

CHAPTER 23: TECHNICAL SPECIFICATION FOR 132KV & 33KV CURRENT TRANSFORMERS (AIS)

23.1.0 SCOPE OF CONTRACT

This Section of the Specification covers general requirements for design, engineering, manufacture, assembly and testing at manufacturer's works of 132kV, 66kV and 33 kV outdoor Current Transformers.

23.2.0 STANDARDS

- 23.2.1 The equipment covered by this specification shall, unless otherwise stated be designed, constructed and tested in accordance with the latest revisions of relevant Indian Standards and shall conform to the regulations of local statutory authorities.
- 23.2.2 In case of any conflict between the Standards and this specification, this specification shall govern.
- 23.2.3 The current transformer shall comply also with the latest issue of the following Indian standard.

(i)	IS: 2705(Part-I)	Current transformers: General requirement.
(ii)	IS: 2705(Part-II)	Current transformers : Measuring Current transformers
(iii)	IS: 2705(Part-III)	Current transformers : Protective Current transformers
(iv)	IS: 2705(Part-IV)	Current transformers: Protective Current transformers for special purpose application.
(V)	All relevant IEC	

23.3.0 GENERAL Ip REQUIREMENTS

- 23.3.1 The cores of the instrument transformers shall be of high grade, non-aging CRC steel of low hysteresis loss and high permeability.
- 23.3.2 Current transformers shall be of Live Tank design.
- 23.3.3 The instrument transformers shall be truly hermetically sealed to completely prevent the oil inside the tank coming into contact with the outside temperature. To take care of oil volume variation the tenderer are requested to quote the current transformers with stainless steel diaphragm (bellow).
- 23.3.4 The instrument transformers shall be completely filled with oil.
- 23.3.5 A complete leak proof shrouded secondary terminal arrangement shall be provided with instrument transformers, secondary terminals shall be brought into weather, dust and vermin proof terminal box. Secondary terminal boxes shall be provided with facilities for easy earthing, shorting, insulating and testing of secondary circuits. The terminal boxes shall be suitable for connection of control cable gland. IP rating of terminal box shall be IP 55. Spare terminals shall be provided. **CT secondary shorting links shall be provided along with one terminal earthing arrangement of CT winding. All doors and**

removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement.

- 23.3.6 All instrument transformers shall be of single phase unit.
- 23.3.7 The instrument transformers shall be so designed to withstand the effects of temperature, wind load, short circuit conditions and other adverse conditions.
- 23.3.8 All similar parts, particularly removable ones, shall be interchangeable with one another.
- 23.3.9 All cable ferrules, lugs, tags, etc. required for identification and cabling shall be supplied complete for speedy erection and commissioning as per approved schematics.
- 23.3.10 The instrument transformers housing shall be porcelain.
- 23.3.11 All steel work shall be degreased, pickled and phosphated and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint.
- 23.3.12 Test terminal for tan-delta/capacitance shall be provided for 132kV CT's.
- 23.3.13 Accuracy specified shall be maintained at 25% of rated burden.
- 23.3.14 All winding(Primary/Secondary) shall be of copper. Aluminium is not acceptable

23.4.0 INSULATING OIL

The quantity of insulating oil for instrument transformers and complete specification of oil shall be stated in the tender. The insulating oil shall conform to the requirement of latest edition of IS: 335

23.5.0 COMMON MARSHALLING BOXES (shall be supplied by CT manufacturer)

- 23.5.1 The outdoor type common marshalling boxes shall conform to the latest edition of IS 5039 and other general requirements specified hereunder.
- 23.5.2 The common marshalling boxes shall be suitable for mounting on the steel mounting structures of the instrument transformers.
- 23.5.3 One common marshalling box shall be supplied with each set of instrument transformers. The marshalling box shall be made of sheet steel and weather-proof. The thickness of sheet steel used shall be not less than 3.0 mm. It is intended to bring all the secondary terminals to the common marshalling. The marshalling box shall be of hot dipped galvanized steel.
- 23.5.4 The enclosures of the common marshalling boxes shall provide a degree of protection of not less than IP 55 (As per IS 2147).
- 23.5.5 The common marshalling boxes shall be provided with double hinged front doors with pad locking arrangement. All doors and removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement.
- 23.5.6 Each marshalling box shall be fitted with terminal blocks made out of moulded non-inflammable plastic materials and having adequate number of terminals with binding screws washers etc. Secondary terminals of the instrument transformers shall be connected to the respective common marshalling boxes. All out going terminals of each instrument transformer shall terminate on the terminal blocks of the common marshalling boxes. The terminal blocks shall be arranged to provide maximum accessibility to all conductor terminals.
- 23.5.7 Each terminal shall be suitably marked with identification numbers. Not more than two wires shall be connected to any one terminal. At least 20 % spare terminals shall be provided over and above the required number. All terminals of control circuits shall be wired up to marshalling box including spare terminals evenly distributed on all TB's.
- 23.5.8 All terminal strips shall be of isolating type terminals and they will be of minimum 10 A continuous current rating.
- 23.5.9 All cable entries shall be from bottom. Suitable removable gland plate shall be provided on the box for this purpose. Necessary number of cable glands shall be supplied fitted on to this gland plate. Cable glands shall be screw on type and made of brass.

- 23.5.10 Each common marshalling box shall be provided with two numbers of earthing terminals of galvanised bolt and nut type.
- 23.5.11 All steel, inside and outside work shall be degreased, pickled and phosphated and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint. The colour of finishing paint shall be as follows: -

- i) Inside: Glossy White
- ii) Outside: Light Grey (Shade No. 697 of IS: 5)

23.6.0 BUSHINGS AND INSULATORS

23.6.1 Bushings and Insulators shall be of Porcelain, Solid core type. Porcelain used for the manufacture of bushings and insulators shall be homogeneous, free from defects, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture **and shall conform to IEC 60135, 60168/IS.**

- 23.6.2 Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. Bushings shall be designed to have sufficient mechanical strength and rigidity for the conditions under which they will be used. All bushings of identical ratings shall be interchangeable.
- 23.6.3 Puncture strength of bushings shall be greater than the dry flashover value. When operating at normal voltage, there shall be no electric discharge between the conductors and bushing. No radio interference shall be caused by the bushings when operating at the normal rated voltage
- 23.6.4 The design of bushing shall be such that the complete bushing is a self-contained unit and no audible discharge shall be detected at a voltage up to a working voltage (Phase Voltage) plus 10%. The minimum creepage distance for severely polluted atmosphere shall be 31 mm/KV.
- 23.6.5 Sharp contours in conducting parts should be avoided for breakdown of insulation. The insulators shall be capable to withstand the minimum seismic acceleration of 0.5 g in horizontal direction and 0.6g in vertical direction..
- 23.6.6 Bushings shall satisfactorily withstand the insulation level specified in data sheet.
- 23.6.7 Rain shed/drain cover/dome shall be present in CT.
- 23.6.8 Bellow level indicator shall be present in CT.
- 23.6.9 Nitrite butyl rubber/Neoprene gaskets shall be used.
- 23.6.10 Critical flashover voltage of insulator and bushing shall be provided.

23.7.0 TESTS

23.7.1 Routine/Acceptance Tests (all units)

All routine tests shall be carried out in accordance with relevant Standards. All routine/acceptance tests shall be witnessed by the Employer/his authorised representative.

23.7.2 **Type Tests:** The bidder shall furnish type test certificates and results for the all tests as per relevant Standards along with the bid for current and potential transformers of identical design.

Type test certificates so furnished shall not be older than 5 (five) years as on date of Bid opening.

23.7.3 **QAP:** QAP indicating all brought out materials tests shall be submitted.

23.8.0 NAME PLATES

All equipment shall have non-corrosive name plates fix at a suitable position indelibly mark with full particular there on in accordance with the standard adapted. Thickness (1mm), purchase order, project name, serial no etc. shall be present in the Name plate.

23.9.0 MOUNTING STRUCTURES

23.9.1 All the equipment covered under this specification shall be suitable for mounting on steel structures. Supply of mounting on **galvanised** structures is also in the scope of this tender.

23.9.2 Each equipment shall be furnished complete with base plates, clamps, and washers etc. and other hardware ready for mounting on steel structures.

23.10.0 SAFETY EARTHING

23.10.1 The non-current carrying metallic parts and equipment shall be connected to station earthing grid with two terminals.

TERMINAL CONNECTORS (Shall be under manufacturer scope)

23.11.1 The equipment shall be supplied with required number of terminal connectors of approved type suitable for ACSR. The type of terminal connector, size of connector, material, and type of installation shall be approved by the AEGCL, as per installation requirement while approving the equipment drawings. No part of a clamp shall be less than 12mm. thick. All connectors shall be of Aluminium Alloy and type tested as per IEC/IS including RIV and short circuit.

PRE-COMMISSIONING TESTS

23.12.1 Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Current Transformers

- (i) Insulation Resistance Test for primary and secondary.
- (ii) Polarity test.
- (iii) Ratio identification test - checking of all ratios on all cores by primary injection of current.
- (iv) Dielectric test of oil (wherever applicable).
- (v) Magnetising characteristics test.
- (vi) Tan delta and capacitance measurement
- (vii) Secondary winding resistance measurement
- (viii) Contact resistance measurement (wherever possible/accessible).
- (ix) Knee-point voltage measurement

23.13.0 TECHNICAL DATA SHEET FOR CURRENT

23.13.1 For **145/72.5/36** kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

23.14.0 TYPE AND RATING:

23.14.1 All instrument transformer shall be outdoor type, single phase, oil immersed, self-cooled suitable for mounting on steel structure. The instrument transformer shall have the following ratings and particulars.

SL No.	A. Item	Ratings and Particulars		
I	II	III	IV	
A	Nominal system voltage	132 kV	33 kV	66 kV
B	Highest system voltage, kV	145	36	72.5
C	Rated frequency, HZ	50	50	50
D	System earthing	Solidly earthed	Solidly earthed	Solidly earthed
E	Insulation level			
a)	Full Wave Impulse withstand voltage: kVp (1.2/50)	650	170	325
b)	One-minute p.f. Withstand voltage, kV (r.m.s.) (dry and wet)	275	70	140
F	Short time current for 3 seconds, kA	40	31.5	31.5
G	Minimum creepage distance, mm	4495	1116	2247.5
H	Temperature rise	As per IS	As per IS	As per IS
I	C.T.			
	(i) No. of Cores	5	2/5	5
	(ii) Transformation ratio	As per BoQ		
	(iii) Rated out put			
	(a) Core-1	20 VA	20 VA	20 VA
	(b) Core-2	20 VA	20 VA	20 VA
	(c) Core-3	(PX CLASS)	PX (for trafo only)	PX
	(d) Core-4	(PX CLASS)	PX (for trafo only)	PX

	(e) Core-5	(PX CLASS)	PX (for trafo only)	PX
	(iv) Accuracy class			
	(a) Core-1	0.2S	0.2S	0.2S
	(b) Core-2	5P20/PX (trafo)	5P20/PX (trafo)	5P20
	(c) Core-3	PX	PX (for trafo only)	PX
	(d) Core-4	PX	PX (for trafo only)	PX
	(e) Core-5	PX	PX (for trafo only)	PX
	(vi) Instrument security factor			
	(a) Core-1	<5	<5	<5
	(b) Core-2	-	-	-
	(c) Core-3	-	-	-
	(d) Core-4	-	-	-
	(e) Core-5	-	-	-
	(vii) Minimum Knee point voltage, Volts			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(d) Core-4	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(e) Core-5	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(viii) Maximum secondary resistance, ohm			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	<3	<3	<3
	(d) Core-4	<3	<3	<3
	(e) Core-5	<3	<3	<3
	(ix) Maximum exciting current, at $V_k/4$ mA			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	-	-	-
	(d) Core-4	-	-	-

	(e) Core-5	-	-	-
	Tandelta at Um/ root 3	< 3	< 3	< 3
	Rated extended primary current	120%	120%	120%

Note:

- (i) It is intended to use different ratios of the same CT at the same time for various protections and metering cores. The CTS should therefore be suitable for the above purpose by secondary tapings only. The ratio change by secondary taps is acceptable as long as the required CT specifications are achieved at all ratios.
- (ii) The knee point voltage specified above shall be at higher ratio/ taps.
- (iii) CT and PT sizing calculations shall be submitted. Burden values and knee point voltage, shall be decided as per the calculations during detailed engineering
- (iv) For Station service bay equipments rated system voltage shall be 33kV and highest system voltage shall be 72.5kV.

CHAPTER 10: TECHNICAL SPECIFICATION FOR ISOLATORS (AIS)

10.0 TECHNICAL PARTICULARS OF 400 kV, 220 kV, 132 kV & 33 KV ISOLATOR are as follows:

	Type:	400 kV	220 kV	132 kV	66 kV	33 kV
I	II	III	IV	V	VI	VII
1	Main switch	Centre break/Pantograph	Horizontal Centre break	Horizontal Centre Break	Horizontal Centre break	Horizontal Double break
2	Service		Outdoor			
3	Applicable standard		IS : 9921 / IEC-62271-102			
4	No. of Phases		3 phase			
5	Design Ambient temperature		50°C			
6	Type of operation	Electrically Ganged	Mechanically Ganged			
7	Rated voltage (kV)	In KV	In KV	In KV	In KV	In KV
	a) Nominal	400	220	132	66	33
	b) Maximum	420	245	145	72.5	36
8	Rated current (Amps)	4000	3150	2000	1250	1250
9	Short time current for 1sec.(kA)	63	50	40	31.5	31.5
10	Rated frequency		50 HZ \pm 5%			
11	System earthing		Effectively earthed			
12	Temperature rise		As per relevant IS/IEC standards			
13	Lightening Impulse withstand voltage (kVp)					
	(a) Across Isolating distance	1425(+240)	1220	750		195
	(b) To earth	1425	1050	650		170
14	1-minute power frequency withstand voltage					
	a) Across Isolating distance	815	605	315		80
	b) To earth	650	460	275		70
15	Switching Impulse					

	Type:	400 kV	220 kV	132 kV	66 kV	33 kV
I	II	III	IV	V	VI	VII
	withstand voltage (kVp)					
	a) Across Isolating distance	900(+345)	-	-		-
	b) To earth	1050	-	-		-
16	Max. RIV for frequency between 0.5MHz and 2MHz (micro-volt)	1000 at 267kV	1000 at 156kV	500 at 92kV		-
17	Corona Extinction Voltage (kV)	320	-	-		-
18	Operating mechanism					
	a) Isolator	Motor	Motor	Motor	Motor	Motor
	b) Earth switch	Motor	Motor	Motor	Manual	Manual
19	Auxiliary voltage					
	a) Control & Interlock		220V DC 80% to 110%			
	b) Motor voltage		3 Phase 415V AC 50Hz			
	c) Heater, lamp & socket		Single phase 240 V 50HZ			
20	Safe duration of overload					
	150% of rated current		5 minute			
	120% of rated current		30 minute			
21	Minimum creepage distance of insulator (mm)					
22	Mounting structure	Tubular / Lattice	Tubular / Lattice	Tubular / Lattice	Tubular / Lattice	Tubular / Lattice
23	Operating time		Less than 12 secs			
24	Insulator Data					
	a) Bending Strength (kgf)	1000	800	800	As per IS/IEC	600
	b) Height (mm)	3650	2300	1500		508
	c) Bottom PCD (mm)	300	254	184		76
	d) No. of holes & hole dia.	8x18	8x18	4x18		4xM12
	e) Top PCD	127	127	127		76
	f) No. of holes & hole dia.	4xM16	4xM16	4xM16		4xM12

	Type:	400 kV	220 kV	132 kV	66 kV	33 kV
I	II	III	IV	V	VI	VII
	g) Minimum creepage distance (mm) 31mm/kV	13020	7595	4495	2248	1116
25	Working clearance (live part to ground) (in mm)	8000	5900	4900	As per IS/IEC	4000
26	Phase Spacing (mm.)	6000	4000	3000		1500
27	Minimum clearances (mm.)					
	a) Phase to Phase	4000	2100	1300		320
	b) Phase to earth	3500	2100	1300		320
	c) Sectional clearance	6500	5000	4000		3000

• SCOPE

This specification provides for design, manufacturer, testing at manufacturer's Works and delivery, supervision of erection, commissioning (if required) of outdoor station type 400kV/220KV/132KV/ 33KV, Isolator with/ without earth switches, with electrical/**mechanical** interlock, insulators and complete in all respect with bimetallic connectors arcing horns operating mechanism, auxiliary switches, indicating devices, fixing detail etc. as described hereinafter.

10.1 STANDARDS

Disconnecting switches covered by this specification shall conform to latest edition IEC-129/IEC 62271-102 I.S.1813 and IS: 9921, IS-325 and unless specifically stated otherwise in this specification.

10.2 TYPE

The 400,220&132 KV Isolators shall be outdoor type with centre break type/Pantograph type as required [Single(SI)/ Double(DI)] Isolators suitable for electrical as well as manual operation and local/ remote operation; but 33KV Isolators (SI or DI) shall be outdoor type with three phase double break center rotating manual as well as motor operated type with local/remote operation. They shall have crank and reduction gear mechanism.

All Isolators offered shall be suitable for horizontal upright mounting on steel structures. Each pole unit of the multiple Isolators shall be of identical construction and mechanically linked for gang operation.

Each pole of the Isolator shall be provided with two sets of contacts to be operated in series and the moving contact blades shall rotate in horizontal plane.

The design shall be such that the operating mechanism with the linkages shall be suitable for mounting on any of the outer pole ends without much difficulty and with minimum shifting of parts.

Moving contacts of all isolators shall rotate through 90 deg. from their "fully closed position" to "fully open position so that the break is distinct and clearly visible from ground level.

The Isolators offered by the Bidder shall be designed for Normal rating current for Isolator as follows:

400kV	220kV	132kV	66kV	33kV
4000A	3150A	2000/1600/1250A	2000/1250A	2500/1600/1250A

It should be suitable for continuous service at the system voltages specified herein. The Isolators shall be suitable to carry the rated current continuously and full short circuit current of 63/50/40/31.5 KA for 400/220/132/33 KV respectively for 3 second at site condition without any appreciable rise in temperature. These shall also be suitable for operation at 110% rated (normal) voltage. The Isolators shall be suitable for Isolating low capacitive / inductive currents of 0.7amp at 0.15 power factor. The isolators shall be so constructed that they don't open under the influence of short circuit conditions.

The Isolators and earthing switches are required to be used on electrically exposed installation and this should be taken into account while fixing the clearance between phases and between phase and earth. so that de-energized isolator and earth switch also can be manually operated when the parallel

circuit is energized.

10.3 MAIN CONTACTS

All Isolators shall have heavy duty, self-aligning and high-pressure line type **dust-free jaw** contacts made of high conductivity, corrosion resistant, hard-drawn electrolytic copper strips of proper thickness and contact area. Fixed contact should consist of loops of above copper strips suitable for 4000 Amps, 3150 Amps, 2000 Amps, and 1250Amps ratings for 400kV, 220 KV, 132KV and 33KV Isolators respectively. The hard drawn electrolytic copper strips should be silver plated 25micron thickness and fixed contacts should be backed by powerful phosphor bronze/stainless steel springs of suitable numbers. The main contacts should be preferably of tulip type design. However, the thickness and contact area of the contact should conform to the drawing approved during type test. Moving contact with moving arm should be of hard-drawn electrolytic copper of proper thickness and contact area.

These fixed and moving contacts shall be able to carry the rated current continuously and the maximum fault current of 63/50/40/31.5 KA for 400/220/132/33KV respectively for **3 seconds** without any appreciable rise in temperature. The Isolator blades shall retain their form and straightness under all conditions of operation including all mechanical stress arising out of operation as well as under rated short circuit condition.

Fixed guides shall be provided so that even when the blades are out of alignment, closing of the switches, proper seating of the blades in between contacts and adequate pressure to give enough contact surface is ensured. The contact shall be self-cleaning by the wiping action created by the movements of the blades.

The Isolator shall be self-cleaning type so that when isolators remain closed for long periods in a heavily polluted atmosphere, binding does not occur. No undue wear or scuffing shall be evident during the mechanical endurance tests, contacts and springs shall be designed so

that adjustment of contact pressure shall not be necessary throughout the life of the isolator. Each contact or part of contacts shall be independently sprung so that full pressure is maintained on all contact at all times.

10.4 ARCING HORN AND GRADING HORN

Suitable arcing horn made of tinned electrolytic copper which are required for guiding contacts shall be provided on the fixed and moving contacts of all Isolators. The contacts shall be of 'make before and break after' type. Aluminium alloy grading ring are to be provided for 220kV and above voltage level.

10.5 ELECTRICAL INTERLOCK / MECHANICAL INTERLOCK

The disconnecting switches whenever required shall be with an approved type electrical interlock for interlocking with the associated circuit breakers and earth switch.

Electrical interlock shall ensure reliable operation. The design should be such that the electrical circuit for the interlocking mechanism **will remain energised as per operation of the isolator with integrated earth switches.**

10.6. AUXILIARY SWITCHES

All isolators and earthing switches shall be provided with 220VDC auxiliary switches for their remote position indication on the control board and for electrical locking with other equipment. The auxiliary switch shall be provided with a minimum of six auxiliary contacts- 10 normally open and 10 normally closed and 10 normally open and 10 normally closed for earth switch. Separate auxiliary switches shall be provided for isolating and earth switches. 6 additional NO and NC contact to be provided as spare in each case.

The auxiliary switches and auxiliary circuits shall have a continuous current carrying capacity of at least 10 Amps. Auxiliary switches shall not be used as limit switches. Details of make, rating and type of limit switch shall be furnished in the offer.

10.7 EARTH SWITCH

Line earth switch shall consist of three earthing blades for Isolator which normally rest against the frame when the connected Isolator is in closed position. The earthing blades for three phases shall be mechanically linked to a coupling shaft which shall be capable of being fitted on either side of the Isolator. The earthing blades shall match and be similar to the main switch blades and shall be provided at the hinge; with suitable flexible conductors with terminal lugs for connecting to the station ground bus. The earthing blades shall be operated by a separate mechanism but shall be mechanically interlocked with the main switch so that the earthing blades can be closed only when the main switches are in open position and vice-versa. The earthing blades shall be gang operated and all the three blades will operate simultaneously.

10.8 OPERATING MACHANISM

The operating mechanism shall be simple and shall ensure quick and effective **10000** mechanical operation. The design shall be such as to enable one man to operate it with nominal effort. The operating mechanism box shall be made out of aluminium extruded (Aluminium alloy) sections of minimum 3.0 mm thickness. The operating mechanism shall be strong rigid and not subject to rebound.

The Isolator blades shall be in positive continuous control throughout the entire cycles of operation. The operating rods and pipes shall be rigid enough to maintain positive control under most adverse conditions and to withstand all torsional and bending stresses arising from operation. Operation of the switches at any speed should not result in improper functioning, in displacement of parts / machines after final adjustment has been made. All holes in cranks, linkages etc. having moving pins shall be fitted accurately so as to prevent slackness and lost motion.

Provision shall be made for padlocking the operating mechanism of disconnecting and earth switches in both open and closed positions.

Bearings shall be ball and roller type shall be protected from weather and dust by means of cover and grease retainers. Bearings pressures shall be kept low to ensure long life and care of operation.

Each power operated isolator shall be motor driven as well as manually operated and shall be complete with local / remote selector switch and open /close push buttons.

Provision shall be made in the control cabinet to disconnect power supply to prevent local / remote power operation. **Limit switches shall be provided with required number of contacts for isolators and earth switches.**

All the terminal blocks to be used in the operating mechanism should of **Ring type** of Polyamide/Melamine material of make like Elmex/Connectwell.

10.9 DESIGN, MATERIALS AND WORKMANSHIP

The live parts shall be designed to eliminate sharp points, edges and corona producing surfaces. Where this is impracticable, adequate shields to be provided. All ferrous metal parts shall be hot dip galvanized, as per IS 2629. All metal parts shall be of such materials or treated in such a way so as to avoid rust, corrosion and deterioration due to continued exposure to atmosphere and rain. All current carrying parts shall be made from high conductivity electrolytic copper .

Bolts, screws and pins shall be provided with standard locking device viz. Locknuts, spring washers, keys etc. and when used with current carrying parts, they shall be made of copper silicon or other high conductivity and wear resistant alloys.

The **isolators** should not need lubrication of any parts except at very long interval of five year minimum.

10.10 PROTECTIVE COATINGS

All ferrous parts including bolts, nuts and washers of the switches assembly shall be galvanized to withstand at least six one minute dips in copper sulphate solution of requisite strength (Prece tests) except the threaded portions which should withstand four dips.

10.11 INSULATORS

Support insulators for all type of isolators shall be of solid core type. The insulator shall be made of homogeneous and vitreous porcelain of high mechanical and dielectric strength. It shall have sufficient mechanical strength to sustain electrical and mechanical loading on account of wind load, short circuit, **seismic** forces etc. Glazing of the porcelains shall be of uniform dark brown colour with a smooth surface arranged to shed away raise water. The porcelain shall be free from laminations and other flaws or imperfections that might affect the mechanical or dielectric quality. It shall be thoroughly vitrified, tough and impervious

to moisture. The porcelain and metal parts shall be assembled in such a manner and with such material that any thermal differential expansion between the metal and porcelain parts throughout the range of temperature specified in this specification shall not loosen the parts or create under internal stresses which may affect the mechanical or electrical strength or rigidity. The assembly shall not have excessive concentration of electrical stresses in any section or across leakage surfaces. The cement used shall not give rise to chemical reaction with metal fittings. The insulator shall be suitable for water washing by rain or artificial means in service condition. Profile of the insulator shall also conform to IEC-815. Caps to be provided on top of the insulator shall be of high-grade cast iron or malleable steel casting. It shall be machine faced and hot dip galvanized. The cap shall have four numbers of tapped holes spaced on a pitch circle diameter of 127mm. The holes shall be suitable for bolts with threads having anti corrosive protection. The effective depth of threads shall not be less than the nominal diameter of the bolt. The cap shall be so designed that it shall be free from visible corona and shall have radio interference level **as specified in table of Clause 10.0** of Casing shall be free from blow holes cracks and such other defects.

10.12 CONTROL CABINET:

The control cabinet of the operating mechanism shall be made out of minimum 3mm thick aluminium alloy sheet. Hinged door shall be provided with pad locking arrangement. Sloping rain hood shall be provided to cover all sides. 15 mm thick neoprene or better type of gaskets shall be provided to ensure degree of protections of at least IP 55 as per IS 2147/IS-3947. The cabinet shall be suitable for mounting on support structure with adjustment for vertical, horizontal and longitudinal alignment. Details of these arrangements shall be furnished along with the offer.

10.13 MOTOR:

Motors rated 0.5 KW and above shall be **provided with** suitable for operation on 3 phase, 415 V, 50 Hz supply. Motors of lower rating shall be single phase type suitable for 240V, 50Hz system. It shall be totally enclosed type if mounted outside the control cabinet. The motor shall withstand without damage stalled torque for at least 3 times the time lag of the tripping device. The motor shall, in all other respects, conform to the requirement of I.S. 325. **Suitable relay/device shall be provided to prevent over loading of the motor. Single phase preventer (for 3 phase meter) shall be provided to operate on open circuiting of any phase and shall trip off the motor. Complete details of the devices shall be furnished in the offer.**

10.14 GEAR:

The dis-connector / isolator may be required to operate occasionally, with considerably long idle intervals. Special care shall be taken for selection of material for gear and lubrication of gears to meet this requirement. The gear shall be made out of aluminium bronze or any other better material lubricated for life with graphite or better-quality non-drawing and non-hardening type grease. Wherever necessary automatic relieving mechanism shall be provided.

10.15 SPACE HEATERS:

Space heaters suitable for 1 phase 240V AC supply shall be provided for each motor operated operating mechanism to prevent condensation and shall be operated by MCB.

10.16 TERMINAL BLOCK AND WIRINGS

Each operating mechanism shall be provided with 1100V grade **ring** type terminal block. All auxiliary switches, **spare contact of the contactors**, interlocks and other terminals shall be wired up to terminal block. The terminal block shall have at least 20% extra terminals. All wiring shall be carried out with 1.1KV grade **PVC** insulated 2.5 sq.mm. copper wires.

10.17 INTERIOR ILLUMINATION:

A holder suitable for a 240 V lamp shall be provided in each of the motor operated mechanism of three poles & shall be door operated type.

10.18 CONTROL AND AUXILIARY SUPPLY:

A 3-phase switch with MCB for phases and link for neutral, shall be provided for power supply and a 2 pole MCB shall be provided for control supply.

10.19 POSITION INDICATOR:

A position indicator to show the isolator is in ON or OFF position to be provided.

10.20 NAME PLATE:

Isolator, earthing switches and their operating devices shall be provided with name plate. The name plate shall be weatherproof and corrosion proof. It shall be mounted in such a position that it shall be visible in the position of normal service and installation. It shall carry the following informations duly engraved or punched on it.

A. Isolator Base

Name: AEGCL

Name of manufacturer –

Order No. –

Type Designation –

Manufacturers serial No. –

Rated voltage –

Rated normal current –

Rated short time current (rms) and duration –

Rated short time peak current (KAP)

Weight-

Manufacturing Statndard-

B. Earthing Switch

Name: AEGCL

Name of manufacturer –

Order No. –

Type Designation –

Manufacturers serial No. –

Rated voltage –

Rated normal current –

Rated short time current (rms) and duration

Rated short time peak current (KAP)

Weight

C. Operating Device

Name – AEGCL

Name of manufacturer –

Order No.

Type Designation –

Reduction gear ratio –

AC motor

- i) Rated auxiliary voltage
- ii) Starting current
- iii) Designation of AC motor as per IS 4722/325
- iv) Starting torque at 80% of supply voltage
- v) Over travel in degrees after cutting off supply

Total operating time in seconds

- i) Close operation – Electrical
- ii) Open operation – electrical
- iii) Open operation – manual

10.21 PAINTING GALVANIZING AND CLIMATE PROOFING:

At interiors and exteriors of enclosures, cabinets and other metal parts (other than made up of aluminium) shall be thoroughly cleaned to remove all rust, scales, corrosion, grease and other adhering foreign matter and the surfaces treated by phosphating (e.g. seven tank phosphating sequence). After such preparation of surfaces, two coats of zinc oxide primer shall be given by suitable stoving and air drying before final painting **with epoxy paint**. Colour of the final paints shall be of shade no. 697 of IS:5. The finally painted cubicle shall present aesthetically pleasing appearance free from any dent or uneven surface.

Paint inside the metallic housing shall be of anti-condensation type and the paint on outside surfaces shall be suitable for outdoor installation.

All components shall be given adequate treatment of climate proofing as per IS:3202 so as to withstand corrosive and severe service conditions.

All metal parts not suitable for painting such as structural steel, pipes, rods, levers, linkages, nuts and bolts used in other than current path etc. shall be hot dip galvanized as per IS –2629. Galvanization test will be carried out during routine test.

Complete details of painting, galvanizing and climate proofing of the equipment shall be furnished in the offer.

10.22 TESTS:

Type Tests:

Isolators offered, shall be fully type tested as per the relevant standards. The Bidder shall furnish Three sets of the following valid type test reports for their different type of offered Isolators along with the offer. The AEGCL reserves the right to demand repetition of some or all the type tests in the presence of AEGCL's representative. For this purpose, the Bidder may quote unit rates for carrying out each type test and this will be taken during bid price evaluation, if required.

- a) short time withstand & peak withstand current test for Isolator & Earth Switch.
- b) power frequency (Dry & Wet), Lightning Impulse dry withstand Test
- c) Mechanical endurance Test
- d) IP-55 test
- e) **Seismic test**
- f) **Temperature Rise test**

During type tests the isolator shall be mounted on its own support structure or equivalent support structure and installed with its own operating mechanism to make the type tests representative. Drawing of equivalent support structure and mounting arrangements shall be furnished for Purchaser's approval before conducting the type tests.

The type tests shall be conducted on the isolator along with approved insulators and terminal connectors. Mechanical endurance test shall be conducted on the main switch as well as earth switch of one isolator of each type.

Acceptance and Routine Test:

All acceptance and routine test as stipulated in the relevant standards shall be carried out by the supplier in presence of Purchaser's representative.

Mechanical operation test (routine test) shall be conducted on isolator (main switch and earth switch) at the supplier's works as well as purchaser's substation site.

Immediately after finalization of the programme of type / acceptance, routine testing the supplier shall give sufficient advance intimation (clear 20 days advance intimation), along with shop routine test certificates, valid calibration reports from Govt. approved (**NABL**) test house for the equipment, instruments to be used during testing for scrutiny by the AEGCL to enable him to depute his representative for witnessing the tests. If there will be any discrepancies in the shop routine test certificates and calibration reports furnished by the firm then after settlement of the discrepancies only, purchaser's representative will be deputed for witnessing the tests. Special tests proposed to be conducted (if decided to conduct) as type test on isolators, are given at Annexure- II. These special type test charges shall be quoted along with all other type tests as per relevant IEC standard and these charges shall be included in the total bid price

Test certificates of various items including but not limited to the following shall be furnished at the time of routine tests.

- a) Chemical analysis of copper along with a copy of excise certificate indicating genuine source of procurement of electrolytic grade copper.
- b) Bearings
- c) Fasteners
- d) Universal / swivel joint coupling
- e) Insulators
- f) Motor
- g) Gears
- h) Auxillary switch
- i) Limit switch
- j) Timer
- k) Overload / single phase preventer relay
- l) Interlocking devices
- m) Terminal block
- n) Any other item

10.23 INSPECTION:

- i) The Purchaser shall have access at all times to the works and all other places of manufacture, where the disconnectors, earth switches and associated equipment are being manufactured and the supplier shall provide all facilities for unrestricted inspection of the works raw materials manufacture of all the accessories and for conducting necessary tests as detailed herein.
- ii) The supplier shall keep the purchaser informed in advance of the time of starting of the progress of manufacture of equipment in its various stages so that arrangements could be made for inspection.
- iii) No material shall be dispatched from its point of manufacture unless the material has been satisfactorily inspected and tested.
- iv) The acceptance of any quantity of the equipment shall in no way relieve the supplier of his responsibility for meeting all the requirements of this specification and shall not prevent subsequent rejection if such equipment is later found to be defective.

10.24 QUALITY ASSURANCE PLAN:

The Bidder shall invariably furnish following information along with his offer, failing which his offer shall be liable for rejection.

- (i) Names of sub suppliers for raw materials, list of standards according to which the raw materials are tested, list of tests normally carried out on raw materials in presence of Supplier's representative, copies of test certificate
- (ii) Information and copies of test certificates as in (i) and (ii) above in respect of bought out accessories.

- (iii) List of manufacturing facilities available
- (iv) Level of automation achieved and lists of areas where manual processing still exists.
- (v) List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.
- (vi) List of testing equipment with calibration certificates from Govt. approved(**NABL**) test house available with supplier for final testing equipment and test plant limitation if any, vis-à-vis the type, special acceptance and routine test specified in the relevant standards. These limitations shall be very clearly brought out in the specified test requirements.
- (vii) QAP shall include acceptance criteria mentioning clause no. of applicable standard against each parameter.

The supplier shall within 30 days of placement of order, submit following information to the purchaser.

- i) List of raw material as well as bought out accessories and the names of sub-suppliers selected from the lists furnished along with offer.
- ii) Type test certificates of the raw material and both bought out accessories.
- iii) Quality Assurance Plan (QAP) withhold points for purchaser's inspection.

The supplier shall submit the routine test certificates of bought out accessories and raw material viz. Copper, aluminum conductors, lubricating material, gear material etc. at the time of routine testing of the fully assembled isolator.

10.25 DOCUMENTATION:

All drawings shall conform to relevant international standards organization (ISO).. All dimensions and data shall be in S.I. Units.

List of Drawings and Documents

The Bidder shall furnish **four** sets of following drawings / documents along with his offer.

- a) General outline and assembly drawings of the dis-connector operating mechanism, structure, insulator and terminal connector.
- b) Sectional views and descriptive details of items such as moving blades, contacts, arms contact pressure, contact support bearing housing of bearings, balancing of heights, phase coupling pipes, base plate, operating shaft, guides, swivel joint operating mechanism and its components etc.
- c) Loading diagram
- d) Drawings with structure for the purpose of type tests.
- e) Name plate.
- f) Schematic drawing.
- g) Type test reports.
- h) Test reports, literature, pamphlets of the bought-out items and raw material.
- i) Deviation sheet/compliance sheet if applicable

Six sets of the type test report, duly approved by the Purchaser shall be submitted by the supplier for distribution, before commencement of supply Adequate copies of acceptance and routine test certificates, duly approved by the Purchaser shall accompany the dispatched consignment.

The manufacturing of the equipment shall be strictly in accordance with the approved drawings and no deviation shall be permitted without the written approval of the purchaser. All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawing shall be at the supplier risk.

The supplier shall within 2 weeks of placement of order submit four sets of final versions of all the above said drawings for AEGCL's approval. The purchaser shall communicate his comments / approval on the drawings to the supplier. The supplier shall, if necessary, modify the drawings and resubmit four copies of the modified drawings for AEGCL's approval within two weeks from the date of comments.

10.26 INSTRUCTION MANUALS:

Fifteen copies of the erection, operation and maintenance manuals in English to be supplied for each type of disconnector one month prior to dispatch of the equipment. The manual shall be bound volumes and shall contain all drawings and information required for erection, operation and maintenance of the disconnector including but not limited to the following particulars.

- (a) Marked erection prints identifying the component parts of the disconnector as shipped with assembly drawings.
- (b) Detailed dimensions and description of all auxiliaries.
- (c) Detailed views of the insulator stacks, metallics, operating mechanism, structure, interlocks, spare parts etc.

10.27 PACKING AND FORWARDING:

The equipment shall be packed in crates suitable for vertical / horizontal transport, as the case may be and suitable to withstand handling during transport and outdoor storage during transit. The supplier shall be responsible for any damage to the equipment during transit, due to improper and inadequate packing. The easily damageable material shall be carefully packed and marked with the appropriate caution symbols.

Wherever necessary, proper arrangement for lifting, such as lifting hooks etc. shall be provided. Any material found short inside the packing cases shall be supplied by supplier without any extra cost.

Each consignment shall be accompanied by a detailed packing list containing the following information:

- (a) Name of the consignee.
- (b) Details of consignment.
- (c) Destination.

- (d) Total weight of consignment.
- (e) Handling and unpacking instructions.
- (f) Bill of material indicating contents of each package.

The supplier shall ensure that the bill of material is approved by the purchaser before dispatch.

10.28 SUPERVISION OF ERECTION TESTING AND COMMISSIONING (ET&C):

Purchaser proposes to utilize the services of the supplier for supervision of testing and commissioning of the equipment being supplied by him, if it is required. For this purpose, the supplier should make available the services of trained personnel (Engineers) who shall correct in the field, any errors or omissions in order to make the equipment and material properly perform in accordance with the intent of this specification. The Engineer shall also instruct the plant operators in the operation and maintenance of the commissioned equipment. The supplier shall be responsible for any damage to the equipment on commissioning the same, if such damage results for the faulty or improper ET&C. Purchaser shall provide adequate number of skilled / semi-skilled workers as well as ordinary tools and equipment and cranes required for equipment erection, at his own expenses. Apart from the above, the Purchaser shall not be responsible for providing any other facilities to the supplier. Special tools if required for erection and commissioning shall be arranged by the supplier at his cost and on commissioning these shall be supplied to the purchaser free of cost for future use.

APPENDIX – I

(Isolators)

LIST OF SPECIAL TESTS TO BE CARRIED OUT IF DECIDED BY THE PURCHASER

Sl. No.	Name of the Test	Standard to which it conforms.
1.	Test for visible Corona and Radio interference voltage (RIV) on disconnectors and terminal	NEMA Pub No. 107-1964 ISRI Pub No. 1-1972
2.	Tests on insulators	IS-2544 IEC. 168
3.	Tests on terminal connectors	IS:5561
4.	Tests on galvanized components	IS:2633
5.	Stalled torque test on motor operating mechanism	At 110% of supply voltage

CHAPTER 47: TECHNICAL SPECIFICATION FOR OPTICAL GROUND WIRE (OPGW)

47.1. FIBRE OPTIC CABLES PARTICULAR SPECIFICATIONS (OPGW AND APPROACH CABLES)

47.1.1 OVERVIEW AND GENERAL REQUIREMENTS

OPGW and approach cables are required to provide:

- Ground/earth shielding of the 132KV/220KV/400 KV new lines under this project and
- Use the OPGW/Approach fibre component to the new 132KV/220KV/400KV grid substations of AEGCL to the existing Fibre Optic Network that can support grid communications with SLDC. The proposed augmentation will enable integration of SAS of the grid substations to SLDC. The new Fibre Optic Network will also enable transmission of Tele-protection and Tele-control Signalling; other Data transfer, Voice/Telephony and an Energy Management (EMS) System as fibre media-based functions of its grid communications network and enhanced operation and maintenance of Assam's transmission system and also non power utility communications.

47.1.2 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 D3349.
- (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 and latest amendment of IEEE 1138.
- (4) Electronic Industries Association, EIA-455-3, 455-25A, 455-31B, 455-32, , 455-41, 455-91, 455-78, 455- 59, 455-80, 455-81, 455-169, 455-81, EIA RS 598
- (5) International Electro technical Commission standards, IEC -1396 and IEC - 1089.
- (6) International Electro technical Commission standards, IEC 61395, 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 Bidder shall attempt to comply with such, provided that no additional expenses are charged to the Owner without Owner's written consent.

In addition, and particular recognition of this Contract's purpose to deliver a Fibre based power utility grid operation communication network the following reference documents are to be made available to the Employer its Project Manager and there content reflected as appropriate in the Contractor's Facilities detailed engineering design and implementation programme. These additional reference documents are:

- i. CIGRE Guide for Planning of Power Utility Digital Communications Networks
- ii. CIGRE Optical Fibre Planning Guide for Power Utilities
- iii. CIGRE New Opportunities for Optical Fibre Technology in Electricity Utilities
- iv. CIGRE guide to fittings for Optical Cables on Transmission Lines.

47.1.3 BASIC TECHNICAL DATA

47.1.3.1 Site and Service Conditions

The OPGW and the Communication Equipment covered under this Contract are to run entirely within the State of Assam, India and shall be suitable for the topical climatic conditions prevailing in the Project areas as mentioned in chapter 2 of this bidding document.

47.1.3.2 Fibre optic cabling

The OPGW shall have 96 nos. optical fibres. The OPGW cable, associated hardware and fittings shall meet the requirements of G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable. All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

47.1.3.3 Required optical fibre characteristics

The optical fibre to be provided should have following characteristics.

47.1.3.4 Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristic.

47.1.3.5 Physical Characteristic

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

47.1.3.6 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 1-1 (a) shall be "guaranteed" fibre attenuation of any & every fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550nm: $0.21 \text{ dB/km} \times \text{total km} + 0.05 \text{ dB/splice} \times \text{no. of splices} + 0.5 \text{ dB/connector} \times \text{no. of connectors}$.

Maximum attenuation @ 1310nm: $0.35 \text{ dB/km} \times \text{total km} + 0.05 \text{ dB/splice} \times \text{no. of splices} + 0.5 \text{ dB/connector} \times \text{no. of connectors}$.

Table-1

DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 μm ($\pm 0.6 \mu\text{m}$)
Cladding Diameter:	125.0 $\mu\text{m} \pm 1 \mu\text{m}$
Mode field concentricity error	$\leq 0.6\mu\text{m}$
Cladding non-circularity	$\leq 1\%$

Cable Cut-off Wavelength lcc	≤ 1260 nm
1550 nm loss performance	As per ITU-T G.652 D
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.21 dB/km
Chromatic Dispersion; Maximum:	18 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:	1300 to 1324nm
Zero Dispersion Slope:	0.092 ps/nm ² xkm maximum
Polarization mode dispersion coefficient	≤ 0.2 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 @ 1550 nm (30±1 mm radius Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB

47.1.3.7 Fibre Optic Cable Construction

The OPGW (Optical Ground Wire) cable is proposed to be installed on the EHV transmission lines. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirements of all the transmission lines.

47.1.3.8 Optical Fibre Cable Link Lengths

The estimated optical fibre link lengths are provided in Appendices/Section Project/BoQ as transmission line route length. However, the Contractor shall supply & install the optical fibre cable as required based on detailed site survey to be carried out by the Contractor during the project execution. The Contractor shall verify the transmission line route length during the survey and the Contract price shall be adjusted accordingly.

For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths & wastage etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price Schedules shall take into account all such factors.

47.1.3.9 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.

Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing.

Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres is included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be suitably bundled, tagged and identified at the factory by the vendor.

47.1.3.10 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. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.

47.1.3.11 Optical Fibre Strain & Sag-Tension chart

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

For the purpose of this specification, 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
- 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.
- The cable max strain is defined as the maximum strain experienced by the Cable under the worst-case loading condition.
- The cable Every Day Tension (EDT) is defined as the maximum cable tension on any span under normal conditions.
- 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.

- 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 of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted along with the bid under various conditions mentioned below:

1. 53° C , no wind and no ice
2. 32° C, no wind and no ice
3. 0°C, no wind and no ice
4. 32° C, full wind and no ice
5. 32° C, 75% full wind and no ice
6. 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. Max. Vertical sag, max. tension and max sag at 0° C & no wind shall be considered in line with the design parameter of transmission line. The typical details are indicated in the Appendix A. The full wind load shall be considered as the design wind load for all the specified transmission lines as per relevant IS 802 version and the sag-tension chart shall be submitted considering the transmission lines.

47.1.3.12 Cable Materials

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

47.1.3.13 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibiting 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, non-hygroscopic, 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 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.

47.1.3.14 Metallic Members

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

47.1.3.15 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 white lettering with the vendors' address, the Purchaser's destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line & segment no., factory inspection stamp and date.

(b) Cable Drums: All optical fibre cabling shall be supplied on strong drums 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.

The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

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 on each drum shall be determined by a "schedule" prepared by the Contractor and approved by the owner.

47.1.3.16 Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 2009. 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 cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy/stainless steel with aluminium coating protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single buffer tube or directly in central fibre optic unit is not acceptable. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

47.1.3.17 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 OPGW design of dissimilar materials such as stainless-steel tube with aluminium or aluminium-clad-steel wire strands are not allowed. Central fibre optic unit may be of aluminium or stainless-steel tube with aluminium protective coating. In case of aluminium protective coating, the coating must completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

Transmission Line Voltage and Wind Zone	OPGW Cable Parameters						
	UTS (kg)	Area (sqmm)	Wt (Kg/m)	Dia (mm)	Modulus of Elasticity (Kg/sqmm)	Coeff of Linear Expansion (per deg c)	Central Fibre Optic Unit Design
400kV M/C WZ 1-4 400kV D/C WZ 1-5	9350±150	56.5±2.5	0.45±0.01	12±0.2	14290±110	0.0000138 ± 0.0000003	Al tube
220kV D/C WZ 1-4 132kV D/C WZ 1-5	7376±50	51±2	0.355±0.01	11.4±0.2	12344±100	0.0000149 ± 0.0000003	Al Tube
River Crossing Section	20059±100	118±5	0.884±0.01	14.7±0.2	16355±100	0.0000127 ± 0.0000003	Stainless Steel Tube

Table: OPGW Parameters to be considered for different line voltage and wind zone

47.1.3.18 Basic Construction

The OPGW cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 1.2(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. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

47.1.3.19 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.

47.1.3.20 Electrical and Mechanical Requirements

Table 1-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics

shall be similar to that of the earth wire being replaced such that there is no or minimal consequential increase in stresses on towers. 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 installation sag & tension charts shall be based on IS 802 version to which the line is originally designed. 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 1.2(a)

OPGW Electrical and Mechanical Requirements

(1)	Everyday Tension	≤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

47.1.3.21 Operating conditions

Since OPGW shall be located at the top of the 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 same or similar as those required of conventional ground conductors.

47.1.3.22 Installation

OPGW installed 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 Conductors (IEEE STD. 524 with latest revisions), with additional instructions and precautions for live line working and fibre optic cable handling.

A tower structural analysis shall be carried out by the Contractor wherever required, based on the relevant data to be provided by Employer, 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 at no additional cost to Employer. The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional 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 at no additional cost to Employer.

47.1.3.23 Installation Hardware

The scope of supply includes all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The quantity of hardware & fittings to meet any eventuality during site installation minimum@ 1% shall also be provided as part of set/km for each transmission line without any additional cost to Employer. The OPGW hardware fittings

and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 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 OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts:

- (1) A technical particular sheet
- (2) An assembly drawing i.e. level 1 drawing and
- (3) Component level drawings i.e. level 2 & lower drawings. 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 aluminium 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. 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). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

(b) Dead End Clamp Assemblies: All dead-end clamp assemblies shall preferably be of 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 corresponding to wind speed of 1m/s to 7 m/s, 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 technical specifications.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 400 meters. For all other ruling spans, the number of vibration damper shall be based on vibration analysis.

The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chaffing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the strands or causing premature fatigue failure of the OPGW cable under the clamp. The clamp groove shall be in uniform contact with the OPGW cable over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the OPGW cable when the clamp is installed. Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanised steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS:4826 for heavily coated wires.

The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blow holes etc. The surface of the damper masses shall be smooth.

The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions. The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the OPGW cable shall not cause excessive stress concentration on the OPGW cable leading to permanent deformation of the OPGW strands and premature fatigue failure in operation. The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed in Technical Specification, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows

SI No	Description	Technical Particulars
1	Span Length in meters (i) Ruling design span: (ii) Maximum span: (iii) Minimum Span:	400 meters 1100 meters 100 meters
2	Configuration:	As per Specifications
3	Tensile load in each:	As per sag tension calculations
4	Armour rods used:	Standard preformed armour rods/AGS
5	Maximum permissible dynamic strain:	+/- 150 micro strains

The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Contractor.

Placement charts should be duly supported with relevant technical documents and sample calculations.

The damper placement charts shall include the following

- (1) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per OPGW cable per span.
- (2) Placement distances clearly identifying the extremities between which the distances are to be measured.
- (3) Placement recommendation depending upon type of suspension clamps (viz Free center type/Armour grip type etc.)
- (4) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

47.1.3.24 Fibre Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply with ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 12 fibres shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures. 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 transmission line towers above anticlimb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

47.1.3.25 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

- (a) All fibre splices shall be accomplished through fusion splicing.
- (b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.
- (c) All splices and bare fibre shall be neatly installed in covered splice trays.
- (d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.
- (e) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

47.1.3.26 Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices/BoQ. However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

47.1.3.27 Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

47.1.3.28 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

47.1.3.29 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

47.1.4.0 Fibre Optic Distribution Panel

Fibre Optic Distribution Panels is required for each location for termination of fibres in a manner consistent with the following:

- (a) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.
- (b) FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement
- (c) All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.

47.1.5.0 Optical Fibre Connectors

Optical fibres shall be connectorised with FC-PC type connectors preferably. Alternatively, connector with matching patch cord shall also be acceptable. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

47.1.5.1 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

(a) Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.

(b) Indoor Cable Service Loops: FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.

(c) Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(d) Pigtail Service Loops : Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

(e) Fibre Service Loops : At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

47.1.6.0 Test Equipment

Appendix-B provides mandatory test equipment requirements, to be provided. The parameters / features of the mandatory equipment are enumerated in Table 1.3 below and Chapter “ Spares and Tools”

Table 1.3		
SI No	Test Equipment	
A.	Test Equipment for OPGW cable	
1	OTDR (Optical Time Domain Reflectometer) for 1310/1550 nm	
2	Optical Attenuators (variable 1310/1550nm).	
3	Optical Power meter (1310/1550nm)	
4	Laser Light Source (1310/1550nm)	
5	Optical Fibre Fusion Splicer incl. Fibre cleaver etc	
6	OFC Tool kit consisting of Fibre stripping tool and tools for cutting and stripping of sheathing, jacket armouring of OFAC/ADSS/OPGW cables including two nos of high resolution hand held Binoculars	
7	Optical test accessory kit including all Necessary connectors, adaptors, cables, terminations and other items required for testing	

In case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for use in the high EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment from at least one customer.

47.1.7.0 Inspection & Testing Requirement

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.

Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory, 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.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

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 Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

47.1.8.0 Testing Requirements

Following are the requirements of testing :

1. Type Testing
2. Factory Acceptance Testing
3. Site Acceptance Testing

47.1.9.0 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) All cable & equipment being supplied shall conform to type tests as per technical specification.

(b) The test reports submitted shall be of the tests conducted within last seven (7) years for OPGW cable prior to the date of proposal/offer submitted. In case the test reports are older than seven (7) years for OPGW cable on the date of proposal/offer, the Contractor shall repeat these tests at no extra cost to the Employer.

(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports 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 accredited labs and witnessed by third party / customer's representatives. In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

In case the Type Test is required to be carried out, then following shall be applicable:-

(d) 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 defined in the technical specifications 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.

(e) 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.

(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

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 test(s) 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.

47.1.9.1 Type Test Sample

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 for selection. For Splice enclosures at least three samples shall be offered for selection.

47.1.9.2 List of Type Tests

The type testing shall be conducted on the following items

- (a) Optical fibres
- (b) OPGW Cable
- (c) OPGW Cable fittings

- (d) Vibration Damper
- (e) Splice Enclosure (Joint Box)
- (f) Approach Cable

47.1.9.3 Type Tests for Optical Fibres

The type tests listed below in table 2-1 shall be conducted on DWDM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

SL. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Section-01 of TS	IEC 60793-1-40 Or EIA/TIA
2	Attenuation Variation with Wavelength		IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak		IEC 60793-1-40 Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles
5	Attenuation With Bending(Bend Performance)		IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field dia.		IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174
7	Chromatic Dispersion		IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter		IEC 60793-1-20 Or EIA/TIA 455-176
9	Point Discontinuities of		IEC 60793-1-40 Or
	attenuation		EIA/TIA 455-59
10	Core -Clad concentricity error		IEC 60793-1-20 Or EIA/TIA 455-176
11	Fibre Tensile Proof Testing		IEC 60793-1-30 Or EIA/TIA 455-31B

47.1.9.4 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 2-2 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.

S. No.	Test Name	Test Description	Test Procedure
1	Water Ingress	IEEE 1138-2009	IEEE 1138-2009

	Test		(IEC 60794-1-2 Method F5 or EIA/TIA 455-82B) : Test duration : 24 hours	
2	Seepage of filling compound	IEEE 1138-2009	IEEE 1138-2009 (EIA/TIA 455-81B)	Preconditioning period:72 hours. Test duration: 24 hours.
3	Short Circuit Test	IEEE 1138-2009	IEEE 1138-2009	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.
		Or IEC60794-4-10 / IEC 60794-1-2 (2003) Method H1		Initial temperature during the test shall be greater than or equal to ambient field temperature.
4	Aeolian Vibration Test	IEEE 1138-2009 Or IEC60794 4-10 / IEC 60794-1-2, Method E19	IEEE 1138-2009	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

S. No.	Test Name	Test Description	Test Procedure	
5	Galloping test	EEE 1138-2009	IEEE 1138-2009	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 cable sample shall be spliced together in serial for attenuation monitoring.
6	Cable Bend Test	Procedure 2 in IEC 60794-1-2 Method E11		The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC 60794-1-2 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 1138-2009 OR IEC 60794-1-2 (2003) Method E1B	IEEE 1138-2009	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 1138-2009	IEEE 1138-2009 (IEC 60794-1-2, Method E3/ EIA/TIA 455-41B)	The crush test shall be carried out on a sample of approximately one (1) metre long in accordance with IEC 60794-1-2 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 1138-2009	IEEE 1138-2009, (IEC 60794-1-2 E4/ EIA/TIA 455-25B)	The impact test shall be carried out in accordance with IEC 60794-1-2 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.
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S. No.	Test Name	Test Description	Test Procedure	
10	Creep Test	IEEE 1138-2009	IEEE 1138-2009	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 calculated.
11	Fibre Strain Test	IEEE 1138-1994	IEEE 1138-1994	
12	Strain Margin Test	IEEE 1138-2009	IEEE 1138-2009	
13	Stress strain Test	IEEE 1138-2009	IEEE 1138-2009	
14	Cable Cut-off wavelength Test	IEEE 1138-1994	IEEE 1138-2009	
15	Temperature Cycling Test	IEEE 1138-2009	IEEE 1138-2009 Or IEC 60794-1-2, Method F1	
16	Corrosion (Salt Spray) Test	EIA/TIA 455-16A		
17	Tensile Performance Test	IEC 60794-1-2 E1 / EIA/TIA 455-33B	The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 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.	
18	Lightning Test	IEC 60794-4-10 /	The OPGW cable construction shall be tested in accordance with IEC 60794-1-2, Method	

		IEC 60794-1-2 (2003)	H2 for Class 1.
19	DC Resistance Test (IEC 60228)	On a fibre optic cable sample of minimum 1 metre length, two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially zero metre and subsequently one metre apart. The tests shall be repeated at least five times and the average value recorded after correcting at 20°C.	

47.1.9.5 Type Test on OPGW Cable Fittings

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

- (i) Mechanical Strength Test for Suspension/Tension Assembly

Applicable Standards: 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 be 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.

(ii) 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 positions 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.

(iii) Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on an 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 increase 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.

(iv) 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.

(v) 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.

47.1.9.6 Type Test on Vibration Damper

(a) 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 ranging from $0.18/d$ to $1.4/d$ – where d is the OPGW cable diameter in meters. 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.

(i) Force Vs frequency

(ii) Phase angle Vs frequency

(iii) 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.

Acceptance criteria for vibration damper:

- (i) The above dynamic characteristics test on five dampers shall be conducted.
- (ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
- (iii) The above mean reactance response curve should lie within following limits: V.D. for OPGW - $0.060 f$ to $0.357 f$ kgf/mm* Where f is frequency in Hz.
- (iv) The above mean phase angle response curve shall be between 25° to 130° within the frequency range of interest.
- (v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
- (vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(b) 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.

- (i) The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as 25% of RTS of fibre optic cable for a span ranging from 100 m to 1100 m.
- (ii) 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.

(iii) The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.

(iv) 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.

(v) 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.

(vi) 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.

(c) Fatigue Tests

(i) Test Set Up

The 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 25% of RTS of fibre optic cable 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.

(ii) 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 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:

- (1) There shall not be any resonant frequency shift before and after the test by more than $\pm 20\%$
- (2) The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than $\pm 20\%$ Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper.

SI No	Test Name	Test Procedure
1	Visual examination & Dimensional and material verification	IEC 61897 Clause 7.1 & 7.2
2	Clamp Slip test	IEC 61897 Clause 7.5
3	Clamp bolt tightening test	IEC 61897 Clause 7.7
4	Attachments of weights to messenger cable	IEC 61897 Clause 7.8
5	Attachment of clamps to messenger cable	IEC 61897 Clause 7.8
6	Damper effectiveness evaluation	IEC 61897 Clause 7.11.3.2

47.1.9.7 Type Tests for Splice Enclosures (Joint Box)

Following Type tests shall be demonstrated on the 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 60794-1 procedures).

(i) 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 $+65^{\circ}\text{C}$ 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 60794-1-C10. The variation in attenuation shall be less than $\pm 0.05\text{dB}$. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

(ii) Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of $+55^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 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 $\pm 0.05\text{dB}$, and the internal humidity rate measured, less than 2%.

(iii) Rain Withstand Test / Water Immersion 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 60060 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 $\pm 0.05\text{dB}$.

(iv) 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 $\pm 0.05\text{dB}$. 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.

(v) 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

(vi) 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.

(vii) Drop Test

With 2 lengths of 11 metres of cable fixed to the box, it shall be dropped five times from a height of 10 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test surface shall be carried out in accordance with IEC 60068-2-32.

47.1.9.8 Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in Table 2-3: Type Tests for Fibre Optic Approach Cable. 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.

SI No	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24

		hours
2	Seepage of filling	(EIA 455-81A)
	compound	Preconditioning : 72 hours, Test duration : 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength Test	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) – 2 cycles

47.1.9.10 Impact Test

The Impact test shall be carried out in accordance with IEC:60794-1-E4. Five separate impacts of 2.0 kg shall be applied at different locations. 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 0.05 dB/km shall constitute failure.

47.1.9.11 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on OPGW Cable and associated hardware & fittings, Approach Cable, Joint Box, FODP etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Material 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 authorised 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 by the Employer.

The factory acceptance tests for the supplied items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general, the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces etc. For Test equipment FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

47.1.9.12 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. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. 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.

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

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, Joint box and other similar items. 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.

47.1.9.13 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), alongwith 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.

47.1.9.14 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138/IEC 60794. 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 2-4
Factory Acceptance Tests for Optical Fibres: Optical Tests

SI No	Test Name	Acceptance Criteria	Test Procedure
1	Attenuation Coefficient	T S, Table 1-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS, Section 1.1.2	EIA/TIA 455-59
3	Point Discontinuities of attenuation	TS ,Table 2-1(a)	EIA/TIA 455- 78A
4	Chromatic Dispersion		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

The test report for the above tests for the fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

47.1.9.15 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table follow the requirements set forth in IEEE standard 1138 / IEC 60794. 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 2-5
Factory Acceptance Tests on OPGW
Applicable standard: IEEE 1138 / IEC 60794

SI 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

47.1.9.16 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 2-6. The sampling plan shall be as per relevant standard:

Table 2-6
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
5	Galvanising test

Tension Assembly	
6	Clamp Slip Strength test
7	Visual Material verification and dimensional checks as per approved DRS/Drawings
8	Mechanical strength of each component
9	Galvanising Test
Vibration Damper	
10	Galvanising test on damper, masses and messenger wires
11	Damper response (resonant frequencies)
12	Clamp Slip test
13	Strength of messenger wires
14	Attachments of weights to messenger cable
Factory Acceptance Test	
15	Attachments of clamps to messenger cable
16	Clamp bolt tightening test
17	Clamp bolt torque test
18	Dynamic characteristic test.
19	Visual Material verification and dimensional checks as per approved DRS/Drawings
Structure Mounting Clamp	
20	Clamp fit test
21	Clamp Strength test
22	Visual Material verification and dimensional checks as per approved DRS/Drawings

47.1.9.17 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 2-7:

Table 2-7
Factory Acceptance Tests On Approach Cable

SI No	Factory Acceptance Test
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

47.1.9.18 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below in Table: 2 8

Table 2-8
Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP

S. No.	Factory Acceptance Test
1	Visual check of Quantities and Specific Component Number for each component of Splice Enclosure/FODP and dimensional checks against the approved drawings.

47.1.9.19 Factory Acceptance Test on Test Equipment & other items

As per technical specification and approved DRS/Documents.

47.1.9.20 Site Acceptance Tests

The Contractor shall be responsible for the submission of all material & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for FO cable etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

47.1.9.21 Minimum Site Acceptance Testing Requirement for FO Cabling

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

47.1.9.22 Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links. The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents. Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be documented. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Table 2- 9(a) through 2-9(c) below:

Table 2-9(a)
Fibre Optic Cable Pre-Installation Testing

Item:	Description:
1	Physical Inspection of the cable assembly for damage
2	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
3	Fibre Optic Cable length measurement using OTDR

Table 2-9(b)
Fibre Optic Cable Splicing Testing

Item:	Description:
1	Per splice bi-directional average attenuation with OTDR

2	Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
3	Physical inspection of sealing techniques, weatherproofing, etc.

Table 2-9(c)
Fibre Optic Cable Commissioning Testing

Item:	Description:
1	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
2	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.
3	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.

47.1.10 Installation of OPGW Cabling

47.1.10.1 OPGW cable installation requirements

The following shall be under the scope of OPGW Cabling:

- Supply of OPGW Cable & Hardware Fittings needed to tie the OPGW cable to the towers/gantries.
- Supervision of stringing of OPGW Cable at sites as per instruction by Employer. The supervision shall include the inspection as per stringing procedure, proper location of drum site, installation of stringing blocks/pulleys, proper sagging, proper installation of hardware, proper tension as per Sag-Tension chart, provision of service loops of OPGW in jointing locations
- The Splicing work of OPGW Cable and after that testing of link.

47.1.10.3 Installation Hardware

All required hardware's shall be installed along with OPGW Cable.

47.1.10.4 Installation of Approach Cable

The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The Contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval. However, the approach cable shall be laid in the HDPE pipe in all condition. Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable. All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the Contractor.

47.1.10.5 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack /wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer's approval.

47.1.10.6 Fibre Optic Distribution Panel

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

- (a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.
- (b) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

47.1.10.7 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification. The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

47.1.16.0 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

- (a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.
- (b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anticorrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to- paint bond.
- (c) Mechanical construction drawings of the cable raceways shall be submitted for Employer's information & review



APPENDIX-A

Table A-1

Typical transmission line details (To be filled by the Bidder)

Line Voltage	S/C or D/C	Nominal Span (E/W & Conductors in mtrs.)	Wind Zone as per IS 802	Design Tension at Every Day Temp (32° C) and full wind condition – Earthwire in kg	Wind Pressure (kg/Sq-m) considering gust factor	Max Sag – Ground Wire at 53°C (in mtrs)	UTS – Earthwire (in Kg)	Weight – Earth wire (in Kg/km)	Minimum Clearance in mtrs.		
									A 1	B 1	C 1
400KV	S/C										
	D/C										
220 KV	S/C										
	D/C										
132 KV	S/C										
	D/C										

A1 Minimum clearance between conductor and ground (in meters)

B1 Minimum clearance between two phase conductors (in meters) – vertical in case of D/C towers and horizontal in case of S/C towers.

C1 Minimum clearance between conductor and earth wire (in meters)