

Sl. No.	Equipment	Description of Type Tests	Total Charges
1	2	3	4
1.	Type Testing of OPGW cable (24 Fibre)	(i) Water Ingress Test	
		(ii) Seepage of filling compound	
		(iii) Short Circuit Test	
		(iv) Aeolian Vibration Test	
		(v) Galloping Test	
		(vi) Cable Bend Test	
		(vii) Sheave Test	
		(viii) Crush Test	
		(ix) Impact Test	
		(x) Creep Test	
		(xi) Fibre Strain Test	
		(xii) Strain Margin Test	
		(xiii) Stress Strain Test	
		(xiv) Cable cutoff wavelength Test	
		(xv) Temperature Cycling Test	
		(xvi) Corrosion (Salt Spray) Test	
		(xvii) Tensile Performance Test	
		(xviii) Fault Current/Lightning Test	
		(xix) DC Resistance Test	
2	Type Testing of OPGW cable Hardware including all cable Fittings & Accessories	(i) Mechanical Strength Test for Suspension / Tension Assembly	
		(ii) Clamp Slip Strength Test for Suspension Assembly	
		(iii) Slip Strength Test of Tension Clamp	
		(iv) Grounding Clamp and Structure Mounting Clamp Fit Test	
		(v) Structure Mounting Clamp Strength Test	
		(vi) Type Test on Vibration Damper	
		(a) Dynamic Characteristic Test	
		(b) Vibration Analysis	
		(vii) Vibration Damper Clamp Slip and fatigue Tests	
		(a) Clamp Slip Test	
		(b) Fatigue Test	
		(viii) Type Tests for In Line Splice Enclosure	
		(a) Temperature Cycling Test	
		(b) Humid Heat Test	
		(c) Rain withstand Test	
(d) Vibration Test			
(e) Bending and Torsion Test			
(f) Tensile Test			
(g) Drop Test			
3	Type Testing of OpticalFibres	(i) Attenuation	
		(ii) Attenuation Variation with Wavelength	
		(iii) Attenuation at Water Peak	
		(iv) Temperature Cycling (Temperature dependence of Attenuation)	
		(v) Attenuation with Bending (Bend performance)	
		(vi) Mode field Dia.	
		(vii) Chromatic Dispersion	
		(viii) Cladding Diameter	
		(ix) Point Discontinuities of attenuation	
		(x) Core - clad concentricity error	
		(xi) Fibre Tensile Proof Testing	
4	GRAND TOTAL FOR TYPE TEST		
Note :			
	1. Bidder should indicate the test laboratory where type tests are proposed to be conducted typetestwise.		

TQR

In case of sole bidder:

1. Bidder shall be manufacturer of OPGW who must be manufacturing OPGW for at least last five (5) years.
2. Bidder shall have the experience of live line installation of OPGW.
3. Bidder shall have laid at least 500 km of OPGW on 132 kV or higher voltage EHV transmission lines on live line which must be in satisfactory operation for at least two (2) years prior to the date of opening of bid.

In case of JV:

Lead Partner:

1. Lead Partner shall be manufacturer of OPGW who must be manufacturing OPGW for at least last five (5) years.
2. Lead Partner shall have laid at least 250 km of OPGW on 132 kV or higher voltage EHV transmission lines on live line which must be in satisfactory operation for at least two (2) years prior to the date of opening of bid.

Other partner:

1. The other partner shall have an experience of supply of at least 500 KM of OPGW cable during last 5 years.
2. Other partner shall have the experience of live line installation of OPGW.
3. Other partner shall have laid at least 500 km of OPGW on 132 kV or higher voltage EHV transmission lines on live line which must be in satisfactory operation for at least two (2) years prior to the date of opening of bid.