ODISHA TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION

FOR

33/132/220 KV H.T. XLPE POWER CABLE

(A) TECHNICAL SPECIFICATION FOR 33 kV CROSS LINKED ETHYLENE INSULATED PVC SHEATHED SINGLE CORE, (DIFFERENT CROSS SECTION AREA) COPPER POWER CABLE.

1. SCOPE

This specification covers the design, manufacture, testing, inspection at manufacturer's work, supply & delivery F.O.R. destination of **(DIFFERENT CROSS SECTION AREA)** Single Core XLPE insulated PVC sheathed Cable and single core XLPE cable suitable for solidly grounded system size as per clause(5) mentioned below.

2. PARTICULARS OF THE SYSTEM

The cable should be suitable for use on 50 Cycles, 3 Phases solidly earth neutral system & working voltage of 33kV.

3. STANDARDS

The cable covered under this Specification shall conform in all respects with the latest editions of IS-7098 (Part-2) 2011 & IS-8130-2013 & IEC: 60502 of the latest version thereof.

4. TECHNICAL PARTICULARS

33kV, Single Core underground XLPE insulated PVC sheathed cable suitable for working potential of 33kV on earthed system manufactured in accordance with IS-7098 (Part-2) 2011 with latest amendments or latest editions thereof. The electrolytic grade copper conductor with formation of segmental type as per IEC-60228, tapped with semi conducting conductor shall comply with requirements specified in IS:8130-2013. The insulation shall be chemically cross-linked polyethylene confirming to the physical, electrical and ageing property as required in latest edition of IS-7098 (Part-2) 2011. Cable shall be provided with both conductor screening and insulation screening. The conductor screening shall be non-metallic and shall be consisting of either a layer of semi-conducting compound or combination of two. The insulation screening shall consist of non-metallic extruded semi conducting compound layer in combination with non- magnetic metallic shield. Armouring shall be arranged over the core and it shall be of non-magnetic material. The material for the Armouring shall be as per relevant ISS. Over the Armouring the cable shall be provided with extruded PVC outer sheath. The composition of PVC compound shall be type ST-2 of IS- 5831-1984 & the colour of outer sheath shall be black or grey. A conductive layer of graphite shall be provided on outer sheath to facilitate sheath integrity test if required

5. TESTS

5.1 Type Tests

The equipment offered should be type tested. Type test report should not be more than seven years old, reckoned from the date of bid opening, in respect of the following tests, carried out in accordance with ISS-7098/IEC-871/IEC- 60502, from Govt. /Govt. approved test house, shall be submitted along with bid:

i) Physical tests for insulation and outer sheath. ii) Bending test.
iii) Di-electrical power factor test.
iv) Heating cycle test followed by di-electrical power factor as a function of voltage and partial discharge test.
v) Impulse withstand test.

The remaining type test report as per clause 3 of ISS-7098/IEC-871/IEC-60502 shall be submitted by the successful bidder within three months from the date of placement of order. These type test reports shall be from Govt./Govt. approved test house and shall not be more than seven years old, reckoned from the date of placement of order. The failure to do so will be considered as a breach of contract.

5.2 ROUTINE TESTS AND ACCEPTANCE TESTS

All routine and acceptance tests shall be carried as per relevant ISS in the presence of Nigam's representative.
Following additional tests shall be carried out

1. Convolution and protrusion (as per Annexure A)
2. Sheath integrity test

6. INSPECTION

The material shall be inspected and tested before dispatch by an authorized representative of OPTCL in respect of quality.

7. TEST CERTIFICATES

The supplier shall supply test certificates from a Govt. agency in respect of quality as per IS:7098(part-II) 2011 with latest amendments thereof for approval of the purchaser.

8. PACKING

The cable shall be supplied in non-returnable wooden drum as per IS: 10418:1982 so constructed, as to enable the cable to be transported on each drum. The cable wound on such drum shall be one continuous length. The ends of cables shall be sealed by means of non-hygroscopic sealing material.

9. MARKING

The marking on the drum shall have the following information: -

a) Reference to Indian Standard & cable code. b) Name of the manufacturer & trade name.
c) Nominal cross section area of conductor for the cables. d) Number of core.
e) Sequential No. at each meter.
f) Type of the cable & voltage for which it is suitable. g) Length of cable on the drum.
h) Approximate gross weight.
i) Net weight of the cable.
j) Drum identification number.
k) P.O. No. and date.
l) Consignee's name with designation.
m) Year of manufacture.

Note: Cable should be marked with ISI Certification mark.

10. DRAWINGS & INSTRUCTION MANUAL

The tenderer shall supply the following drawings with the tender: -

i) Detailed drawing of the cable showing conductor, screening insulation, Armouring, outer sheath etc.
ii) Detailed drawing showing jointing of cable and sealing of end boxes.

Copies of instruction manuals for testing, installation jointing operation and maintenance of cables, shall also be submitted with the offer for reference of the purchaser.

11. CONTINUOUS A.C. CURRENT & OTHER DATAS (ALUMINIUM CONDUCTOR):

Conductor sizes in sq.mm.		Continuous A.C. current capacity in Amps at maximum conductor temp. of 90 deg .c. for 33 kV cable					
	When laid direct in the ground	When laid in air	Short circuit current in kA 1sec (I=0.094 x A/sq.rt (t))	A.C resistance at 90 deg in Ohm/Km	D.C resistance at 20 deg in Ohm/Km	Reactance at 50 Hz in Ohm/Km	Capacitance at 50Hz in µF/Km
70	170	220	6.58	0.567	0.443	0.152	0.14
95	200	265	8.93	0.410	0.320	0.145	0.15
120	225	300	11.28	0.325	0.253	0.140	0.16
150	250	340	14.10	0.265	0.206	0.135	0.18
185	280	385	17.39	0.211	0.164	0.130	0.19
240	315	450	22.56	0.162	0.125	0.126	0.21
300	345	500	28.20	0.130	0.100	0.122	0.23
400	385	570	37.60	0.1023	0.0778	0.117	0.25
500	415	640	47.00	0.0808	0.0605	0.113	0.27
630	450	720	59.22	0.0648	0.0469	0.111	0.29
800	485	790	75.20	0.0530	0.0367	0.105	0.34
1000	510	850	94.00	0.0444	0.0291	0.102	0.37

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12. CONTINUOUS A.C. CURRENT & OTHER DATAS (COPPER CONDUCTOR):

Conductor sizes in sq.mm.		Continuous A.C. current capacity in Amps at maximum conductor temp. of 90 deg .c. for 33 kV cable					
	When laid direct in the ground	When laid in air	Short circuit current in kA 1sec (I=0.094 x A/sq.rt (t))	A.C resistance at 90 deg in Ohm/Km	D.C resistance at 20 deg in Ohm/Km	Reactance at 50 Hz in Ohm/Km	Capacitance at 50Hz in µF/Km
70	215	280	10.01	0.343	0.268	0.152	0.14
95	255	335	13.59	0.248	0.193	0.145	0.15
120	285	380	17.16	0.197	0.153	0.140	0.16
150	310	430	21.45	0.159	0.124	0.135	0.18
185	345	485	26.46	0.127	0.0991	0.130	0.19
240	390	560	34.32	0.0976	0.0754	0.126	0.21
300	420	620	42.90	0.0778	0.0601	0.122	0.23
400	455	690	57.20	0.0678	0.0470	0.117	0.25
500	480	750	71.50	0.0489	0.0366	0.113	0.27
630	510	820	90.10	0.0391	0.0283	0.111	0.29
800	540	840	114.40	0.0319	0.0221	0.105	0.34
1000	550	940	143.00	0.0268	0.0176	0.102	0.37

13. TESTS AND TESTING FACILITIES:

13.1 TYPE TESTS:

All the type tests in accordance with IS: 7098 (Part 2), IEC 60228, (amended upto date), shall be performed on cable. The same is to be furnished for verification if the type test has been conducted in last five years, reckoned from the date of bid opening. If the same is not available than the firm to conduct the type test again and submission for verification.

13.2 ROUTINE TESTS:

All the Routine tests as per IS: 7098 (Part 2) ,IEC 60228,(amended upto date) shall be carried out on each and every delivery length of cable. The result should be given in test report. Partial discharge test must be carried out in a fully screened test cell. It is, therefore, absolutely essential that the manufacturer should have the appropriate type of facility to conduct this test which is routine test.

The details of facility available in the manufacturer's works in this connection should be given in the bid.

13.3 ACCEPTANCE TESTS:

All Acceptance tests as per IS: 7098 (Part 2) /IEC 60228, (amended upto date) including the optional test as per clause no 18.4 and Flammability Test shall be carried out on sample taken from the delivery lot. In addition, test for convolution and protrusion shall be carried out as per Annexure- “A”

13.4 SHORT CIRCUIT TEST:

The contractor shall also undertake to arrange for the short circuit test as a type test on any one size of each voltage grade i.e on one size of 33 kV earthed grade shielded XLPE cables. If facilities for carrying out short circuit tests are available at the works of the supplier, and provided the certification procedure is approved by the Purchaser, testing at the supplier's works will be acceptable.

Short Circuit test shall be witnessed by the purchaser's representative.

13.4.1 The short circuit test shall be preceded and followed by the following tests so as to ensure that the characteristics of the cable remain within the permissible limits even after it is subjected to the required short circuit rating.

a) Partial Discharge Test.

b) Conductor Resistance Test.

c) High Voltage Test.

13.4.2 The manufactured cable will be acceptable only after such a sample test is successfully carried out at CPRI /ERDA or at suppliers works and approved by the Purchaser.

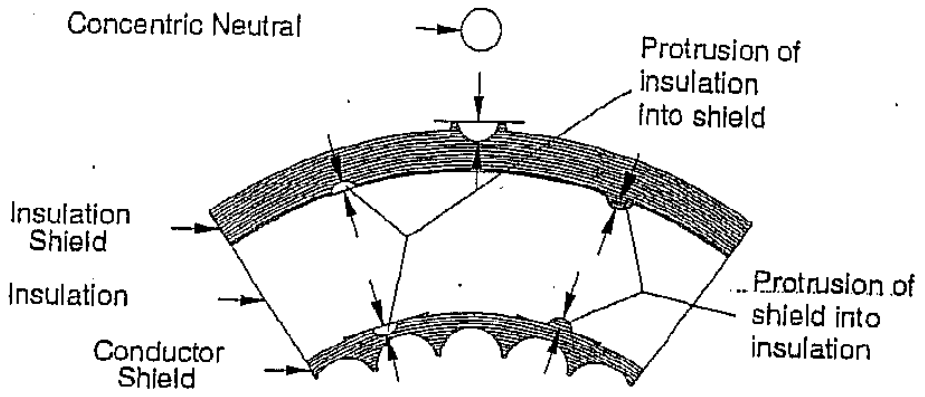
13.5 TESTING FACILITIES

The supplier / tenderer shall clearly state as to what testing facilities are available in the works of manufacturer and whether the facilities are adequate to carry out type, routine and acceptance tests mentioned in specified IS. The facilities shall be provided by the bidder to purchaser's representative for witnessing the tests in the manufacturer's works. If any test cannot be carried out at manufacturer's works reason should be clearly stated in the tender.

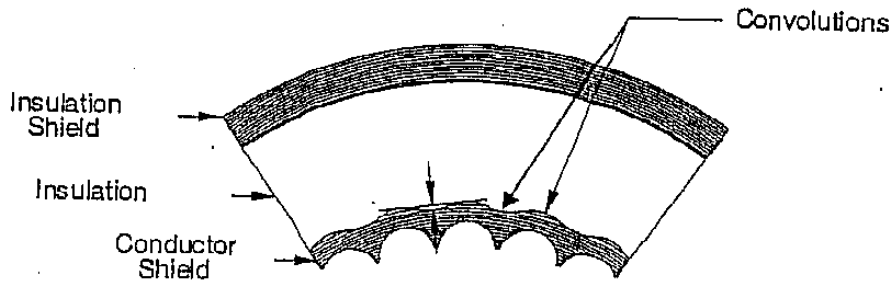
ANNEXURE A

Item (For XLPE/TR XLPE insulation)	Clause of AEIC CS8	Unit	Requirement
Protrusions into insulation from conductor screen	3.2	mm	≤ 0.076
Protrusions into conductor screen	3.2	mm	≤ 0.18
Strand Convolutions	3.3	mm	≤ 0.18
Protrusions into insulation from insulation screen	5.2	mm	≤ 0.13
Protrusions into insulation screen	5.2	mm	≤ 0.18

Procedure to Measure Protrusions and Indentations



Procedure to Measure Convolutions



14 QUALITY ASSURANCE PLAN:

A detailed list of bought out items which got into the manufacture of cables should be furnished indicating the name of the firms from whom these items are procured. The bidder shall enclose the quality assurance plan invariably along with offer followed by him in respect of the bought out items, items manufactured by him & raw materials in process as well as final inspection, packing & marking. The Company may at its option order the verification of these plans at manufacturer's works as a pre-qualification for technically accepting the bid. During verification if it is found that the firm is not meeting with the quality assurance plan submitted by the firm, the offer shall be liable for rejection.

15 LIST OF STANDARDS

(All amended up to date)

SR.NO.	STANDARD NO.	TITLE
1.	IS: 8130 ,IEC 60228:	Conductors for insulated electric cables and flexible cords.
2.	IS :7098 (Part 2) ,IEC 60502:	XLPE PVC sheathed cable for working voltages from 3.3 kV upto and including 33 kV.
3.	IS:7098(pt-2),IEC 60502:	Insulation XLPE.
4.	IS: 7098(pt-2),IEC:60502:	Insulation Metallic & Non Metallic Screen.
5.	IS: 7098(pt-2),IEC:60502:	Fillers: Non Hygroscopic PVC/Polypropylene Fiber to maintain roundness of cable.
6.	IS:7098 (pt-2),IS:3975,IEC:60502 (pt-2): Armour.	
7.	IS:7098(pt-2), IEC:60502 (pt-2): Outer Sheath:PVC ST 2.	

8. IS :10462 (Part I) –1983 : Fictitious calculation method for determination of dimensions of protective coverings of cable.

16.0 TECHNICAL DATA FOR 33kV SINGLE CORE 300 SQMM & 630 SQMM, XLPE INSULATED, COPPER CONDUCTOR ARMOURED CABLE

Sl. No.	**Name of the Particulars**	1CX300 SQMM	1CX630 SQMM
1	Type of cable	Copper Conductor ,XLPE Insulated	Copper Conductor ,XLPE Insulated
2	Standard according to which cable has been manufactured and tested	IS: 7098- Part 2, IEC- 60840, IEC-62067	IS: 7098- Part 2, IEC- 60840, IEC-62067
3	Rated Voltage (Uo/U}	19/33(36) kV	19/33(36) kV
4	Highest System Voltage which the cable can withstand	36 kV (Um)	36 kV (Um)
5	Maximum Conductor temperature for continuous operation	90 0 c	90 0 c
6	(a) Maximum short time conductor temperature with duration	250 °C for 1 sec.	250 °C for 1 sec.
	(b) Maximum allowable conductor temp. during overload	95°C for 2 hours	95°C for 2 hours
7	Conductor Details		
	Normal Cross-Sectional Area	300 mm2	630 mm2
	Material and Grade	Annealed Plain Copper to IS 8130/2013	Annealed Plain Copper to IS 8130/84
	Shape of Conductor	Compacted stranded circular	Compacted stranded circular
	Diameter of Conductor	20 mm (Approx.)	30 mm (Approx.)
	No. of Strands and Diameter of each Strand	53 (Min.) /2.04 mm (Approx.)	55 (Min.) /4.10 mm (Approx.)
	Water swellable powder/yarn/non conducting water blocking tape provided	Yes	Yes
	Conducting water swellable tape with 50% overlap over compacted conductor provided	Yes	Yes
8	Extruded Conductor Screen		
	Material	Extruded Semi-Conducting compound	Extruded Semi-Conducting compound
	Nominal Thickness	0.50 mm (Approx.)	0.5 mm (Approx.)
	Diameter over Conductor screen	26.5 mm (Approx.)	32.2 mm (Approx.)
	Designed maximum stress at conductor screen	3.05 kV/mm	3.05 kV/mm
9	Insulation		
	Material	XLPE	XLPE
	Nominal Thickness	8.80 mm	8.80 mm
	Minimum thickness at any point	7.1 mm	7.1 mm

	Diameter over insulation	37.5 mm(Approx)	50.0 mm(Approx)
	Designed maximum stress	1.90 kV/mm	1.90 kV/mm
	Detail of vulcanization process		
	Extrusion method	Triple Extrusion Process	Triple Extrusion Process
	Curing method	Dry Cured	Dry Cured
	Cooling method	Water cooling	Water cooling
	CO/ or VOI Line	CCV/VCV line	CCV/VCV line
10	Extruded Insulation Screen		
	Material	Extruded Semi-Conducting XLPE	Extruded Semi-Conducting XLPE
	Thickness	1.0 mm	1.0 mm
	Diameter over insulation screen	39.5 mm (Approx.)	52.2 mm (Approx.)
	Strippable/ Bonded	Bonded	Bonded
11	Conducting Longitudinal Water Sealing		
	Material	Water Swellable Tape applied with 50% overlap.	Water Swellable Tape applied with 50% overlap.
	Thickness	0.3 mm (Approx.)	0.3 mm (Approx.)
12	Metallic Sheath/ Screen		
	Material	Copper	Copper
	No. of strands	64	55
	Diameter of each Strand (Nom/Min)	2.0 mm	2.8 mm
	Diameter of Cable after stranding	50 mm (Approx.)	59 mm (Approx.)
	Armour coverage	Full coverage. Armour wires shall be applied as closely as practicable. Overall gap between armour wires should be less than diameter of single wire. Min coverage required 90 % with supporting calculations	Full coverage. Armour wires shall be applied as closely as practicable. Overall gap between armour wires should be less than diameter of single wire. Min coverage required 90 % with supporting calculations
13	Non-conducting Longitudinal Water Sealing		
	Material	Water Swellable Tape applied with 50% overlap.	Water Swellable Tape applied with 50% overlap.
	Thickness	0.3 mm (Approx.)	0.3 mm (Approx.)
14	HDPE Outer Sheath		

	Type	Extruded HDPE Type ST-7	Extruded HDPE Type ST-7
	Colour	Black	Black
	Thickness (Nom/Min)	2.6 mm (Nominal)/2.11 mm (Min. Spot)	2.6 mm (Nominal)/2.11 mm (Min. Spot)
	Conductive Coating Provided	Graphite Coating	Graphite Coating
15	Nominal overall Diameter of cable	51 mm (Approx.)	72 mm (Approx.)
16	Nominal OVerall Weight of Cable per Meter	5.46 kg/m (Approx)	12.0 kg/m (Approx)
17	Standard Drum Length with Tolerance	500m±5%	500m±5%
18	Minimum Bending Radius allowable during installation	1180 mm (during installation) 944 mm (after laying)	1180 mm (during installation) 944 mm (after laying)
19	Short Circuit Current Rating of Conductor with maximum conductor temperature (90°C) at the commencement of fault 1Sec. Duration	42.90 kA	90.09
20	Maximum Continuous Current Rating of a Circuit Comprising of 3 nos. Single Core Cable laid in trefoil formation at a depth of 1.05 M.		
	Soil Temperature	300 C	300 C
	Ambient Temperature	400 C	400 C
	Soil Thermal Resistivity	150°C Cm/W	150°C Cm/W
	System of Bonding	Solidly earthed at both ends	Solidly earthed at both ends
	Laid in ground (at a depth of 1.05 m)	445A	580A
	Laid in dusts	380A	500A
	Installed in Air	650A	920A
21	Short Time Overload capacity with Duration of cable installed as per conditions mentioned in Item no.22 (2 hours)		
	Laid in ground (at a depth of 1.05 m)	543A	708A
	Laid in dusts	473A	610A
	Installed in Air	826A	1168A
22	Maximum AC Resistance at 90°C	0.078 ohm/km	0.040 ohm/km
23	Equivalent Star Reactance of a Circuit comprising of 3 Nos. of Single Core cable laid in Trefoil Formation	0.111	0.115
24	Maximum Charging Current per Conductor at Nominal Voltage 1.64 Al km	1.43 A/Km (at 19kV)	1.91 A/Km (at 19kV)
25	Loss in Metallic Screen of a Circuit comprising of 3 nos. of Single Core Cable installed in Trefoil Formation as per item no. 22	13.53 W/m	22.38 W/m
26	Maximum Current in Metallic Screen when the cable is installed as per item no. 22 (Circulating Current)	88A	110A
27	Derating factor of Cable installed as per Item No.22 under following conditions Ambient		

	Temperature		
	35°C	As Attached file	As Attached file
	45°C	As Attached file	As Attached file
28	Group derating factor of Cable Circuits installed as per Item no. 22 under following conditions		
	Laid 100 mm. apart	As Attached	As Attached
	Laid 250 mm. apart	As Attached	As Attached
29	Induced voltage in metallic screen when Conductor is carrying 100 Amps(V/Km)	5	5
30	Circulating current in metallic screen when conductor is carrying 100 Amps	34A	34A
31	Test Voltages		
	Impulse Withstand Voltage at 90°C	170kVp	170kVp
	Rated Power Frequency Withstand Voltage (kV)	63 kV for 5 minutes	63 kV for 5 minutes
	Water penetration test as per IEC 60502-2 on core	Yes Water penetration test as per IEC 60502-2	Yes Water penetration test as per IEC 60502-2
	Abrasion Test on HOPE Outer sheath as per IEC 60229	Yes (Physical Abrasion test as per IEC 60229 clause 4.1.2.1)	Yes (Physical Abrasion test as per IEC 60229 clause 4.1.2.1)
	Recommended Test Voltage after installation	Comply with Clause 20 as per IEC 60502-2	Comply with Clause 20 as per IEC 60502-2
32	Details of Drum		
	Material and Weight of Drum	Wooden or Steel Reel/ 500 kg (Approx.)	Wooden Reel/ 500 kg (Approx.)
	Weight of Drum with Cable	4500 kg (Gross Weight) (Approx.)	6300 kg (Gross Weight) (Approx.)
	Flange Diameter of Drum	2150 mm (Approx.)	2750 mm (Approx.)
	Barrel Width of Drum	1100 mm(Approx.)	1100 mm(Approx.)
	Spindle hole Diameter	120 mm (Approx.)	120 mm (Approx.)
33	Safe Pulling force	5kg/mm2 of CU area.	5kg/mm2 of CU area.
34	Inner sheath		
	Material	PVC Compounded ST-2	PVC Compounded ST-2
	Extruded or Wrapped	Extruded	Extruded
	Min. Thickness (in mm)	0.5	0.5
35	Armour		
	Material	Aluminium Wire	Aluminium Wire

		as per IS:8130	as per IS:8130
	Type of Armouring	Round wire Armour	Round wire Armour
	Nominal Diameter in (mm)	2.5	2.5
36	The following details shall be embossed/ Printed on outer sheath at regular interval not exceeding one metre. (a) Manufacturer's Name or Trade name (b) Year of Manufacture (c) Voltage grade of Cable i.e. 19/33kV (d) Cable Code i.e. 2XWa2Y (e) Number of cores & cable size e.g. 300 Sq mm (Cu) 1 core 630 Sqmm (Cu) 1 core		
	Sequential length marking shall also be provided on outer sheath by inkjet printing.		
	Cable shall be supplied in steel drums		

17.0 GUARANTEED TECHNICAL PARTICULARS FOR 33 KV CABLE: (To be filled up by the bidder & submission of the same during approval)

Sl. No.	Name of the Particulars	1CX300 SQMM	1CX630 SQMM
1	Type of cable		
2	Standard according to which cable has been manufactured and tested		
3	Rated Voltage (Uo/U}		
4	Highest System Voltage which the cable can withstand		
5	Maximum Conductor temperature for continuous operation		
6	(a) Maximum short time conductor temperature with duration		
	(b) Maximum allowable conductor temp. during overload		
7	Conductor Details		
	Normal Cross-Sectional Area		
	Material and Grade		
	Shape of Conductor		
	Diameter of Conductor		
	No. of Strands and Diameter of each Strand		
	Water swellable powder/yarn/non conducting water blocking tape provided in intermediate layers of conductor?		
	Conducting water swellable tape with 50% overlap over compacted conductor provided		
8	Extruded Conductor Screen		
	Material		
	Nominal Thickness		
	Diameter over Conductor screen		
	Designed maximum stress at conductor screen		

9	Insulation		
	Material		
	Nominal Thickness		
	Minimum thickness at any point		
	Diameter over insulation		
	Designed maximum stress		
	Detail of vulcanization process		
	Extrusion method		
	Curing method		
	Cooling method		
	CO/ or VOI Line		
10	Extruded Insulation Screen		
	Material		
	Thickness		
	Diameter over insulation screen		
	Strippable/ Bonded		
11	Conducting Longitudinal Water Sealing		
	Material		
	Thickness		
12	Metallic Sheath/ Screen		
	Material		
	No. of strands		
	Diameter of each Strand (Nom/Min)		
	Diameter of Cable after stranding		
	Armour coverage		
13	Non-conducting Longitudinal Water Sealing		
	Material		
	Thickness		
14	HDPE Outer Sheath		
	Type		
	Colour		
	Thickness (Nom/Min)		
	Conductive Coating Provided		
15	Nominal overall Diameter of cable		
16	Nominal OVerall Weight of Cable per Meter		
17	Standard Drum Length with Tolerance		
18	Minimum Bending Radius allowable during installation		
19	Short Circuit Current Rating of Conductor with maximum conductor temperature (90°C) at the commencement of fault 1Sec. Duration		
20	Maximum Continuous Current Rating of a Circuit Comprising of 3 nos. Single Core Cable laid in trefoil formation at a depth of 1.05 M.		
	Soil Temperature		
	Ambient Temperature		

	Soil Thermal Resistivity		
	System of Bonding		
	Laid in ground (at a depth of 1.05 m)		
	Laid in dusts		
	Installed in Air		
21	Short Time Overload capacity with Duration of cable installed as per conditions mentioned in Item no.22 (2 hours)		
	Laid in ground (at a depth of 1.05 m)		
	Laid in dusts		
	Installed in Air		
22	Maximum AC Resistance at 90°C		
23	Equivalent Star Reactance of a Circuit comprising of 3 Nos. of Single Core cable laid in Trefoil Formation		
24	Maximum Charging Current per Conductor at Nominal Voltage 1.64 Al km		
25	Loss in Metallic Screen of a Circuit comprising of 3 nos. of Single Core Cable installed in Trefoil Formation as per item no. 22		
26	Maximum Current in Metallic Screen when the cable is installed as per item no. 22 (Circulating Current)		
27	Derating factor of Cable installed as per Item No.22 under following conditions Ambient Temperature		
	35°C		
	45°C		
28	Group derating factor of Cable Circuits installed as per Item no. 22 under following conditions		
	Laid 100 mm. apart		
	Laid 250 mm. apart		
29	Induced voltage in metallic screen when Conductor is carrying 100 Amps(V/Km)		
30	Circulating current in metallic screen when conductor is carrying 100 Amps		
31	Test Voltages		
	Impulse Withstand Voltage at 90°C		
	Rated Power Frequency Withstand Voltage (kV)		
	Water penetration test as per IEC 60502-2		
	Abrasion Test on HOPE Outer sheath as per IEC 60229		
	Recommended Test Voltage after installation		
32	Details of Drum		
	Material and Weight of Drum		
	Weight of Drum with Cable		
	Flange Diameter of Drum		

	Barrel Width of Drum		
	Spindle hole Diameter		
33	Safe Pulling force		
34	Inner sheath		
	Material		
	Extruded or Wrapped		
	Min. Thickness (in mm)		
35	Armour		
	Material		
	Type of Armouring		
	Nominal Diameter in (mm)		
36	The following details shall be embossed/ Printed on outer sheath at regular interval not exceeding one metre. (a) Manufacturer's Name or Trade name (b) Year of Manufacture (c) Voltage grade of Cable i.e. 19/33kV (d) Cable Code i.e. 2XWa2Y (e) Number of cores & cable size e.g. 300 Sq mm (Cu) 1 core 630 Sqmm (Cu) 1 core		
	Sequential length marking shall also be provided on outer sheath by inkjet printing.		
	Cable shall be supplied in steel drums		

18.0 33 kV CABLE JOINTING KITS: SPECIFICATION OF CABLE KITS:

The distribution system in which the cables along with the Straight through and end termination kits joints are expected to perform reliably over a period of 30-35 years, is a five phase, 3-wire System operating at 33 KV with solidly earthed neutral at the source neutral terminal with maximum possible continuous voltages being 36KV, and cable conductor temperatures up to 90°C on a continuous basis and This specification defines the requirements for 33KV Straight through and end termination kits jointing Cable Joints kits for underground 33 kV XLPE insulated power cables. The requirements cover the material properties of the components used in the Cable Joints as well as the performance of these products after installation on cables. Heat shrinkable components are based on polymeric materials and are to be supplied in an expanded state. Heating of these components to a temperature generally above 120°C would activate their elastic memory and cause these components to recover or shrink down on a substrate within a specific application range.

Service Conditions:

under short circuit conditions up to 250°C.

The Service conditions include ambient temperatures range from -5°C to 50°C, height of installation up to 700 m above sea level, dusty, industrially polluted as environments, humidity levels up to 95% and heavy average rainfall of 600 mm (annually).

18.1 GENERAL REQUIREMENTS

All materials used and products provided under this specification must be in accordance with the standards listed below of this specification

18.2 REFERENCES:

1. Standard Number ESI-09-13- Performance Specification for high voltage, heat shrinkable components for use with high voltage solid cables up to an including 33,000 volts.

2. IS 13573 Type Test and Performance Requirements for cable Terminations and Joints on XLPE Cables from 6.6 KV to 33 KV ratings.
3. IEC 61238-1 : Compression and Mechanical Connectors for Power Cables with copper or aluminum conductors - Tests Materials and Requirements.

All materials components and products offered shall be of the latest designs, incorporating any improvements in materials and installation procedures knowledge of which has been gained through the manufacturers' research or experience.

The jointing materials and components shall be offered in the form of kits. The kits shall be supplied complete with all necessary tubings components (mechanical connectors/ earthing/ cable preparation etc) to form a ready to energize joint / termination.

18.3 QUALITY, ENVIRONMENTAL MANAGEMENT SYSTEM AND LABORATORY ACCREDITATION:

The kits shall be offered from the factory having a valid IS0 9001:2000 Quality Management System(QMS) certificate for the goods offered. The goods shall include the shrinkable and moulded components, as well as connectors.

Units **of measurement**

In all correspondence, in all technical schedules and drawings metric units of measurement shall be used.

18.4 PACKING AND MARKING

The joint/termination kit shall be properly packed with all the shrinkable tubings, moulding components and connectors, lugs, other accessories as required to form a self contained kit. The packing shall be of such design as to prevent moisture and dust ingress and shall also protect the contents against mechanical damage.

External packing shall carry a label with the following information clearly marked:

- Name of Manufacturer
- Manufacturers reference
- Year of Manufacture/ Purchase order No.
- Expiry date whenever applicable

The kits shall also include the following:

a) Installation Instruction sheet manuals containing complete step by step instructions in the English language.
b) A check list stating the quantities and description of components contained in the kit shall be supplied in each kit.

Each component of the kit shall be separately packed in polyethylene and component name/part number shall be marked on the polyethylene packing.

All materials and components comprising the kit shall be clearly and permanently marked in a prominent position with the supplier's/manufacturer's name, product identification, batch number and year of manufacture. The batch number shall allow for full traceability of manufacture including the new materials which make up the polymeric compounds used in extrusion and moulding processes. Extruded components (tubing and wrap-arounds) shall additionally be marked with their expanded and fully recovered internal diameter. They may alternatively be marked with the upper and lower diameters of their range of application.

Markings on extruded components shall be repeated along the length with gaps not exceeding 200mm. Components which cannot be marked shall have the above information provided on immediate packaging.

Packed kits shall be packed in carton boxes which shall be placed in wooden pallets in order to facilitate fork-lift handling.

18.5 STORAGE

Components and kits shall be capable of being stored without deterioration in an ambient air temperature 5°C to 50°C when protected from direct sunlight.

Inspection and testing

All materials covered by this Specification shall be subject to inspection and test by the Authority during manufacture and before final despatch from manufacturer's works. The approval of the Authority of any such inspection or test will not, however, prejudice the right of the Authority to reject the materials or any part thereof, if it does not comply with the specification when erected or does not give complete satisfaction in service. The contractor shall make available to the Authority for the inspection and testing all required personnel and offer facilities (equipment, testing instruments etc.) at no cost to the Authority. The Authority may, however, use his own instruments and apparatus as a check.

Before any part of the jointing materials is packed or despatched from the manufacturers works, all tests called for are to have been successfully and satisfactorily carried out in the presence of the Inspector and a certificate issued to that effect by the Inspector in writing.

Adequate notice is to be given when any part of the jointing materials is ready for inspection or test and every facility is to be provided by the Contractor and his subcontractors to enable the Inspector to carry out the necessary inspection and witness the tests. Duplicate copies of all principal Test Records and Test Certificates are to be supplied to the Inspector for all tests carried out in accordance with the provisions of this specification.

The jointing materials and all component parts thereof are to be fully tested in accordance with the provisions of the latest relevant standards as stated in paragraph 2.0 of this Specification or as may be agreed in writing with the Inspector. Test Certificates are to be forwarded to the Purchaser together with the invoices.

Guarantee.

The Straight through and end termination kits jointing kits shall be guaranteed for five years form the date of supply.

18.6 SAMPLES

Bidders are required to submit with their BIDs two No's samples of the kits offered as to be delivered in case of order. The kits shall include the installation instructions.

BIDs without samples shall not be considered. The samples shall be returned to the BIDers, after the award, at their own expenses.

18.7 TRAINING

Bidders are required to provide training for OPTCL staff and also to the available outsourced cable jointers for at least 10 man days in phase wise over the period of the contract, at dates that will be decided at a later stage. All expenses i.e trainers wages, living expenses. Training materials i.e cables and jointing materials shall be provided by shall be covered by the Bidder.

18.8 TECHNICAL REQUIREMENTS

The technical requirements described below refer to heat shrinkable, elastic and moulded products (separable connectors).

18.9 DESIGN **AND** TECHNOLOGY

Product design shall be based on the use of heat-shrinkable or elastic tubings and moulded parts to provide for the functions of high voltage insulation, electrical stress control, electrical screening, sealing and environmental protection as necessary. The use of tapes to provide primary insulation, screening or primary stress control is not acceptable.

BIDers shall submit evidence with their BIDs that designs are based on sound engineering principles, accumulated know-how and satisfactory service experience.

Design shall aim at minimizing the number of component parts and the time and skill required for satisfactory installation.

For joints single anti tracking tube design is required, which shall provide both anti tracking and stress control grading.

Anti-track and weather-resistant tubing shall be used in outdoor Straight through and end termination kits kits in all positions where the material surface is subject to electrical stress. Mastics or adhesives used as sealants for these tubings must be similarly anti-track and weather-resistant.

All necessary sealants shall be provided pre-coated on the internal surfaces of tubings and moulded parts. Sealant surfaces shall be protected by release paper as necessary.

Screening of conductor connectors shall be achieved with *single* co-extruded dual wall tubing/Tripple wall tubing comprising an inner insulating layer and an outer conducting layer. Separate or additional insulating and conducting tubings are not acceptable. The insulating layer shall provide an insulation thickness at least 30% more than the cable insulation.

18.10 LUGS **AND CONNECTORS**

Mechanical shear bolt type

Mechanical shear bolt type connectors shall be used as follows:

They shall have the following characteristics/features:

(i) They shall be in accordance with EN 61238-1.

(v) Connectors shall be of the water block type, and the shear bolt heads to be hexagonal.

(vi) Lugs on aluminium cores shall be provided with oxidation inhibiting compound, or any other approved means for inhibiting oxidation.

(vii) Bolts of the shear bolt type shall be suitable for M12 bolt

Installation Instructions

Detailed installation instructions with drawings for all joints and terminations offered, including all parts, shall be provided with the BID documents in English language.

The successful BIDer shall provide installation instructions in English language.

Component types

For heat shrinkable materials:

(i) The tubing components (such as internal insulating tubing, stress control tubing, anti-track tubing, external protective tubing) shall conform to the requirements given of EA TS 09

The moulded components shall conform to the requirements given in List 2 of EA TS 09-13.

(ii) The sealants shall conform to the requirements given in List 3 of EA TS 09-13 and EA TS 09-11.

Specific requirements for components

Electric stress control for the cable insulation screen ends and over the connectors shall be achieved by tubings.

The stress control material shall have defined impedance characteristic, volume resistivity, and permittivity (dielectric constant). The AC impedance shall remain constant despite of thermal ageing, which will take place due to heating effect within the conductor and the temperature of the environment.

Non tracking erosion and weather resistant, insulating tubing and moulded parts

Bidders must provide proof of weather and track resistance of the polymeric material offered, through actual field studies or through accelerated laboratory studies, to confirm a minimum of 30 years expectancy.

This should include:

(i) Thermal Endurance - An Arrhenius plot to confirm the life expectancy on continuous

exposure at 90° C.

(ii) Tracking and Erosion Resistance Test to prove the withstand ability against effects of surface electrical leakage currents.

(iii) Weathering Data properties.

Track Resistant Sealant is (Insulating and Weather Resistant)

Sealing of the interfaces between components subject to electrical stress shall be achieved by using a track resistant sealant or a hot melt adhesive. This sealant/adhesive shall be pre-coated inside the shrinkable components. **Bidders must provide the following information**:

(a) The adhesive peel strength the sealant provides between Non tracking tubing and non tracking moulded part.

(b) The dielectric strength, tracking and erosion resistance of the sealant as per ASTM D2303.

Triple wall co, extruded Tubing

(a) The Tripple wall tubings are manufactured by means of co extrusion.

Further the Bidder shall have

- Proof of accelerated laboratory and long term field usage to confirm the retention of key properties within permissible limits due to thermal ageing. Minimum key properties before and after ageing to be stated.
- Confirmation of the minimum thickness of insulation provided over the connector for the maximum size of conductor for which the tubing is supplied.

The insulation layer shall provide an insulation thickness at least 30% more than the cable insulation.

Void Filling, Stress Relieving Mastic

Bidders must submit:

(a) Data of the stress relieving mastic, which should include information on the volume resistivity, and permittivity.

The mastic shall provide a void free interface between the stress control layer and the cable insulation as well as the connector and Proof of long term usage in the field to confirm satisfactory performance.

Specific **Requirements for Joints.**

General requirements for joints.

External leakage insulation between the live conductor and earth potential using anti-track and weather resistant material.

Electrical stress control using electrical stress control material over the cores.

Hermetic sealing of the interfaces between the cable accessory and cable surfaces, bushings or cable lugs by use of track resistant adhesive/sealant.

Detail technical characteristics wrap around sleeve if offered must be provided.

Outdoor termination kits shall provide means for protecting the exposed insulation of the conductors from UV radiation.

18.11 TESTS

Type Tests on Components

1. The BIDer shall submit with the BID documents test certificates tested not more than 5 years to prove that shrinkable or elastic or moulded components connectors used for cable joints and termination kits comply with the performance specification as indicated IS 13573 1992 with latest amendments and EATS 09-13. Test certificates shall be submitted with the BID documents.

Routine Tests on Components

BIDers must submit with their BIDs routine tests certificates as per the requirements of EA TS 09-11 and EA TS 09-13.

In addition, during the acceptance testing of the first and any other subsequent consignment, components will be randomly selected by the Inspector from jointing kits and will be subjected to the following routine and type tests, at CPRI.

The cost of testing shall be inclusive of all tests specified at CPRI in the bid cost. Visual examination

a) Dimension
b) Flame Retardance
c) Packing and markings.

Type Tests on 33 kV Straight through and end termination kits kit

The Bidders are required to submit with their BIDs the type test certificates mentioned in the following paragraphs, for Straight through and end termination kits kit

Bidders must submit

2. Test certificates certified by CPRI or any international recognized testing laboratory as per IS 13573 1992 with latest amendments not more than 5 years..
3. Test certificates certified by CPRI or any international recognized testing laboratory as per EATS 09-13 not more than 5 years.
4. Test certificate as per IEC 61238-1 from CPRI or any international recognized Mechanical Connectors testing laboratory not more than 5 years.
5. Documentary evidence including graphs showing the effects of temperature and thermal ageing on the impedance of the stress control material offered.

4 A technical explanation as to how the correct electrical properties of the material Vs volume resistivity, permittivity and AC impedance, have been derived
5 The recommended lengths of the stress control material.
6 Proof of accelerated laboratory and long term field usage to confirm the retention of the properties within permissible limits under variations of temperature and thermal ageing
7 Full set of dimensioned drawings including installation instructions
8 Transport, storage and installation requirements
9 Acceptance letter of two samples to be submitted

18.12 GUARANTEED TECHNICAL PARTICULARS FOR ACCESSORIES:

Outdoor type Cable end Termination (Sealing End) With unicon tube

Class of Power Cables		
1	Manufacturer's Name	
2	Country of Manufacture	
3	Class and Type	
4	No. of years the design is in commercial use	
5	Rated Voltage kV	
6	Total Creepage distance (mm)	
7	Maximum conductor size, Al (sq.mm)	
8	Details of terminal connectors	
9	Power frequency voltage 1 min. (kV rms) dry withstand test	
10	Power frequency voltage wet with stand voltage KV & duration	

11	Power frequency voltage 6 H Dry withstand voltage Kv. Rms.	
12	Radio interference voltage (R.I.V) Test (Micro Volts)	
13	Practical discharge (corona) extinction test :	
	a) Extinction voltage Kv rms	
	b) Minimum detector sensitivity PC	
14	Impulse voltage Lightning voltage Dry with stand kV (Crest)	
15	Direct voltage 15 Min. Dry with stand KV	
16	Description of materials used in the terminations with electrical & mechanical particulars	
17	Mounting Structure Details for termination	
18	Electrical & Mechanical Particulars of	
	a) Heat Shrinkable Tubing	
	b) Heat Shrinkable Moulded parts	
	c) Heat Shrinkable adhesives / sealents	
19	Type tested to (standard(s))	
20	Other details	
20.1	Please enclose complete Technical literature	
20.2	Comply with IS	
20.3	Comply with EATS/ESI	
20.4	Comply with IEC	
20.5	Type test report	
20.6	All Drawings	

19.0 INSTALLATIOIN OF 33 kV U.G. CABLES:

19.1 **SYSTEM PARTICULARS:**

Nominal system voltage	33 kV
Highest system voltage	36.3 kV
Maximum permissible one phase System voltage (both cores insulated)	42 kV
Maximum permissible one phase System voltage (one core earthed)	21 kV
Number of phases	3
Frequency	50 Hz
Method of grounding	Solidly Earthed
Total relay and breaker operation time	15 to 20 cycles
Basic impulse level	170 KVp

19.2 METHOD OF LAYING:

19.2.1 This involves digging a trench in the ground in all types of soils including laterite and rock and laying cable(s) on a bedding of minimum 75-mm sand at the bottom of the trench, and covering with additional sand of minimum 75-mm and protecting it by means of tiles, bricks or slabs. The desired minimum depth of laying from ground surface to the top of the cable shall not be less than 1.2-m. At railway crossings the same shall be measured from bottom of sleepers to the top of pipe.

19.2.2 The desired minimum clearances are as follows:

Power cable to power cable: Clearance not necessary; however, larger the clearance, better would be current carrying capacity.

Power cable to control cables:	0.2-m
Power cable to communication cable:	0.3-m
Power cable to gas/water main:	0.3-m

19.2.3 RCC Hume pipes or earthenware/stoneware pipes depending on the crossing and load should be used where cables cross roads and railway tracks depending on the requirement, and at each particular location either RCC Hume pipes or stoneware pipes shall be used as directed by the Owner's representative. Spare ducts/pipes for future extension should be provided as per the directions of OPTCL. Such spare ducts/pipes shall be sealed off. The inner diameter of the ducts/pipes shall not be less than 225 mm. The ducts/pipes shall be mechanically strong to withstand forces due to heavy traffic when they are laid across the roads/railway tracks.

19.2.4 The power cable should not be laid above the telecommunication cable, to avoid danger to the life of the person, digging to attend to the fault in telecommunication cable. For identification of power cables, the cable protective cover, such as bricks or RCC slabs shall be marked as "OPTCL". The likely interference to the existing telecommunication cables should be avoided by referring to and coordinating with the appropriate telecommunication authorities.

19.3 ROUTE PLANS:

Tentative cable route plans will be furnished to the contractors, indicating the roads, position of substations and road crossings. The exact route survey and alignment will be decided on evaluating the findings by excavating trial holes by the contractor / subcontractor. The work should be taken upon only after OPTCL's Engineers approve the final route. The OPTCL reserves the right to change, alter deviate the route on technical reasons. It is the responsibility of the contractor to conduct necessary detailed route survey and submit of proposals to the owner for approval.

19.4 TRIAL HOLES:

The Bidder shall excavate trial holes, for alignment purpose at appropriate distance apart as warranted by the local conditions, keep a record of the findings and close the trial holes properly to avoid hindrance / accidents to pedestrian traffic. The final route / alignment of the cable shall be decided based on the finding of the trial holes.

It is the responsibility of the bidder to maintain as far as possible the required statutory clearances from other utility services.

Any damage caused, inadvertently to any utility services shall be set right & it is the sole responsibility of the contractor to do the same to the satisfaction of the concerned utility.

19.5 LAYING OF CABLES:

The contractor shall excavate the cable trench using manual and mechanical modes. An air compressor driven pneumatic drill or equivalent mechanical excavating tool will be essential if the crossing is to be made with minimum delay. Where paved footpaths are to be dug to excavate the cable trench, care must be taken to carefully remove the pavement slabs and store them properly and relay them properly after the work is completed.

The contractor shall take all precautions while excavating the trench to protect the public / private property and to avoid any accidental damage. Any accidental damage should immediately be reported to the concerned utility.

The contractor is liable to pay for all damages caused by his workmen. The sides of the excavated trench shall, wherever necessary be well shored up with timber and sheeting and use of danger boards wherever required. The depth of the cable trench shall be 1. 2 m.

The width shall be sufficient for easy handling of the cables during the laying operations depending upon the method of laying employed. For road crossings and railway crossings the same shall be 1.0 m. At other places the width varies from 0.45m to 1.0 m depending on number of cables to be laid in the trench.

The excavated material shall be properly stored to avoid obstruction. The bottom of the excavated trench should be carefully leveled and freed from pebbles / stones. Any gradient encountered shall be gradual.

There is a likelihood of a situation demanding that more than one cable is required to be run in the same trench. The contractors shall agree to increase the width of the trench to accommodate more than one cable.

The arrangement of cable trench duly indicating the position of cable, sand cushion, back fill and concrete finishing shall be as per sketch enclosed. It should be noted that the excavation required for laying the cable shall be finished accordingly by providing the sand cushion, back fill etc.

19.6 PAVING OUT OF THE CABLE:

The pulling shall be done by hand and in such a manner as to provide good bedding for the protective cable covers like tiles or bricks. The maximum permissible pulling force on XLPE armored cables shall not exceed $P= 9 D^2$ Newton where P is the pulling force in Newton and D is the outer diameter of the cables in mm. However the normal values of pulling force shall be around 15 to 20 percent of this force when laid in trenches, 20 to 40 percent with one or two 90 degree bends in trenches, 50 to 60 percent when the bends are 3 or more. The cables shall have a minimum of 0.3-m clearance from the communication cables or water supply mains whenever they are encountered.

The excavated cable trench shall be drained of all water and bed surface shall be smooth, uniform and fairly hard before laying out the cable. The cable shall be pulled in the trench only on cable rollers spaced out at uniform intervals to prevent damage to cable.

The laying out process shall be smooth and steady, without subjecting the cable to abnormal tension. The cable laid out shall be smoothly and evenly transferred to the ground after providing sand cushion and shall never be dropped. All snake bends in the cable shall be straightened out.

19.7 FLAKING:

Wherever it is not possible to lay off the entire cable drum length, the cable should be cut and properly sealed and if it is necessary to remove the cable from the drum, it should be properly flaked, in the form of figure 8. Such cable lengths should be properly stored at site.

19.8 SAND CUSHION:

When the cable has been properly straightened the trench shall be covered with 75mm thick layer of good quality clean sand cushion. Then the cable shall be lifted and placed over the sand cushion. Again, another layer of sand 75mm thick should be laid and gently pulled on to the top of the cable to form a depth of 75mm from the top of the cable. The minimum envelope cushion around the cable shall not be less than 150 mm.

19.9 CABLE COVERING TILES:

The earthen ware cable covers / tiles shall be of burnt clay and so made and fired that they shall be true in shape, well burnt in kilns throughout and free from detrimental cracks. Except for the interlocking features straight covers shall be rectangular in plan with the underside flat.

The size of RCC covers should be 250mm long x 350mm wide. The thickness at the outer edge should be 50mm. The average breaking load shall be not less than 135Kg. The tiles should be laid side-by-side without any gap in between.

19.10 PREVENTION OF DAMAGE DUE TO SHARP EDGES:

After the cable has been laid in the trench and until the cable is covered with its protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench.

Rollers used during laying of the cables shall have no sharp projecting parts liable to damage the cables.

While pulling cable through Hume pipes/stoneware pipes/G.I. pipes/M.S. pipes, the cable shall be protected to avoid damage due to sharp edges.

Warning tape:

A pre warning, Red color plastic / PVC tape, 250 mm wide 150 microns thick, two runs shall be laid at approximate 500mm above the cable specified depth, throughout the Trenched cable route. The tape shall carry the legend printed in black continuously as under

CAUTION / OPTCL / 33 KV CABLES ARE BELOW. With a '**SKULL AND BONE'** Signs

The cables shall never be bent, beyond the specified bending radius

19.11 CABLES OVER BRIDGES:

Wherever the cable route crosses bridges the cable shall be laid in the ducts, if provided, by removing and replacing the R.C.C. covers and filled with sand cushion.

In the absence of the cable ducts over bridges, the cable shall be laid in suitable size RCC/steel/G.I. pipes or as directed by the engineer In-charge and the pipe covered by cement concrete if necessary to protect from direct sunrays and Masonry/RCC supports at suitable intervals, wherever required as decided by the Engineer in charge and/or stipulations of concerned Highway/Railway/local authorities.

19.12 CABLE CROSSING OPEN DRAINS WITH LONG SPAN:

Wherever the cable has to cross open drains, with a long span, the cable shall be laid in suitable size RCC closed duct/GI pipe/ hume pipe properly jointed with suitable collars. The GI pipe/hume pipe shall be firmly supported on pillars, columns, or suitable support of R.C.C. foundation & walls in CC 1:1½ : 3 to the required depth & width as required at site and directions & drawings as per technical specifications & procedures of PWD.

Wherever the U.G. cable has to cross the sewerage or water supply line the U.G. cable has to be taken below them maintaining adequate clearance. Further wherever the U.G. cable runs parallel to the telephone cable a separation distance of at east 300-mm shall be maintained. The cable should be taken inside Hume Pipes wherever required.
The cables shall be laid in Hume pipes/stoneware pipe wherever the cable and trench crosses private roads, gates, etc. In order to avoid inconvenience the stoneware pipe should be laid first after excavation and excavated trench shall be back filled, compacted and surface properly redone to restore that original condition.

19.13 ROAD CROSSINGS:

The road cutting whether cement concrete, asphalt or macadam road shall be taken after obtaining approval from civic authorities, Police, Telecom authorities and work should be planned to be completed in the shortest possible time. Where necessary the work shall be planned for night time or light traffic time. . In the excavated trench across the road the GI pipe or hume pipe (NP3 class) of appropriate size shall be laid, excavation back filled compacted and surface shall be redone in shortest time to allow the traffic on the road.

19.14 FOOTPATH CUTTING:

The pavement slabs shall be removed, neatly stacked on side before starting excavation.

19.15 REINSTATMENT:

After the cables and /or pipes have been laid and before the trench is filled in all joints and cable positions should be carefully plotted and preserved till such time the cable is energized and taken over by the engineer in charge. The requisite protective covering will then be provided, the excavated soil replaced after removing large stones and well rammed in successive layers of not

more than 20cm in depth, where necessary the trench being watered to improve consolidation. It is advisable to leave a crown of earth not less than 50 mm and not more than 100 mm in the center and tapering towards the sides of the trench.

The temporary reinstatement of roadways should be inspected at regular intervals, more frequently during the wet weather and immediately after overnight rain. If trench is to be closed overnight and settlement should be made good by further filling to the extent required, such temporary reinstatement should then be left for a time so that soil thoroughly settles down.

After the subsistence has ceased the trench may be permanently reinstated and the surface restored to the best possible condition.

19.16 CIVIL AND STRUCTURAL WORKS:

The scope of civil works include:

(a) Earth excavation and cable laying, removal of excavated earth, design, supply and provide plain and / or reinforced cement concrete for the cable trenches, back filling, de-watering of trenches. The surplus earth should be disposed off suitably at all leads/lifts. Excavation should be done in all types of soils laterite or rock either manually or using machines as per site requirements & instructions.

(b) The design of cable duct/pipe ducts for crossing drains, roads, Railways, Highways, canals etc., shall be suitably done and rates quoted shall include complete supplies and erection as per relevant schedules. The Masonry work / concrete work should be done as per standard PWD practices and specifications & instructions of engineer-in-charge.

(c) Design, fabrication, supply & erection of galvanized steel structures for cable end terminations.

(d) Supply of all consumables and sundry materials not included in the specifications in detail but are necessary to meet the intent of the project.

Codes and standards: Unless otherwise stated, latest editions of the following standards are applicable.

1) IS: 1255: Installation and maintenance of power Cable.
2) IS : 5820: Specification for pre-cast concrete cable cover.
3) IS : 209 : Quality of zinc for galvanizing.
4) IS : 2062 : Structural steel.
5) IS : 456 : Plain and reinforced cement concrete.
6) IS : 800 : Use of structural steel in general building construction.
7) IS : 2016 : Plain washers
8) IS : 2633: Zinc coating on galvanized steel.
9) IS : 3063 : Spring washers.
10) IS : 5358: Hot Dip Galvanized coating on fasteners.
11) IS : 6639 : Hexagonal bolts for steel structures.
12) Any other equivalent International/ National standard

19.17 Excavation and measurement in hard rock: Blasting in hard rock shall be done as per IS: 4081 (latest edition). The hard rock excavated shall be stacked, measured and reduced by 40% for voids. Pre-measurement of rock is to be recorded when measured on section. The quantity whichever is less shall be paid.

19.18 Back, filling materials: The back filling of excavated trenches around foundation, shall consists of one of the following materials as the Engineer-in-charge may direct in each location.

i. Selected sieved earth from excavated soil.
ii. Selected sieved earth brought from borrow area
iii. Sand filling (sieved).

NOTE: Sieved sand shall be strictly used for all the works.
Filling shall be done after the work of laying cables and providing sand cushion is completed. The contractor shall commence concrete finish only after the proper reinstatement and approved by the Engineer-in-charge.

19.19 Back filling for cable trench: Back filling shall be done in horizontal layers of thickness not exceeding 300-mm thickness, free from pockets with careful watering where necessary for compaction. The backfill earth shall be riddled free from materials likely to cause damage to the cables. The thermal backfill surrounding the cable shall be as per the design approved by the owner. Surplus available/ New earth after refilling should be disposed off to a place away from site at all leads & lifts.

19.20 Cable route markers/joint markers:

Permanent and durable type, cable route markers/joint indicating blocks should be provided as per the design supplied by the purchaser. The cement concrete shall consist of one part cement, two parts sand, four parts aggregate of size 20 mm and down. The finishing should be given a smooth cover surface of cement mortar and shall have the appropriate legends, 5 mm deep engraved on them as "OPTCL 33 KV CABLE", or "OPTCL 33 KV CABLE JOINT" as the case may be. Markers shall be of size 700x240x75mm thick RCC and fixed in cement concrete at top of cable trench at 250mts distances.

19.21 Pipes: Hume pipes and accessories conforming to the relevant Indian standard specifications shall be used wherever required. All sundry materials like coupling, collars, caps to cover the pipe ends before cable is pulled in shall be provided. Stoneware pipes, shall be of good quality, salt glazed and approved by the Owner's representative. Hume pipes, stoneware pipes, can also be used where the cable passes through the passage or driveways of public and private buildings as per the directions of the Owner's representative for each particular location. The size of the pipe shall be at least 225 MM. The pipe joint shall be done by using proper sleeves so as to get tight fitting. Suitable steel rope will be drawn in pipe to pull the cable. Before drawing the cable, wire brush to be drawn through pipe to clean the burrs and steel ball (sphere) shall be pushed through pipe to know whether pipe is smooth for drawing the cable. G.I pipes of suitable size shall be used wherever required as per site requirement G.I pipes shall be of "**B**" grade.

19.22 SAND: The sand used for filling should be sieved, free from pebbles and approved quality. Only river sand should be used. The depth & width of sand filling should correspond to the details shown in the drawing.

19.23 RCC Work: RCC work required for supports to hume pipe /G.I. Pipes & others shall be of required size and depth constructed as per PWD specifications. The foundations should be of RCC as per design and drawing (to be furnished by the bidder) and got approved. Care to be taken to divert/bailout water wherever necessary during constructions. All RCC work should be of 1:1½ :3 proportion. The surface of supporting wall should be neatly plastered and finished suitable clamps should be provided for holding the pipes in position.

19.24 **CONCRETE:** All plain concrete/RCC provided should correspond to relevant IS codes. Concrete mixing should be done with machines. Curing should be as per codal requirements. All plain concrete should of 1:2:4 proportions. Before laying concrete at top of cable trenches, the back fill earth should be thoroughly compacted with water. The Concrete should be compacted and nearly finished to correspond to the road level.

19.25 Precast RCC slabs/ or interlocking stones for cable protection at top shall be provided as per drawing and design with wedge shaped notches on one side and protruding wedges on the other to facility interlocking and placing RCC shall be of M20 grade and shall be provided in stretches of concrete roads and such others reaches specified and decided during execution. Interlocking stones of approved quality should be provided wherever instructed.

19.26 CABLE AND JOINT MARKERS:

Permanent means of indicating the positions of joints on site should be provided. During the course of permanent reinstatement cable and joint markers, should be laid directly above the route of the cable and the position of the joint respectively.

Wherever it is not possible to place the marker directly over the cable route or the joint, the marker should be suitably placed near the cable route or joint on which the distance of the cable route or joint at right angles to and parallel to the marker should be clearly indicated.

The position of fixing the markers will be at the discretion of the Engineer In-charge.

19.27 JOINTING OF CABLES:

GENERAL: It shall be noted that the U.G. cables are of XLPE insulation and needs special care in jointing. The cable jointer and his assistant shall have experience in making joints/terminations. Jointing work should commence as soon as two or three lengths of cables have been laid. All care should be taken to protect the factory-plumbed cap/seal by laying the end solid in bitumen until such time as the jointing is commenced.

Jointing of cables in carriage ways, drives, under costly paving, under concrete or asphalt surfaces and in proximity to telephone cables and water mains, should be avoided whenever possible.

JOINT PITS: The joint pits should be of sufficient dimensions as to allow jointers to work with as much freedom of movement and comfort as possible. The depth of the pit should be at least 0.3-m below the cables proposed to be jointed. The sides of the pit should be draped with tarpaulin sheet to prevent loose earth from falling on the joint during the course of making. The pit should be well shored with timber, if necessary. An overlap of about 1.0-m of the cables to be jointed may be kept, for allowance to adjust the position of the joint. When two or more cables are laid together the joints shall be arranged to be staggered by 2 to 2.5 m.

SUMP PITS: When jointing cables in water logged ground or under monsoon conditions, a sump pit should be excavated at one end of the joint pit in such a position so that the accumulating water can be pumped or baled out by buckets without causing interference to the jointing operation.

TENTS: A tent should be used in all circumstances wherever jointing work is carried out in the open irrespective of the weather conditions. The tent should be so covered as to have only one entrance and the back facing the direction of the wind. The tent cover should be properly weighted or tied down on the sides.

19.28 PRECAUTIONS BEFORE MAKING A JOINT OR CUTTING A CABLE: The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/inclement weather conditions, which might become uncontrollable. The cable seals should be examined to ascertain if they are intact and also that the cable ends are not damaged. If the seals are found **broken or the lead** sheath punctured, the cable ends should not be jointed until after due examination and testing by the engineer in charge of the work.

MEASUREMENT OF INSULATION RESISTANCE: Before jointing is commenced the insulation resistance of both sections of the cable to be jointed should be checked by insulation resistance testing instrument. An insulation resistance-testing instrument of 2.5/5 kV shall be used. The insulation resistance values, between phases and phase to earth shall be recorded. The actual jointing operation shall start only after the approval of the engineer in charge of works.

PRECAUTIONS TO BE TAKEN ON LIVE CABLES IN SERVICE: Sometimes it becomes necessary that a H.V. cable, which is in service, be cut for making a straight joint with a new cable. In such cases work on joint should start only after the in service cable is properly identified, isolated, discharged, tested and effectively earthed. Search coils, interrupters or cable-identifying instruments should be used for this purpose.

IDENTIFICATION NUMBERS / COLORS AND PHASING: The cables should be laid and jointed number to number or color to color shown on the core identifying marks and prevent cross jointing. In all cases, the cables should be tested and phased out, and more particularly so when the cable terminates at Ring Main Unit/Sub-Station.

MAKING A JOINT: The Heat shrinkable joints used shall conform to the specification vide Annex 2. The contractor should furnish all the technical particulars of these joints and obtain approval only in case they are found superior to the heat shrinkable joints. Epoxy based joints are not permitted. Comprehensive jointing instructions obtained from the manufacturer of joint kits shall be meticulously followed. The connection of the earth wires should be done using flexible bonds connected to cable sheath using clips or soldering. Aluminum conductor strands shall be joined by mechanical compression method, using suitable die and sleeve with a good quality tool. The joints shall conform to specification as per IS 13573.

TRANSITION JOINTS: Wherever straight through joints will have to be made with existing cables under the following conditions the contractor shall arrange such type of joints and execute them with skilled jointers:

(1) Between cables having two different types of insulation viz., paper and XLPE.
(2) Between cables having two different types of conductor material, viz., copper and aluminum.
(3) Or a combination of the above.

The transition joints shall conform to IS: 13705 - Transition joints for cables for working voltages from 11 kV up to and including 33 KV _ performance requirements and type tests.

19.29 CABLE TERMINATIONS: Cable terminations required are both indoor and outdoor type and invariably be of heat shrinkable type conforming to the specifications vide Annex 2. All the technical particulars to establish the superiority in the performance of these joints shall be furnished while seeking approval. The terminations shall conform to specifications as per IS: 13573. The instructions furnished by the manufacturer of termination boxes/kits should strictly be followed.3

Wherever a cable rises from the trench to end in a termination, to be finally connected to an overhead line or a transformer, the following instructions should be complied with:

i) One coil to be made and left in the ground for future needs.
ii) The rise of cable, immediately from the ground level should be enclosed in suitable diameter GI pipe to a height of 2 m.
iii) The balance portion of the cable should be neatly curved, in 'S' shape.
iv)The cable and pipe should be properly fastened by using appropriate clamps/support. The hardware of clamps shall be painted with red oxide and enamel paint or galvanized.
v) The lugs on the termination shall be compressed with a suitable compression tool.

EARTHING AND BONDING:

The metal sheath and Armor should be efficiently bonded and earthed at all terminals to earth electrodes provided. The cross sectional area of the bond shall be such that the resistance of each bond connection shall not exceed the combined resistance of an equal length of the metal sheath and Armor of the cable.

19.29 TESTING BEFORE AND AFTER LAYING AND JOINTING:

All new cables should be tested for insulation resistance before jointing with a 2.5 kV megger. After satisfactory results are obtained cable jointing and termination work should commence. Records of this shall be maintained.

All cables after laying and jointing works are completed should be tested systematically and insulation and pressure tests should be made on all underground cables.

All test results should be recorded in tabular form in logbooks kept for the purpose.

The cable cores should be tested for: -

i) Continuity;
ii) Absence of cross phasing;
iii) Insulation resistance to earth; Insulation resistance between conductors.
iv) Conductor Resistance (dc) measured with a suitable bridge.
v) Capacitance. Using Capacitance Bridge.

19.30 H.V. TESTS:

After the laying and jointing work is completed, a high voltage test should be applied to the cable to ensure that the cable has not been damaged during or after the laying operations and there is no defect in the jointing.

The high voltage tests should be as per IS 1255 or as per international standards. The H.V. testing instruments shall be brought by the bidder. The dc test voltage to be applied after installation and before commissioning between any conductor and metallic sheath/screen/armor shall be 60 kV.

19.31 TESTING AND RECORD OF CABLE CONSTANTS:

When the cable is ready, just before commissioning, the cable constants, viz., the resistance, capacitance and inductance of each conductor should be determined and recorded, along with frequency at which the values of capacitance and inductance are determined.

19.32 GUARANTEE:

All cable joints/termination done by the contractor shall be guaranteed for 24 months from the date of energization of the complete cable. In the event of failure during the guarantee period, the restoration work shall be done free of cost by the contractor within 24 hours of giving notice or else the expenditure incurred by OPTCL to re-do the joint/termination will be recovered from the performance guarantee amount with the OPTCL. (See Performance guarantee clause in special Conditions of contract.)

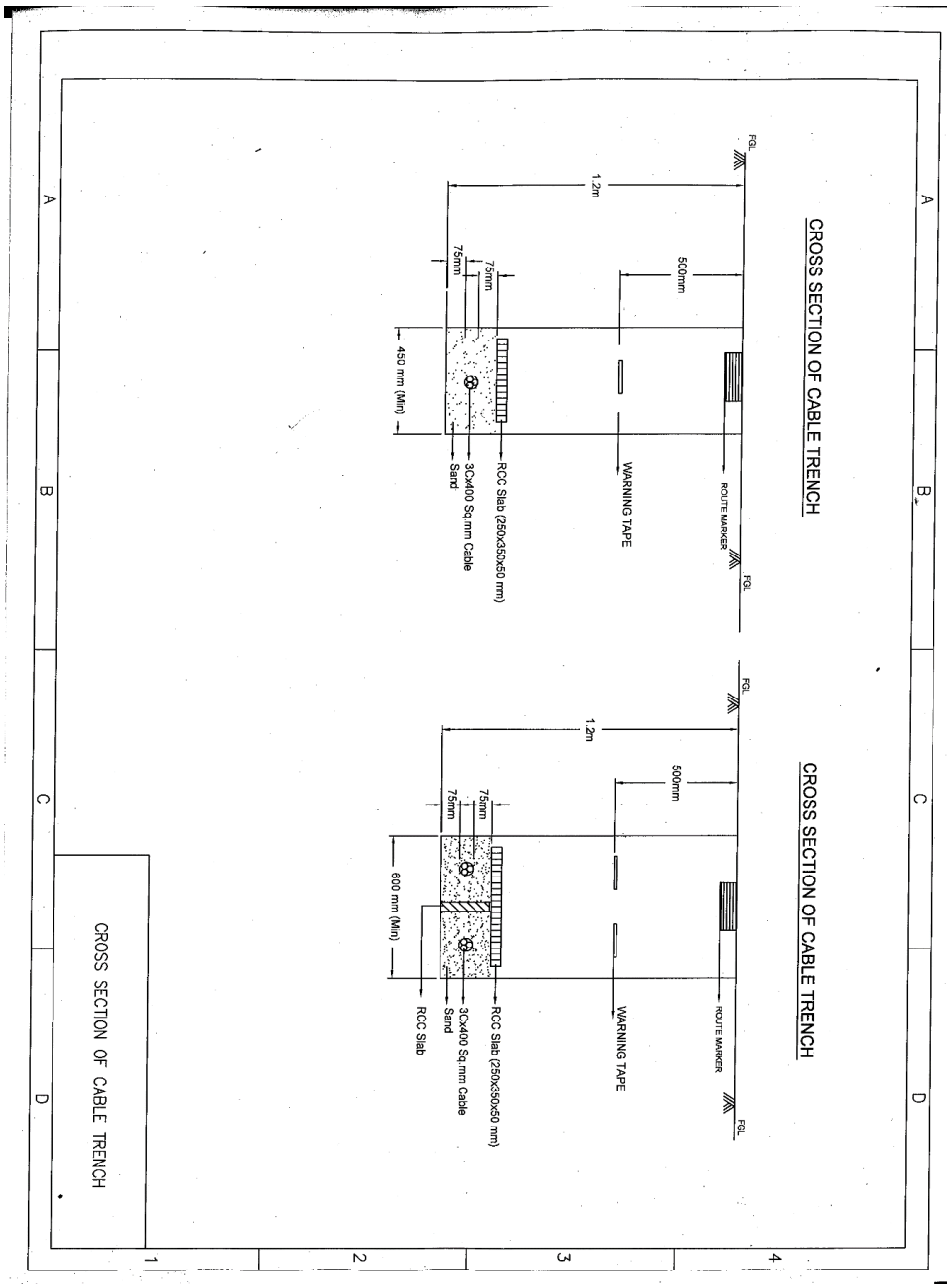
19.33 CABLE RECORDS:

Accurate neat plans/sketches, drawn to suitable scale (1 cm = 10M) should be prepared and furnished by the contractor after the completion of each work.

All relevant information should be collected at site, during the progress of work and preserved for preparation of drawings.

The following essential data should be incorporated on all drawings.

a) Size, type of cable or cables.
b) Location of the cable in relation to prominent land mark property. Kerb-line, etc., with depths.
c) The cross section showing where cables are laid in pipes or ducts, giving their sizes, type and depths.
d) Position and type of all joints.
e) Location of other cables which run alongside or across the cable route.
f) Position and depths of all pipes, ducts, etc., which are met as obstruction to the cable route.
g) Accurate lengths from joint to joint and
h) Manufacturers name and drum number of the cable, between sections/joint to joint.
i) Year and month of laying


CROSS SECTION OF CABLE TRENCH
FGL
1.2m
500mm
75mm
75mm
75mm
450 mm (Min)
ROUTE MARKER
WARNING TAPE
RCC Slab (250x350x50 mm)
3Cx400 Sq.mm Cable
Sand
CROSS SECTION OF CABLE TRENCH
FGL
1.2m
500mm
75mm
75mm
75mm
600 mm (Min)
ROUTE MARKER
WARNING TAPE
RCC Slab (250x350x50 mm)
3Cx400 Sq.mm Cable
Sand
RCC Slab
CROSS SECTION OF CABLE TRENCH
A
B
C
D
1
2
3
4

B) TECHNICAL SPECIFICATION FOR 132 kV XLPE (CROSS LINKED POLYETHYLENE) INSULATED POWER CABLE:

1.1 SCOPE

1.1.1 The scope under this section covers design, manufacturer, testing, packing, supply, delivery and laying of 132kV XLPE, insulated power cable including integrated testing and commissioning, technical support, supervision of maintenance, training of Employer's staff and documentation for a complete System necessary to deliver the requirements of this Specification.

1.2 STANDARDS:

Unless otherwise specified, the cables shall conform, in all respects, to IEC-60840 and IS:7098 (Part-III)/1993 with latest amendment or latest edition for cross linked polyethylene insulated PVC sheathed cable for working voltage of 132 kV.

The following standard specifications of latest version updated to as on date of opening of this bid document will govern supply, laying testing and commissioning of cables and their accessories that are being used in this Contract. In case of conflict between such codes and/ or standards and the specification, the specifications shall govern.

Sr. No	Title of Specification	Specification No.
1	Cross linked polyethylene insulated Thermoplastic sheathed cables	IEC: 60502–2 IEC: 60840, IEC: 62067
2	Conductors for insulated cables.	IEC : 60228
3	Test on cable over Sheath which have a special protective function and are applied by extrusion	IEC 60229
4	HDPE pipes	BIS 4984
5	Power cables with extruded insulation and their accessories for rated voltage above 30 kV and up to 150 kV- Test Methods & requirements	IEC 60840
6	Power Cables with extruded insulation and their accessories for rated voltages above 150kV.	IEC: 62067
7	Impulse test on cables & their accessories.	IEC 60230
8	Cyclic and emergency rating of cable	IEC 60852-2

Sr. No	Title of Specification	Specification No.
9	Common test methods for insulating and sheathing material of electrical cables.	IEC 60811
10	Electric test methods for Electric cables – Test methods for Partial Discharge measurements on lengths of extruded power cables.	IEC 60885

1.3 PRINCIPAL PARAMETERS:

1.3.1 132 KV (E) grade XLPE single core power cable conductor electrolytic grade copper of single length, with formation of stranded compacted circular water blocked conductor for size up to 630/800/1000 Sqmm and segmental type for size above 1000mm2 as per IEC-60228, tapped with high penetration semi conducting water blocking tape, shielded with extruded semi-conducting layer, insulated with dry gas cured cross linked polyethylene (XLPE) insulation, insulation screened with extruded semi- conducting layer, lapped with a combination of foam type semi- conducting water swellable Corrugated Aluminium armoured and black HDPE ST7 with baked on graphite coating or extruded conductive layer overall cable, confirming to IEC-standards for construction and also confirming to IS:7098 (Part-III)/1993 or any latest amendments thereof. *Cable shall be preferred of FIPC type. Alternatively, 48 F OFC shall be quoted (Optional).*

1.3.2 Outer sheathing should be designed to afford high degree of mechanical protection and should also be heat, oil chemicals and weather resistant.

1.3.3 The cable should be suitable for laying in covered trenches and/or underground for outdoor

1.3.4 The sheath/screen bonding system shall provide a continuous current path through the cable sheath and jointing kits and shall be bonded. The bonding ends shall be suitably earthed with/without SVL as per approved configuration/design. The sheath voltage under full load condition shall not exceed the voltage specified/allowed in relevant standard for safety of personal as well as satisfactory working of cable i.e 65 v. Sheath shall be solidly grounded at suitable location with or without SVL. Bidder must indicate details of configuration proposed along with sufficiency calculation with the bid so as to limit induced voltage of sheath within 65V. Detailed calculation supporting selection of SVL and bonding cable size and rating with margin of protection to be submitted with bid.

Note: Method of LILO of integrated fiber at each joint for sensing purpose, jointing

methodology, Power cable termination to FMS connection method to be submitted for a FIPC cable

1.3.5 **CABLE PARAMETERS**

Sr. No.	System Particulars	132kV
i)	Voltage Grade (Uo/U)	76/132
ii)	No. of Cores	Single
iii)	Size (mm^2)	630mm^2, 800mm^2,1000mm^2, 1200 mm^2
iv)	Nominal system voltage KV	132
v)	Highest system voltage KV	145
vi)	System Frequency Hz	50
vii)	Variation in Frequency	± 3%
viii)	Fault level individually for i) Conductor ii) Metallic Sheath	 31.5 KA for1sec 31.5 KA for 1sec
ix)	Maximum allowable temperature	
	a) Design continuous operation at rated full load current, the max, temp. of conductor shall not	90
	b) The conductor temperature after a short circuit for 1.0 sec shall not exceed. ^0C	250
x)	Basic insulation level (1.2/50 Micro Second Wave)	625 KVP
xi)	30-min. power frequency withstand voltage (rms)	190 KV
xii)	System earthing	Effectively earthed

1.4 **OPERATION CHARACTERISTICS:**

a) One/Two Three-phase feeders, each consisting of 1 runs of 4 Single core cables, feed power at 132 kV

b) In normal situation, each cable will have to be designed to carry a continuous current, to deliver a rated power of Transformers and its designed overload.

c) The cable should be designed for a suitable current carrying capacity under normal situation, and which will cater for the above overload capabilities also, will be required.

1.5 **GENERAL TECHNICAL REQUIREMENTS**:

1.5.1 **CONDUCTOR:**

The cable conductor shall be made from electrolytic grade copper with formation as stranded compacted circular conductor for size upto 1000 sqmm and segmental type as per IEC-60228 for the size above 1000mm^2.The conductor shall confirm to IS:8130/2013. Conductor should be water blocked. Water blocking to be achieved by combination of water blocking yarn and non-conducting water blocking tapes in intermediate layers of conductor.

1.5.2 **CONDUCTOR SCREEN:**

A Conductor screen made of semiconducting compound shall be provided over the conductor, by extrusion. The extruded coat shall be continuous, with a constant mean depth, without bump, perfectly adhering to the insulation envelope. A high penetration resistant semiconducting water blocking tape(s) shall be provided below the extruded semi-conducting conductor screen to prevent penetration of the compound into the underlying conductor with min 50 % overlap. The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be extruded in the same operation as the insulation; the semi-conducting polymer shall be cross-linked. Minimum thickness of the conductor screen shall be 0.8 mm. The electric resistivity of the conductor screen shall not be more than 5000 Ω cm at 20ºC and not more than 25000 Ω cm at the working rated temperature.

1.5.3 **INSULATION:**

The Insulation envelope shall be of cross-linked polyethylene (XLPE) insulation applied by extrusion should be suitable for 132kV system voltage. The nominal thickness of insulation shall not be less than 18 mm, subject to only positive tolerances (no negative tolerance is accepted) as per IEC 60840. The manufacturing process shall ensure that the Insulation shall be applied by extrusion and vulcanized using dry curing process to form a compact homogenous body free from micro voids and contaminants. The insulation compound shall be of high quality, heat, moisture, ozone and corona resistant. The insulation shall withstand mechanical and thermal stressed under steady state and transient operating conditions. The extrusion method should give very smooth interface between semi-conducting screen and insulation.

1.5.3.1 The voltage gradient in the rated working conditions shall be

a) equal to or less than 6kV/mm at the level of internal semiconductor.

b) Equal to or less than 3kV/mm at the level of external semiconductor

1.5.3.2 The mechanical characteristics shall be as follow:

a) In delivery condition:

1) minimal traction resistance : 12.5 Mpa

2) minimal elongation before breaking : 200%

b) After ageing of 240 h at 135°C:

1. maximal variation of traction resistance : □ 25%

2. maximal variation of elongation before breaking : □ 25%

1.5.3.3 The isolating envelope shall comply with the hot condition elongation test:

a) temperature : (200)°C

b) on load duration : 15 minutes

c) mechanical constraint : 0.2 Mpa

d) maximal elongation on load : 100%

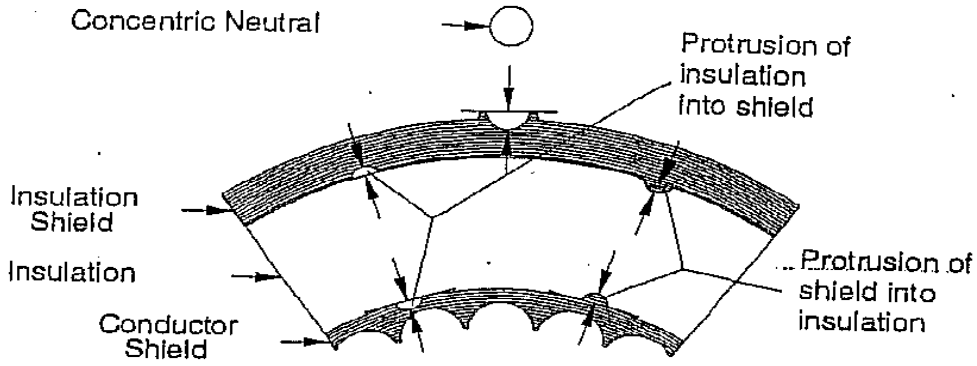
e) maximal elongation after cooling : 15%

1.5.3.4 Test for surface irregularities shall be carried out as below

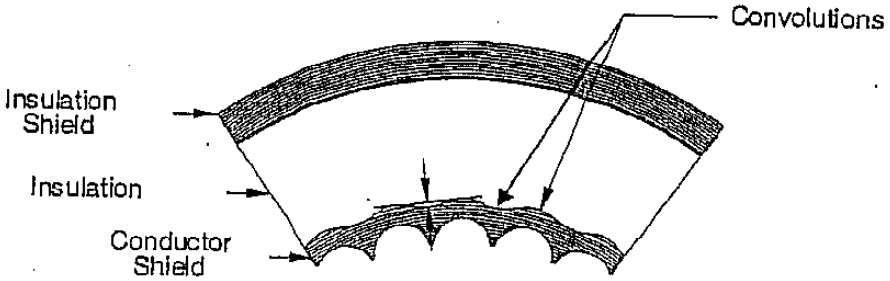
Item (For XLPE/TR XLPE insulation)	Clause of AEIC	Unit	Requirement

	CS8		
Protrusions into insulation from conductor screen	3.2	mm	≤ 0.076
Protrusions into conductor screen	3.2	mm	≤ 0.18
Strand Convolutions	3.3	mm	≤ 0.18
Protrusions into insulation from insulation screen	5.2	mm	≤ 0.13
Protrusions into insulation screen	5.2	mm	≤ 0.18

Procedure to Measure Protrusions and Indentations



Procedure to Measure Convolutions



1.5.4 **INSULATION SCREEN:**

To confine electrical field to the insulation, non-magnetic semi- conducting shield shall be put over the insulation. The insulation shield shall be extruded in the same operation as the

conductor shield and the insulation by suitable extrusion process (triple extrusion). The XLPE insulation shield should be bonded type. It shall be lapped by Foam type semiconducting tape with min thickness of 1 mm. Metallic screening shall be provided. The metallic screen shall be of Seamless*/Seam welded Corrugated Aluminum* having fault current capacity 31.5KA for 1-sec with initial temperature of screen as 80 and final temperature as 250 degC calculated by adiabatic method. Supporting calculations shall be submitted with bid.

1.5.6.1 **ANTI CORROSIVE LAYER**

An anticorrosive layer of Bitumen compound followed by tape shall form the anti-corrosive layer

1.5.7 **OUTER SHEATH:**

The outer extruded semiconducting layer sheath shall be embossed/printed red/yellow/blue colour or similar (as per phase). Suitable semi conducting layer coated on black HDPE ST7 with baked on graphite coating or extruded conductive layer confirming to IEC: 60840, shall be applied over corrugation with suitable additives to prevent attach by rodents and termites. The outer sheath should have embossing/ indelible Printing at every one meter for Supplier Name, buyer's name, PO No, Voltage grade, size, type etc.

1.5.7.1 The Mechanical Characteristics shall be as follow :

c) - In delivery condition

1) - minimal traction resistance : 12.5 Mpa

2) - minimal elongation before breaking : 200%

d) - After ageing of 240 h at 135°C:

1) - traction resistance:

2) - minimum value : 12.5MPa

3) - maximum variation : • 25%

4) - elongation before breaking:

5) - minimum value : 200%

6) - maximum variation : 25%

1.5.7.2 The variation is the difference between the medium value obtained after ageing and the medium value without ageing, expressed in percentage of the last.

1.5.7.3 **Fiber specification for integration in Power cable (Optional)**

Fiber used in the power cable or supplied separately in the OFC shall be as per below specification.

Attenuation	≤ 0.35 dB/km at 1310 nm (Typical ≤ 0.34 dB/km) ≤ 0.35 dB/km at 1383nm (Typical ≤ 0.34 dB/km) # ≤ 0.21 dB/km at 1550 nm (Typical ≤ 0.20 dB/km) ≤ 0.23 dB/km at 1625 nm (Typical ≤ 0.22 dB/km)
Mode field diameter	8.6 ± 0.4 µm at 1310 nm
Cable cutoff wavelength	≤ 1260 nm
Zero dispersion wavelength	1300 nm to 1324nm
Zero dispersion slope	≤ 0.092 ps/nm^2.km
Dispersion at 1550 nm	≤ 18.0 ps/nm.km
PMD Individual Fiber*	≤ 0.1 ps/√km
PMD LDV	≤ 0.06 ps/√km
Cladding diameter	125 ± 0.7 µm
Core-clad concentricity error	≤ 0.5 µm
Cladding non-circularity	≤ 0.8 %
Coating diameter	242 ± 5 µm
Coating-cladding concentricity error	≤ 10 µm

* Individual PMD values may change when cabled
# After hydrogen aging according to IEC-60793-2-50 regarding the B1.3 fiber category

Mechanical Characteristics

Proof Test Levels	≥ 100 kpsi (0.7GN/m^2). This is equivalent to 1% strain
Coating strip force(Force to mechanically strip the dual coating)	≥ 1.3 N (0.3 lbf) and ≤ 5.0 N (1.1lbf)
Fiber curl	≥ 4 m

Macro bend loss: The maximum attenuation with bending does not exceed the specified values with the following deployment conditions

Deployment condition	Wavelength	Induced attenuation
10 turn, 15 mm radius	1550 nm	≤ 0.03 dB
10 turn, 15 mm radius	1625 nm	≤ 0.10 dB
1 turn, 10 mm radius	1550 nm	≤ 0.10 dB
1 turn, 10 mm radius	1625 nm	≤ 0.20 dB
1 turn, 7.5 mm radius	1550 nm	≤ 0.20 dB
1 turn, 7.5 mm radius	1625 nm	≤ 0.50 dB

Environmental Characteristics

Temperature dependence Induced attenuation, -60°C to +85°C at 1310, 1550, 1625 nm	≤ 0.05 dB/km
Temperature humidity cycling Induced attenuation, -10°C to +85°C and 95% relative humidity at 1310, 1550, 1625 nm	≤ 0.05 dB/km
High temperature and humidity aging 85°C at 85% RH, 30 days Induced attenuation at 1310, 1550, 1625 nm due to aging	≤ 0.05 dB/km
Water immersion, 30 days Induced attenuation due to water immersion at 23±2°C at 1310, 1550, 1625 nm	≤ 0.05 dB/km
Accelerated aging (Temperature), 30days Induced attenuation due to temperature aging at 85±2°C at 1310,1550,1625 nm	≤ 0.05 dB/km

Other Performance Characteristics*

Effective group index of refraction	1.4678 at 1310 nm 1.4685 at 1550 nm 1.4689 at 1625 nm
Attenuation in the wavelength region from 1285 - 1330 nm in reference to the attenuation at 1310 nm	≤ 0.03 dB/km
Attenuation in the wavelength region from 1525 - 1575 nm in reference to the attenuation at 1550 nm	≤ 0.02 dB/km
Point discontinuities at 1310 nm & 1550 nm	≤ 0.05 dB
Dynamic fatigue parameter (N_d)	≥ 20

1.5.8 CONSTRUCTION:

1.5.8.1 All materials used in the manufacture of cable shall be new unused and of finest quality. All materials should comply with the applicable provision of the tests of the specification. IS, IEC, Indian Electricity Rules, Indian Electricity Act and any other applicable statutory provisions rules and regulations.

1.5.9 **CURRENT RATING:**

The cable will have current ratings and de-rating factors as per relevant standard IEC.

1.5.9.1 The one-second short circuit rating values each for conductor, & screen shall be furnished and shall be subject to the purchaser's approval.

1.5.9.2 The current ratings shall be based on maximum conductor temperature of 90 deg. C with ambient site condition specified for continuous operation at the rated current.

1.5.9.3 SIZE:

The different sizes of cable shall be 132 kV Single Core

a) 630mm^2
b) 800mm^2
c) 1000mm^2
d) 1200mm^2

1.5.10 OPERATION:

1.5.10.1 Cables shall be capable of satisfactory operation under a power supply system frequency variation of plus minus 3% voltage variation of plus, minus 10% and combined frequency

voltage variation of 10% (absolute sum).

1.5.10.2 Cable shall be suitable for laying in ducts or buried under ground.

1.5.10.3 Cable shall have heat and moisture resistance properties. These shall be of type and design with proven record on transmission network service.

1.5.11 LENGHTS: The cable shall be supplied in standard drum lengths as below:

Size of cable	**Standard Drum Length**
a) Single Core, 630mm^2,800mm^2, 1000mm^2, 1200 mm^2	500 meters ± 5% tolerance and ± 2% overall tolerance in total quantity of cable.

1.5.11 **IDENTIFICATION MARKING:**

Identification of cables shall be provided externally at three meters' intervals to identify as under:-

i) 'Name of Manufacture'
ii) 'Year of manufacture'
iii) 'Voltage grade' to be printed/embossed at the interval of one meter-length. The identification, by printing or embossing shall be done only on the outer sheath. Name of purchaser shall also be embossed.
iv) PO No
v) Scheme

1.6.0 TESTS

1.6.1 Type Tests

The equipment offered should be type tested as a cable system with terminations and both type of joints. Type test report should not be more than five years old, reckoned from the date of bid opening, in respect of the following tests, carried out in accordance with ISS-7098/IEC-871, from Govt./Govt. approved test house, shall be submitted along with bid:

i) Physical tests for insulation and outer sheath.
ii) Bending test.
iii) Di-electrical power factor test.
iv) Heating cycle test followed by di-electrical power factor as a function of voltage and partial discharge test.
v) Impulse withstand test.

The remaining type test report as per clause 3 of ISS-7098/ IEC-871/ IEC-60840 shall be submitted by the successful bidder within three months from the date of placement of order. These type test reports shall be from Govt./Govt. approved test house and shall not be more than five years old, reckoned from the date of bid opening. The failure to do so will be considered as a breach of contract.

1.6.2 ROUTINE TESTS AND ACCEPTANCE TESTS

All routine and acceptance tests shall be carried as per relevant ISS in the presence of Employer's representative.

Following additional tests shall be carried out in routine tests

a) Fiber continuity (For FIPC)

b) Optical loss measurement (for FIPC: 1 sample)

1.7 INSPECTION

The material shall be inspected and tested before dispatch by an authorised representative of the Owner in respect of quality. The inspecting officer shall also satisfy himself about the correctness of length of cables. In case the supplier is not in a position to get these tests carried out at his works, such tests may be got carried out by him at any Govt. recognized test agency at his own expense.

In addition to acceptance tests stipulated by relevant IS/IEC, following additional tests need to be carried out

Measurement of gap below Corrugation

a) Measurement of thickness of Foam type semiconducting water swellable tape
b) Measurement of protrusions and convolutions
c) Sheath integrity test
d) Wafer boil test
e) 4 hours voltage test on 3.5 m sample (once in PO)
f) Volume resistivity (once in PO)
g) Fiber continuity

1.8 TEST CERTIFICATES

The supplier shall supply test certificates from a Govt. agency in respect of quality as per IS: 7098(part-II) 1985 with latest amendments thereof for approval of the purchaser.

1.9 PACKING

The cable shall be supplied in non-returnable wooden drum as per IS:10418:1982 so constructed, as to enable the cable to be transported on each drum. The cable wound on such drum shall be one continuous length. The ends of cables shall be sealed by means of non-hygroscopic sealing material.

1.10 MARKING

The marking on the drum shall have the following information: -

a) Reference to Indian Standard & cable code.
b) Name of the manufacturer & trade name.
c) Nominal cross section area of conductor for the cables.
d) Number of core.
e) Sequential No. at each meter.
f) Type of the cable & voltage for which it is suitable.
g) Length of cable on the drum.
h) Approximate gross weight.
i) Net weight of the cable.
j) Drum identification number.
k) P.O. No. and date.
l) Consignee's name with designation.
m) Year of manufacture.

1.11 DRAWINGS & INSTRUCTION MANUAL

The tenderer shall supply the following drawings with the tender: -

i) Detailed drawing of the cable showing conductor, screening insulation, Armouring, outer sheath etc.
ii) Detailed drawing showing jointing of cable and sealing of end boxes.

Copies of instruction manuals for testing, installation jointing operation and maintenance of cables shall also be submitted with the offer for reference of the purchaser.

1.12 TECHNICAL & GUARANTEED PARTICULARS:

The tenderer shall furnish guaranteed technical particulars as per the tender specification. Particulars, which are subject to guarantee, shall be clearly marked. Offer not containing this information will not be considered.

1.13 TERMINATION KITS AND STRAIGHT THROUGH JOINTS

The entire necessary Straight through joints and Sealing Ends for 132 kV shall be supplied and erected. The Straight through joints and Sealing Ends wherever required shall be moulded Type or equivalent, of reputed make with shear head type mechanical connectors of proven technology & make.

1.14 ISO Accreditation

The cable shall be manufactured by a company having ISO accreditation for quality. The manufacturing process of XLPE cable shall consist of conductor screen, insulation & insulation screen shall be extruded in a single process(triple extrusion) and cross linked by VCV Process (Vertical Continuous Vulcanization process)/ CCV process having dry curing technology to ensure homogeneity and absence of micro voids. The cables shall be manufactured by “Dry Curing” Process. It is mandatory that bidder should submit Plant Installation Certificate for VCV Line/CCV Line and for Metallic sheath machineries indicating the year of installation and other details along with bid. The Employer may decide to visit the works of cable manufacturer to confirm the manufacturing process mentioned.

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PART II

TECHNICAL SPECIFICATION FOR LAYING, TESTING AND COMMISSIONING OF 132kV XLPE UNDERGROUND POWER CABLE

SECTION-1: SPECIFICATION FOR LAYING OF CABLE

1.1 GENERAL

1.1.2 The Cable Laying works shall be executed according to the rules of the Art pertaining to professional grade and generally in compliance with International Standards and Indian Standards.

1.1.3 The EHV Cables between the Power Supply Authorities Substation and the DMRC RSS shall be laid in ground depending upon the site conditions of the selected route, any of the following paying conditions, may be adopted.

1.1.4 Cable Laying Cases

Case 1 - Direct buried, with all cables laid in flat formation.

Case 2 – Direct buried, with the cables (3) of each circuit laid in trefoil formation and side by side in one trench.

Case 3 – Laid in underground duct.

Case 4 – Laid in Trench less piping.

Case 5 – Laid in abutment crossing

Case 6 – Laid in Rail Track crossing

Case 7 – Laid in Air, supported on piers/walls, for nallah-crossing

1.1.5 Details of Case 2 :

The trench for carrying the cables shall be at least 1.8m deep and 1.1m wide, which may vary as per site conditions with the approval of employer. Each of the 2 feeders shall consist of 3 single-core cables, and laid in trefoil formation. Cables shall be laid at a depth of 1.7m below the ground level and over a 100 mm bed of coarse sand. Trench is to be filled with sand upto a depth of 1100mm below the ground level. Warning concrete slabs of at least 50mm thickness shall then be laid above the sand. Trench shall then be filled with earth upto a depth of 300 mm below the ground level. A warning net shall then be laid above the earth filling (at 300 mm depth below the ground level). A warning tape shall also be laid appropriately with Purchaser's Name marked on it. The top space of 300 mm shall be suitably filled with compacted Boulder and Bitumen/Jelly and given a final finish matching the surroundings. The cables shall be tied through locking belts after 2 meters each for keeping the cables intact in case of trefoil formation. At locations, where there is change of level of laying, the cables shall be tied through locking belts after 1 meter each.

1.1.6 Details of Case 3

In specific locations, the Employer may require the cables to be laid in underground ducts. The underground ducts shall be laid where road construction or formation is under construction or where water logging stretch is expected or as per the specific site condition.

1.1.7 Details of Case 4 & 6

On all road/rail crossings and at other specific locations, cable laying shall be through trenchless drilling and the cables shall be passed through High Density Polyethylene (HDPE) Pipes or G.I. Pipes of appropriate diameter and thickness (Case-4). One spare HDPE pipe shall be laid for each feeder of 3 cables at the road/rail crossings.

1.1.8 Details of Case 5 & 7

On all abutment crossing or in air, supported on piers/walls, for Nallah crossing and at other specific locations, cable laying shall be on the galvanized steel structures which can withstand wind velocity of 160kmph, supported on piers and have sufficient structural strength. The minimum average weight of zinc coating should be 1000g/m2 (RDSO). The cables should be well protected by providing MS sheet of thickness 8mm at least fastened with nuts and bolts & tag welded on all sides to be protected from any pilferages. The arrangement shall render cable absolutely safe from any natural calamity. The cable shall not be exposed or get affected due to stray fire caused in the vicinity. Indicative arrangement is shown in the drawing.

1.1.9 Spare Cables and Pipes

When cables are laid in pipes, in addition to the pipes carrying the cables, at least one spare pipe

(minimum 200 mm dia), without cable shall also be provided. In the case cables laid in underground ducts (Case 3) and cables laid in Trenchless piping (Case 4), spare HDPE pipes, one for each circuit, shall be provided. In addition to pipes for power cables, 2 additional pipes, each of not less than 100 mm dia, shall be provided to carry control and monitoring cables, one operational and one spare (As indicated in the Interfacing Requirements, other cables such as pilot wire for pilot wire protection, if required, copper-core or optic fibre cables for control and monitoring, tele-communication etc, supplied by other Suppliers.

1.1.10 **Cable protection at changeover location**

The cable path, when changing from buried in ground to underground duct or trenchless piping shall be adequately protected by proper sealing in concrete or other suitable means of sufficient mechanical strength to avoid cable from suffering damage due to heat/fire/water ingress etc.

1.1.11 **Pulling Chambers**

Pulling chambers shall be provided, as necessary, along the route. Such pulling chambers shall be 4m long, 3m wide and at least 2.5m deep. The masonry structure should be of adequate strength with water proofing to avoid any accumulation of seepage of water inside. The edges of RCC covers and masonry shall be lined in GI angles to achieve a long service life.

1.1.12 **Route Markers**

The route shall be appropriately marked by suitable retro-reflective cable markers, at suitable intervals and positions of straight through joints shall be indicated by suitable boards.

2.0.0 CABLE ACCESSORIES AND BONDING

2.1.0 Straight Through Joints

2.1.1 The straight through Joints should be HEAT SHRINKABLE type or cold shrink type of proven technology and make, suitable for underground buried cables. The joint should comprise of stress control sleeves, insulating sleeves and co-extruded dual wall Tubing comprising of an insulating and semi-conducting layer. A mechanical connector with shear head bolts shall make the conductor connection.

2.1.2 The product should be type tested as per IEC /KEMA specifications

2.1.3 GENERAL SPECIFICATIONS

a. The product offered should be proven and should be in use in India for a minimum period of 5 years for the same voltage class. List of past supplies in India to be furnished. Performance certificates to be submitted along with the offer.

b. The product offered should have unlimited shelf life.

c. Offers should be supported with type test certificates from test laboratories of repute, as per IEC/ KEMA specifications, failing which the offers shall be ignored.

2.1.4 General Specifications for Joints and Terminations for 132 kV XLPE Cables

The Terminations (Outdoor Sealing ends) and Straight Through Joints for 132 kV cables shall be of 'Heat-shrinkable, '' type or cold shrink type of proven technology and make, suitable for 132 kV (E) grade or higher, Single core 400 sq mm or higher, XLPE Insulated, Aluminium sheathed cables. The Indoor termination for use in the GIS Substation.

2.2.0 Bonding

2.2.1 Suitable bonding methods viz., Single End, Both End and Cross Bonding shall be used.

2.2.2 Link boxes with & without SVL shall be used as required.

3.0.0 TESTING AND INSPECTION

7.1.0.1.1 TYPE-TESTS

7.1.0.2 General

All the equipment which are used for this work shall be of proven design and standards to achieve a very high level of reliability in service. An equipment is considered to be proven if it is in successful operation at least for a period of two years. Irrespective of the fact that the summary of type test reports was submitted for 132kV (E) or higher grade Single core, XLPE insulated, Copper conductor Aluminium Sheathed cable along with the bid, the Supplier shall furnish a summary of type test reports for all the equipment listed below except those equipment which are yet to be type tested being under development within three (3) months period from the date of signing the contract.

7.1.0.3 Heat Shrinkable type or cold shrink type of proven technology and make straight through joint suitable for 132 kV (E) grade Single Core 400 sq. mm or above size XLPE insulated cable with Aluminum sheath.

7.1.0.4 Heat Shrinkable type or cold shrink type of proven technology and make cable terminations (indoor & outdoor) suitable for 132 kV (E) grade

7.1.0.5 The cable and cable accessories intended to be used for this work shall be

(i) Type-tested within the last Five (5) years period prior to the date of bid opening. (ii) Proven in service for at least two (2) years as on the date of bid opening.

7.1.0.6 Submission of Performance Certificates

As a proof of satisfactory performance of following equipments during last two years from the bidder /JV partner /sub Supplier from whom Bidder intends to supply them.

7.1.0.7 Heat shrinkable '' type or cold shrink type of proven technology and make straight through joint suitable for 132 kV (E) grade or above grade, Single Core 400 sq. mm or above size XLPE insulated cable with Aluminum sheath.

7.1.0.8 Heat shrinkable '' type or cold shrink type of proven technology and make cable terminations (indoor & outdoor) suitable for 132 kV (E) grade

7.1.1 Type Test Results

Summary of type test results of the above mentioned equipment will be in the following format:

Sl.No.	Equipment	Manufactured By	Rating	Governing specification for type test	Name of type test	Month/ Year conducted	Testing Lab/Testing House/In House	Result/ Remark

7.1.1.1 If the type tests of any equipment being supplied for this work are not yet conducted by the Supplier then all the type tests as per the relevant IEC shall be conducted at his expense in the

presence of employer's representative either at manufacturer's works having requisite facilities and approved by independent laboratory like CPRI,KEEMA, Netherland or CESI Italy, or at KEEMA, Netherlands or CESI, Milano, Italy.

7.1.1.2 Details of 'Make of Cables/Accessories

The bidder shall submit to the employer the proposed "make" of all the above equipment in the bid form along with other details such as rating, quantity in use, place of installation number of years in satisfactory operation, summary of type test reports of required rating of 132kV or higher grade, Aluminum/copper conductor, XLPE insulated, Aluminum or Copper sheath cable along with the bid so as to decide the 'make' of the items. Based on the information thus furnished the employer shall decide the 'make' of the items to be used for the work. The plant & equipment being supplied against this bid shall conform to relevant IEC standards.

7.1.1.3 Rejection of Type Test Report

When the Employer rejects any specific type test report for a particular equipment stating the grounds for such rejection, the Supplier shall re-conduct the relevant type tests as per the specification in the presence of Employer's representatives before the item is supplied by him. Such type test shall be conducted by the Supplier at his own expense at the manufacturer's works approved by CPRI, KEMA Netherland or CESI Italy in the presence of Employer's representative.

7.1.1.4 Type Test Reports

The type test reports of the equipment shall be of the tests carried out either at the manufacturer's works having requisite facilities or at CPRI, KEEMA, Netherlands, CESI, Milano, Italy during the last ten (10) years period as on the date of bid opening. If any type test report is older than 10 years, the type tests will have to be repeated at Supplier's cost. Employer shall waive some of these tests in case of equipment / sub assemblies where the manufacturer can establish to the satisfaction of employer that such tests have already been carried out earlier or where the equipment have been proved in service. In such a case, manufacturer shall submit complete test reports along with necessary certification.

7.2.0 ROUTINE TESTS

Routine tests shall comprise of visual inspection of the items and all the routine tests as per specification. All these tests shall be conducted in the presence of Employer's nominated representative at the manufacturer's works. Routine test shall be carried out as per specification IEC 60840 latest version.

7.2.1.1 General

The following tests shall be carried out on each manufactured length of cable:

a) Partial discharge test (see 5.2.2);

b) Voltage test (see 5.2.3);

c) Electrical test on over sheath of the cable, if required (see 5.2.4).

7.2.1.2 The order in which these tests are carried out is at the discretion of the manufacturer. The main insulation of each prefabricated necessary shall undergo partial discharge (see 5.2.2) and voltage (see 5.2.3) tests according to either 1), 2) or 3) below:

1) On accessories installed on cable;

2) By using a host accessory into which a component of an accessory is substituted for test;

3) By using a simulated accessory rig in which the electrical stress environment of a main insulation component is reproduced.

7.2.1.3 In cases 2) and 3), the test voltage shall be selected to obtain electrical stresses at least the same as those on the component in a complete accessory when subjected to the test voltages specified in 5.2.2 and 5.2.3

7.2.1.4 NOTE: The main insulation of prefabricated accessories consists of the components that come in direct contact with the cable insulation and are necessary to control the electric stress distribution in the accessory. Examples are pre-moulded or pre-cast elastomer or filled epoxy resin insulating components that may be used singly or jointly to provide the necessary insulation or screening of accessories.

7.2.1.5 Partial discharge test

The partial discharge test shall be carried out in accordance with IEC 60885-3 for cables, except that the sensitivity as defined in IEC 60885-3 shall be 10pC or better. Testing of accessories follows the same principles, but the sensitivity shall be 5pC or better. The test voltage shall be raised gradually to and held at 1.75 Uo for 10 s and then slowly reduced to 1.5 Uo There shall be no detectable discharge exceeding the declared sensitivity from the test object at 1.5 Uo.

7.2.1.6 Voltage test

The voltage test shall be made at ambient temperature using an alternating test voltage at power frequency. The test voltage shall be raised gradually to 2.5 Uo) and then be held for 30 min between the conductor and metallic screen/sheath. No breakdown of the insulation shall occur 60840 @ IEC: 2004 Electrical test on over sheath of the cable When the test is required by the particular contract, the cable over sheath shall be subjected to the electrical test specified in Clause 3 of IEC 60229.

7.3.0 Acceptance tests

7.3.1 General

Acceptance tests for the power cable & its accessories shall be carried out wherever the same is mentioned in the relevant specification governing the cable and its accessories. All the acceptance tests as mentioned in the governing specification to which the product is manufactured shall be conducted in the presence of Employer's nominated representative by the Supplier at their manufacturing works. The following tests shall be carried out on samples which, for the tests in terms b) and g), may be drum lengths of cable, taken to represent batches:

a) Conductor examination (see 5.3.4);

b) Measurement of electrical resistance of conductor and of metallic screen (see 5.3.5);

c) Measurement of thickness of insulation and over sheath

d) Measurement of thickness of metallic sheath

e) Measurement of diameters, if required

f) Hot set test for XLPE, EPR and HEPR insulations Measurement of capacitance

g) Water penetration test, if applicable

h) Tests on components of cables with a longitudinally applied metal foil

7.3.2 Frequency of tests

The sample tests in items a) to h) of 5.3.1 shall be carried out on one length from each batch (manufacturing series) of the same type and cross-section of cable, but shall be limited to not more than 10% of the number of lengths in any contract, rounded to the nearest whole number. The frequency of the tests in items I) and j) of 5.3.1 shall be in accordance with agreed quality control procedures. In the absence of such an agreement, one test shall be made for contracts with a cable length above 20 km.

7.3.3 Repetition of tests

If the sample from any length selected for the tests falls in any of the tests in 5.3.1, further samples shall be taken from two further lengths of the same batch and subjected to the same tests as those in which the original sample failed. If both additional samples pass the tests, the other cables in the batch from which they were taken shall be regarded as having complied with the requirements of this standard. If either fail, this batch of cables shall be regarded as having failed to comply.

7.3.4 Conductor examination

Compliance with the requirements of IEC 60228 for conductor construction, or the declared construction, shall be checked by inspection and measurement when practicable. Measurement of electrical resistance of conductor and metallic screen The cable length, or a sample thereof, shall be placed in the test room, which shall be maintained at a reasonably constant temperature for at least 12 h before the test. If there is a doubt that the conductor or metallic screen temperature is not the same as the room temperature, the resistance shall be measure after the cable has been in the test room for 24 h. Alternatively, the resistance can be measured on a sample of conductor or metallic screen, conditioned for at least 1 h in a temperature controlled liquid bath.

7.3.5 Additional Acceptance Tests

The following additional acceptance tests shall be carried out.

1. Additional acceptance tests (1 sample/offered lot) shall be carried out for Ovality & Eccentricity.

2. Tensile strength and Elongation on insulation and over sheath before and after ageing and Thermal Stability on outer sheath of power cable.

3. finish and length measurement shall be carried on one length of each size of offered lot of power cables.

7.3.6 Short Circuit Test :

Short Circuit test for Power Cables will be conducted by the Supplier on the cable at Manufacturer's works having requisite facilities approved by KEMA Netherlands or CESI Italy or at KEEMA, Netherlands or CESI Milano, Italy & shall be witnessed by the Employer's authorized representative.

7.3.7 TEST CERTIFICATES

Three copies of the test certificates of successful type tests if any carried out on cables and cable accessories shall be furnished to the Employer within fifteen days after completion of such type tests. Three copies of successful acceptance & routine tests carried out on cables and cable accessories and the certificate of inspection issued by the Employer's representative shall be furnished within 15 days, after the completion of tests by the Employer's representative.

7.3.8 RESPONSIBILITY OF SUPPLIER FOR DELIVERY/SUPPLY

(a) All defects detected as a result of testing / inspection shall be rectified by the manufacturer at his own expense and shall be documented and corrected prior to shipment. If in opinion of Employer, a repeat of the test is required after such rectification, this shall also be carried out at the expense of the Supplier.

(b) No cable / accessory shall be supplied until Employer has inspected the same to his satisfaction and accepted. However, such inspection and/or acceptance certificate shall not relieve the Supplier of his responsibility for furnishing the cables and cable accessories conforming to the requirements of the contract nor prejudice any claim, right or privilege which the Employer may have because of the use of defective or unsatisfactory items. Should the Employer waive the right to inspect any item, such waiver shall be obtained by the Supplier from the Employer in writing and such a waival shall not relieve the Supplier in anyway from his obligation under the contract.

(c) Only after obtaining clearance from the Employer, the Supplier shall despatch the items to site.

7.3.9 INSPECTION OF ERECTION WORK

All erection work will be subject to inspection by the Employer or his representative to ensure that the work is done in accordance with the specification and approved drawing.

7.3.10 INSPECTION AND TESTS OF COMPLETELY LAID CABLE

7.3.10.1 General

As soon as the work is completed and ready for inspection and testing, the Supplier shall advise the Employer in writing. Tests will be carried out by the Employer jointly with the Supplier. Testing equipments and staff required for the tests shall be provided by the Supplier free of charge. The Supplier shall take full responsibility for these tests interalia his other responsibilities. The Supplier shall notify the manufacturer of cable and cable accessories regarding likely date of pre-commissioning tests, one month in advance so that their representative may be available at site at the time of conducting the tests. It shall be Supplier's responsibility to ensure that the cable and it's accessories are commissioned as per laid down procedures.

7.3.11 Pre commissioning Tests for the facility as a whole The following site tests shall be conducted on a completed power cable installation as per specification IEC 60840 latest version.

(i) Visual Inspection and Continuity Check Visual inspection shall include check for satisfactory workmanship Continuity check shall be carried out on the cable to ensure that the cable is continuous.

(ii) DC voltage test of the over sheath The test shall be conducted as per Clause 15.1 of IEC 60840.

(iii) AC voltage test for the installation. The test shall be conducted as per Clause 15.2 of IEC 60840.

(iv) the insulation resistance of the cable shall be checked before & after the HV test on cable. The core resistance shall be measured and the value corrected in accordance with clause 5 of IEC 60228.

(v) The cable must be discharged on completion of DC High Voltage Test and the cable shall be kept earthed until it is put into service. The values obtained during these tests shall be in conformity with the values obtained during inspection of the materials at the manufacturer's works.

7.3.12 PROFORMA FOR TESTS

The Supplier shall submit the results of tests in quadruplicate in an approved proforma within 7 days

from the date of completion of the tests but before actual commissioning of the cable. The proforma shall be developed by the Supplier and got approved from Employer within three (3) months from the effective date of the contract.

7.3.13 TECHNICAL DATA FOR 132kV SINGLE CORE 1000 & 630 SQMM XLPE INSULATED, ARMOURED CABLE:

Sl. No	**Name of the Particulars**	**Desired Value**	
		1000 sqmm	630 sqmm
1	No. of cores	1(Single)	1(Single)
2	Size (in mm2)	1000	630
3	Voltage Grade(in kV)	76/132(145) kV	76/132(145) kV
4	Type of cable	2XA2Y	2XA2Y
5	Standard according to which cable has been manufactured and tested	IS: 7098- Part 3, IEC-62067, Testing as per IEC- 60840.	IS: 7098- Part 3, IEC-62067, Testing as per IEC- 60840.
6	Permissible Voltage & Frequency variation for satisfactory operation.		
	Voltage	± 10%	± 10%
	Frequency	± 5%	± 5%
7	Maximum rated conductor temperature	90^0C	90^0C
8	Max. allowable conductor temperature during short circuit	250^0C	250^0C
9	Conductor Details		
	(a) Normal Cross-Sectional Area	1000 mm^2	630 mm^2
	(b) Material and Grade	Annealed Plain Copper to IS 8130/84	Annealed Plain Copper to IS 8130/84
	(c) Shape of Conductor	Compacted stranded circular	Compacted stranded circular
10	**Conductor Screen**		
	(a) Material	Extruded Semi-Conducting XLPE as per IS-7098 Pt 3/93	Extruded Semi-Conducting XLPE as per IS-7098 Pt 3/93
	(b) Nominal Thickness	1.5 mm (Approx.)	1.5 mm (Approx.)
11	**Insulation**		
	(a) Material	Cross linked Polyethylene to IS-7098 Pt 3/93	Cross linked Polyethylene to IS-7098 Pt 3/93
	(b) Nominal Thickness	18.0 mm	18.0 mm
12	**Insulation Screen**		

	(a) Material	Extruded Semi-Conducting XLPE (SC) layer followed by water swellable SC tapes	Extruded Semi-Conducting XLPE (SC) layer followed by water swellable SC tapes
	(b) Min. Thickness	1.0 mm followed by water swellable SC tapes	1.0 mm followed by water swellable SC tapes
	(c) Longitudinal Water Sealing	Semiconducting water blocking tape(s) with 50% over lap	Semiconducting water blocking tape(s) with 50% over lap
13	**Metallic Sheath**		
	(a) Material	Seam Welded/ Corrugated Aluminium sheath with anti corrosion protection	Seam Welded/ Corrugated Aluminium sheath with anti corrosion protection
	(b) Thickness	3.0 mm	2.0 mm
	(c) Short Circuit current of metallic screen for 1 sec (kA)	>40	>40
14	**Outer Sheath**		
	(a) Material	Extruded HDPE Type ST-7 to IS-7098 (P-III)/93	Extruded HDPE Type ST-7 to IS-7098 (P-III)/93
	(b) Colour	Black	Black
	(c) Thickness (Nom/Min)	4.0 mm	4.0 mm
	(d) Conducting layer over outer sheath	Graphite Coating	Graphite Coating
15	Nominal overall Diameter of cable	115 mm (Approx.)	107 mm (Approx.)
16	Nominal Overall Weight of Cable per Meter	25.9 kg/m (Approx)	16.3 kg/m (Approx)
17	Standard Drum Length with Tolerance	500m±5%	500m±5%
18	Minimum Bending Radius allowable during installation	20 x OD	20 x OD
19	Safe Pulling force	5kg/mm^2 of CU area.	5kg/mm^2 of CU area.

20	(a) Impulse Withstand	650kVp	650kVp
21	(b) One minute Power Frequency Withstand Voltage (kV)	190kV for 30 sec	190kV for 30 sec
22	Short circuit current for one second(kA)	143	90.10
	Max conductor DC resistance at 20^{o}C	0.0176 ohm/km	0.0283 ohm/km
	Approx. AC resistance at 90^{o}C	0.0233 ohm/km	0.0356 ohm/km
	Max. capacitance	0.309 microF/km	0.229 microF/km
23	Continuous Current Rating for cable laid in close trefoil formation	**BEB/ SPB**	**BEB/ SPB**
	(i) In ground at 30^{o}C ground temp, Depth of laying 1.0 m, Thermal Resistivity of soil 150°C Cm/W	655/795	655/795
	(ii) In free air at 40^{o} C Ambient Air Temperature	1095/1305	1095/1305
	BEB: Sheath both end bonded **SPB:** Sheath single point/ Cross bonded		
	1. The following details shall be embossed/ Printed on outer sheath at regular interval not exceeding one metre. (a) Manufacturer's Name or Trade name (b) Year of Manufacture (c) Voltage grade of Cable i.e. 127/220kV (d) Cable Code i.e. 2XA2Y (e) Number of cores & cable size e.g. 1000 Sqmm (Cu) 1 core/630 Sqmm (Cu) 1 core		
	2. Sequential length marking shall also be provided on outer sheath by inkjet printing.		
	3. Cable shall be supplied in steel drums		

7.3.14 GUARANTEED TECHNICAL PARTICULARS FOR 132 KV CABLE:

Sl. No.	Name of the Particulars	1CX630 SQMM/1x800 sq.mm	1CX1000 SQMM/1x1200 sq.mm
1	Type of cable		
2	Standard according to which cable has been manufactured and tested		
3	Rated Voltage (Uo/U}		
4	Highest System Voltage which the cable can withstand		
5	Maximum Conductor temperature for continuous operation		
6	(a) Maximum short time conductor temperature with duration		
	(b) Maximum allowable conductor temp. during overload		
7	Conductor Details		
	Normal Cross-Sectional Area		
	Material and Grade		
	Shape of Conductor		
	Diameter of Conductor		
	No. of Strands and Diameter of each Strand		
	Water swellable powder/yarn provided		
	Conducting water swellable tape with 50% overlap over compacted conductor provided		
8	Extruded Conductor Screen		
	Material		
	Nominal Thickness		
	Diameter over Conductor screen		
	Designed maximum stress at conductor screen		
9	Insulation		
	Material		
	Nominal Thickness		
	Minimum thickness at any point		
	Diameter over insulation		
	Designed maximum stress		
	Detail of vulcanization process		
	Extrusion method		
	Curing method		
	Cooling method		
	CO/ or VOI Line		
10	Extruded Insulation Screen		
	Material		
	Thickness		
	Diameter over insulation screen		
	Strippable/ Bonded		

11	Conducting Longitudinal Water Sealing		
	Material		
	Thickness		
12	Metallic Sheath/ Screen		
	Material		
	No. of strands		
	Diameter of each Strand (Nom/Min)		
	Diameter of Cable after stranding		
	Armour coverage		
13	Non-conducting Longitudinal Water Sealing		
	Material		
	Thickness		
14	HDPE Outer Sheath		
	Type		
	Colour		
	Thickness (Nom/Min)		
	Conductive Coating Provided		
15	Nominal overall Diameter of cable		
16	Nominal OVerall Weight of Cable per Meter		
17	Standard Drum Length with Tolerance		
18	Minimum Bending Radius allowable during installation		
19	Short Circuit Current Rating of Conductor with maximum conductor temperature (90°C) at the commencement of fault 1Sec. Duration		
20	Maximum Continuous Current Rating of a Circuit Comprising of 3 nos. Single Core Cable laid in trefoil formation at a depth of 1.05 M.		
	Soil Temperature		
	Ambient Temperature		
	Soil Thermal Resistivity		
	System of Bonding		
	Laid in ground (at a depth of 1.05 m)		
	Laid in dusts		
	Installed in Air		
21	Short Time Overload capacity with Duration of cable installed as per conditions mentioned in Item no.22 (2 hours)		
	Laid in ground (at a depth of 1.05 m)		
	Laid in dusts		
	Installed in Air		
22	Maximum AC Resistance at 90°C		
23	Equivalent Star Reactance of a Circuit comprising of 3 Nos. of Single Core cable laid in Trefoil Formation		
24	Maximum Charging Current per Conductor		

	at Nominal Voltage 1.64 Al km		
25	Loss in Metallic Screen of a Circuit comprising of 3 nos. of Single Core Cable installed in Trefoil Formation as per item no. 22		
26	Maximum Current in Metallic Screen when the cable is installed as per item no. 22 (Circulating Current)		
27	Derating factor of Cable installed as per Item No.22 under following conditions Ambient Temperature		
	35°C		
	45°C		
28	Group derating factor of Cable Circuits installed as per Item no. 22 under following conditions		
	Laid 100 mm. apart		
	Laid 250 mm. apart		
29	Induced voltage in metallic screen when Conductor is carrying 100 Amps(V/Km)		
30	Circulating current in metallic screen when conductor is carrying 100 Amps		
31	Test Voltages		
	Impulse Withstand Voltage at 90°C		
	Rated Power Frequency Withstand Voltage (kV)		
	Water penetration test as per IEC 60840		
	Abrasion Test on HDPE Outer sheath as per IEC 60229		
	Recommended Test Voltage after installation		
32	Details of Drum		
	Material and Weight of Drum		
	Weight of Drum with Cable		
	Flange Diameter of Drum		
	Barrel Width of Drum		
	Spindle hole Diameter		
33	Safe Pulling force		
34	Moisture barrier		
	Material		
	Min. Thickness (in mm)		
35	Metallic sheath		
	Material		
	Type of corrugation		
	Gap (in mm)		
	Min & nom thickness		
	Diameter above metallic sheath		
	Anti Corrosive layer		
	Material		
	Tape		
36	The following details shall be embossed/ Printed on outer sheath at regular interval not exceeding one metre.		

	(a) Manufacturer's Name or Trade name (b) Year of Manufacture (c) Voltage grade of Cable i.e. 132 kV (d) Cable Code (e) Number of cores & cable size e.g. 630 Sq mm (Cu) 1 core 1000 Sqmm (Cu) 1 core		
	Sequential length marking shall also be provided on outer sheath by inkjet printing.		
	Cable shall be supplied in steel drums		

C) TECHNICAL SPECIFICATION FOR 220 kV XLPE (CROSS LINKED POLYETHYLENE) INSULATED POWER CABLE:

1.1 SCOPE

1.1.1 The scope under this section covers design, manufacturer, testing, packing, supply, delivery and laying of 220 kV XLPE, insulated power cable including integrated testing and commissioning, technical support, supervision of maintenance, training of Employer‟s staff and documentation for a complete System necessary to deliver the requirements of this Specification.

1.2 **STANDARDS:**

Unless otherwise specified, the cables shall conform, in all respects, to **IEC 62067 and IS:7098 (Part-III)/1993** with latest amendment or latest edition for cross linked polyethylene insulated , metallic sheathed & PVC or Polythylene sheathed cable for working voltage of 220 kV.

The following standard specifications of latest version updated to as on date of opening of this bid document will govern supply, laying testing and commissioning of cables and their accessories that are being used in this Contract. In case of conflict between such codes and/ or standards and the specification, the specifications shall govern.

Sr. No	Title of Specification	Specification No.
1	Cross linked polyethylene insulated Thermoplastic sheathed cables	IEC: 60502–2 IEC: 60840, IEC: 62067
2	Conductors for insulated cables.	IEC : 60228
3	Test on cable over Sheath which have a special protective function and are applied by extrusion	IEC 60229
4	HDPE pipes	BIS 4984
5	Power cables with extruded insulation and their accessories for rated voltage above 150 kV- Test Methods & requirements	IEC 60840
6	Power Cables with extruded insulation and their accessories for rated voltages above 150kV.	IEC: 62067

7	Impulse test on cables & their accessories.	IEC 60230
8	Cyclic and emergency rating of cable	IEC 60852-2
9	Common test methods for insulating and sheathing material of electrical cables.	IEC 60811
10	Electric test methods for Electric cables – Test methods for Partial Discharge measurements on lengths of extruded power cables.	IEC 60885

1.3 PRINCIPAL PARAMETERS:

1.3.1 220 KV (E) grade XLPE single core power cable conductor electrolytic grade copper of single length, with formation of stranded compacted circular water blocked conductor for size up to 1000 Sqmm and segmental type for size above 800mm2 as per, as per IEC-60228, tapped with high penetration semi conducting water blocking tape, shielded with extruded semi-conducting layer, insulated with dry cured cross linked polyethylene (XLPE) insulation, insulation screened with extruded semi- conducting layer, insulated core lapped with a combination of semi- conducting water swell able and Corrugated Aluminium sheath (acting as a screen and also as a mechanical protector) and black HDPE ST7 (as per IEC 62067 – 2011) with graphite coating or extruded conductive layer overall cable confirming to IS:7098 (Part-III)/1993 or any latest amendments thereof. *Cable shall be preferred of FIPC type. Alternatively, 48 F OFC shall be quoted (Optional).*

1.3.2 Outer sheathing should be designed to afford high degree of mechanical protection and should also be heat, oil chemicals and weather resistant.

1.3.3 The cable should be suitable for laying in covered trenches and/or underground for outdoor

The sheath/screen bonding system shall provide a continuous current path through the cable sheath and jointing kits and shall be bonded. The bonding ends shall be suitably earthed with/without SVL as per approved configuration/design. The sheath voltage under full load condition shall not exceed the voltage specified/allowed in relevant standard for safety of personal as well as satisfactory working of cable i.e 65 v. Sheath shall be solidly grounded at suitable location with or without SVL. Bidder must indicate details of configuration proposed along with sufficiency calculation with the bid so as to limit induced voltage of sheath within 65V. Detailed calculation supporting selection of SVL and bonding cable size and rating with margin of protection to be submitted with bid.

NOTE: Method of LILO of integrated fiber at each joint for sensing purpose, jointing methodology, Power cable termination to FMS connection method to be submitted for a FIPC cable

1.3.5 CABLE PARAMETERS

Sr. No.	System Particulars	220kV
i)	Voltage Grade (Uo/U)	127/220 kV
ii)	No. of Cores	Single
iii)	Size (mm^2)	630mm2, $800mm^2$,$1000mm^2$, 1200 mm^2
iv)	Nominal system voltage KV	220
v)	Highest system voltage KV	245
vi)	System Frequency Hz	50
vii)	Variation in Frequency	± 3%
viii)	Fault level individually for i) Conductor ii) Corrugated Aluminium sheath	 **40 kA for1sec** **40 kA for1sec**
ix)	Maximum allowable temperature	
	a) Design continuous operation at rated full load current, the max, temp. of conductor shall not exceed. ^0C	90
	b) The conductor temperature after a short circuit for 1.0 sec shall not exceed. ^0C	250
x)	Basic insulation level (1.2/50 Micro Second Wave)	1050 KVP
xi)	System earthing	Effectively earthed

1.4 **OPERATION CHARACTERISTICS:**

a) One/more Three-phase feeders, each consisting of 1 runs of 3/4 Single core cables, feed power at 220 kV.

b) In normal situation, each cable will have to be designed to carry a continuous current, to deliver a rated power of Transformers and its designed overload.

c) The cable should be designed for a suitable current carrying capacity under normal situation, and which will cater for the above overload capabilities also, will be required.

1.5 **GENERAL TECHNICAL REQUIREMENTS**:

1.5.1 **CONDUCTOR:**

The cable conductor shall be made from electrolytic grade copper with formation as stranded compacted circular conductor for size upto 1000 sqmm and segmental type as per IEC-60228 for the size above $1000mm^2$.The conductor shall confirm to IS:8130/2013. Conductor should be water blocked. Water blocking to be achieved by combination of water blocking yarn and non-conducting water blocking tapes in intermediate layers of conductor.

1.5.2 **CONDUCOTR SCREEN:**

A Conductor screen made of semiconducting compound shall be provided over the conductor, by extrusion. The extruded coat shall be continuous, with a constant mean

depth, without bump, perfectly adhering to the insulation envelope. A high penetration resistant semiconducting water blocking tape(s) shall be provided below the extruded semi-conducting conductor screen to prevent penetration of the compound into the underlying conductor with min 50 % overlap. The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be extruded in the same operation as the insulation; the semi-conducting polymer shall be cross-linked. Minimum thickness of the conductor screen shall be **nominal 0.80 mm** (**minimum**). The electric resistivity of the conductor screen shall **as per IS 7098 (part 3).**

1.5.3 **INSULATION:**

The Insulation envelope shall be of cross-linked polyethylene (XLPE) insulation applied by extrusion should be suitable for **220 kV system** voltages. The nominal thickness of insulation **shall not be less than 27 mm (minimum** subject to only positive tolerances (no negative tolerance is accepted) as per IEC 60840. The manufacturing process shall ensure that the Insulation shall be applied by extrusion and vulcanized using dry curing process to form a compact homogenous body free from micro voids and contaminants. The insulation compound shall be of high quality, heat, moisture, ozone and corona resistant. The insulation shall withstand mechanical and thermal stressed under steady state and transient operating conditions. The extrusion method should give very smooth interface between semi-conducting screen and insulation.

1.5.3.1 The nominal thickness of insulation shall not be less than **27 mm (minimum)** (IS 7098 (part 3).

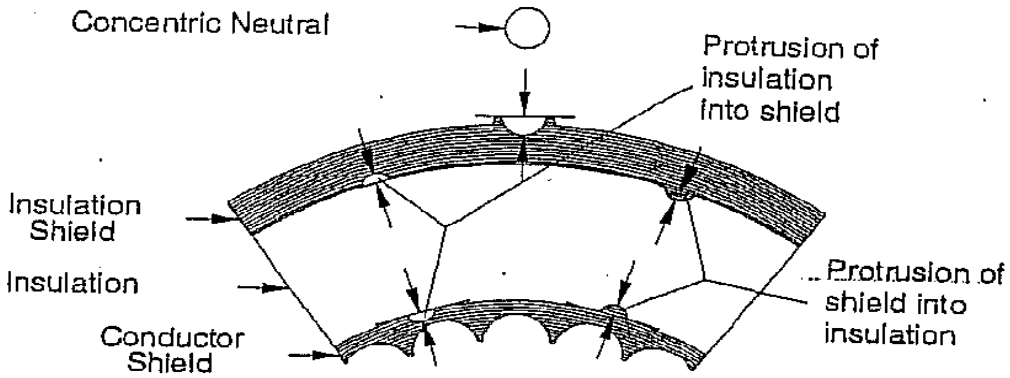
1.5.3.2 **The mechanical characteristics shall be as per IS 7098 (Part 3) :**

1.5.3.3 **The isolating envelope shall be as per IS 7098 (Part 3) :**

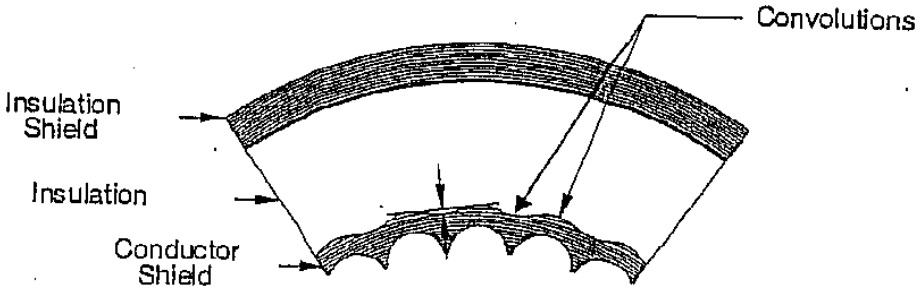
1.5.3.4 Test for surface irregularities shall be carried out as below

Item (For XLPE/TR XLPE insulation)	Clause of AEIC CS8	Unit	Requirement
Protrusions into insulation from conductor screen	3.2	mm	≤ 0.076
Protrusions into conductor screen	3.2	mm	≤ 0.18
Strand Convolutions	3.3	mm	≤ 0.18
Protrusions into insulation from insulation screen	5.2	mm	≤ 0.13
Protrusions into insulation screen	5.2	mm	≤ 0.18

Procedure to Measure Protrusions and Indentations



Procedure to Measure Convolutions



1.5.**4** **INSULATION SCREEN:**

To confine electrical field to the insulation, non-magnetic semi- conducting shield shall be put over the insulation. The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by suitable extrusion process (triple extrusion). The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by suitable extrusion process (triple extrusion). The XLPE insulation shield should be bonded type. It shall be lapped by Foam type semiconducting tape with min thickness of 1 mm. Metallic screening shall be provided by **Aluminium Sheath**.

1.5.6 **Metallic sheath:**

The metallic screen shall be of *Seam Welded/ Extruded Corrugated Aluminum* having fault current capacity 40KA for 1-sec with initial temperature of screen as 80 and final temperature as 250 degC calculated by adiabatic method. Supporting calculations shall be submitted with bid

1.5.6.1 **ANTICORROSIVE LAYER.**

An anticorrosive layer of Bitumen compound followed by tape shall form the anti-corrosive layer

1.5.7 **OUTER SHEATH:**

The outer extruded semiconducting layer sheath shall be embossed/printed red/yellow/blue colour or similar (as per phase). Suitable semi conducting layer coated on black HDPE ST7 with baked on graphite coating or extruded conductive layer confirming to IEC: 60840, shall be applied over corrugation with suitable additives to prevent attach by rodents and termites. The outer sheath should have embossing/ indelible Printing at every one meter for Supplier Name, buyer's name, PO No, Voltage grade, size, type etc.

1.5.7.1 The Mechanical Characteristics shall be as follow :

a) - In delivery condition

1) - minimal traction resistance : 12.5 Mpa

2) - minimal elongation before breaking : 200%

b) - After ageing of 240 h at 135°C:

1) - traction resistance:

2) - minimum value : 12.5MPa

3) - maximum variation : □ 25%

4) - elongation before breaking:

5) - minimum value : 200%

6) - maximum variation : 25%

1.5.7.2 The variation is the difference between the medium value obtained after ageing and the medium value without ageing, expressed in percentage of the last.

1.5.7.3 Fiber specification for integration in Power cable

Fiber used in the power cable or supplied separately in the OFC shall be as per below specification.

Attenuation	≤ 0.35 dB/km at 1310 nm (Typical ≤ 0.34 dB/km) ≤ 0.35 dB/km at 1383nm (Typical ≤ 0.34 dB/km) # ≤ 0.21 dB/km at 1550 nm (Typical ≤ 0.20 dB/km) ≤ 0.23 dB/km at 1625 nm (Typical ≤ 0.22 dB/km)
Mode field diameter	8.6 ± 0.4 µm at 1310 nm
Cable cutoff wavelength	≤ 1260 nm
Zero dispersion wavelength	1300 nm to 1324nm
Zero dispersion slope	≤ 0.092 ps/nm^2.km
Dispersion at 1550 nm	≤ 18.0 ps/nm.km
PMD Individual Fiber*	≤ 0.1 ps/√km
PMD LDV	≤ 0.06 ps/√km
Cladding diameter	125 ± 0.7 µm
Core-clad concentricity error	≤ 0.5 µm
Cladding non-circularity	≤ 0.8 %
Coating diameter	242 ± 5 µm
Coating-cladding concentricity error	≤ 10 µm

* Individual PMD values may change when cabled
# After hydrogen aging according to IEC-60793-2-50 regarding the B1.3 fiber category

Mechanical Characteristics

Proof Test Levels	≥ 100 kpsi (0.7GN/m^2). This is equivalent to 1% strain
Coating strip force(Force to mechanically strip the dual coating)	≥ 1.3 N (0.3 lbf) and ≤ 5.0 N (1.1lbf)
Fiber curl	≥ 4 m

Macro bend loss: The maximum attenuation with bending does not exceed the specified values with the following deployment conditions

Deployment condition	Wavelength	Induced attenuation
10 turn, 15 mm radius	1550 nm	≤ 0.03 dB
10 turn, 15 mm radius	1625 nm	≤ 0.10 dB
1 turn, 10 mm radius	1550 nm	≤ 0.10 dB
1 turn, 10 mm radius	1625 nm	≤ 0.20 dB
1 turn, 7.5 mm radius	1550 nm	≤ 0.20 dB
1 turn, 7.5 mm radius	1625 nm	≤ 0.50 dB

Environmental Characteristics

Temperature dependence Induced attenuation, -60°C to +85°C at 1310, 1550, 1625 nm	≤ 0.05 dB/km
Temperature humidity cycling Induced attenuation, -10°C to +85°C and 95% relative humidity at 1310, 1550, 1625 nm	≤ 0.05 dB/km
High temperature and humidity aging 85°C at 85% RH, 30 days Induced attenuation at 1310, 1550, 1625 nm due to aging	≤ 0.05 dB/km
Water immersion, 30 days Induced attenuation due to water immersion at 23±2°C at 1310, 1550, 1625 nm	≤ 0.05 dB/km
Accelerated aging (Temperature), 30days Induced attenuation due to temperature aging at 85±2°C at 1310,1550,1625 nm	≤ 0.05 dB/km

Other Performance Characteristics*

Effective group index of refraction	1.4678 at 1310 nm 1.4685 at 1550 nm 1.4689 at 1625 nm
Attenuation in the wavelength region from 1285 - 1330 nm in reference to the attenuation at 1310 nm	≤ 0.03 dB/km
Attenuation in the wavelength region from 1525 - 1575 nm in reference to the attenuation at 1550 nm	≤ 0.02 dB/km
Point discontinuities at 1310 nm & 1550 nm	≤ 0.05 dB
Dynamic fatigue parameter (N_d)	≥ 20

1.5.8 CONSTRUCTION:

1.5.8.1 All materials used in the manufacture of cable shall be new unused and of finest quality. All materials should comply with the applicable provision of the tests of the specification and any other applicable statutory provisions rules and regulations (IS, IEC, Indian Electricity Rules, Indian Electricity Act).

1.5.9 **CURRENT RATING:**

The cable will have current ratings and de-rating factors as per relevant standard IEC.

1.5.9.1 The one-second short circuit rating values each for conductor, Metal sheath shall be furnished and shall be subject to the purchaser's approval.

1.5.9.2 The current ratings shall be based on maximum conductor temperature of 90 deg. C with ambient site condition specified for continuous operation at the rated current.

1.5.9.3 SIZE:

The different sizes of cable shall be 220 kV Single Core

- **a) 630mm^2**
- **b) 800mm^2**
- **c) 1000mm^2**
- **d) 1200mm^2**

1.5.10 OPERATION:

1.5.10.1 Cables shall be capable of satisfactory operation under a power supply system frequency variation of plus minus 3% voltage variation of plus, minus 10% and combined frequency voltage variation of 10% (absolute sum).

1.5.10.2 Cable shall be suitable for laying in ducts or buried under ground.

1.5.10.3 Cable shall have heat and moisture resistance properties. These shall be of type and design with proven record on transmission network service.

1.5.11 LENGHTS: The cable shall be supplied in standard drum lengths as below:

Size of cable	**Standard Drum Length**
a) Single Core, 1000 sq.mm	500 meters + 2% tolerance

1.5.11 **INDENTIFICATION MARKING:**

Identification of cables shall be provided externally at three meters' intervals to identify as under: -

i) 'Name of Manufacture'
ii) 'Year of manufacture'
iii) 'Voltage grade' to be printed/embossed at the interval of one meter-length.
The identification, by printing or embossing shall be done only on the outer sheath.
iv) Name of purchaser shall also be embossed.

1.6.0 TESTS

1.6.1 Type Tests

The equipment offered should be type tested as a cable system with terminations and both type of joints. Type test report should not be more than Five years old, reckoned from the date of bid opening, in respect of the following tests,
carried out in accordance with **IEC 62067**, from Govt./Govt. approved test house, shall be submitted along with bid:

i) Physical tests for insulation and outer sheath.
ii) Bending test.
iii) Di-electrical power factor test.
iv) Heating cycle test followed by di-electrical power factor as a function of voltage and partial discharge test.
v) Impulse withstand test.

The remaining type test report as per **IEC 62067** shall be submitted by the successful bidder. These type test reports shall be from Govt. /Govt. approved test house and shall not be more than five years old, reckoned from the date of bid opening. The failure to do so will be considered as a non-responsive.

1.6.2 ROUTINE TESTS AND ACCEPTANCE TESTS

All routine and acceptance tests shall be carried as per relevant ISS in the presence of Employer's representative.

Following additional tests shall be carried out in routine tests (Optional)

a) Fiber continuity (For FIPC)

b) Optical loss measurement (for FIPC: 1 sample)

1.7 INSPECTION

The material shall be inspected and tested before dispatch by an authorised representative of the Owner in respect of quality. The inspecting officer shall also satisfy himself about the correctness of length of cables. In case the supplier is not in a position to get these tests carried out at his works, such tests may be got carried out by him at any Govt. recognized test agency at his own expense.

In addition to acceptance tests stipulated by relevant IS/IEC, following additional tests need to be carried out

Measurement of gap below Corrugation

a) Measurement of thickness of Foam type semiconducting water swellable tape

b) Measurement of protrusions and convolutions

c) Sheath integrity test

d) Wafer boil test

e) 4 hours voltage test on 3.5 m sample (once in PO)

f) Volume resistivity (once in PO)

g) Fiber continuity

1.8 **TEST CERTIFICATES**

To be submitted.

1.9 PACKING

The cable shall be supplied in returnable Steel drum as per so constructed, as to enable the cable to be transported on each drum. The cable wound on such drum shall be one continuous length. The ends of cables shall be sealed by means of non-hygroscopic sealing material. The Top end shall be provided with Suitable Pulling eye.

1.10 MARKING

The marking on the drum shall have the following information: -

a) Reference to Indian Standard & cable code.

b) Name of the manufacturer & trade name.

c) Nominal cross section area of conductor for the cables.

d) Number of core.

e) Sequential No. at each meter.

f) Type of the cable & voltage for which it is suitable.
g) Length of cable on the drum. h)
Approximate gross weight.
i) Net weight of the cable.
j) Drum identification number.
k) P.O. No. and date.
l) Consignee's name with designation.
m) Year of manufacture.

1.11 DRAWINGS & INSTRUCTION MANUAL

The tenderer shall supply the following drawings with the tender: -

i) Detailed drawing of the cable showing conductor, screening insulation, Armouring, outer sheath etc. ii) Detailed drawing showing jointing of cable and sealing of end boxes.

Copies of instruction manuals for testing, installation jointing operation and maintenance of cables shall also be submitted with the offer for reference of the purchaser.

1.12 TECHNICAL & GUARANTEED PARTICULARS:

The tenderer shall furnish guaranteed technical particulars as per the tender specification. Particulars, which are subject to guarantee, shall be clearly marked. Offer not containing this information will not be considered.

1.13 TERMINATION KITS AND STRAIGHT THROUGH JOINTS

The entire necessary Straight through joints and Sealing Ends for **220 kV** shall be supplied and erected. The Straight through joints and Sealing Ends wherever required shall be Heat Shrink Type or equivalent, of reputed make with shear head type mechanical connectors or cold shrink type of proven technology & make.

1.14 ISO Accreditation

The cable shall be manufactured by a company having ISO accreditation for quality. The manufacturing process of XLPE cable shall consist of conductor screen, insulation & insulation screen shall be extruded in a single process (Triple extrusion) and cross linked by a suitable proven & latest Process having dry curing technology to ensure homogeneity and absence of micro voids. The cables shall be manufactured by "Dry Curing" Process. It is mandatory that bidder should submit Plant Installation Certificate for process Line and for Metallic sheath machineries indicating the year of installation and other details along with bid. The Employer may decide to visit the works of cable manufacturer to confirm the manufacturing process mentioned & decision of accepting the process is the sole discretion of OPTCL.

PART II

TECHNICAL SPECIFICATION FOR LAYING, TESTING AND COMMISSIONING OF 220 kV XLPE UNDERGROUND POWER CABLE
SECTION-1 SPECIFICATION FOR LAYING OF CABLE:

1.1 GENERAL

1.1.2 The Cable Laying works shall be executed according to the rules of the Art pertaining to professional grade and generally in compliance with International Standards and Indian Standards.

1.1.3 The EHV Cables between the Power Supply Authorities Substation and the DMRC RSS shall be laid in ground depending upon the site conditions of the selected route, any of the following paying conditions, may be adopted.

1.1.4 Cable Laying Cases

Case 1 - Direct buried, with all cables laid in flat formation.

Case 2 – Direct buried, with the cables (3) of each circuit laid in trefoil formation and side by side in one trench.

Case 3 – Laid in underground duct.

Case 4 – Laid in Trench less piping.

Case 5 – Laid in abutment crossing

Case 6 – Laid in Rail Track crossing

Case 7 – Laid in Air, supported on piers/walls, for nallah-crossing

1.1.5 Details of Case 2 :

The trench for carrying the cables shall be at least 1.8m deep and 1.1m wide, which may vary as per site conditions with the approval of employer. Each of the 2 feeders shall consist of 3 single-core cables, and laid in trefoil formation. Cables shall be laid at a depth of 1.7m below the ground level and over a 100 mm bed of coarse sand. Trench is to be filled with sand upto a depth of 1100mm below the ground level. Warning concrete slabs of at least 50mm thickness shall then be laid above the sand. Trench shall then be filled with earth upto a depth of 300 mm below the ground level. A warning net shall then be laid above the earth filling (at 300 mm depth below the ground level). A warning tape shall also be laid appropriately with Purchaser‟s Name marked on it. The top space of 300 mm shall be suitably filled with compacted Boulder and Bitumen/Jelly and given a final finish matching the surroundings. The cables shall be tied through locking belts after 2 meters each for keeping the cables intact in case of trefoil formation. At locations, where there is change of level of laying, the cables shall be tied through locking belts after 1 meter each.

1.1.6 Details of Case 3

In specific locations, the Employer may require the cables to be laid in underground ducts. The underground ducts shall be laid where road construction or formation is under construction or where water logging stretch is expected or as per the specific site condition.

1.1.7 Details of Case 4 & 6

On all road/rail crossings and at other specific locations, cable laying shall be through trenchless drilling and the cables shall be passed through High Density Polyethylene (HDPE) Pipes or G.I. Pipes of appropriate diameter and thickness (Case-4). One spare HDPE pipe shall be laid for each feeder of 3 cables at the road/rail crossings.

1.1.8 Details of Case 5 & 7

On all abutment crossing or in air, supported on piers/walls, for Nallah crossing and at other specific locations, cable laying shall be on the galvanized steel structures which can withstand wind velocity of 160kmph, supported on piers and have sufficient structural strength. The minimum average weight of zinc coating should be 1000g/m2 (RDSO). The cables should be well protected by providing MS sheet of thickness 8mm at least fastened with nuts and bolts & tag welded on all sides to be protected from any pilferages. The arrangement shall render cable absolutely safe from any natural calamity. The cable shall not be exposed or get affected due to stray fire caused in the vicinity. Indicative arrangement is shown in the drawing.

1.1.9 Spare Cables and Pipes

When cables are laid in pipes, in addition to the pipes carrying the cables, at least one spare pipe (minimum 200 mm dia), without cable shall also be provided. In the case cables laid in underground ducts (Case 3) and cables laid in Trenchless piping (Case 4), spare HDPE pipes, one for each circuit, shall be provided. In addition to pipes for power cables, 2 additional pipes, each of not less than 100 mm dia, shall be provided to carry control and monitoring cables, one operational and one spare (As indicated in the Interfacing Requirements, other cables such as pilot wire for pilot wire protection, if required, copper-core or optic fibre cables for control and monitoring, tele-communication etc, supplied by other Suppliers.

1.1.10 **Cable protection at changeover location**

The cable path, when changing from buried in ground to underground duct or trenchless piping shall be adequately protected by proper sealing in concrete or other suitable means of sufficient mechanical strength to avoid cable from suffering damage due to heat/fire/water ingress etc.

1.1.11 **Pulling Chambers**

Pulling chambers shall be provided, as necessary, along the route. Such pulling chambers shall be 4m long, 3m wide and at least 2.5m deep. The masonry structure should be of adequate strength with water proofing to avoid any accumulation of seepage of water inside. The edges of RCC covers and masonry shall be lined in GI angles to achieve a long service life.

1.1.12 **Route Markers**

The route shall be appropriately marked by suitable retro-reflective cable markers, at suitable intervals and positions of straight through joints shall be indicated by suitable boards.

2.0.0 CABLE ACCESSORIES AND BONDING

2.1.0 Straight Through Joints

2.1.1 The straight through Joints should be HEAT SHRINKABLE type or cold shrink type of proven technology and make, suitable for underground buried cables. The joint should comprise of stress control sleeves, insulating sleeves and co-extruded dual wall Tubing comprising of an insulating and semi-conducting layer. A mechanical connector with shear head bolts shall make the conductor connection.

2.1.2 The product should be type tested as per IEC /IS specifications

2.1.3 GENERAL SPECIFICATIONS

a. The product offered should be proven and should be in use in India for a minimum period of 5 years for the same voltage class. List of past supplies in India to be furnished. Performance certificates to be submitted along with the offer.

b. The product offered should have unlimited shelf life.

c. Offers should be supported with type test certificates from test laboratories of repute, as per IEC /IS specifications, failing which the offers shall be ignored.

2.1.4 General Specifications for Joints and Terminations for 220 KV XLPE Cables

Suitable Terminations (Outdoor & Indoor Sealing ends) and Straight through Joints having proven technology of reputed international make & of 220 kV grade or higher for single core 220 kV cables,XLPE Insulated, Aluminium sheathed cables to be used. The Indoor termination for use in the GIS Substation.

2.2.0 Bonding

2.2.1 Suitable bonding methods viz., Single End, Both End and Cross Bonding shall be used.

2.2.2 Link boxes with & without SVL shall be used as required.

3.0.0 TESTING AND INSPECTION:

AS per IS/IEC to be carried out before election.

3.1 TECHNICAL DATA FOR 220kV SINGLE CORE 1000 SQMM XLPE INSULATED, ARMOURED CABLE:

Sl. No	**Name of the Particulars**	**Desired Value**
1	No. of cores	1(Single)
2	Size (in mm2)	1000
3	Voltage Grade(in kV)	127/220(245) kV
4	Type of cable	2XA2Y
5	Standard according to which cable has been manufactured and tested	IS: 7098- Part 3, IEC-60840, IEC-60502-2, Testing as per IEC- 62067.
6	Permissible Voltage & Frequency variation for satisfactory operation.	

	Voltage	± 10%
	Frequency	± 5%
7	Maximum rated conductor temperature	90^0C
8	Max. allowable conductor temperature during short circuit	250^0C
9	Conductor Details	
	(a) Normal Cross-Sectional Area	1000 mm^2
	(b) Material and Grade	Annealed Plain Copper to IEC 60228
	(c) Shape of Conductor	Compacted stranded circular
	(d) Separator over conductor	Semi-conducting tapes
10	**Conductor Screen**	
	(a) Material	Extruded Semi-Conducting XLPE compound
	(b) Nominal Thickness	1.5 mm (Approx.)
11	**Insulation**	
	(a) Material	Cross linked Polyethylene to IEC 62067
	(b) Nominal Thickness	27.0 mm
12	**Insulation Screen**	
	(a) Material	Extruded Semi-Conducting XLPE (SC) layer followed by water swellable SC tapes
	(b) Min. Thickness	1.0 mm
	(c) Longitudinal Water Sealing	Semiconducting water blocking tape(s) with 50% over lap
13	**Metallic Sheath**	
	(a) Material	Seam Welded/ Extruded, Corrugated Aluminium sheath with anti-corrosion protection
	(b) Thickness	2.3mm
	(c) Short Circuit current of metallic screen for 1 sec (kA)	>40
14	**Outer Sheath**	

	(a) Material	Extruded HDPE Type ST-7 to IEC 62067	
	(b)Colour	Black	
	(c)Thickness (Nom/Min)	4.0 mm	
	(d)Conducting layer over outer sheath	Graphite Coating	
15	Nominal overall Diameter of cable	125 mm (Approx.)	
16	Nominal Overall Weight of Cable per Meter	18.6 kg/m (Approx)	
17	Standard Drum Length with Tolerance	500m±5%	
18	Minimum Bending Radius allowable during installation	20 x OD	
19	Safe Pulling force	5kg/mm^2 of CU area.	
20	(a) Impulse Withstand Voltage	1050kVp	
21	(b) One minute Power Frequency Withstand Voltage (kV)	318kV for 30 sec	
22	Short circuit current for one second(kA)	143	
	Max conductor DC resistance at 20^{o}C	0.0176 ohm/km	
	Approx. AC resistance at 90^{o}C	0.0234 ohm/km	
	Max. capacitance	0.17 microF/km	
23	Continuous Current Rating for cable laid in close trefoil formation	**BEB**	**SPB**
	(i) In ground at 30^{o}C ground temp, Depth of laying 1.0 m, Thermal Resistivity of soil 150°C Cm/W	650	820
	(ii) In free air at 40^o C Ambient Air Temperature	1100	1345
	BEB: Sheath both end bonded **SPB:** Sheath single point/ Cross bonded		

3.2 GTP FORMAT:

Sl. No	**Name of the Particulars**	**Value**
	Name of the manufacturer	
1	No. of cores	
2	Size (in mm2)	
3	Voltage Grade(in kV)	
4	Type of cable	
5	Standard according to which cable has been manufactured and tested	
6	Permissible Voltage & Frequency variation for satisfactory operation.	
	Voltage	
	Frequency	
7	Maximum rated conductor temperature	
8	Max. allowable conductor temperature during short circuit	
9	Conductor Details	
	a. Normal Cross-Sectional Area	
	b. Material and Grade	
	c. Shape of Conductor	
	d. (d) Separator over conductor	
10	**Conductor Screen**	
	e. Material	
	f. Nominal Thickness	
11	**Insulation**	
	(c) Material	
	(d) Nominal Thickness	
12	**Insulation Screen**	
	(d) Material	
	(e) Min. Thickness	
	(f) Longitudinal Water Sealing	
13	**Metallic Sheath**	

	(d) Material		
	(e) Thickness		
	(f) Short Circuit current of metallic screen for 1 sec (kA)		
14	**Outer Sheath**		
	(e)Material		
	(f) Colour		
	(g)Thickness (Nom/Min)		
	(h)Conducting layer over outer sheath		
15	Nominal overall Diameter of cable		
16	Nominal Overall Weight of Cable per Meter		
17	Standard Drum Length with Tolerance		
18	Minimum Bending Radius allowable during installation		
19	Safe Pulling force		
20	Impulse Withstand Voltage		
21	(c) One minute Power Frequency Withstand Voltage (kV)		
22	Short circuit current for one second(kA)		
	Max conductor DC resistance at 20^{o}C		
	Approx. AC resistance at 90^{o}C		
	Max. capacitance		
23	Continuous Current Rating for cable laid in close trefoil formation	**BEB**	**SPB**
	(iii) In ground at 30^{o}C ground temp, Depth of laying 1.0 m, Thermal Resistivity of soil 150°C Cm/W		
	(iv) In free air at 40^{o} C Ambient Air Temperature		
	BEB: Sheath both end bonded **SPB:** Sheath single point/ Cross bonded		

(D) TECHNICAL SPECIFICATION CABLE SEALING END KIT for 220 KV, 132 KV & 33 KV

(a) Specifications of 245 KV, 145 kV & 33 KV Dry type.
(b) Termination, Dry type O/D Termination & St through Joints
(c) Applicable IECs: IEC 60840 for technical data, IEC 62271-209 for dimensioning, EN 50089 for routine tests on Epoxy insulators

1.0 TYPE & MAKE OF CABLE KITS

1.1 **SF6 SWITCHGEAR TYPE SEALING END:**

1.1.1 For the feeder bays having power cable connections, the suitable cable sealing end enclosures will be supplied by the GIS bidder but 245 KV, 145 kV & 33 KV XLPE cables and cable sealing end terminators with cable cone will not be included in the GIS bidder's supply. Interface between GIS and power cable will be in accordance with IEC 62271-209 (2007-08).

1.1.2 The GIS Plug-in (Dry) type cable sealing end, confirming to IEC: 60840 for termination of the Cables for maximum continuous voltage of 245 KV, 145 kV & 33 KV at SF6 switchgear end will be supplied by the cable manufacturer. The contractor shall be responsible for the preparation of the cable insulation and conductors and correct termination of each cable to these sealing ends.

1.1 3 Bidders are requested to quote cable sealing end with design that helps reducing, if possible, the works on the gas compartments. The cable sealing end shall be of plug-in type that allows easy plugging and unplugging of high voltage power cable without the need of opening the GIS and related time consuming gas works. The supplier of GIS Plug-in (Dry) type Termination will coordinate closely with GIS manufacturer for mounting the epoxy insulator in the GIS cable chamber .The cable contractor will supply only the Plug-in part and associated components.

1.1.4 Cable manufacturer shall furnish large scale general assembly drawings of the SF6 sealing ends, mounting flange details, size of terminal opening in the junction box, weight of terminal including accessories, physical shape and dimensions of all live part, recommended clearances form live parts to the inside surface to permit the SF 6 switch gear manufacturer to design and supply junction boxes of adequate dimensions and construction to permit the installation and maintenance of the terminals without difficulty.

1.1.5 The stress cone made of EPDM rubber shall inhibit possible mechanical stress and deformation of the cable insulation surface during operation and also shall be capable of accommodating minor radial and longitudinal movement without determent to the dielectric stress in the insulation shield.

1.1.6 Manufacturer shall state the connector clearances required when the assembled cable DC proof test is undertaken for co-ordination with the SF6 switch gear design.
1.1.7 All supporting structures for the SF6 bus-duct connections between the XLPE cable sealing ends and the GIS shall be supplied by the outdoor GIS supplier. The supplier may specify connecting & supporting arrangements for approval of the purchaser.

1.2 **OUTDOOR TYPE SEALING END.**

1.2.1 The Dry type cable sealing end (where no oil filling is required in the Termination), conforming to IEC-60840 will be preferred, for maximum continuous voltage of 245 KV, 145 kV & 33 KV cables at the outdoor yard shall be supplied by the cable manufacturer. The contractor shall be responsible for correct termination of each cable to sealing ends, installation of the cable sealing end and providing of terminal connectors for connecting to terminal conductor. The requisite interconnection between line end & sealing end is required to be designed (as per safety and statutory provision aspects) and executed (after approval of Owner) by successful bidder.

1.2.2 The silicone rubber /composite bushing termination of rated capacity, suitable for outdoor installation in heavily polluted atmosphere shall be used. The minimum creepage offered should not be less than 31mm/kV. It should resistant to UV exposure. The termination stress control shall be means of stress cone.

1.2.3 The stress cone made of EPDM rubber shall inhibit possible mechanical stress and deformation of the cable insulation surface during operation and also shall be capable of accommodating minor radial and longitudinal movement without determent to the dielectric stress in the insulation shield.

1.3 **STRAIGHT THROUGH JOINTS**

1.3.1 The Pre-Moulded type straight through joints for XLPE cable, conforming to IEC 60840 shall be suitable for underground buried installation with incorporated back fill and chances of flooding by water. The straight through joints should be absolutely impervious to the entry of water. The manufacturer shall use the proven technology and design to prevent entry of water or any other liquid inside the straight through joints and cables.

1.3.2 The stress cone made of EPDM rubber shall inhibit possible mechanical stress and deformation of the cable insulation surface during operation and also shall be capable of accommodating minor radial and longitudinal movement without determent to the dielectric stress in the insulation shield.

1.4 Type tests conducted for offered make cable and accessories separately will be considered for evaluation.

Type test for cable conducted shall be as per IEC 60840 or equivalent/higher standard for 245 KV, 145 kV 1000sqmm, & 33 KV 630 & 300 Sqmm copper cable or above sizes offered make cable & pre moulded joints and end terminations.

i) The above tests should have been conducted from any one of the reputed International Test Laboratories mentioned below.

a) CPRI, Bangalore .
b) STRI Sweden.
c) Hydro-Quebec, Canada
d) EDF, France.
e) KEMA, Holland.
f) CESI, Italy.
g) IPH, Germany.
h) NEETRAC (USA).

However, the type tests conducted at any other international accreditation test laboratory is also considered, subject to verification of accreditation certification issued by international accreditation board only and for the purpose of conducting type test.

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(E) TECHNICAL SPECIFICATION OF LINK BOXES FOR

Sl. No	PARTICULARS
1.0	Link boxes and sheath voltage limiters
1.1	General
1.2	Cross Bonding
1.3	Mechanical Design
1.4	Electrical Design
1.5	Applications
1.6	Type Tests
1.7	Dimensions
1.8	Factory Type Tests
1.9	Routine Tests

CROSS BONDING OF EHV CABLES:

1.0 Link boxes and sheath voltage limiters:

1.1 General

Link boxes are used with cable joints and terminations to provide easy access to shield breaks for test purposes and to limit voltage build-up on the sheath. Lightening, fault currents and switching operations can cause over voltages on the cable sheath. The link box optimizes loss management in the cable shield on cables grounded both sides.

1.2 Cross Bonding:

For cross bonding, the cable length is divided into 3 equal sections. Each of the alternating magnetic fields induces a voltage with a phase shift of 120° in the cable shields.The cross bonding takes place in the link boxes. Ideally, the vectorial addition of the induced voltages becomes zero. In practice, the cable length and the laying conditions will vary, resulting in a small residual voltage and a negligible current. Since there is no current flow, there are practically no loses in the screen. The total of the three voltages is zero, thus the ends of the three sections can be grounded. However sections for cross bonding may vary depending on the length of cables.

1.3 Mechanical Design:

1.3.0 Made of stainless steel

1.3.1 Compact design

1.3.3 Single phase and 3-phase link boxes

1.3.4 Hermetically sealed

1.3.4.1 Resists water pressure up to 1 bar (20 psi)

1.3.4.2 Lugs and bonding cables are heat shrink sealed inside and outside

1.3.5 Suitable for different applications

1.3.5.0 Single point bonding

1.3.5.1 Cross bonding

1.3.5.2 Direct grounding

1.3.5.3 Grounding through SVL

1.3.5.4 Combined direct and SVL grounding

1.3.5.5 Cross bonding and transposition

1.4 Electrical Design:

1.4.1 Grounding box
1.4.2 Link box
1.4.3 ZnO sheath voltage limiter
1.4.4 3 kV and 6kV protection levels
1.4.5 Same outer dimensions for both levels

1.5 Applications:

1.5.1 Can be installed in underground pits at a depth of 2mtr and more.

1.5.2 Use with single core or concentric bonding lead

1.6 Type Tests:

1.6.1 Tested to ANSI/IEEE Std 575-1988 IEEE-Guide for the application of sheath-bonding methods for single conductor cables and the calculation of induced voltages and currents in cable sheaths.

1.6.2 Any NABL accredited laboratories..

1.7 Dimensions:

1.7.1 Single Phase Link Box: L 300 x W 190 x H 165 (mm)

1.7.2 Three Phase Link Box with or Without SVL: L 310 x W 310 x H 255 (mm)

Note: This is Dimensions are indicative only which will be finalized during detailed engineering.

1.8 Factory Type Tests:

1.8.1 Water Immersion Test (IP 68- IEC 60529)
1.8.2 Impulse Voltage Withstand Test
1.8.3 Dust Test
1.8.4 Water Jet Test

1.9 Routine Tests:

1.9.1 DC Withstand Test:

25 kV DC voltage is applied for 5 minutes to each cable lug meanwhile all other lugs to be earthed. If exist(s), SVL(s) dismounted during test. In the DC withstand test is no breakdown and flash over.

1.9.2 Insulation Resistance Measurement Test:

5 kV DC voltage is applied for 1 minute to each cable lug meanwhile box itself to be earthed. If exist(s), SVL(s) dismounted during test. At the end of test duration insulation resistance of each link box is greater than 100 MΩ.

1.9.3 Contact Resistance Measurement Test:

50 A DC current will be applied to each contact points which had been squeezed with 40 kN torque. If exist(s), SVL(s) dismounted during test. Contact resistance each contact point is less than 10μΩ.

1.9.4 Water Sealing Test:

All underground type link boxes after manufacturing with cover bolted closed, and phase glands capped, filled with water trough earthing gland will be subject to equivalent 3.0 meter water pressure (0.3 bars) for 15 miutes. VISUALY inspection of external surf. There is no leaks and water spots.

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