HTLS CONDUCTOR AND HARDWARES

(High Temperature Low Sag Conductor)

JANUARY 2026

Engineering Department

WEST BENGAL STATE ELECTRICITY TRANSMISSION COMPANY LIMITED

পশ্চিমবঙ্গ রাজ্য বিদ্যুৎ সংবহন কোম্পানি লিমিটেড

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TECHNICAL SPECIFICATION FOR

HTLS CONDUCTOR AND HARDWARES

SCOPE:

a) This specification covers design, manufacturing, testing, and supply of High Temperature Low Sag (HTLS) conductor as well as required associated hardware fittings and accessories, such as suspension clamps, dead end clamps, mid-span compression joints, repair sleeves, T-Connectors, vibration dampers, suspension and tension strings, etc.

b) The materials shall be supplied complete in all respects, including all components, fittings, and accessories which are necessary or are usual for their efficient performance and satisfactory maintenance under various operating and atmospheric conditions. Such parts shall be deemed to be within the scope of the Contract, whether specifically included or not in the Specification or in the Contract Schedules. The Supplier shall not be liable for any extra charges for such fittings.

c) The entire stringing work of conductor shall be carried out by tension stringing technique except where geography, topographical, or other site constraints do not permit the use of tension stringing equipment. In such cases, manual stringing along with other appropriate tools and equipment may be deployed with the approval of the Owner's site in charge.

d) Complete technical details of the proposed HTLS conductor with relevant calculations are to be submitted to adjudge the compatibility of the already designed tower of WBSETCL to be used in the line. This shall be carried out in compliance with and adherence to all safety and standard requirements as per Indian Electricity Rules 1956. Design parameters and submission of detailed drawings of conductor hardware and accessories, and preparation of sag-tension chart, stringing chart, of the conductor used showing sag and tension at various temperatures are included in the scope.

DEVIATIONS:

Normally, the offer should be as per the Technical Specification without any deviation. However, any deviation felt necessary to improve performance, efficiency, and utility of equipment must be mentioned in the 'Deviation Schedule' with reasons duly supported by documentary evidence and advantages of such deviation. Such deviation suggested may or may not be accepted. Deviations not mentioned in the 'Deviation Schedule' will not be considered afterward.

TEST REPORTS:

Copies of type test reports shall be furnished to WBSETCL for verification. Only after authentication of reports by WBSETCL, commercial production of the material shall start. Records of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the WBSETCL's representative.

Test certificates of tests during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by WBSETCL.

INSPECTION:

The WBSETCL's representative shall at all times be entitled to have access to the works and all places of manufacture, where material shall be manufactured. WBSETCL's representative shall have full facilities for unrestricted inspection of the Supplier's works, raw materials, and process of manufacture for conducting necessary tests.

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

No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the WBSETCL in writing. In the latter case, also, the material shall be dispatched only after satisfactory testing for all tests has been completed.

The acceptance of any quantity of material shall in no way relieve the Supplier of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection if such material is later found to be defective.

PART–I

HTLS CONDUCTOR

1. STANDARD:

The conductor shall conform to the following Indian/International Standards, which shall mean the latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification.

In the event of the supply of conductor conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the Supplier and those specified in this document will be provided by the Supplier to establish their equivalence.

Sl. No.	Indian Standard	Title	International Standard
1.	IS:209-1992	Specification for zinc	BS:3436-1986
2.	IS:398-1982	Specification for Aluminium Conductors for Overhead Transmission Purposes	IEC:1089-1991 BS:215-1970
3.	IS:398-1990 Part-II	Aluminum Conductor Galvanised Steel Reinforced	BS;215-1970 IEC:1089-1991
4.	IS:398-1992 Part-V	Aluminum Conductor Galvanised Steel- Reinforced For Extra High Voltage(400KV) And above	IEC:1089-1991 BS:215-1970

5.	IS:1778-1980	Reels and Drums for Bare Conductors	BS:1559-1949
6.	IS:1521-1991	Method of Tensile Testing of Steel Wire	ISO6892-1984
7.	IS:2629-1990	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
8.	IS:2633-1992	Method of Testing Uniformity of Coating on Zinc Coated Articles	
9.	IS:4826-1992	Galvanised Coating on Round Steel Wires	IEC:888-1987 BS:443-1969
10.	IS:6745-1990	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433-1969 ISO1460-1973
11.	IS:8263-1990	Method of Radio Interference Tests on High Voltage Insulators	IEC:437-1973 NEMA:107-1964 CISPR
12.	IS:9997-1988	Aluminium Alloy Redraw Rods	IEC104-1987
13.		Zinc Coated steel wires for stranded Conductors	IEC:888-1987
14.		Hard drawn Aluminium wire for overhead line conductors	IEC:889-1987
15.	IS:398(Part-IV)	Aluminium Alloy stranded conductor	IEC:208-1966 BS-3242-1970
16.		Aluminium clad steel wires	IEC:1232
17.		Method of measurement of resistivity of Metallic materials	IEC:468
18		Ampacity	IEEE738

2. **DESCRIPTIONS AND TECHNICAL REQUIREMENTS:**

a) The HTLS Conductor shall be capable of carrying the minimum specified current of 1574 Amps for conductor equivalent to ACSR Moose, 1200 Amps for conductor equivalent to ACSR Zebra and 800 Amps for conductor equivalent to ACSR Panther at a continuous operating conductor temperature not exceeding the maximum permissible operating temperature of the offered HTLS Conductor without exceeding the level of maximum permissible sag of the existing Conductor (e.g., ACSR Moose , ACSR Zebra or ACSR Panther) as indicated in the following clauses.

The physical and operating performance requirements of the transmission line with HTLS conductor are mentioned below. The bidder shall offer HTLS conductor complying with the specified requirements. The Bidder shall indicate particulars of the proposed conductor in the relevant GTP schedule along with calculations to establish compliance with the specified requirements.

b) Current Carrying Capacity/ Ampacity Requirements:

Each conductor/sub-conductor in the bundle of HTLS conductor shall be suitable to carry the minimum specified 50 Hz alternating current of 1574 Amps for conductor equivalent to ACSR Moose, 1200 Amps for ACSR Zebra equivalent and 800 Amps for ACSR Panther equivalent under the ambient conditions and maximum conductor sag specified below while satisfying other specified technical requirements/parameters.

Elevation above sea level	1000m
Ambient temperature	45^{o}C
Solar Absorption coefficient	0.8
Solar Radiation	1045watt/sq.m
Emissivity Constant	0.45
Wind velocity	0.6m/sec
Effective angle of incidence of sun's rays	90 degree

Maximum permissible Conductor sag for 400 mtr (for 400 KV) ,320mtr (for 220KV) or 300mtr (for 132KV) span at steady state conductor temperature and nil wind corresponding to specified 50 Hz alternating current 1574 Amps (for 400 KV), 1200 Amps (for 220KV) or 800 Amps (for 132KV) per conductor under ambient conditions specified above shall be 12.977 mtr(for 400 KV),7.95 m (for 220KV) or 6 m (for 132KV).

The calculations for ampacity shall be based on IEEE Standard 738. The bidder in his bid shall furnish calculations for the ampacity based on the above Standard for the proposed HTLS conductor. The AC resistance & DC resistance for HTLS conductor shall be calculated as follows:

Rac=Rdc×(1+0.00519X(mr)n×k1+k2) where, mr =

0.3544938/ (Rdc) ½ ifmr<2.8, then n=4-0.0616+0.0896Xmr–0.0513 X(mr)2 if2.8<mr<5.0, then

n=4+0.5363-0.2949Xmr+0.0097X(mr)2 k1={cos(90(d/D)P)}2.35where, p=0.7+0.11Xmr–

0.04Xmr2+0.0094Xmr3

k2 = 0.15 for single aluminium layer HTLS conductor

= 0.03 for three aluminium layer HTLS conductor

= 0.003 for two or four aluminium layer HTLS conductor

= 0 for composite core type HTLS conductor

where, D=conductor outer diameter in metres d=conductor inner diameter in metres

R_{dc}=dc resistance of conductor at given temperature, ohms/km

R_{ac}=ac resistance of conductor at given temperature,ohms/km

The bidder in his bid shall furnish calculations for the ampacity based on the above for the proposed HTLS conductor.

The design of the conductor shall be suitable for operation at a steady-state conductor temperature experienced for a sub-conductor for specified AC current flow (1574 Amps ,1200 Amps or 800 Amps, as the case may be) under the above ambient conditions based on ampacity calculations mentioned above. Maximum DC resistance at 20 degree centigrade should be less than 0.0552 ohm/KM, 0.0680 ohm/KM and 0.1375 ohm/KM respectively for the above variant HTLS conductor.

The bidder shall also indicate the maximum permissible conductor temperature for continuous operation without any deterioration of its electrical, mechanical, and metallurgical properties. The bidder shall also furnish the maximum permissible conductor temperature for short-term operations, including the permissible duration of such short-term operation. The UTS (Ultimate Tensile Strength) of the conductor in the GTP shall hold good up to the designed maximum temperature.

c) TECHNICAL PARTICULARS OF HTLS CONDUCTOR:

The HTLS conductor shall meet the following minimum requirements:

Item	**ACSR PANTHER equivalent**	**ACSR ZEBRA equivalent**	**ACSR MOOSE equivalent**
Overall Diameter of complete conductor	Not exceeding existing conductor overall diameter 21mm and not less than 19 mm	Not exceeding existing conductor over all diameter 28.62 mm and not less than 26mm	Not exceeding existing conductor over all diameter 31.77 mm and not less than 30.5mm
Approx. mass of complete conductor (kg/km)	Less than or equal to existing conductor weight per unit length - 974 kg/km	Less than or equal to existing conductor weight per unit length - 1621 kg/km	Less than or equal to existing conductor weight per unit length - 2004 kg/km
Direction of lay of outer layer	Right Hand		

The bidder shall indicate the technical particulars and details of the construction of the conductor in the relevant schedule of GTP. The bidder shall also guarantee the DC resistance of the conductor at 20°C and AC resistance at the calculated temperature corresponding to 50 Hz specified alternating current flow (1574 Amps ,1200 Amps or 800 Amps, as the case may be) at specified ambient conditions (maximum continuous operating temperature).

The bidder shall submit the supporting calculations for the AC resistance, indicating details and justifications of values of temperature coefficient of resistance and DC to AC resistance conversion factor(s) with due reference to the construction/geometry of the conductor.

d) SAG TENSION REQUIREMENT:

Particulars	Limiting value		
	ACSR PANTHER equivalent (for 132 KV)	ACSR ZEBRA equivalent (for 220 KV)	ACSR MOOSE equivalent (for 400 KV)
Wind Pressure (kg/m2)	For JBIC (DA,DB,DC,DD) towers : I) Conductor : 170 II)GW/OPGW : 212 For IDA-10 (A2,B2,C2) towers : I) Conductor : 113 II)GW/OPGW : 113	For JBIC (DA,DB,DC,DD) towers : I) Conductor : 173 II)GW/OPGW : 217 For IDA-IV (T2,ST2,MT2,LT2) towers : I) Conductor : 52 II)GW/OPGW : 52	I) Conductor : 178 II)GW/OPGW : 221
Tension at everyday condition (32°C, no wind)	a) For JBIC (DA,DD,DC,DD) towers : i) 1991.46 kgs and not exceeding 25% of UTS of proposed conductor b) For IDA-10 (A2,B2,C2) towers <2282 kgs and not exceeding 25% of UTS of proposed conductor .	a) For JBIC (DA,DB,DC,DD) towers :2589.12 kgs and not exceeding 25% of UTS of proposed conductor . b) For IDA-IV (T2,ST2,MT2,LT2) towers <3285 kgs and not exceeding 25% of UTS of proposed conductor	3574.9 kg and not exceeding 22% of UTS of proposed conductor
Maximum Design Tension	a) For JBIC (DA,DB,DC,DD) towers : 4743.499 kg at 32 degree FW condition for conductor and 2921.22 kg for GW/OPGW. b) For IDA-10 (A2,B2,C2) towers : 3806 kg at 4 degree 2/3 rd wind condition for conductor and 1842 kg for GW/OPGW.	a) For JBIC (DA,DB,DC,DD) towers : 6243.587 kg at 32 degree FW condition b) For IDA-IV (T2,ST2,MT2,LT2) towers :4341.44 kg at 4 degree 2/3rd wind condition for conductor and 1392 kg for GW/OPGW.	8528.6 kg at 32 degree FW condition for conductor and 3577.9 kg for GW/OPGW.

Sag at maximum continuous operating temperature (corresponding to specified current per conductor and ambient conditions)	a) For JBIC (DA,DB,DC,DD) towers : 6.64 m b) For IDA-10 (A2,B2,C2) towers : 5.989 m	a) For JBIC (DA,DB,DC,DD) towers : 7.95 m b) For IDA-IV (T2,ST2,MT2,LT2) towers : 7.987 m	12.977 m
Tension at knee point temperature and no wind	Not exceeding 40% of the UTS of the core* of proposed conductor		

 # For details, Civil technical specifications are to be followed related to Sag/Tension (UTS) parameter.

*UTS of the core shall be equal to the Breaking strength of the individual core wires after stranding X no. of wires in the core of offered conductor.

After the award of the contract, the Supplier shall submit Sag-Tension calculations corresponding to various conditions given above for all the spans as per check survey /tower schedule (as applicable).

Besides the above, the Supplier shall also furnish details of creep characteristics in respect of HTLS conductor based on laboratory investigations/experimentation (creep test as per IEEE 1138 or IEC 61395) conducted on similar types of conductor and shall indicate creep strain values corresponding to 1 month, 6 months, 1 year, 10 years, and 20 years' creep at everyday tension and at maximum continuous operating temperature. As such, the initial stringing tension shall be creep compensated with (-18)°C, satisfying the design tension values of the tower as stipulated above.

3. WORKMANSHIP:

All the conductor strands shall be smooth, uniform and free from all imperfections, such as spills and splits, cracks, die marks, scratches, abrasions, rust etc.

The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protrusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

4. JOINTS IN WIRES:

Aluminium/ Aluminium Alloy Wires

During stranding, no Aluminium/ Aluminium Alloy wire welds shall be made for the purpose of achieving the required conductor length.

No joint shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer(s) of the conductor unavoidably broken during

stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of Aluminium/ Aluminium Alloy wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other Aluminium Alloy wire of the completed conductor. A record of such joints for each individual length of the conductor shall be maintained by the Contractor for Employer's review.

Joints shall be made by electric butt welding, electric butt cold upset welding or cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand guaranteed.

Core/ Core Wires

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no joints or splices in any length of the completed core. However, during the production run, splicing of the galvanic protection barrier is allowed, provided diameter specifications are maintained.

5. TOLERANCES:

Manufacturing tolerances on the dimensions to the extent of one percent (±1 %) shall be permitted for individual strands and the complete conductor. In case manufacturing tolerances more than one percent (±1%) is proposed for individual strands of a particular conductor as per applicable Indian/ International standard, the same may be permitted subject to submission of supporting documents/ details by the Contractor while approval of GTP during detailed engineering.

In case of Polymer Matrix composite core, the tolerances shall be ±0.05 mm as per ASTM B987.

6. MATERIALS:

The materials used for the construction of the conductor shall be such that the conductor meets the specified technical requirements.

A) Aluminium/ Aluminium Alloy layers

a) The material of outer layer of HTLS conductor shall be of high temperature resistant aluminum alloy manufactured by adding zirconium or any other suitable element(s) etc. to electrolytic aluminium or annealed aluminium (0 tempered) having purity not less than 99.5% and a copper content not exceeding 0.04%. The strands shall be manufactured through appropriate manufacturing process to ensure consistent electrical, mechanical and metallurgical properties under continuous high temperature operation. Bidder shall guarantee the chemical composition in the schedule GTP of BPS and also furnish description of the manufacturing process in the Bid.

b) In case of fully annealed type (0 tempered) aluminium strands, round wire/ trapezoidal/ Z-shaped wire shall be accepted.

B) Core

a) The core wire strand(s) shall be of galvanized steel/ Invar wires/ or Zinc-5% Aluminium–Mischmetal alloy coated steel/ Invar wires or aluminium clad steel/ Invar wires or composite materials etc. and shall have properties conforming to the technical performance requirements of the finished

conductor. In case of Polymer Matrix Composite (PMC) core, only Single strand i.e. solid, PMC core shall be acceptable. In case, the temperature of core corresponding to the designed maximum temperature of the offered HTLS conductor exceeds 180^0 C, ordinary zinc coating/ galvanizing of the Steel/ Invar core wires shall not be accepted and only aluminium clad or Mischmetal coated wires shall be permitted. Bidder shall furnish properties and composition of the core wire strand(s) in the schedule GTP of BPS. The properties & composition of core wires guaranteed by the bidder shall be based on the relevant published Indian/International Standards, wherever applicable. Offered polymer matrix composite core shall meet the requirement of "Galvanic Protection Barrier Layer Thickness test" as per ASTM B987. However, in no case, the guaranteed values for torsion & elongation of Steel/ Invar core of the offered HTLS Conductor shall be less than as indicated below:

Minimum No. of twists in gauge length equal to 100 times the dia. of wire which the strand can withstand in the torsion test (before stranding) *	12
Minimum elongation (%) of the core strand (after stranding) for a gauge length of 250 mm (at break)	1.5
**A reduction of 2 number of twists is permitted for after stranding values.*	

b) The zinc used for galvanizing of core (if used) shall be electrolytic High-Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS 209. The

minimum mass of zinc coating shall conform to the requirements of relevant standard. Zinc-5% Aluminium–Mischmetal alloy coating, if used, shall conform to and satisfy all the requirements of ASTM B 803/ B 958.

c) The aluminium cladding of wires shall be of aluminum having purity not less than 99.5 % and shall be thoroughly bonded to the core wire strand(s). The minimum conductivity of offered aluminium clad wire shall be 14% of IACS. The minimum thickness of aluminium cladding shall be 3% & 5% of nominal wire diameter, for 14% & 20% IACS conductivity respectively.

d) Where Polymer Matrix composite material is offered for core, the material shall be either of high strength grade or extra high strength grade as per ASTM B987. The materials shall be of such proven quality that its properties are not adversely influenced by the normal operating conditions of transmission line in tropical environment conditions as experienced by the existing line. The bidder shall provide adequate details including specifications/ test reports/ operating experience details/ performance certificates etc. in support of the suitability of the offered materials.

7) Standard Length

a) The standard length of the conductor shall be indicated in the guaranteed **t**echnical particulars of offer. A tolerance of ±5% on the standard length offered by the Bidder shall be permitted. Standard Length shall not be more than 2500 meters. All lengths outside this limit of tolerance shall be treated as random lengths.

b) Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of such random lengths shall not be more than 10% of the total quantity ordered. At no

point, the cumulative quantity supplied of such random lengths shall be more than 12.5% of the total cumulative quantity supplied including such random lengths. However, the last 20% of the quantity ordered shall be supplied only in standard lengths as specified except for one last drum, which may be supplied with any random length necessary to complete the supply of ordered conductor quantity.

c) During implementation stage, supply of HTLS conductors by contractor in 3 or 4 different standard lengths depending upon actual tower schedule/ site conditions, may be permitted based on approval by site in-charge.

d) Bidder shall also indicate the maximum single length, above the standard length, he can manufacture in the guaranteed technical particulars of offer. This is required for special stretches like river crossing etc. The Employer reserves the right to place orders for the above lengths on the same terms and conditions applicable for the standard lengths during the pendency of the Contract.

8) Tests and Standards

A) Type Tests

a) Type Tests on Stranded Conductor/ Core

The following tests shall be conducted on sample/ sample(s) of the conductor required under the package from manufacturing works from which the conductor is to be manufactured & supplied: -

i) On complete Conductor

a)	DC resistance test on stranded conductor	Annexure-A
b)	UTS test on stranded conductor i) at Room Temperature and ii) at Elevated Temperature	Annexure-A
c)	Radio interference voltage test (dry) (*Applicable for 220KV & above voltage rating*)	Annexure-A
d)	Corona extinction voltage test (dry) (*Applicable for 220KV & above voltage rating*)	Annexure-A
e)	Stress-Strain test on stranded conductor and core	IEC 61089
f)	creep test on stranded conductor	Annexure-A
g)	Sheaves Test (Applicable for Composite core conductors only)	Annexure-A
h)	Radial Crush Test	Annexure-A
i)	Torsional Ductility Test	Annexure-A
j)	Aeolian Vibration Test	Annexure-A
k)	Temperature Cycle Test	Annexure-A

b) **On Conductor Strand/core**

a)	Heat resistance test on Aluminium Alloy strands (Not applicable for Annealed Aluminium)	Annexure-A
b)	Bending test on aluminium clad core strands (if applicable)	Annexure-A
c)	Compression test on aluminium clad core strands (if applicable)	Annexure-A
d)	Coefficient of linear expansion on core	Annexure-A
e)	Brittle fracture test on Polymer composite core (if applicable)	Annexure-A
f)	Bending test on composite core (if applicable)	Annexure-A

c) Type tests specified under 8 A) shall not be required to be carried out if a valid test certificate is available for the offered design. The test certificate shall be considered valid if,

i) Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/ IEC vide 25/ 17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of WBSETCL or utility and

ii) Type test reports contain valid Calibration reports of the relevant testing equipment and information pertaining to ratings, the relevant drawings, model number, test circuit, calculations (if any), photos, acceptance criteria/ values specified in Technical Specification/relevant standards (IS/ IEC) and compliance to the same and

iii) Tests conducted on the samples of conductor manufactured from same manufacturing works within 7 (seven) years as on the date of NIT.

Further, test certificates of samples manufactured from same manufacturing works shall also be considered valid, if the same has already been approved/ accepted by WBSETCL & tests have been conducted within the abovementioned validity period.

In case the tests have been conducted earlier than the above stipulated period or carried out on samples manufactured from any other manufacturing works or in case of revision/ amendment in the provisions/ test procedure of the IS/ IEC as referred in the TS or in the event of any discrepancy in the test report (i.e. due to non-inclusion of valid calibration certificate, desired information etc. or any test not applicable due to any design/ material/ manufacturing process change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the supplier at no extra cost to the purchaser.

B) **Acceptance Tests**

a)	Visual and dimensional check on drum	Annexure-A

b)	Visual check for joints scratches etc. and length measurement of conductor by rewinding	Annexure-A
c)	Dimensional check on core/core strands and Aluminium/ Aluminium Alloy strands	Annexure-A
d)	Check for lay-ratios of various layers	Annexure-A
e)	Galvanising & adherence of coating test on core strands (if applicable)	Annexure-A
f)	Coating Test on Zinc-5% Al-Mischmetal alloy coating (if applicable)	ASTM B803/ B958
g)	Adherence of Coating Test on Zinc-5% AlMischmetal alloy coating (if applicable)	ASTM B803/ B958
h)	Thickness & adherence of aluminum cladding on aluminium clad strands	Annexure-A
i)	Torsion and Elongation tests on core strands/ composite core	Annexure-A
j)	Breaking load test on core strands and Aluminium/ Aluminium Alloy strands	Annexure-A
k)	Wrap test on Aluminium Alloy strands (Not applicable for Annealed aluminium wires)	IEC 62641
l)	Wrap test on core strands (Not applicable for composite core)	IEC 63248
m)	Minimum conductivity test on thermal resistant Aluminium Alloy/ Aluminium strands	Annexure-A
n)	Procedure qualification test on welded joint of Aluminium/ Aluminium Alloy wire	Annexure-A
o)	Heat resistance test on Aluminium Alloy strands (Not applicable for Annealed Aluminium)	Annexure-A
p)	Ageing test on filler (if applicable)	Annexure-A
q)	Minimum conductivity test on aluminium clad core strands (if applicable)	Annexure-A
r)	Glass transition temperature test on Polymer composite core/ core strands (if applicable)	Annexure-A
s)	Flexural Strength test on Polymer composite core/ core strands (if applicable)	Annexure-A
t)	Bending test on composite core (if applicable)	Annexure-A
u)	Galvanic Protection Barrier Layer Thickness test on composite core	ASTM B987

Note: 1) All the above tests except (n) shall be carried out on Aluminium Alloy and core strands after stranding only. 2) Wrap test on Aluminium/ Aluminium Alloy strands is only applicable for round wires.

C) Routine Test

a)	Check to ensure that the joints are as per Specification
b)	Check that there are no cuts, fins etc., on the strands
c)	Check that drums are as per Specification
d)	All acceptance tests as mentioned above to be carried out on 10 % of drums

D) Tests During Manufacture

a)	Chemical analysis of zinc used for galvanizing	Annexure-A
b)	Chemical analysis of Aluminium alloy used for making Aluminium Alloy strands	Annexure-A
c)	Chemical analysis of Core strands (not applicable on composite core)	Annexure-A

E) **Testing Expenses**

a) Testing expenses will be guided by terms of NIT.

F) **Additional Tests**

a) The Employer reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier's premises, at site or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the materials comply with the Specifications.

b) The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test centre. In case of evidence of non-compliance, it shall be binding on the part of Contractor to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items all without any extra cost to the Employer.

G) **Sample Batch for Type Testing**

a) The Contractor shall offer material for selection of samples for type testing only after getting Quality Assurance Plan approved from WBSETCL. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Employer.

b) The Contractor shall offer at least three drums for selection of sample required for conducting all the type test.
The Contractor is required to carry out all the acceptance tests successfully in presence of Employer's representative before sample selection.

H) **Test Reports**

a) Copies of type test reports shall be furnished in at least three copies along with one original. One copy will be returned duly certified by the Employer only after which the commercial production of the material shall start.

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

c) Test Certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Employer.

9) **Inspection**

a) The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where conductor shall be manufactured and representative shall have full facilities for unrestricted inspection of the Supplier's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

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

c) No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Employer in writing. In the latter case also the conductor shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

d) The acceptance of any quantity of material shall in no way relieve the Contractor of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection it such material is later found to be defective.

10) Test Facilities

The following additional test facilities shall be available at the Supplier's works:

a) Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer etc.

b) Standard resistance for calibration of resistance bridges.

c) Finished conductor shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc. with traverse laying facilities.

11) **Packing**

a) The conductor shall be supplied in non-returnable, strong, wooden drums provided with lagging of adequate strength, constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Supplier shall be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS 1778, except as otherwise specified hereinafter.

b) The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5 KN.

c) The standard drawing of the wooden/steel drum for HTLS conductors is enclosed with the specification. The Bidder should submit drum drawing during detailed engineering for approval after incorporating standard length and dimensions required as per standard drawing.

d) For conductor, one standard length shall be wound on each drum.

All wooden components shall be manufactured out of seasoned soft wood free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the conductor.

e) The flanges shall be of two-ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75mm. Where a slot is cut in the flange to receive the inner end of the conductor the entrance shall be in line with the periphery of the barrel.

f) The wooden battens used for making the barrel of the conductor shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the conductor.

g) Barrel studs shall be used for the construction of drums. The flanges shall be holed and the barrel supports slotted to receive them. The barrel studs shall be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing.

h) Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.

i) The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.

j) Before reeling, card board or double corrugated or thick bituminised water-proof bamboo paper shall be secured to the drum barrel and inside of flanges of the drum by means of a suitable commercial adhesive material over which HDPE sheet to be provided. In case of steel drum, for securing HDPE sheet onto the bamboo paper & drum flanges, the HDPE sheet shall be secured onto the drum by means of a commercial adhesive/self-locking nylon cable zip ties such that there is no protrusion above the general surface that may cause damage to the conductor strands. After reeling the conductor, the exposed surface of the outer layer of conductor shall be wrapped with thick plastic sheet secured using adhesive tapes to preserve the conductor from dirt, grit and damage during storage, transport and handling. Medium grade craft/crepe/polythene paper shall be used in between the layers of conductor. Additionally, in case of Annealed
aluminium being used for aluminium layers of offered HTLS conductor, medium grade kraft paper of 90 to 100 mm width shall be wrapped over HTLS conductor during production and re-winding such that the no conductor layer is directly in contact with other side, below & upper conductor layers in a drum.

k) A minimum space of 75 mm for conductor shall be provided between the inner surface of the external protective tagging and outer layer of the conductor.

l) Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp, edges or allow the battens to be released due to corrosion.

m) The nuts on the barrel studs shall be tack welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.

n) A steel collar shall be used to secure all barrel studs. This collar shall be located between the washers and the steel drum and secured to the central steel plate by welding.

o) Outside the protective lagging, there shall be minimum of two binder consisting of hoop iron/galvanised steel wire. Each protective lagging shall have two recesses to accommodate the binders.

p) The conductor ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the conductor layers during transit and handling.

q) As an alternative to wooden drum, Supplier may also supply the conductors in returnable/ non-returnable painted steel drums. After preparation of steel surface according to IS 9954, synthetic enamel paint shall be applied after application of one coat of primer. Wooden/Steel drum will be treated at par for evaluation purpose and accordingly the Bidder should quote in the package.

r) In case of returnable steel drums for conductor, following clauses shall apply:

(i) The Ownership of the empty conductor drums shall lie with the conductor Supplier who shall ultimately take back the empty conductor drum from the Project site(s) from the erection contractor's designated stores after the running out of conductor from the drum.

(ii) The erection contractor shall intimate the Conductor supplier and Employer regarding empty steel drums at their designated stores. Necessary coordination for taking back the empty steel drums in this regard shall be done by the Conductor Supplier with the erection Contractor.

(iii) The empty drum shall be taken back by the conductor supplier from the stores of erection contractor as & when these are available after usage of conductor. Conductor Supplier shall be required to take back the empty steel drum within a period of one month from date of information by erection contractor regarding availability of the drums at erection contractor stores. However, drums of spare conductor shall not be returned to the conductor Supplier as these may be used for storage of spare conductor by the Employer.

(iv) The steel drums may get damage and wear & tear due to transportation, normal handling & operation at site, which shall be rectified by the conductor Contractor before re-use. However, 2% of the total drums shall not be returned on account of damages/ wastage for which no compensation will be payable. The wastage beyond 2% shall be reimbursed by Erection Contractor.

s) As an alternative to outer wooden lagging, in case of returnable/ non-returnable steel drums, solid polypropylene sheet (of min 3mm thickness) can be used for outer covering of conductor. In case of PP sheets are proposed to be used by the Contractor, the conductor Contractor shall supply two nos. additional binders per drum for re-wrapping PP sheet with each lot of conductor and 5 nos. crimping machines with the first lot of conductor for crimping the binders at site.

12) **Marking**

Each drum shall have the following information stenciled on it in indelible ink along with other essential data:

(a) Contract/Specification number.

(b) Name and address of the consignee.

(c) Manufacturer's name and address.

(d) Drum number

(e) Size of conductor

(f) Length of conductor in meters

(g) Arrow marking for unwinding

(h) Position of the conductor end (For Wooden Drums only)

(i) Number of turns in the outer most layer.

(j) Gross weight of the drum (with protective lagging in case of wooden drums) including conductor.

(k) Weight of empty drum (with protective lagging in case of wooden drums).

(l) Net weight of the conductor in the drum.

(m) CIP No.

The above should be indicated in the packing list also.

13) **Verification of Conductor Length**

The Employer reserves the right to verify the length of conductor after unreeling at least ten (10) percent of the drums in a lot offered for inspection.

14) **Standards**

a) The conductor shall conform to the following Indian/International Standards, which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification.

b) In the event of the supply of conductor conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

Sl. No.	**Indian Standard**	**Title**	**International Standard**
1	IS 209:1992	Specification for Zinc	
2	IS 398:1982	Specification for Aluminium Conductors for Overhead Transmission Purposes	
3	IS 398 (Part-II): 1990	Aluminum Conductor Galvanised Steel Reinforced	
4	IS 398 (Part-IV)	Aluminium Alloy stranded conductor	
5	IS 398 (Part-V): 1992	Aluminum Conductor Galvanised Steel-Reinforced For Extra High Voltage (400 KV) and above	
6	IS 1778:1980	Reels and Drums for Bare Conductors	
7	IS 1521:1991	Method of Tensile Testing of Steel Wire	
8	IS 2629:1990	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
9	IS 2633:1992	Method of Testing Uniformity of Coating on Zinc Coated Articles	
10	IS 4826:1992	Galvanised Coating on Round Steel Wires	

11	IS 6745:1990	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	
12	IS 8263:1990	Method of Radio Interference Tests on High Voltage Insulators	
13	IS 9997:1988	Aluminium Alloy Redraw Rods	
14		Coated or cladded metallic wire for concentric lay stranded conductors	IEC 63248
15		Aluminium and Aluminium Alloy Wires for Concentric Lay Stranded Conductors	IEC 62641
17		Method of measurement of resistivity of metallic materials	IEC 60468
18		IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors	IEEE 738:2023
20		Overhead electrical conductors – Formed wire, concentric lay, stranded conductors	IEC 62219
21		Concentric lay stranded overhead electrical conductors containing one or more gap(s)	IEC 62420
22		Standard Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes	ASTM B609
23		Standard Specification for High Strength Zinc-5% Aluminium-Mischmetal alloy coated steel core wire for use in Overhead Electrical Conductors	ASTM B803
24		Standard Specification for Concentric Lay Stranded Aluminum Conductors, Coated Steel supported (ACSS)	ASTM B856
25		Standard Specification for Shaped Wire Compact Concentric Lay Stranded Aluminum Conductors, Coated Steel supported (ACSS/TW)	ASTM B857
26		Standard Specification for Extra-High Strength and Ultra-High Strength Zinc coated (Galvanized) steel core wire for Overhead Electrical Conductors	ASTM B957

27		Standard Specification for Extra-High Strength and Ultra-High Strength Class A Zinc-5% Aluminium-Mischmetal alloy coated steel core wire for use in Overhead Electrical Conductors	ASTM B958
28		Carbon Fibre Composite core (CFCC/TS) for use in Overhead Electrical Conductors	ASTM B987-20
29		Conductors for overhead lines – Aluminium Conductors Steel Supported (ACSS)	BS EN 50540
30		Standard Test Method for Dropping point of Lubricating Grease	ASTM D566
31		Standard Test Method for Dropping point of Lubricating Grease over wide temperature range	ASTM D2265

The standards mentioned above are available from: -

Reference Abbreviation	**Name and Address**
BS	British Standards, British Standards Institution 101, Pentonvile Road, N - 19-ND, UK
IEC/CISPR	International Electro technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de verembe, Geneva, SWITZERLAND
BIS/IS	Bureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA

ISO	International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK.
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017, U.S.A.
ASTM	ASTM International 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA

Annexure-A

1 **DC Resistance Test on Stranded Conductor**

On a conductor sample of minimum 5m length two contact-clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge or using micro ohm meter of suitable accuracy by placing the clamps initially zero metre and subsequently one metre apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20^0 C as per *IS 398 (Part-IV)/ (PartV)*. The resistance corrected at 20^0 C shall conform to the requirements of this Specification.

2 **UTS Test on Stranded Conductor**

i) UTS test on stranded conductor at room temperature*

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample of conductor of minimum 10m length between fixing arrangement suitably fixed by appropriate fittings on a tensile testing machine. The load shall be increased at a steady rate upto 50% of minimum specified UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall be increased at steady rate to minimum UTS and held for one minute. The Conductor sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

In case, fracture occurs within 1 cm of the end fittings and the tensile strength falls below the specified breaking strength requirements, a retest, up to a total of three tests, may be made.

**The test is to be conducted at ambient temperature, between minimum and maximum ambient temperature of 0^0C and 50^0C respectively.*

ii) UTS test on stranded conductor at elevated temperature

UTS Test on Stranded Conductor shall be conducted as per *Sl. no.* 2(i) *of this Annexure-A* specified above keeping conductor temperature at the designed maximum temperature.

3 **Corona Extinction Voltage Test**

The sample assembly with each conductor of 5 m length shall be strung as per the configuration shown in the Table below:

Line Configuration	No of conductors per Bundle	Sub conductor Spacing (mm)	Maximum Height of the conductor above ground (m)	Minimum Corona extinction voltage (kV)
220 kV with HTLS conductor	1	N.A.	7	154
400 kV with twin HTLS conductor	2	NA	8.84	320

The sample assembly when subjected to power frequency voltage under dry condition shall have a corona extinction voltage of not less than the values indicated in the table above. There shall be no evidence of corona on any part of the samples. The test should be conducted without corona control rings. However, small corona control rings may be used to prevent corona in the end fittings. The atmospheric conditions during testing shall be recorded and test results should be corrected for standard atmospheric conditions.

4 **Radio Interference Voltage Test**

Under the conditions as specified under *Sl. no.* 3 *of this Annexure-A*, the conductor samples shall have radio interference voltage below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 305 kV line to ground under dry conditions for 400kV and 154 kV line to ground under dry conditions for 220 kV. This test may be carried out with corona control rings and arcing horns. The test procedure shall be in accordance with IEC 60437.

5 **Creep test on Stranded Conductor**

One conductor samples of length equal to at least 100 x d + 2 x a (where, d is the conductor diameter and a is the distance between the end fitting and the gauge length) shall be strung at tension equal to 25 % of conductor UTS. The distance, a, shall be at least 25 % of the gauge length or 2 m whichever is the smaller.

The conductor temperature shall be maintained at 20^0 C for 1000 hours. The elongation/ creep strain of the conductor during this period shall be measured and recorded at end of 1-hour, 10-hour, 100-hour and subsequently every 100 hour upto 1000 hours time period.

The Supplier shall furnish details of creep characteristic in respect of the conductor based on laboratory test and other laboratory investigations/ experiments conducted on conductor and shall indicate creep strain values corresponding to 1 month, 6-months, 1 year, 10 years & 20 years creep at everyday tension & room temperature.

6 **Sheaves Test (applicable for Composite core conductors only)**

The conductor sample of minimum length of 35 meter shall be tensioned at 20 % of the UTS; pulley diameter shall be not more than 32 times that of the conductor; angle between the pulleys shall be 20 degrees. The conductor shall be passed over the pulleys 36 times at a speed of 2 m/sec. After this test, UTS test on the conductor shall be carried out as per Sl. no. *2(i) of this Annexure-A*. In the case of polymer composite core conductors, the core shall be inspected for damage by subjecting the core to a dye penetration test as per ASTM B987 section 14. Dye penetrant exposure time shall be 30±0 minutes.

7 **Radial Crush Test**

A section of conductor is to be crushed between two six-inch steel plates. Load shall be held at 350 Kgs for 1 minute and then released. Core strands shall be subsequently disassembled and tensile tested. Core strands shall exhibit full strength retention vis-a-vis guaranteed breaking strength of core wires (after stranding).

8 **Torsional Ductility Test**

The conductor sample of minimum 1500 times diameter of conductor core shall be loaded to 20% of UTS and then rotated in increasing steps of +/-180 deg. The entire conductor shall withstand atleast 16 such rotation and there shall not be any damage to Aluminium/ Aluminium Alloy or core wires.

In case of composite core conductors, after 4 rotations or after separation of aluminium strands, the aluminium wires shall be cut and removed from the conductor and the exposed core shall be twisted and shall withstand upto 16 rotations.

9 **Aeolian Vibration Test**

The conductor and supporting hardware shall be loaded to 25% of UTS. A dynamometer, load cell, calibrated beam or other device shall be used to measure the conductor tension. Some means should be provided to maintain constant tension to allow for temperature fluctuations during the testing. The overall span between system terminations shall be a minimum of 30 m. The span shall be supported at a height such that the static sag angle of the cable to horizontal is (1.5±0.5) deg in the active span. Means shall be provided for measuring and monitoring the mid-loop (antinode) vibration amplitude at a free loop, not a support loop. An electronically controlled shaker shall be used to excite the conductor in the vertical plane. The shaker armature shall be securely fastened to the conductor so it is perpendicular to the conductor in the vertical plane. The shaker should be located in the span to allow for a minimum of six vibration loops between the suspension assembly and the shaker

The test shall be carried out at one or more resonance frequencies (more than 10 Hz). The amplitude (peak-to-peak) at the antinode point shall be one third of conductor diameter. The assembly shall be vibrated for not less than 10 million cycles without any failure. After the test, the conductor should not exhibit any damage (broken strands). The conductor shall be tested as per *Sl. no.* 2(i) *of this Annexure-A* to demonstrate that it retains at least 95% UTS.

10 **Temperature Cycle Test**

The purpose of this test is verification of degradation characteristics of metallic and non-metallic material when subjected to thermal cycling. Temperature cycling can create large internal stresses due to thermal expansion mismatch between constituents.

Test Methods: -

- Conductor Sample of minimum 10m length.
- Mechanical tension, 20 % UTS, marks on the conductor at the edge of the conductor.
- 100 cycles from room temperature up to designed maximum temperature. Hold at designed maximum temperature $\pm$ 2.5^0 C for 5 minutes.
- After the above mentioned 100 cycle, the Mechanical tension shall be increased to 70% UTS at room temperature and kept at this tension for 24 hours. Thereafter, release to 20% UTS
- This cycling test shall be repeated 5 times.
- During the test, temperature of connectors, conductor and resistance are recorded according to ANSI C 119.
- A breaking load test as per *Sl. no.* 2(i) *of this* Annexure-A shall be applied at the end of the test. Conductor strength has to be higher than 95 % UTS.
- In case of polymer composites, after thermal cycling, the flexural strength and the Glass Transition temperature (Tg) shall not degrade by more than 10 % of the value guaranteed in GTP. Flexural strength shall be obtained on the basis of test procedure indicated at *Sl. no.* 33 *of this Annexure-A*. The value of Tg after the test, shall however, in no case be less than the temperature of core corresponding to the designed maximum temperature of conductor.

11 **Heat Resistance test on Aluminium Alloy Strands (as Type Test)**
(Not applicable for Annealed Aluminium* Strands*)

The 400 h test shall be carried out as per Clause 6.4.8.2 of IEC 62641 except that specimen shall be taken from all the wires of a conductor under test. The breaking strength of the wire after heating shall not be less than the 90% of the breaking strength before heating.

12 **Heat Resistance test on Aluminium Alloy Strands (as Acceptance Test)**
(Not applicable for Annealed Aluminium* Strands*)

The 1 h test shall be carried out as per Clause 6.4.8.2 of IEC 62641 except that specimen shall be taken from all the wires of a conductor under test. The breaking strength of the wire after heating shall not be less than the 90% of the breaking strength before heating.

13 **Bending test on aluminium clad core strands (if applicable)**

A sample of aluminium clad core strand measuring 30 cm in length shall be subject to bending with help of a vise. The vised length of wire should be 5 cm and radius of bend 4.8 mm. The bending should be first 90 degrees left and 90 degree right. After this operation the strand should cut at the bending point. There should be no separation of core and aluminium at the bending point after this operation.

14 **Compression test on aluminium clad core strands (if applicable)**

A sample of aluminium clad core strand 10 mm in length is to be compressed by a plate with a load of 3600 kgs. The aluminium clad core strand should not break.

15 **Coefficient of linear expansion for core**

A minimum length of 10m of entire core (intact) shall be tested. The temperature and elongation on a sample shall be continuously measured and recorded at interval of approximately 15^0 C from room temperature to the temperature of core corresponding to the designed maximum temperature by changing the temperature by suitable means. Coefficient of linear expansion shall be determined from the measured results.

16 **Brittle fracture test on polymer Composite Core (if applicable)**

The core sample shall be tensioned to approx. 25 % of UTS with simultaneous application of 1N-HNO3 acid directly in contact with naked polymer composite core for 96 hrs. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm. After 96 hours, the core shall withstand UTS test as per ASTM B 987.

17 **Bending Test on Composite Core (as Type Test)**

Bending test on composite core before stranding shall be performed as per ASTM B987/B987M-20 on composite core samples taken from composite core at conductor manufacturing unit before stranding of conductor. Alternatively, supplier may carry out bending test on composite core before stranding on the samples taken at the core manufacturing unit, from the same reel being supplied to conductor manufacturer subject to proper traceability of the same at the conductor manufacturers works.
Bending test on composite core shall also be performed as per ASTM B987/ B987M-20 on composite core samples taken from stranded conductor. For test after stranding the diameter of cylindrical mandrel shall be as following:

For high strength grade composite core: 60 times the diameter of composite core.

For Extra high strength grade composite core: 70 times the diameter of composite core.

18 **Visual and Dimensional Check on Drums**

The drums shall be visually and dimensionally checked to ensure that they conform to the approved drawings.

19 **Visual Check for Joints, Scratches etc. and Length Measurement of Conductor by Rewinding**

Conductor drums shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and that the conductor generally conform to the requirements of this Specification. Ten percent (10%) drums from each lot shall be rewound in the presence of the Employer's representative.

20 **Dimensional Check on Core /Core Strands and Aluminium/ Aluminium Alloy Strands**

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this Specification. Diameter of formed wires shall be determined as per clause 6.4.2.3 of IEC 62641.

21 **Check for Lay-ratios of Various Layers**

The lay-ratios of various layers shall be checked to ensure that they conform to the guaranteed values furnished by the Contractor.

22 **Galvanising & adherence of coating Test on Core Strands (If applicable)**

The test procedure shall be as per clause 7.4.5.1.1 & 7.4.5.2.1 of IEC 63248. The material shall conform to the requirements of this Specification. Mandrel diameter for adherence test shall be four times the diameter of steel wire.

23 **Thickness & adherence of Aluminum cladding on aluminum clad Strands (if applicable)**

The test procedure shall be as per clause 7.4.5.1.2 & 7.4.5.2.2 of IEC 63248. The material shall conform to the requirements of this Specification. Mandrel diameter for adherence test shall be five times the diameter of al clad wire.

24 **Torsion and Elongation Tests on Core Strands / Composite core**

The test procedures for Torsion and Elongation Tests on Core Strands shall be as per clause No. 7.4.4.1 and 7.4.3.4 of IEC 63248 respectively. In torsion test, the number of complete twists before fracture shall not be less than the value specified in the GTP on a length equal to 100 times the standard diameter of the strand. In case test sample length is less or more than 100 times the stranded diameter of the strand, the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number. In elongation test, the elongation at fracture of the strand shall not be less than the value specified in the GTP for a gauge length of 250 mm.

In case of composite core HTLS conductor, the following procedure shall be applicable: -

i) **Elongation Test**

The elongation of the composite core sample at shall be determined using extensometer. The load along the core shall be gradually increased. The elongation achieved on reaching the tensile strength of the core shall not be less than the value guaranteed in the GTP.

ii) **Torsion Test**

The purpose of the test is to determine the resilience of the composite core to twisting and to show that after the composite core has experienced the prescribed twisting, it will not crack or have a loss in tensile strength due to the twisting. The sample length shall be such that the gauge length in between the gripping fixtures is 170 times the diameter of the core in case of High Strength Grade composite cores and 340 times the diameter of the composite core in case of Extra High strength composite core. However, the gauge length shall not be more than 4m. One grip shall then be fixed so that it does not twist and the other end shall be twisted a full 360 degrees and then fixed in this position for 2 minutes. Once the twist time is completed, the core is untwisted and inspected for any crazing or other damage. If no damage is observed, the composite core is then tensile tested to failure and the final load recorded. For the test to be accepted, the composite core must withstand at least 100% of its rated tensile strength. Two samples need to be completed in order to satisfy the testing requirement.

25 **Breaking load test on Aluminium/ Aluminium Alloy & Core Strands/ Composite core**

The above test shall be carried out as per IEC 62641/63248 except in case of Composite core which may be tested as per IEC 63248 or other relevant Indian/ International standards. The results shall meet the requirements of this specification.

26 **Minimum Conductivity test on Thermal Resistant Aluminium Alloy/ Aluminium strands**

Resistivity test as per IEC 60468shall be conducted to confirm minimum conductivity as per specification requirement.

27 **Procedure Qualification test on welded Aluminium/ Aluminium Alloy Wires**

Two Aluminium Alloy wires shall be welded as per the approved quality plan and shall be subjected to tensile load. The breaking strength of the welded joint of the wire shall not be less than the guaranteed breaking strength of individual strands.

28 **Ageing Test on Filler (if applicable)**

The test shall be done in accordance with test method specified in ASTM D566/ D2265 or relevant Indian/International standards. The specimen should not drop as a droplet when kept at a temperature 40 deg. C above designed maximum temperature of the conductor for 30 minutes. The temperature shall then be increase till one droplet drops and the temperature recorded.

29 **Minimum Conductivity Test on Aluminium Clad Core-Strands (if applicable)**

Resistivity test as per IEC 60468 shall be conducted to confirm minimum conductivity as per specification requirement.

30 **Glass Transition Temperature Test on Polymer Composite Core/ Core Strands (if applicable)**

Test shall be conducted as per ASTM B987. The minimum glass transition temperature shall be either (i) the temperature of core corresponding to the designed maximum temperature of the offered HTLS conductor + 35^0 C or (ii) minimum glass transition temperature as per ASTM B987 i.e. 180^0 C+ 25^0 C; Whichever is lower.

In case, the temperature of core corresponding to the designed maximum temperature of the offered HTLS conductor is more than the minimum glass transition temperature as per ASTM B987 i.e. more than 180^0 C, the test shall be conducted as per ASTM B987 & the minimum glass transition temperature shall be the temperature of core corresponding to the designed maximum temperature of the offered HTLS conductor+25^0 C.

31 **Flexural Strength Test on Polymer Composite Core/ Core Strands**

Supplier can carry out the test as per ASTM D4475. The flexural strength shall not be less than the value guaranteed in the GTP.

32 **Bending test on Composite Core (as Acceptance test)**

Bending test on composite core shall be performed as per ASTM B987/ B987M20 on composite core samples taken from stranded conductor. For test after stranding the diameter of cylindrical mandrel shall be as following:

1) For high strength grade composite core: 60 times the diameter of composite core.

2) For Extra high strength grade composite core: 70 times the diameter of composite core.

33 **Chemical Analysis of Zinc**

Samples taken from the zinc ingots shall be chemically/ spectrographically analysed. The same shall be in conformity to the requirements stated in the Specification.

34 **Chemical Analysis of Aluminium/ Aluminium Alloy**

Samples taken from the Aluminium/ Aluminium Alloy shall be chemically/ spectrographically analysed. The same shall be in conformity to the particulars guaranteed by the bidder so as to meet the requirements stated in this Specification.

35 **Chemical Analysis of Core Strands (not applicable for Composite Core/ Core Strands)**

Samples taken from the core coils/ strands shall be chemically/ spectrographically analysed. The same shall be in conformity to the particulars guaranteed by the bidder so as to meet the requirements stated in this Specification.

PART–II

HARDWARE FITTINGS AND ACCESSORIES

CLAMP FITTINGS AND ACCESSORIES FOR HTLS CONDUCTOR

TECHNICAL SPECIFICATIONS

1.0 Technical Description of Clamp Fittings for HTLS Conductor

1.1 General

This section details technical particulars of fittings viz. suspension clamps and compression type dead end clamps for the HTLS Conductor to be supplied by the bidder. Each fitting shall be supplied complete in all respects.

1.2 The fittings shall be suitable for attachment to suspension and tension insulator strings along with hardware fittings. For owner supplied fittings, 2.5 % extra fasteners (excluding factory fitted fasteners) & retaining rods shall be provided to the Contractor to take care of losses during erection. No payment shall be admissible for these extra supplies. For fittings included in the scope of the Contractor, the contractor is permitted to get inspected and supply upto 2.5% extra fasteners & retaining rods to take care of losses during erection. No payment shall be admissible for these extra supplies. Indicative drawings of complete insulator strings along with hardware fittings as well as indicative drawings for suspension clamps and dead-end clamps are enclosed with this specification. The supplier shall be responsible for satisfactory performance of complete conductor system along with fittings offered by them for continuous operation at the designed maximum temperature specified for the HTLS conductor. The material of the components should be suitable for continued performance corresponding to these maximum temperatures without any deterioration. Maximum allowable temperature for aluminium/ aluminium alloy components, corresponding to the designed maximum temperature of conductor shall be limited to 93 Deg C.

In case, some special arrangement viz. semi-strain assembly is required to maintain low sag behavior of offered HTLS conductor in longer spans, supply & installation of such arrangements shall be in the

scope of the Contractor. Documentary evidence regarding contractor/ supplier's previous experience of using such arrangements along with exact number of such arrangements required to be used in longer sections shall be submitted during post award engineering activities. Cost of supply and installation of required number of such arrangements shall be deemed to be included in the total quoted price.

1.3 Corona and RI Performance

Sharp edges and scratches on all the hardware fittings shall be avoided. All surfaces must be clean, smooth, without cuts and abrasions or projections. The Supplier shall be responsible for satisfactory corona and radio interference performance of the materials offered by him.

1.4 Maintenance

1.4.1 The hardware fittings offered shall be suitable for employment of hot line maintenance technique so that usual hot line operations can be carried out with ease, speed and safety. The technique adopted for hot line maintenance shall be generally bare hand method & hot stick method.

1.5 Split Pins

1.5.1 Split pins shall be used with bolts & nuts (wherever applicable).

1.6 Suspension Assembly

1.6.1 The suspension assembly shall be suitable for the HTLS Conductor, the bidder intends to supply. The technical details of the conductor shall be as proposed by the bidder.

1.6.2 The suspension assembly shall include either free centre type suspension clamp along with standard preformed armour rods or armour grip suspension clamp, except for Pilot insulator string for which only suitable Envelope type suspension clamp shall be used.

1.6.3 The suspension clamp along with standard preformed armour rods set shall be designed to have maximum mobility in any direction and minimum moment of inertia so as to have minimum stress on the conductor in the case of oscillation of the same.

1.6.4 The suspension clamp shall be designed for continuous operation at the designed maximum temperature for conductor.

1.6.5 The suspension assembly shall be designed, manufactured and finished to give it a suitable shape, so as to avoid any possibility of hammering between suspension assembly and conductor due to vibration. The suspension assembly shall be smooth without any cuts, grooves, abrasions, projections, ridges or excrescence which might damage the conductor.

1.6.6 The suspension assembly/ clamp shall be designed so that it shall minimize the static & dynamic stress developed in the conductor under various loading conditions as well as during wind induced conductor vibrations. It shall also withstand power arcs & have required level of Corona/RIV performance.

1.6.7 Slip strength of the offered suspension clamp shall be within 12% to 18% of UTS of the offered HTLS Conductor.

1.7 Free Centre Type Suspension Clamp

For the Free Centre Suspension Clamp seat shall be smoothly rounded and curved into a bell mouth at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together.

1.7.1 Standard Preformed Armour Rod Set

1.7.1.1 The Preformed Armour Rods Set shall be used to minimise the stress developed in the sub-conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs, chafing and abrasion from suspension clamp and localised heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

1.7.1.2 The preformed armour rods set shall have right hand lay and the inside diameter of the helix shall be less than the outside diameter of the conductor to have gentle but permanent grip on the conductor. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions etc.

1.7.1.3 The pitch length of the rods shall be determined by the Bidder but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.

1.7.1.4 The length and diameter of each rod shall be furnished by the bidder in the GTP. The tolerance in length of the rods between longest and shortest rods in complete set should be within the limits specified in the relevant Indian/ International Standards. The ends of armour rod shall be parrot billed.

1.7.1.5 The number of armour rods in each set shall be as per supplier's design to suit HTLS conductor offered. Each rod shall be marked in the middle with paint for easy application on the line.

1.7.1.6 The armour rod shall not loose their resilience even after five applications.

1.7.1.7 The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS) & Minimum tensile strength shall not be less than 35kg/mm2.

1.8 Armour Grip Suspension Clamp

1.8.1 The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminium reinforcements and AGS preformed rod set.

1.8.2 Elastomer insert shall be resistant to the effects of temperature up to designed maximum conductor temperature guaranteed by the bidder corresponding to peak current, Ozone, ultraviolet radiations and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS performed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene insert.

1.8.3 The supplier shall submit relevant type/ performance test certificates as per applicable standard/product specifications for elastomer to confirm suitability of the offered elastomer for the specified application.

1.8.4 The AGS preformed rod set shall be as detailed in clause 1.7.1.4 to 1.7.1.7 in general except for the following.

1.8.5 The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength as detailed under clause 1.6.7 and shall not introduce unfavourable stress on the conductor under all operating conditions. The length of the AGS preformed rods shall be indicated in the GTP.

1.9 Envelope Type Suspension Clamp

1.9.1 The seat of the envelope type suspension clamp shall be smoothly rounded & suitably curved at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together. Hexagonal bolts and nuts with split-pins shall be used for attachment of the clamp.

1.10 Dead end Assembly

1.10.1 The dead-end assembly shall be suitable for the offered HTLS Conductor.

1.10.2 The dead-end assembly shall be of compression type with provision for compressing jumper terminal at one end. The angle of jumper terminal to be mounted (including angle of pad) should be 30° with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I2R losses. The resistance of the clamp when compressed on HTLS conductor shall not be more than 75% of the resistance of equivalent length of HTLS conductor.

1.10.3 Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions and shall bear the words ‘COM PRESS FIRST’ suitably inscribed near the point on each assembly where the compression begins. If the dead-end assembly is designed for intermittent die compressions it shall bear identification marks ‘COMPRESSION ZONE’ AND ‘NON-COMPRESSION ZONE’ distinctly with arrow marks showing the direction of compressions and knurling marks showing the end of the zones. The letters, number and other markings on the finished clamp shall be distinct and legible. The dimensions of dead-end assembly before & after compression along with tolerances shall be

guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification. These shall be guaranteed in the relevant schedules of bid.

1.10.4 The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

1.10.5 Jumper bolting arrangement between jumper terminal/cone and terminal pad/plate of dead-end assembly of tension hardware fittings shall be designed to suit the ampacity at continuous operating conductor temperature as specified in Section-I of this specification and shall conform to the relevant Indian/International standards

1.10.6 For composite core HTLS conductor, dead end assembly may inter-alia include collets, collet housing, inner sleeve etc., suitable for the offered design of HTLS conductor

1.11 Fasteners: Bolts, Nuts and Washers

1.11.1 All bolts and nuts shall conform to IS 6639. All bolts and nuts shall be galvanised as per IS 1367 (Part-13)/ IS 2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.

1.11.2 Bolts upto M16 and having length upto 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS 12427. Bolts should be provided with washer face in accordance with IS 1363 (Part-1) to ensure proper bearing.

1.11.3 Nuts should be double chamfered as per the requirement of IS 1363 Part-III 1984. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4 mm oversize on effective diameter for size upto M16.

1.11.4 Fully threaded bolts shall not be used for parts/components requiring shear/tensile strength. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts. Bolts & Nuts for these parts/components shall be of minimum 5.6 grade conforming to IS 1367 or equivalent International standards.

1.11.4.1 For parts/ components requiring grip strength viz. arcing horn, corona rings & dead-end jumper assembly, fully threaded bolts can be used as an alternative.
Bolts & nuts for these parts/ components shall be of minimum 4.6 grade conforming to IS 6639 or equivalent International standards

1.11.4.2 In case of fasteners of other materials viz. stainless steel, aluminium alloy, etc. are proposed to be used by the supplier, these shall conform to relevant Indian/International standards and complete details shall be submitted by the supplier for review & approval by the Employer.

1.11.5 All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but no further. It shall be ensured that the threaded

portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.

1.11.6 Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanised. The thickness of washers shall conform to IS 2016.

1.11.7 The Supplier shall indicate required size & length of various bolts in the drawings based on thickness of components connected, the nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.

1.11.8 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.

1.11.9 Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

1.11.10 To ensure effective in-process Quality control it is essential that the manufacturer should have all the testing facilities for tests like weight of zinc coating, shear strength, other testing facilities etc, in-house. The manufacturer should also have proper Quality Assurance system which should be in line with the requirement of this specification and IS 9001 services Quality System standards.

1.11.11 Fasteners of grade higher than 8.8 are not to be used and minimum grade for bolt shall be 5.6.

1.12 Materials

The materials of the various components shall be as specified hereunder. The Bidder shall indicate the material proposed to be used for each and every component of hardware fitting stating clearly the class, grade or alloy designation of the material, manufacturing process & heat treatment details and the reference standards.

1.12.1 The details of materials for different component are listed as in Table No-1.

1.13 Workmanship

1.13.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for the applicable voltage level of transmission lines and will give continued good performance. For Employer's review of the offered design of clamps/ fittings, the supplier shall submit document/ design details of similar type of clamps/ fittings used in past for similar type of HTLS conductor application.

1.13.3 The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and corners to limit corona and radio-interference, best resistance to corrosion and a good finish.

1.13.4 All ferrous parts including fasteners shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised. The bolt threads shall be undercut to take care of the increase in diameter due to galvanising. Galvanising shall he done in accordance with IS 2629/ IS 1367 (Part-13) and shall satisfy the tests mentioned in IS 2633. Fasteners shall withstand four dips while spring washers shall withstand three dips of one minute duration in the standard Preece test. Other galvanised materials shall have a minimum average coating of zinc equivalent to 600 gm/sqm, shall be guaranteed to withstand at least six successive dips each lasting one (1) minute under the standard preece test for galvanising.

1.13.5 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash rust, stains, bulky white deposits and blisters. The zinc used for galvanising shall be grade Zn 99.95 as per IS:209.

1.13.6 In case of casting, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm.

1.13.7 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localized heating phenomenon is averted.

1.13.8 No equipment shall have sharp ends or edges, abrasions or projections and cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under service conditions.

1.13.9 All the holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of the holes shall be free from burrs.

1.13.10 The fasteners shall conform to the requirements of IS:6639. All fasteners shall have suitable corona free locking arrangement to guard against vibration loosening.

1.13.11 Welding of aluminium shall be by inert gas shielded tungesten arc or inert gas shielded metal arc process. Welds shall be clean, sound, smooth, uniform without overlaps, properly fused and completely sealed. There shall be no cracks, voids incomplete penetration, incomplete fusion, under-cutting or inclusions. Porosity shall be minimised so that mechanical properties of the aluminium alloys are not affected. All welds shall be properly finished as per good engineering practices.

1.14 Bid Drawings

1.14.1 The Bidder shall furnish full description and illustrations of materials offered.

1.14.2 Fully dimensioned drawings of the hardware and their component parts shall be furnished along with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

All drawings shall be identified by a drawing number and contract number. All drawings shall be neatly arranged. All drafting & lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions & dimensional tolerances shall be mentioned in mm.

The drawings shall include:

(i) Dimensions and dimensional tolerance.
(ii) Material, fabrication details including any weld details & any specified finishes & coatings. Regarding material designation & reference of standards are to be indicated.
(iii) Catalogue No.
(iv) Marking
(v) Weight of assembly
(vi) Installation instructions
(vii) Design installation torque for the bolt or cap screw.
(viii) Withstand torque that may be applied to the bolt or cap screw without failure of component parts.
(ix) The compression die number with recommended compression pressure.
(x) All other relevant terminal details.

1.14.3 After placement of award, the Contractor shall submit fully dimensioned drawing including all the components in four (4) copies to the Employer for approval. After getting approval from the Employer and successful completion of all the type tests, the Contractor shall submit six (6) more copies of the same drawings to the Employer for further distribution and field use at Employer's end.

TABLE-1
(Details of Materials)

Sl. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks
1.	Security Clips	Stainless Steel/ Phospher Bronze	-	AISI 304 IS7811	
2.	**For Free Centre /Envelope type clamps**				
(a)	Clamp Body, Keeper Piece	Al. Alloy 4600	Casted & Heat treated	IS 617	
		Al. Alloy 65032	Forged & Heat treated	IS 733	
		Al Alloy ENAW6082	Forged & Heat treated	EN 573-3	
(b)	Cotter bolts	Mild Steel	Hot dip galvanised	IS-2062	
(c)	Shackles	Forged Steel (Class-IV)	Hot dip galvanised	IS-2004	
(d)	U Bolts	Stainless Steel		AISI 304 IS7811	
		Al alloy 65032	Forged & Heat treated	IS 733	
(e)	P. A. Rod	Al. Alloy 65032	Extruded & Heat	IS 733	

			treated		
3.	**For AGS type clamp**				
(a)	Supporting House	Al. Alloy 4600	Casted & Heat treated	IS:617	
		Al alloy 65032	Forged & Heat treated	IS 733	
(b)	Al insert & Retaining strap	Al. Alloy 4600	Casted & Heat treated	IS:617	
		Al alloy 65032	Forged & Heat treated	IS 733	
(c)	Elastomer	Moulded on Al. reinforcement			
4.	**For Dead End Assembly & Mid Span Compression Joint**				
(a)	Outer Sleeve (for Annealed Aluminium Conductor)	Al Alloy 19500	Extruded	IS 733	
(b)	Outer Sleeve (for Aluminium alloy Conductor)	Al Alloy 19500	Extruded	IS 733	
		Al Alloy 63400	Extruded & heat treated	IS 733	
		Al Alloy 6060		EN 573-3	
(c)	Steel Sleeve	Mild Steel	Hot Dip Galvanised	IS-2062	
		Forged Steel (Class-II)		IS-2004	
5	For Repair Sleeve				
(a)		Al Alloy 19500	Extruded	IS 733	
6	**For T-Connector**				
		Al Alloy 19500	Extruded	IS 733	
		Al Alloy 63400	Extruded & heat treated	IS 733	
		Al Alloy 6060		EN 573-3	
7	**For Rigid Spacer**				
	Clamp Body, Keeper Piece, Frame	Al. Alloy 4600	Casted & Heat treated	IS 617	
		Al. Alloy 65032	Forged & Heat treated	IS 733	
		Al Alloy ENAW6082	Forged & Heat treated	EN 573-3	
	Al Tube	Al Alloy 63400	Extruded & heat treated	IS 733	
		Al. Alloy 65032		IS 733	
8	**For Spacer Damper**				
(a)	Clamp Body, Keeper Piece, Frame & Al Insert	Al. Alloy 4600	Casted & Heat treated	IS 617	
		Al. Alloy 65032	Extruded/Forged & Heat treated	IS 733	
		Al Alloy ENAW6082	Forged & Heat treated	EN 573-3	
		Al Alloy 63400	Extruded & Heat treated	IS 733	

9	**For Vibration Damper**				
(a)	Clamp Body, Keeper Piece	Al. Alloy 4600	Casted & Heat treated	IS 617	
(b)	Damper Mass	Cast Iron/Steel			
(c)	Messenger Cable	High strength galvanised steel/stain less steel			
10.	Yoke Plate	Mild Steel	Hot dip galvanized	IS-2062	Mechanical strength of welded joint shall not be less than 20 KN
11 (a)	Corona Control ring/ Grading ring	Al. Alloy 65032	Extruded & Heat treated	IS 733	
		Al. Alloy 63400	Extruded & Heat treated	IS 733	
		Al. Alloy 63401	Extruded & Heat treated	IS 5082	
11 (b)	Supporting Brackets & Mounting Bolts	Al Alloy 65032/63400	Heat treated	IS 733	
		Mild Steel	Hot dip galvanized	IS 2062	

Note: Alternate materials conforming to International/ national standards of other countries also may be offered provided the properties and compositions of these are close to the properties and compositions of material specified. Bidder should furnish the details of comparison of material offered during detailed engineering

2.0 Accessories for the HTLS Conductor

2.1 General

2.1.1 This portion details the technical particulars of the accessories for Conductor.

2.1.2 For owner supplied accessories, 2.5 % extra fasteners (excluding factory fitted fasteners) & retaining rods shall be provided to the Contractor to take care of losses during erection. No payment shall be admissible for these extra supplies. For fittings included in the scope of the Contractor, the contractor is permitted to get inspected and supply upto 2.5% extra fasteners & retaining rods to take care of losses during erection. No payment shall be admissible for these extra supplies.

2.1.3 The supplier shall be responsible for satisfactory performance of complete conductor system along with accessories offered by him for continuous operation at the designed maximum temperature specified for the HTLS Conductor.

2.1.4 The material of the components should be suitable for continued performance corresponding to these maximum temperatures without any deterioration. Maximum allowable temperature for aluminium/ aluminium alloy components, corresponding to the designed maximum temperature of conductor shall be limited to 93 Deg C.

2.2 Mid Span Compression Joint

2.2.1 Mid Span Compression Joint shall be used for joining two lengths of conductor. The resistance of the joint when compressed on the conductor shall not be more than 75% of the resistance of equivalent length of conductor. The joint shall not permit slipping off, damage to or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

2.2.2 The dimensions of mid span compression joint before & after compression along with tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification. For composite core conductor, suitable sleeve, collets, collet housing may be used for core jointing.

2.3 T-Connector

T-Connector of compression type shall be used for jumper connection at transposition tower. It shall be manufactured out of 99.5% pure aluminium/ aluminium alloy and shall be strong enough to withstand normal working loads as well as able to withstand the continuous maximum operating temperature of conductor. The T-connector shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper

piece shall be so rounded that the conductor strands are not damaged during installation. The resistance of T-connector when compressed on the conductor shall not be more than 75% of the resistance of equivalent length of conductor. The T-connector shall not permit slipping off, damage to or failure of complete conductor. The welded portions shall be designed for 30 kN axial tensile load. Leg sleeve of T-connector should be kept at an angle of 15 deg. from vertical and horizontal plane of the conductor in order to minimise jumper pull at the welded portion. The dimensions of T-connector along with tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification.

2.4 Repair Sleeve

Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium/ aluminium alloy and shall have a smooth surface. It shall be able to withstand the designed maximum operating temperature of conductor. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation. The dimensions of Repair sleeve alongwith tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the

conductor size & conform to electrical & mechanical requirement stipulated in the specification.

2.5 Vibration Damper

2.5.1 Vibration dampers of 4R-stockbridge type with four (4) different resonances spread within the specified aeolian frequency band width corresponding to wind speed of 1 m/s to 7 m/s are installed in the existing line at suspension and tension points on each conductor in each span to damp out aeolian vibration. One damper on each side per sub-conductor for suspension points and two dampers on each side per sub-conductor for tension points has been used for a ruling design span specified in Section-I. In case, more no. of dampers are recommended by the supplier, the payment shall be restricted to the number of dampers indicated above.

2.5.2 The damper shall be designed to have minimum 4 nos. of resonance frequencies to facilitate dissipation of vibration energy through inter-strand friction of the messenger cable and shall be effective in reducing vibration over aeolian frequency band ranging from 0.18/d Hz to 1.4/d Hz (where d is conductor diameter in meter). The vibration damper shall meet the requirement of frequency or wind velocity range and also have mechanical impedance closely matched with the offered HTLS conductor. The vibration dampers shall be installed at suitable positions to ensure damping effectiveness across the frequency range. The power dissipation of the
vibration dampers shall exceed the wind power so that the vibration level on the conductor is reduced below its endurance limit i.e. 150 micro strain.

2.5.3 The clamp of the vibration damper shall be made of high strength aluminium alloy grade 4600. It shall be capable of supporting the damper and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the conductor without damaging the strands or causing premature fatigue failure of the conductor under the clamp. The clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the conductor when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and designed to prevent corrosion of threads or loosening in service.

2.5.4 The messenger cable shall be made of high strength galvanised steel/stain less steel with a minimum strength of 135 kg/mm2. It shall be of preformed and post-formed quality in order to prevent subsequent drop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in the messenger cable shall be 19. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS 4826 for heavily coated wires.

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

2.5.6 The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the

mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

2.5.7 The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.

2.5.8 The vibration damper shall be capable of being installed and removed from energised line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the conductor at the designated torque without shearing or damaging of fasteners.

2.5.9 The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.

2.5.10 The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed under Annexure-A, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

Sl.No.	Description	Voltage class		
1.	Span length in meters	132 KV	220 KV	400 KV
i)	Ruling design span (meter)	295	320	400
ii)	Maximum span (meter)	295	320	400
iii)	Minimum span (meter)	50	70	60
2.	Configuration	Double / Single Circuit conductor per phase in vertical configuration.	Double / Single Circuit conductor per phase in vertical configuration.	Double circuit in vertical configuration and single circuit in horizontal configuration
3.	Maximum Tensile load	25% of the UTS of the conductor used	25% of the UTS of the conductor used	22% of the UTS of the conductor used
4.	Armour rods used	Standard preformed armour rods/AGS		

5.	Maximum permissible dynamic strain i.e. endurance limit.	+/-150micro strains

2.5.14 The damper placement chart shall be submitted for spans ranging from 100 m to 1100 m. Placement charts should be duly supported with relevant technical documents and sample calculations.

2.5.15 The damper placement charts shall include the following

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

2.6 Rigid Spacer for Jumper (For 400 KV line with twin HTLS Conductor only)

2.6.1 Jumpers at tension points shall be fitted with spacers so as to limit the length of free conductor to 3.65 m and to maintain the sub conductor spacing of 450 mm for twin bundle conductors. It shall meet all the requirements of spacer used in line except for its vibration performance. Spacers requiring retaining rods shall not be quoted for jumpers.

2.6.2 The spacer offered by the Bidder shall satisfy the following requirements.

2.6.2.1 Spacer shall restore normal spacing of the sub-conductors after displacement by wind, electromagnetic and the electrostatic forces under all operating conditions including the specified short circuit level without permanent deformation damage either to conductor or to the assembly itself. They shall have uniform grip on the conductor

2.6.2.2 Where elastomer lined clamp grooves are used, the elastomer shall be firmly fixed to the clamp.

2.6.2.3 Any nut used shall be locked in such a manner so as to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded.

2.6.2.4 Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened.

2.6.2.5 The clamp grooves shall be in uniform contact with the conductor over the entire surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and

free of projections, grit or other material which cause damage to the conductor when the clamp is installed.

2.6.2.6 For the spacer involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.

2.6.2.7 Universal type bolted clamps, covering a range of conductor sizes, will not be permitted.

2.6.2.8 No rubbing, other than that of the conductor clamp hinges or clamp swing bolts, shall take place between any parts of the spacer. Joint incorporating a flexible medium shall be such that there is no relative slip between them.

2.6.2.9 The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service.

2.6.2.10 The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance.

2.6.2.11 The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep.

2.6.2.12 The spacer assembly shall not have any projections, cuts, abrasions etc. or chattering parts which might cause corona or RIV.

2.6.2.13 The spacer tube shall be made of aluminium alloy 65032/63400. If fasteners of ferrous material are used, they shall conform to and be galvanised conforming to relevant Indian Standards.

2.6.2.14 Elastomer, if used, shall be resistant to the effects of temperature upto the designed maximum temperature specified for the conductor, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be as per relevant Indian/International standard. The supplier shall submit relevant type/ performance test certificate as per applicable standard/ product specification for elastomer to confirm suitability of the offered elastomer for the specified application.

2.6.2.15 The spacer assembly shall have electrical continuity. The electrical resistance between the sub-conductor across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.

2.5.2.16 The spacer assembly shall have complete ease of installation and shall be capable of removal/ reinstallation without any damage.

2.6.2.17 The spacer assembly shall be capable of being installed and removed from the energized line by means of hot line technique.

2.7 Spacer Damper (For 400 KV line with twin HTLS Conductor only)

2.7.1 The spacer damper covered by this specification shall be designed to maintain the bundle spacing of 450 mm under all normal operating conditions and to effectively control Aeolian vibrations as well as sub span oscillation and to restore conductor spacing after release of any external extraordinary load. The nominal sub conductor spacing shall be maintained within ±5 mm.

2.7.2 The spacer damper shall restore the normal sub-conductor spacing due to displacement by wind, electromagnetic and electrostatic forces including the specified short circuit level without permanent deformation or damage either to bundle conductors or to spacer damper itself.

2.7.3 The design offered shall be presented as a system consisting of spacer dampers and their staggering scheme for spans ranging from 100 m to 1100 m.

2.7.4 Under the operating conditions specified, the spacer damper system shall adequately control Aeolian vibrations throughout the life of the transmission line with wind velocity ranging from 0 to 30 km per hour in order to prevent damage to conductor at suspension clamps, dead end clamps and spacer damper clamps.

2.7.5 The spacer damper system shall also control the sub-span oscillations in order to prevent conductor damage due to chaffing and severe bending stresses at the spacer damper clamps as well as suspension and dead end clamps and to avoid wear to spacer damper components.

2.7.6 The spacer damper shall consist of a rigid central body called the frame linked to the conductor by two articulated arms terminated by suitable clamping system. The articulation shall be designed to provide elastic and damping forces under angular movement of the arms. The dynamic characteristics of the articulations shall be maintained for the whole life of the transmission line.

2.7.7 The clamping system shall be designed to provide firm but gentle and permanent grip while protecting the conductor against local static or dynamic stresses expected during normal operating conditions. The clamping system shall be designed to compensate for any reduction of conductor diameter due to creep.

2.7.8 Bolted type clamps shall allow installation without removal of the bolts or the clamps from clamp body. Locking mechanism shall be suitable to prevent bolt loosening. Clamp locking devices with small loose components shall not be accepted. Nut cracker, hinged open or boltless type clamps are acceptable provided adequate grip can be maintained on the conductor.

2.7.9 Bolts and nuts shall be of mild steel, stainless steel, or high strength steel in accordance with the design of the spacer damper.

2.7.10 Where elastomer lined clamps are used, the elastomer elements shall be firmly fixed to the clamp. In case of elastomer covered clamps, the insert should be forged from aluminium alloy 65032 or equivalent aluminium alloy having minimum tensile strength of 25 kg/mm2. The insert shall be moulded on the insert surface. The insert shall be duly heat treated and aged to retain its consistent characteristics during service. The grain flow of the forged insert shall be in the direction of the maximum tension and compression loads experienced.

2.7.11 In case of Spacer dampers with pre-formed rods, the articulated arms shall be terminated by elastomer lined or elastomer covered clamps and securely held by pre-formed retaining helical, factory formed rods. Minimum four (4) no. of rods shall be applied on each clamp to hold the clamp in position., These rods shall be designed for specific conductor size & shall be made of high strength aluminium alloy 65032 or equivalent having a minimum tensile strength of 35 kg/mm². The rods shall be parrot bill ended. The rods shall be heat treated and aged to achieve specified mechanical properties and to retain the same during service. The length of the rods shall be such that the ends fall inside the imaginary square whose sides are vertical and horizontal outer tangents to the conductor sections.

2.7.12 The spacer damper body shall be cast/ forged from suitable high strength corrosion resistant aluminum alloy. The aluminium alloy shall be chosen in relation with the process used.

2.7.13 The rubber components involved in the design such as damping elements shall be made with rubber compound selected specifically for that particular application. The Contractor shall submit a complete list of physical and mechanical properties of the elastomer used. This list shall make reference to all applicable Indian/International standards.

2.7.14 The rubber components used shall have good resistance to the effects of temperature up to the designed maximum temperature of the conductor and to ultraviolet radiation, ozone and other atmospheric contaminants. The rubber shall have good wear and fatigue resistance and shall be electrically semi-conductive.

2.7.15 The spacer damper assembly shall have electrical continuity. The electrical resistance between the sub-conductors across the assembly in case of spacer damper involving elastomer surfaced clamps shall be suitably selected by the manufacturer to ensure satisfactory electrical performance and avoid deterioration of elastomer under service conditions.

2.7.16 The spacer damper assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.

2.7.17 The spacer damper assembly shall be capable of being installed and removed from the energized line by means of hot line techniques. The Supplier shall furnish the complete description of the installation, removal and reinstallation procedure.

2.7.18 A typical placement chart of spacer dampers for spans ranging from 100m to 1100m is indicated in table at Annexure-D. Sub span spacing indicated in Annexure-D may be varied by the manufacturer as per requirement, provided total no. of Spacer Damper in sub-span shall not be less than indicated in table at Annexure-D. In case of tension towers, one additional Spacer Damper shall be placed within 10m of dead end clamp. Incase more Spacer dampers

are recommended by the supplier, the payment shall be restricted to the number of Spacer dampers indicated in table at Annexure-D for different spans and one additional incase of tension towers.

2.7.19 The staggering scheme shall be such that no sub span shall be greater than 65 m and no end sub span shall be longer than 40 m & the spacer dampers be unequally distributed along the span to achieve sufficient detuning of adjacent subs pans for oscillations of sub span mode and to ensure bundle stability for wind speeds up to 60 km/hr.

2.7.20 In case of Spacer Damper with bolted clamps, the manufacturer/ supplier shall supply free of cost 25 number fixed setting torque wrench (of torque as per spacer damper design) along with 1st batch of supply of spacer dampers for installation of spacer damper on the line by the tower contractors.

2.7.21 The Bidder shall furnish all the relevant technical documents in supports of the staggering scheme recommended for the spacer damper.

2.8 Material and Workmanship

2.8.1 All the equipment shall be of the latest proven design and conform to the best modern practice adopted in the extra high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for intended voltage level of transmission line application and will give continued good performance at all service conditions. For employer's review of the offered design of accessories, the supplier shall submit document/ design details of similar type of accessories used in past for similar type of HTLS conductor application.

2.8.2 The design, manufacturing process and quality control of all the materials shall be such as to achieve requisite factor of safety for maximum working load, highest mobility, elimination of sharp edges and corners, best resistance to corrosion and a good finish.

2.8.3 All ferrous parts shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised as per grade 4 of IS 1573. The bolt threads shall be undercut to take care of increase in diameter due to galvanising. Galvanising shall be'done in accordance with IS 2629/ IS 1367 (Part-13) and satisfy the tests mentioned in IS 2633. Fasteners shall withstand four dips while spring washers shall withstand three dips. Other galvanised materials shall have a minimum average coating of Zinc equivalent to 600 gm/sqm and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanising unless otherwise specified.

2.8.4 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The zinc used for galvanising shall be of grade Zn 99.95 as per IS 209.

2.8.5 In case of castings, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc.

2.8.6 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localised heating phenomenon is averted.

2.8.7 No equipment shall have sharp ends or edges, abrasions or projections and shall not cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under all service conditions.

2.8.8 Particular care shall be taken during manufacture and subsequent handling to ensure smooth surface free from abrasion or cuts.

2.8.9 The fasteners shall conform to the requirements of IS 6639. All fasteners and clamps shall have corona free locking arrangement to guard against vibration loosening.

2.9 Compression Markings

Die compression areas shall be clearly marked on each equipment designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' 'suitably inscribed on each equipment where the compression begins. If the equipment is designed for intermittent die compressions, it shall bear the identification marks 'COMPRESSION ZONE' and 'NON-COMPRESSION ZONE' distinctly with arrow marks showing the direction of compression and knurling marks showing the end of the zones. The letters, number and other markings on finished equipment shall be distinct and legible.

2.10 Bid Drawings

2.10.1 The Bidder shall furnish detailed dimensioned drawings of the equipments and all component parts. Each drawing shall be identified by a drawing number and Contract number. All drawings shall be neatly arranged. All drafting and lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions and dimensional tolerances shall be mentioned in mm.

2.10.2 The drawings shall include

(i) Dimensions and dimensional tolerances
(ii) Material. fabrication details including any weld details and any specified finishes and coatings. Regarding material, designations and reference of standards are to be indicated.
(iii) Catalogue No.
(iv) Marking
(v) Weight of assembly
(vi) Installation instructions
(vii) Design installation torque for the bolt or cap screw
(viii) Withstand torque that may be applied to the bolt or cap screw without failure of component parts

(ix) The compression die number with recommended compression pressure.

(x) All other relevant technical details

2.10.3 Placement charts for spacer/spacer damper and damper

2.10.4 The above drawings shall be submitted with all the details as stated above along with the bid document. After the placement of award, the Contractor shall again submit the drawings in four copies to the Employer for approval. After Employer's approval and successful completion of all type tests, 20 (twenty) more sets of drawings shall be submitted to Employer for further distribution and field use at Employer's end.

3.0 Tests and Standards

3.1 Type Tests

3.1.1 On Suspension Clamp for HTLS Conductor

a)	Visual Examination	IS 2486 (Part-1)
b)	Verification of Dimensions	IS 2486 (Part-1)
c)	Chemical analysis of materials	Annexure-A
d)	Magnetic power loss test	Annexure-A
e)	Slip strength test	Annexure-A
f)	Ozone Test on elastomer	Clause 7.6.3, IEC 61854
g)	Vertical damage load & Failure load test	IEC 61284
h)	Galvanising/Electroplating test	Annexure-A
i)	Thermal Profile test	Annexure-A

3.1.2 On Dead end Tension Assembly for HTLS Conductor

a)	Visual Examination	IS 2486 (Part-1)
b)	Verification of Dimensions	IS 2486 (Part-1)
c)	Chemical analysis of materials	Annexure-A
d)	Electrical resistance test for dead end Assembly	IS 2486-(Part-I)
e)	Heating cycle test for dead end Assembly	Annexure-A
f)	Slip strength test for dead end assembly	Annexure-A
g)	Ageing test on filler (if applicable)	Annexure-A
h)	Thermal Profile test	Annexure-A
i)	Galvanising/Electroplating test	Annexure-A

3.1.3 On Mid Span Compression Joint for HTLS Conductor

a)	Visual Examination	IS 2121 (Part-II)

b)	Dimensional Verification	IS 2121 (Part-II)
c)	Chemical analysis of materials	Annexure-A
d)	Electrical resistance test	IS 2121 (Part-II)
e)	Heating cycle test	Annexure-A
f)	Slip strength test	Annexure-A
g)	Thermal Profile test	Annexure-A
h)	Corona extinction voltage test (dry) (for 400 kV and above voltage level only)	Annexure-A
i)	Radio interference voltage test (dry) (for 400 kV and above voltage level only)	Annexure-A
j)	Ageing test on filler (if applicable)	Annexure-A
k)	Galvanizing test	Annexure-A

3.1.4 T-Connector for HTLLS Conductor

a)	Visual Examination	IS 2121 (Part-IV)
b)	Verification of Dimensions	IS 2121 (Part-IV)
c)	Chemical analysis of materials	Annexure-A
d)	Electrical resistance test	IS 2121 (Part-II)
e)	Heating cycle test	Annexure-A
f)	Axial tensile load test on welded portion	Annexure-A
g)	Tensile Test	IEC61284, Clause 11.6.2
h)	Thermal Profile test	Annexure-A
i)	Corona extinction voltage test (dry) (for 400 kV and above voltage level only)	Annexure-A
j)	Radio interference voltage test (dry) (for 400 kV and above voltage level only)	Annexure-A
k)	Galvanizing test	Annexure-A

3.1.5 Repair Sleeve for HTLS Conductor

a)	Visual Examination	IS 2121 (Part-II)
b)	Dimensional Verification	IS 2121 (Part-II)
c)	Chemical analysis of materials	Annexure-A
d)	Tensile Test	IEC61284, Clause 11.7
e)	Thermal Profile test	Annexure-A
f)	Corona extinction voltage test (dry) *(for 400 kV and above voltage level only)*	Annexure-A

g)	Radio interference voltage test (dry) *(for 400 kV and above voltage level only)*	Annexure-A

3.1.6 Vibration Damper for HTLS Conductor

a)	Visual Examination	IS 9708
b)	Dimensional Verification	IS 9708
c)	Verification of Resonance Frequencies	Annexure-B
d)	Mass pull off test	IS 9708
e)	Chemical analysis of materials	Annexure-A
f)	Dynamic characteristics test*	Annexure-A
g)	Vibration analysis	Annexure-A
h)	Clamp slip test	Annexure-A
i)	Clamp bolt torque test	IS 9708
j)	Fatigue tests	Annexure-A
k)	Magnetic power loss test	Annexure-A
l)	Thermal Profile test	Annexure-A
m)	Corona extinction voltage test (dry) *(for 400 kV and above voltage level only)*	Annexure-A
n)	Radio interference voltage test (dry) *(for 400 kV and above voltage level only)*	Annexure-A
o)	Damper efficiency test	IS 9708
p)	Galvanising/Electroplating test	Annexure-A
* Applicable for 4 R stockbridge dampers. For alternate type of vibration dampers (permitted as per clause 2.5.2), as an alternative to dynamic characteristic test, damper efficiency test as per IEEE-664 Power Manual may be proposed/ carried out by the supplier.		

3.1.7 Rigid Spacer for jumper for twin HTLS Conductor

a)	Visual Examination	IS 10162
b)	Dimensional Verification	IS 10162
c)	Chemical analysis of materials	Annexure-A
d)	Clamp slip test	Annexure-A
e)	Clamp bolt torque test	IS 10162
f)	Assembly Torque test	IS 10162
g)	Magnetic power loss test	Annexure-A
h)	Tension-compression Test	Annexure-A
i)	Thermal Profile test	Annexure-A
j)	Corona extinction voltage test (dry) *(for 400 kV and above voltage level only)*	Annexure-A
k)	Radio interference voltage test (dry) *(for 400 kV and above voltage level only)*	Annexure-A
l)	Galvanising Test	Annexure-A

3.1.8 Spacer Damper for twin HTLS Conductor

a)	Visual Examination	IS 10162
b)	Dimensional Verification	IS 10162
c)	Movement Test	IS 10162
d)	Resilience Test (if applicable)	IS 10162
e)	Clamp bolt torque test	IS 10162
f)	Assembly Torque test	IS 10162
g)	Chemical analysis of materials	Annexure-A
h)	Clamp slip test	Annexure-A
i)	Vibration Test	Annexure-A
	(i) Vertical Vibration	IS 10162
	(ii) Longitudinal Vibration	IS 10162
	(iii)Sub-span oscillation	IS 10162
j)	Dynamic characteristics test	Annexure-A
k)	Fatigue tests	Annexure-A
l)	Magnetic power loss test (if applicable)	Annexure-A
m)	Compressive and tension Test	Annexure-A
n)	Thermal Profile test	Annexure-A
o)	Corona extinction voltage test (dry) *(for 400 kV and above voltage level only)*	Annexure-A
p)	Radio interference voltage test (dry) *(for 400 kV and above voltage level only)*	Annexure-A

3.1.9 Type tests specified under Clause 3.1.1 to 3.1.8 shall not be required to be carried out if a valid test certificate is available for the offered design. The test certificate shall be considered valid if,

i) Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/ IEC vide 25/ 17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of WBSETCL or utility and

ii) Type test reports contain valid Calibration reports of the relevant testing equipment and information pertaining to ratings, the relevant drawings, model number, test circuit, calculations (if any), photos, acceptance criteria/ values specified in Technical Specification/ relevant standards (IS/ IEC) and compliance to the same and

iii) Tests should have been conducted on the samples of clamps & accessories for HTLS conductor manufactured from same manufacturing works within last 7 (seven) years as on the date of NIT.

Further, test certificates of samples manufactured from same manufacturing works shall also be considered valid, if the same has already been approved/ accepted by WBSETCL & tests have been conducted within the above mentioned validity period.

In case the tests have been conducted earlier than the above stipulated period or carried out on samples manufactured from any other manufacturing works or in case of revision/ amendment in the provisions/ test procedure of the IS/IEC as referred in the TS or in the event of any discrepancy in the test report (i.e. due to non-inclusion of valid calibration certificate, desired information etc. or any test not applicable due to any design/ material/ manufacturing process change including substitution of components or due to noncompliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the supplier at no extra cost to the Purchaser.

3.2 Acceptance Tests

3.2.1 On Both Suspension Clamp and Tension clamp fitting for HTLS Conductor

a)	Visual Examination	IS 2486-(Part-I)
b)	Verification of dimensions	IS 2486-(Part-I)
c)	Galvanising/ Electroplating test	Annexure-A
d)	Mechanical strength test of each component	Annexure-A
e)	Mechanical Strength test of welded joint	Annexure-A
f)	Chemical analysis, hardness tests, grain size, inclusion rating & magnetic particle inspection for forgings/castings	Annexure-A

3.2.2 On Suspension Clamp fitting for HTLS Conductor

a)	Slip strength test for suspension clamp	Annexure-A
b)	Shore hardness test of elastomer cushion for AG suspension clamp	Annexure-A
c)	Bend test for armour rod set	IS 2121(Part-I), Clause 7.10.
d)	Resilience test for armour rod set	Annexure-A
e)	Conductivity test for armour rods set	IS 2121(Part-I), Clause 7.5.

3.2.3 On Tension Clamp Fitting for HTLS Conductor

a)	Slip strength test for dead end assembly	Annexure-A
b)	Ageing test on filler (if applicable)	Annexure-A

3.2.4 On Mid Span Compression Joint for HTLS Conductor

a)	Visual examination and dimensional verification	IS 2121 (Part-II), Clause 6.2, 6.3 & 6.7

b)	Chemical analysis of materials	Annexure-A
c)	Galvanising test	Annexure-A
d)	Hardness test	Annexure-B
e)	Ageing test on filler (if applicable)	Annexure-A

3.2.5 On T-Connector for HTLS Conductor

a)	Visual examination and dimensional verification	IS2121 (Part-IV)
b)	Chemical analysis of materials	Annexure-A
c)	Axial tensile load test for welded portion	Annexure-A

3.2.6 On Repair Sleeve for HTLS Conductor

a)	Visual examination and dimensional verification	IS 2121(Part-II), Clause 6.2, 6.3
b)	Chemical analysis of materials	Annexure-A

3.2.7 On Spacer Damper for Line / Rigid Spacer for Jumper for twin HTLS conductor

a)	Visual examination and dimensional verification	IS 9708
b)	Chemical analysis of materials	Annexure-A
c)	Verification of Resonance Frequencies	Annexure-B
d)	Strength of messenger cable test	Annexure-B
e)	Clamp slip test	Annexure-B
f)	Clamp bolt torque test	IS-9708
g)	Mass pull off test	Annexure-B
h)	Dynamic Characteristics test	Annexure-B
i)	Galvanizing/ Electroplating Test	Annexure-A

3.2.8 On Vibration Damper for HTLS conductor

a)	Visual examination and dimensional verification	IS 9708
b)	Chemical analysis of materials	Annexure-A
c)	Verification of Resonance Frequencies	Annexure-B
d)	Strength of messenger cable test	Annexure-B
e)	Clamp slip test	Annexure-B
f)	Clamp bolt torque test	IS-9708
g)	Mass pull off test	Annexure-B
h)	Dynamic Characteristics test	Annexure-B
i)	Galvanizing/ Electroplating Test	Annexure-A

3.3 Routine Tests

3.3.1 For Hardware Fittings

a)	Visual examination	IS 2486 (Part-I
b)	Proof Load Test	Annexure-A

3.3.2 For conductor accessories

a)	Visual examination and dimensional verification	IS 2121(Part-II)/ IS 2121 (Part IV)/ IS 9708/ IS 10162 as applicable

3.4 Tests During Manufacture on all components as applicable

a) Chemical analysis of Zinc used for galvanising IS 2486 (Part-I)
b) Chemical analysis mechanical metallographic test and magnetic particle inspection for malleable castings Annexure-A
c) Chemical analysis, hardness tests and magnetic particle inspection for forging Annexure-A

3.5 Testing Expenses

Testing expenses will be guided by as per terms of NIT.

3.6 Sample Batch For Type Testing

3.6.1 The Contractor shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Employer. The Contractor shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Employer.

3.6.2 Before sample selection for type testing the Contractor shall be required to conduct all the acceptance tests successfully in presence of Employer's representative.

3.7 Schedule of Testing and Additional Tests

3.7.1 The Bidder has to indicate the schedule of following activities in their bids
(a) Submission of drawing for approval.
(b) Submission of Quality Assurance programme for approval.
(c) Offering of material for sample selection for type tests.
(d) Type testing.

3.7.2 The Employer reserves the right of having at his own expense any other test(s) of reasonable nature carried out at Contractor's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material complies with the specifications.

3.7.3 The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Contractor's premises or at any other

test centre. In case of evidence of noncompliance, it shall be binding on the part of Contractor to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items, all without any extra cost to the Employer.

3.8 Test Reports

3.8.1 Copies of type test reports shall be furnished in at least six copies along with one original. One copy shall be returned duly certified by the Employer, only after which the commercial production of the concerned material shall start.

3.8.2 Copies of acceptance test report shall be furnished in at least six copies. One copy shall be returned, duly certified by the Employer, only after which the materials will be dispatched.

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

3.8.4 Test certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Employer.

3.9 Inspection

3.9.1 The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where the material and/ or its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Contractor's, sub-Contractor's works, raw materials. Manufacturer's of all the material and for conducting necessary tests as detailed herein.

3.9.2 The material for final inspection shall be offered by the Contractor only under packed condition as detailed in clause 4.11 of this part of the Specification. The engineer shall select samples at random from the packed lot for carrying out acceptance tests.

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

3.9.4 Material shall not be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Employer in writing. In the latter case also the material shall be dispatched only after all tests specified herein have been satisfactorily completed.

3.9.5 The acceptance of any quantity of material shall in no way relieve the Contractor of his responsibility for meeting all the requirements of the Specification, and shall not prevent subsequent rejection, if such materials are later found to be defective.

3.10 Packing and Marking

3.10.1 All material shall be packed in strong and weather resistant wooden cases/crates. The gross weight of the packing shall not normally exceed 200 Kg to avoid handling problems.

3.10.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

3.10.3 Suitable cushioning, protective padding, dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

3.10.4 Bolts, nuts, washers, cotter pins, security clips and split pins etc. shall be packed duly installed and assembled with the respective parts and suitable measures shall be used to prevent their loss.

3.10.5 Each component part shall be legibly and indelibly marked with trade mark of the manufacturer and year of manufacture. However, in such type of component/ item, which consists of many parts and are being supplied in assembled condition (suspension clamp, rigid spacer, spacer damper etc.), the complete assembly shall be legibly and indelibly marked on main body/on one of the parts. The symbol / alongwith the word 'TOP' shall be marked on the main body of the spacer damper for installing spacer damper in correct position.

3.10.6 All the packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each wooden case/crate shall have all the markings stenciled on it in indelible ink.

3.11 Standards

3.11.1 The clamp fitting and accessories shall conform to the following Indian/ International Standards which shall mean latest revisions, with amendments/ changes adopted and published, unless specifically stated otherwise in the Specification.

3.11.2 In the event of the supply of clamp fitting and accessories conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the Standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

Sl. No.	Indian Standard	Title	International Standard
1	IS 209	Specification for zinc	
2	IS 398 (Part-V)	Aluminum Conductor Galvanised Steel- Reinforced For Extra High Voltage (400 KV) and above	
3	IS 1573	Electroplated Coating of Zinc on iron and Steel	
4	IS 2121 (Part-II)	Specification for Conductor and Earthwire Accessories for Overhead Power lines: Mid-span Joints and Repair Sleeves for Conductors	
5	IS 2486	Specification for Insulator Fittings for Overhead	

	(Part-I)	power Lines with Nominal Voltage greater than 1000 V: General Requirements and Tests	
6	IS 2629	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
7	IS 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
8	IS 4826	Galvanised Coating on Round Steel Wires	
9	IS 6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	
10	IS 8263	Method of Radio Interference Tests on High Voltage Insulators	
11	IS 6639	Hexagonal Bolts for Steel Structures	
12	IS 10162	Specification for Spacers & Spacers Dampers for Twin Horizontal Bundle Conductors	
13	IS 9708	Stockbridge Vibration Damper for Overhead Power Lines- Specification	
14		Overhead Lines-Requirements and tests for Spacers	IEC 61854
15		Overhead Lines-Requirements and tests for fittings	IEC 61284

The standards mentioned above are available from:

Reference Abbreviation	**Name and Address**
BS	British Standards, British Standards Institution 101, Pentonvile Road, N - 19-ND UK
IEC/CISPR	International Electro technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de verembe, Geneva SWITZERLAND
BIS/IS	Beureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA
ISO	International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK.

NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017 U.S.A.

Annexue-A

1.0 Tests on Hardware Fittings

1.1 Magnetic Power Loss Test for Suspension Assembly

The test shall be carried out as per clause no. 12 of IEC 61284 considering 50Hz AC of various magnitude (in steps of 50A) within ±200A of specified ampacity at designed maximum temperature of HTLS conductor. The average power loss for suspension assembly shall be plotted for each value of current. The value of the loss corresponding to specified ampacity at designed maximum temperature of the HTLS conductor shall be read off from the graph and the same shall be limited to the value guaranteed by the supplier.

1.2 Mechanical Strength Test of Each Component

Each component shall be subjected to a load equal to the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. The component shall then again be loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified UTS and held for one minute. No fracture should occur. The applied load shall then be increased until the failing load is reached and the value recorded.

1.3 Mechanical Strength Test of Welded Joint

The welded portion of the component shall be subjected to a Load of 2000 kg for one minute. Thereafter, it shall be subjected to die-penetration/ ultrasonic test. There shall not be any crack at the welded portion.

1.4 Slip Strength Test for Suspension Clamp

The test shall be carried out as per Clause no. 11.1 of IS 2486 (Part-1) by keeping the clamp at minimum specified slip strength for one minute and considering slip strength as specified in the GTP.

1.5 Heating Cycle Test

Heating cycle test shall be performed in accordance with IS 2486 (Part-I) with following modifications: -

i) Temperature of conductor during each cycle: 40 deg. C above designed maximum operating temperature of the conductor but not exceeding maximum permissible conductor temperature for short term operation guaranteed in the GTP.

ii) Number of cycles: 100

iii) Slip strength test shall also be carried out after heating cycle test.

1.6 Slip strength test for dead end assembly

The test shall be carried out as per IS 2486 (Part-I) except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor and retained for one minute at this load.

1.7 Shore Hardness Test for Elastomer Cushion for AG Suspension Assembly

The shore hardness at various points on the surface of the elastomer cushion shall be measured by a shore hardness meter and the shore hardness number shall be between 65 to 80.

1.8 Proof Load Test

Each component shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength which shall be increased at a steady rate to 67% of the UTS specified. The load shall be held for one minute and then removed. After removal of the load the component shall not show any visual deformation.

1.9 Tests for Forging Casting and Fabricated Hardware

The chemical analysis, hardness test, grain size, inclusion rating and magnetic particle inspection for forging, castings and chemical analysis and proof load test for fabricated hardware shall be as per the internationally recognised procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as in the Quality Assurance programme.

1.10 Resilience test for armour rod set

The test shall be carried out as per IS 2121 (Part-I), except that the slip strength test after resilience test shall be conducted as per clause 1.4, Annexure-A of the TS and suspension assembly in this slip strength test shall withstand minimum slip load guaranteed in the GTP.

2.0 Slip Strength Test on Mid Span Compression Joint

The test shall be carried out as per IS 2121 (Part-II), clause 6.4 except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor and retained for one minute at this load. There shall be no movement of the conductor relative to the fittings and no failure of the fittings during this one-minute period.

2.1 Heating Cycle Test on Mid Span Compression Joint & T- Connector

Heating cycle test shall be performed in accordance with IS 2121 (Part-II) with following modifications: -

i) Temperature of conductor during each cycle: 40 deg. C above designed maximum operating temperature of the conductor but not exceeding maximum permissible conductor temperature for short term operation guaranteed in the GTP by the contractor/supplier.

ii) Number of cycles: 100

iii) Slip strength test shall also be carried out after heating cycle test.

2.2 Axial Tensile Load Test for Welded Portion of T-Connector

The sleeve portion of the T-Connector shall be compressed on conductor. The compressed portion shall be held rigidly on some fixtures and axial load shall be applied along with the jumper terminal. The load shall be increased gradually till breaking of welded joint occurs. The breaking load should be above 30 kN.

2.3 Vibration Damper

(a) Dynamic Characteristics, Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for aeolian vibration frequency band ranging from 0.18/d Hz to 1.4/d Hz (where d is conductor diameter in meter) for damper for conductor. The damper assembly shall be vibrated vertically with a + 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at ± 0.5mm to determine following characteristics with the help of suitable recording instruments:

(i) Force Vs frequency

(ii) Phase angle Vs frequency

(iii) Power dissipation Vs frequency

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

Acceptance criteria for vibration damper.

(i) The above dynamic characteristics test on five dampers shall be conducted.

(ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.

(iii) The above mean reactance response curve should lie within following limits:
For ACSR Zebra equivalent HTLS Conductor: 0.135 f to 0.54 f Kgf/mm, where f is frequency in Hz.
For ACSR Panther equivalent HTLS Conductor: 0.0991 f to 0.495 f, where f is frequency in Hz.

(iv) The above mean phase angle response curve shall be between 25o to 130o within the frequency range of interest.

(v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.

(vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

The vibration analysis of the HTLS conductor shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be considered for the purpose of analysis: -

(i) The analysis shall be done for single conductor without armour rods as per the parameters given under clause 2.5.13 of this part of the Specification. The tension corresponding to 25% of UTS of the HTLS conductor shall be taken for a span ranging from 100 m to 1100.

(ii) The self-damping factor and flexural stiffness (El) for HTLS conductor shall be calculated on the basis of experimental results. The details for experimental analysis with these data should be furnished.

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

(iv) Examine the aeolian vibration level of the conductor with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.

(v) From vibration analysis of conductor without damper, anti- node vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.

(vi) From vibration analysis of conductor with damper/ dampers installed at the recommended location, the dynamic strain level, at the clamped span

extremities, damper attachment points and the antinodes on the conductor shall be determined. In addition to above damper clamp vibration amplitude and anti-node vibration amplitudes shall also be examined.

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

(c) Clamp Slip and Fatigue Tests

(i) Test Set Up

The clamp slip and fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30 m. The conductor shall be tensioned at tension corresponding to 25% of UTS of the HTLS conductor Constant tension shall be maintained within the span by means of lever arm arrangement. After the conductor has been tensioned, clamps shall be installed to support the conductor at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the conductor. There shall be no loose parts, such as suspension clamps, U-bolts on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) Clamp Slip test

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

(iii) Fatigue Test

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

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The

resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ± 25/f mm, where f is the frequency in Hz.

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

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

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

For the purpose of acceptance, the following criteria shall be applied.

(1) There shall not be any frequency shift by more than +2 Hz for frequencies lower than 15 Hz and ± 3 Hz for frequencies higher than 15 Hz.

(2) The force response curve shall generally lie within guar anteed % variation in reactance after fatigue test in comparison with that before fatigue test by the Contractor.

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

2.4 Spacer/ Spacer Damper

(a) Vibration Tests (for Spacer Damper only)

The clamp slip tests shall be conducted on a laboratory set up with a minimum effective span length of 30 m. The spacer damper assembly shall be clamped to conductor. The conductor shall be tensioned at tension corresponding to 25% of UTS of the HTLS conductor and shall not be equipped with protective armour rods at any point. Constant tension shall be maintained within the span by means of lever arm arrangement. After the conductor has been tensioned, clamps shall be installed to support the conductor at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the

tension on the conductor. There shall be no loose parts, such as suspension clamps, U bolts on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for stepless speed control as well as stepless amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

During the vibration tests the axis of the clamp of sample shall be maintained parallel to its initial static position by applying a tension corresponding to 25% of UTS of the HTLS conductor. The spacer/ spacer damper assembly shall be free to vibrate and shall not be re-torqued or adjusted between the tests.

All the vibration tests mentioned hereunder shall be conducted on the same sample on the same test span. The samples shall withstand the vibration tests without slipping on the conductor, loosening, damage or failure of component parts. After each vibration test, clamp slip test shall be carried out as per the procedure given in Clause No 2.2 (b) below:

(i) Longitudinal Vibration Test

The stationary conductor and the vibrating conductor/equivalent diameter of aluminium alloy tube shall be restrained by fixed clamps. The displacement of the vibrating conductor shall be 25 mm minimum on either side. The longitudinal movement shall be parallel to the conductor at frequency not less than 2 Hz for minimum one million cycles.

(ii) Vertical Vibration Test

The spacer/spacer damper shall be installed in the middle of the test span and the frequency chosen so as to get an odd number of loops. The shaker shall be positioned at least two loops away from the test specimen to allow free movement of the conductor close to the test specimen. One conductor shall be connected to the shaker and vibrated to an amplitude such that.

$f1.8\ Ymax > 1000$ mm/sec.

Where Ymax being the antinode displacement (mm) and f is the test frequency (Hz). The test frequency shall be greater than 24 Hz and the total number of cycles shall be more than 10 million.

(iii) Sub-span Oscillation Test

The test shall be conducted for oscillation in horizontal plane at frequency higher than 3 Hz for minimum one million cycles. The amplitude for oscillation shall be kept equivalent to an amplitude of 150 mm for a full sub-

span of 80m. Both the conductor shall be vibrated 180 deg. out of phase with the above minimum amplitude.

b) Clamp Slip Test

The spacer assembly shall be installed on test span of twin conductor bundle string at a tension corresponding to 25% of UTS of the conductor. In case of spacer for jumper, the clamp of sample shall be tightened with a specified tightening torque. One of the sample clamps, when subjected to a longitudinal pull parallel to the conductor axis for a minimum duration of one minute, shall not slip on the conductor i.e. the permanent displacement between the conductor and the clamp of the sample measured after removal of the load shall not exceed specified values. The minimum slip under longitudinal pull varies with clamp type according to the following table:

Clamp Type	**Longitudinal Load (kN)**	**Maximum Slip (mm)**
Metal-Metal bolted	6.5	1
Rubber loaded	2.5	2.5
Clamp using Preformed rods	2.5	12

c) Compressive and tensile test

This test shall be conducted on 3 (three) nos samples. The spacer assembly shall withstand ultimate compressive load of 14 kN and tensile load of 7.0 kN applied between sub-conductor bundle and held for one minute without failure. Line distance between clamps shall be recorded during each of the compression and tension test.
Measurement shall be recorded at (i) no load (ii) with load (iii) after release of load. The centre line distance under load shall be within ± 100 mm of the nominal design spacing. After release of load it shall be possible to retain the clamps at their original position using only slight hand pressure. There shall be no deformation or damage to the spacer assembly which would impair its function of maintaining the normal spacing.

d) Dynamic Characteristic Test (for Spacer Damper only)

The purpose of this test is to obtain quantitative information regarding the dynamic characteristics of the spacer damper. The values obtained during this test will serve as references to evaluate the behaviour of the same spacer damper under the fatigue test.

The test will consist in the application of sinusoidal movement of the spacer-damper articulation and measuring the force (F), displacement (X) and phase angle (Ø) between these two, from these values, the stiffness (K) and the damping factor (n) will be calculated.

$$K = \frac{F}{X} \times \text{Cos } Ø; \quad n = \text{Tan } Ø$$

The test frequency shall not be higher than 3 Hz. The test shall be performed at five different displacement amplitudes. The amplitudes shall be selected to reproduce 10, 20, 40, 60 and 90 percent of the maximum displacement permitted by the spacer-damper design.

The test shall be performed on three samples.

e) Fatigue Test (for Spacer Damper only)

The purpose of this test is to evaluate the capacity of the spacer damper to sustain without damage the cyclic movements which can be induced by vibrations.

The spacer damper articulation shall be subjected to cyclic motions for a total of 10 million cycles. The test frequency shall be between 2 and 3 Hz. The amplitude of motion shall be established on the following basis:

- the load applied on the spacer damper clamp shall not be less than ± 300 N.
- the clamp displacement under the applied load shall not be less than 60% of the maximum displacement permitted by the design.
- if the 300 N load generates movement exceeding the maximum permitted displacement, the load can be reduced to limit the movement to 95% of the maximum displacement.
- After the test, the sample shall be subjected to a second dynamic characteristic test. This test shall be performed at two amplitudes, 10% and 60% of the maximum displacement.
- The spacer damper shall show no signs of cracks or deterioration, loosening of bolts or abnormal wear.

  The dynamic characteristics (k and n) shall not be less than 60% of the values measured before the fatigue test. The test shall be performed on three samples.

f) Log Decrement test (for spacer damper only)

The spacer damper assembly shall be mounted on test span of conductor bundle at a tension of 0 deg. C & no wind and ruling span of 400 m. The test span shall be instrumented to continuously monitor and record the horizontal motion of the sub-conductor in the sub-span between suspension point and the first sample.

The log decrement test shall be made with initial peak to peak amplitude of four to six times the conductor diameter in the middle of the sub-span being considered. The conductor shall be excited in a horizontal one loop per sub-span resonant mode with a slow and steady build-up of amplitude that minimises harmonics and other distorsions. After achieving a steady state motion, the conductor excitation shall be

discontinued leaving the conductor undisturbed. The motion shall be recorded until it reduces to amplitude of half of the conductor diameter. The logarithmic (log) decrement shall be the value for a minimum reduction of 80 % in amplitude. The minimum acceptable log decrement average for five or more excitation shall be 0.04 based upon the following formula for decay.

$$\text{Log}_e \frac{A_n}{A_{n+1}} = \frac{1}{n} \text{Log}_e \frac{A_0}{A}$$

Where A0 is the initial amplitude and An is the amplitude 'n' cycles later

2.5 Magnetic Power Loss Test

The test shall be carried out as per clause no. 12 of IEC 61284 considering 50Hz AC of various magnitude (in steps of 50A) within ±200A of specified ampacity at designed maximum temperature of HTLS conductor. The average power loss of the sample shall be plotted for each value of current. The value of the loss corresponding to specified ampacity at designed maximum temperature of the HTLS conductor shall be read off from the graph and the same shall be limited to the value guaranteed by the supplier.

2.6 Thermal Profile test

The fitting/ accessories under the test shall be installed on conductor and current shall be passed through the conductor to achieve steady state conductor temperature corresponding to the designed maximum temperature of the offered HTLS conductor. Temperature achieved in different components of fittings/ accessories shall then be measured. The temperature of the components shall be below the specified maximum allowable temperature of the materials of those components. Maximum allowable temperature for aluminium/ aluminium alloy components shall be limited to 93 Deg C.

2.7 Ageing Test on Filler (if applicable)

The test shall be done in accordance with Grease drop point test method. The specimen should not drop as a droplet when kept at a temperature 40 deg. C above designed maximum operating temperature of the conductor for 30 minutes. The temperature shall then be increase till one droplet drops and the temperature recorded.

2.8 Corona Extinction Voltage Test (Dry)

The sample when subjected to power frequency voltage shall have a corona extinction voltage of not less than 320 kV rms line to ground under dry condition. There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IS 731:1971.

2.9 Radio Interference Voltage Test (Dry)

Under the conditions as specified under (2.5) above, the sample shall have a radio interference voltage level below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 305 kV rms line to ground under dry condition. The test procedure shall be in accordance with IS 8263.

2.10 Chemical Analysis Test

Chemical analysis of the material used for manufacture of items shall be conducted to check the conformity of the same with Technical Specification and approved drawing.

2.11 Galvanising/ Electroplating Test

The test shall be carried out as per Clause no. 9.4 of IS 2486 (Part-1) except that both uniformity of zinc coating and standard preece test shall be carried out and the results obtained shall satisfy the requirements of this specification.

3.0 Tests on All components (As applicable)

3.1 Chemical Analysis of Zinc used for Galvanizing

Samples taken from the zinc ingot shall be chemically analysed as per IS 209:1979. The purity of zinc shall not be less than 99.95%.

3.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognised procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Programme.

3.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic particle inspection for castings will be as per the internationally recognised procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Programme.

Annexure-B

Acceptance Tests

1. Mid Span Compression Joint

(a) Hardness Test

The Brinnel hardness at various points on the steel sleeve of HTLS conductor core and tension clamp shall be measured.

2. T-Connector

(a) Axial Tensile Load Test for Welded Portion

Same as clause 2.2 of Annexure-A.

3. Vibration Damper

(a) Verification of Resonance Frequencies

The damper shall be mounted on a shaker table and vibrate at damper clamp displacement of +/-0.5 mm to determine the resonance frequencies. The resonance shall be visually identified as the frequency at which damper mass vibrates with maximum displacement on itself. The resonance frequency thus identified shall be compared with the guaranteed value. A tolerance of ± 1 Hz at a frequency lower than 15 Hz and ± 2 Hz at a frequency higher than 15 Hz only shall be allowed.

(b) Clamp Slip Test

Same as Clause 2.4 (c) (ii) of Annexure - A.

(c) Strength of the Messenger Cable

The messenger cable shall be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. Alternatively, each strand of messenger cable may be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. In such a case, the 95% of yield strength of each wire shall be added to get the total strength of the cable. The load shall be not less than the value guaranteed by the Contractor

(d) Mass Pull off Test

Each mass shall be pulled off in turn by fixing the mass in one jaw and the clamp in the other of a suitable tensile testing machine. The longitudinal pull shall be applied gradually until the mass begins to pull out of the messenger cable. The pull off loads shall not be less than the value guaranteed by the Contractor.

(e) Dynamic Characteristics Test

The test will be performed as acceptance test with the procedure mentioned for type test with sampling mentioned below: -

(i) 1 Sample for 1 000 Nos. & below

(ii) 3 Samples for lot above 1 000 & up to 5000 nos.

(iii) Additional 1 sample for every additional 1500 pieces abov5000.

The acceptance criteria will be as follows

(i) The above dynamic characteristics curve for reactance & phase angle will be done for frequency range of 0.18/d Hz to 1.4/d Hz (where d is conductor diameter in meter).

(ii) If all the individual curves for dampers are within the envelope as already mentioned for type test for reactance & phase angle, the lot passes the test.

(iii) If individual results do not fall within the envelope, averaging of characteristics shall be done.

(a) Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.

(b) Similar averaging shall be done for phase angle.

(c) Average force Vs frequency and average phase Vs frequency curves shall be plotted on graph paper. Curves of best fit shall be drawn for the entire frequency range.

(d) The above curves shall be within the envelope specified.

4. Spacer/ Spacer Damper

(a) Test Set up

The test set up for the test described hereunder shall be as per clause 2.2 (a) of Annexure-A.

(b) Compressive and Tensile Test

The spacer assembly shall withstand ultimate compressive load of 14 kN and tensile load of 7.0 kN applied between sub-conductor bundle and held for one minute without failure. Line distance between clamps shall be recorded during each of the compression and tension test. Measurement shall be recorded at (i) no load (ii) with load (iii) after release of load. The centre line distance under load shall be within ± 100 mm of the nominal design spacing. After release of load it shall be possible to retain the clamps at their original position using only slight hand pressure. There shall be no deformation or damage to the spacer assembly which would in pair its function of maintaining the normal spacing.

(c) Clamp Slip Test

Same as clause 2.2(b) of Annexure-A.

(d) Hardness test for Elastomer

The shore hardness at different points on the elastomer surface of cushion grip clamp shall be measured by shore hardness meter. It shall lie between 65 to 80.

(e) UTS of Retaining Rods

The ultimate tensile strength of the retaining rods shall be measured.
The value shall not be less than 35 kg/mm2.