ODISHA POWER TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION

FOR

HTLS CONDUCTORS

&

HARDWARE FITTINGS, ACCESSOIREIS

INDEX

HTLS CONDUCTORS

1. GENERAL INFORMATION AND SCOPE

Scope

The scope of work inter-alia includes:

a. Design, manufacturing, testing & supply of High Temperature Low Sag (HTLS) conductor as well as required hardware fittings and accessories viz. suspension clamps, dead end clamps, mid-span compression joints, repair sleeves, T-Connectors, vibration dampers, etc.

b. The materials covered in this package 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 the 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 eligible for any extra charges for such fittings, etc.

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 use of tension stringing equipment. In such cases manual stringing along with other appropriate tools and equipment may be employed with the approval of Owner's site in charge.

d. Submission of complete technical details of the proposed HTLS conductor with relevant calculation along with the bid to adjudge the sufficiency of existing towers for carrying out the up-rating works. This shall be carried out in compliances / 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 & tension at various temperatures are included in the scope of the Bidder.

2. STANDARDS

The conductors & accessories shall comply in all respects to the clauses of this specification as indicated above & with the standards mentioned below.

Sl. No.	Indian Standard	Title	International Standard
1.	IS: 398-1982	Specification for Aluminium Conductors for Overhead Transmission Purposes	IEC:1089-1991 BS:215-1970
2.	IS : 1778-1980	Reels and Drums for Bare Conductors	BS:1559-1949
3.	IS : 8263-1990	Method of Radio Interference Tests on High Voltage Insulators	IEC:437-1973 NEMA:107-1964 CISPR
4.		Method of measurement of resistivity of metallic materials	IEC:468
5.		Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors	IEEE738
6.		Standard Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes	ASTM B609
7.		Standard Specification for Carbon Fiber Thermoset Polymer Matrix Composite Core (CFC) for use in Overhead Electrical Conductors	ASTM B987

3. DESIGN PARAMETERS

3.1 Technical Particulars of HTLS Conductor

The design and other parameters on which the up rating is to be planned are:

The HTLS conductor shall meet the following minimum requirements:

Particulars	**ACSR Moose Equivalent**	**ACSR Zebra Equivalent**	**ACSR Panther Equivalent**
Overall diameter of complete conductor	Overall diameter of the conductor should be 31.77 mm. Negative tolerance not allowed.	Overall diameter of the conductor should be 28.62 mm. Negative tolerance not allowed.	Overall diameter of the conductor should be 21 mm. Negative tolerance not allowed.
Approx. mass of complete conductor (kg/Km)	Less than or equal to 2004 kg/km	Less than or equal to 1621 kg/km	Less than or equal to 974kg/km
Direction of lay of outer layer	Right Hand	Right Hand	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 conductor at 20 deg C and AC resistance at the calculated temperature corresponding to 50Hz alternating current flow (of 1400A/1200A/800A as per case) at specified ambient conditions (maximum continuous operating temperature).

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

3.2 Climatic & Technical details: The climatic and system parameters are detailed below.

3.2.1 Climate details.

Location:- In the state of Orissa
Maximum ambient temperature= 50 ºC
Minimum ambient temperature=05 ºC
Every day temperature=32ºC
Maximum relative humidity=100%
Average rainfall per year=1150mm. Approx.
Isokeraunic level = 100 / year
Number of rainy days per year = 100 days
Altitude = Less than 350 Meters.

3.2.2 Current Carrying Capacity / Ampacity Requirements

Each HTLS conductor shall be suitable to carry minimum 50 Hz alternating current of **1400A/1200A/800A at 125ºC continuously for ACSR Moose/Zebra/Panther equivalent conductor**, respectively under the ambient conditions & maximum conductor sag specified below while satisfying other specified technical requirements/ parameters.

Ambiant température : 50 deg C
Solar Absorption coefficient : 0.8
Solar Radiation :1045 watt/sq.m
Emisitivity Constant : 0.45
Wind velocity : 0.6 m/sec (No wind condition)

Maximum Conductor sag for 400m/350m/300m span for 400KV/220KV/132KV at steady state conductor temperature and no wind corresponding to 50 Hz alternating current of 1400A/1200A/800A per conductor under ambient conditions specified above, shall be such that the statutory ground clearance is maintained throughout the route.

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 design of conductor shall be suitable for operation at a steady state conductor temperature experienced for AC current flow of 1400A/1200A/800A under the above ambient conditions based on ampacity calculations mentioned above. The bidder shall also indicate the maximum permissible conductor temperature for continuous operation without any deterioration of its electrical, mechanical & metallurgical properties. The

bidder shall also furnish the maximum permissible conductor temperature for short-term operations including permissible duration of such short-term operation.

3.2.3 Sag-Tension Requirements

The HTLS conductor shall meet the following sag tension requirements for ruling span of 400m/350m/300m for 400/220/132KV lines.

Particulars	**ACSR Moose/Zebra/Panther Equivalent**
Tension at every day condition (32°C, no wind)	Not exceeding 25% of UTS of proposed conductor
Tension at 32°C, full wind	Not exceeding 50% of UTS of proposed conductor
Tension at 5°C, 2/3 wind pressure	Not exceeding 50% of UTS of proposed conductor
Tension at 50°C ambient, continuous Full current condition and no wind	Not exceeding 25% of UTS of proposed conductor
Sag at continuous operating temp (corresponding to 1400A/1200A/800A and no wind) at all of the above conditions.	Shall be such that a ground clearance of at least 8.84/7.0/6.1m is maintained. The IE rule shall be binding.

Sag-Tension calculations at various conditions & ruling spans mentioned above using parabolic equations **and Wind Zone-5** shall be submitted along with the bid. These calculations shall also include calculations for determination of transition / knee point temperature.

The bidder shall also furnish sag & tensions under no wind for various temperatures starting from 0° C to maximum continuous operating temperature in steps of 5° C.

After award of the contract, the Supplier shall submit Sag-Tension calculations corresponding to various conditions given above for all the existing spans and spans ranging from 50 m to 500 m in intervals of 50 m.

Besides above, the Supplier shall also furnish details of creep characteristics in respect of HTLS conductor based on laboratory investigations/

experimentation (creep test as per IEE1138) conducted on similar type of conductor and shall indicate creep strain values corresponding to 1 month, 6 month, 1 year & 10 year creep at everyday tension & at maximum continuous operating temperature.

3.3 Workmanship

i) 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.
ii) 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.

3.4 Joints in wires

a) Aluminum Wires

During stranding no Aluminium welds shall be made for the purpose of achieving the required conductor length. No joints shall be permitted in the individual wires in the finished conductor.

b) Core

There shall be no joint of any kind in the finished core. Splicing of the carbon fiber is not allowed, fibers shall be fully continuous over the entire length of the core. During the production run, splicing of the galvanic protection barrier is allowed, provided diameter specifications are maintained.

3.5 Tolerances

Manufacturing tolerances on the dimensions to the extent of (+/-1%) one percent shall be permitted for individual strands and the complete conductor. For the carbon composite core, the tolerance shall be ±0.05mm as per ASTM B987.

3.6 Materials

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

a) Outer Layer

The material of outer layer of HTLS conductor shall be of fully annealed aluminium of 1350-O and its conductivity shall not be less than 61.8%

IACS. The test certificates in support of the conductivity and grade of aluminium shall be submitted by the bidder.

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 and also furnish description of the manufacturing process in the bid.

The fully annealed type (tempered) alluminium strands shall be trapezoidal only.

b) Core

The core shall be of carbon composite materials conforming to ASTM B987 and shall have properties conforming to the technical performance requirements of the finished conductor. Bidder shall furnish properties and composition of the core in the GTP schedule. The material for core shall be of such proven quality that its properties are not deteriorated in normal operating conditions as well as permissible short time (emergency) operating temperature condition of transmission line in tropical environment conditions as experienced by the existing lines. 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. Care to be taken for internal friction due to different material having different thermal co-efficient of expansion.

3.7 Conductor Length

After survey of the involved section of the line, the tower schedules, section lengths, special crossing etc. shall be finalized by the supplier/ shall be furnished to the supplier. The supplier shall determine the most appropriate individual conductor lengths to be manufactured & supplied keeping in view tower schedules, section lengths, special crossings etc. And the drum schedules shall be submitted to OPTCL for review & approval.

The standard length of the conductor shall be indicated in the guaranteed technical particulars (GTP) of offer. A tolerance of +/-5% on the standard length offered by the Bidder shall be permitted. All lengths outside this limit of tolerance shall be treated as random lengths.

The bidder shall also indicate the maximum single length of HTLS Conductor; he can manufacture in the guaranteed technical particulars of offer. Such

length of conductor may be required for special stretches like river crossing etc.

3.8 Verification of Conductor Length

The Owner 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.

3.9 STRANDING

For all, constructions, each alternate layer shall be stranded in opposite directions. The wires in each layer shall be evenly and closely stranded round the under laying wire or wires. The final layer of wires shall have a right hand lay.

4. EVALUATION OF OHMIC LOSSES & DIFFERENTIAL PRICE LOADING.

Based on the conductor parameters guaranteed by the bidders, average ohmic losses for different type of conductors offered by the bidders shall be calculated as per the following.

Average ohmic losses= Loss load factor X Line length X (Desired operating current i.e. 1400A/1200A/800A)^2 X AC resistance.(Considering loss load factor=0.53)

Where R_{ac} is the AC resistance per KM guaranteed by the bidder at temperature corresponding to the continuous operating current of 1400A/1200A/800A under normal condition.

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

Differential price evaluation for the conductors offered by the bidder shall be carried out considering the average Ohmic losses calculated as above and considering **Rs.1,65,110/- per KW.**

The best parameter of loss (Lowest Ohmic loss for conductor) corresponding to lowest AC resistance quoted among bidders by the technically responsive & qualified bidders shall be taken as basis & that quoted by the particular bidder shall be used to arrive at differential price to be applied for each bid.

4.1 Liquidated damage for excessive losses:-

On testing, if it is found that actual losses are more than the values, quoted in the bid, undisputed liquidated damages shall be recovered from the supplier at the following rates.

For each KW of excess loss **Rs.3, 30,220.00/ KW.**

For fractional Kilowatt, penalties shall be applied on pro-rata basis. ***No bonus shall be payable for loss, which are less than those, stated in the bid.***

5. TESTS AND INSPECTION

5.1 Type Tests

Type Tests on Stranded Conductor/ Stranded wire

The following Type Tests should have been conducted in last seven year for which offer is made. Any type test conducted beyond seven years shall not be accepted.

The following tests shall be conducted once on sample/samples of conductor from each manufacturing facility

a. On complete Conductor (Refer Annexure-A)	
i.	UTS Test on stranded conductor at room temperature and also at elevated temperature.
ii.	DC resistance test on stranded conductor
iii.	Stress-strain test on stranded conductor and core at room temperature (IEC 1089) and at elevated temperature.
iv.	High temperature endurance & creep test on stranded conductor
v.	Sheaves Test
vi.	Axial Impact Test
vii.	Crush Strength Test
viii.	Torsional Ductility Test

ix.	Aeolian vibration test
x.	Temperature cycle test
xi.	Radio interference voltage test (dry)[for 400KV]
xii.	Corona extinction voltage test (dry) [for 400KV]

b. On core	
i.	All Design validation Tests as per ASTM B987
ii	Coefficient of linear expansion on core
iii	Strand brittle fracture test

5.2 Acceptance Tests (Refer Annexure-A)

i.	Visual and dimensional check on drum
ii.	Visual check for joints scratches etc. and length measurement of conductor by rewinding
iii.	Dimensional check on core and Aluminium strands
iv.	Check for lay-ratios of various layers
v.	Torsion and Elongation tests on core
vi.	Breaking load test on core and Aluminium strands and DC Resistance test on Aluminium strand.
vii.	Wrap test on Aluminum strands (As per IEC:888 & IEC:889)
viii.	Minimum conductivity test on Aluminum strands (As per IEC:468)
ix.	For the core: The routine tests mentioned in ASTM B987

5.3 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 in Cl 5.2 above to be carried out on 10% of drums

5.4 Tests during Manufacture (Refer Annexure-A)

a)	Chemical analysis of Aluminium used for making Aluminium strands

5.5 Test Reports

a. Record of routine test reports shall be maintained by the Supplier at its works for periodic inspection by the Owner's representative.
b. Test Certificates of tests during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Owner.

5.6 Inspection

a. The Owner's representative shall at all times be entitled to have access to the works and all places of manufacture, where conductor/core 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. **All acceptance tests for core and conductor shall be witnessed by OPTCL.**
c. The Supplier shall keep the Owner informed in advance of the time of starting and of the progress of manufacture of conductor/core in its various stages so that arrangements can be made for inspection.
d. ***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 Owner in writing. In the latter case also the conductor/core shall be dispatched only after satisfactory testing for all tests specified herein have been completed.
e. 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 it such material is later found to be defective.

5.7 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.

6. PACKING

i. The conductor shall be supplied in non-returnable, strong, wooden/painted steel/hybrid (painted steel cum wood) 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 select suitable drums for supply of conductor and shall be responsible for any loss or damage to conductor and/or drum during transportation handling and storage due to improper selection of drum or packing.
ii. One protective sheet of waterproof material shall be provided over the drum barrel, inner flanges and over each layer of conductor in the drum to protect the conductor from scratch/damage due to overlapping and movement due to transportation/handling.
iii. The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5000 Kgf.
iv. The Bidder should submit their proposed drum drawings along with the bid.
v. 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.

7. Marking

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

b) Contract/Award letter number.

c) Name and address of consignee.
d) Manufacturer's name and address.
e) Drum number
f) Size of conductor
g) Length of conductor in meters
h) Arrow marking for unwinding
i) Position of the conductor ends
j) Distance between outer-most Layer of conductor and the inner surface of lagging.
k) Barrel diameter at three locations & an arrow marking at the location of the measurement.
l) Number of turns in the outer most layer.
m) Gross weight of drum after putting lagging.
n) Tear weight of the drum without lagging.
o) Net weight of the conductor in the drum.
p) Dispatch instruction.

The above should be indicated in the packing list also.

HARDWARE FITTINGS AND ACCESSORIES FOR HTLS CONDUCTORS

A. HARDWARE FITTINGS

Design of Hardware & accessories should be compatible with the supplied HTLS conductor and existing insulators & structures.

The maximum temperature rise of the hardware and accessories shall be restricted to 90^{0}C in any of the operating conditions including the emergency operating conditions. The manufacturer shall justify the design to OPTCL.

1. Technical Description of Hardware Fittings

a. 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.

The fittings shall be suitable for attachment to suspension and tension insulator strings along with hardware fittings and shall include 2.5 % extra fasteners and Aluminium filler plugs. 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 maximum temperature specified by them for the conductor.

b. 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.

c. Maintenance

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.

2. Components of hardware Fittings

a. Split Pins: Split pins shall be used with bolts & nuts.

b. Suspension Assembly

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

ii. The suspension assembly shall include either free centre type suspension clamp along with standard preformed armour rods or armour grip suspension clamp.

iii. 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.

iv. The suspension clamp suitable for various type of Conductor along with standard preformed armour rods/armour grip suspension clamp set shall have a slip strength between 20 to 29 KN.

v. The suspension clamp shall be designed for continuous operation at the temperature specified by the bidder for conductor.

vi. 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.

vii. The suspension assembly/clamp shall be designed so that it shall minimise 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.

viii. The magnetic power loss shall not be more than 4 watts per suspension clamp, at designed rated sub-conductor current of 800 amperes.

c. 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.

d. Standard Preformed Armour Rod Set

i. The Preformed Armour Rods Set shall be used to minimize 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 localized heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

ii. The preformed armour rods set shall have right hand lay and the inside diameter of the helics 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.

iii. 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.

iv. The length and diameter of each rod shall be specified in the GTP. The tolerance in length of the rods between the shortest and longest rod in complete set should be within the limits specified in relevant standards. The ends of armour rod shall be parrot billed.

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

vi. The armour rod shall not lose their resilience even after five applications.

vii. The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS).

e. Armour Grip Suspension Clamp

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

ii. Elastomer insert shall be resistant to the effects of temperature up to 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.

iii. The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength and shall not introduce unfavorable stress on the conductor under all operating conditions. However the length of AGS preformed rods shall not be less than 1760 $\pm$ 16 mm for HTLS Conductor.

f. Dead end Assembly

i. The dead end assembly shall be suitable for the proposed HTLS Conductor. The design of the tension hardware shall be such that *uniform pressure is applied to the core as well as conductor to avoid any kind of damage to the core or deformation of the conductor itself.*

ii. 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 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 I^2R losses. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

iii. Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions and shall bear the words 'COMPRESS 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. Tapered aluminium filler plugs shall also be provided at the line of demarcation between compression & non-compression zone. 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 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.

iv. The tension hardware fitting shall have two contact pads (1 normal+ 1 spare) for connection of jumpers. Each pad shall be designed to carry maximum load current as per conductor rating.

v. 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.

g. Fasteners : Bolts, Nuts and Washers

i. All bolts and nuts shall conform to IS 6639. All bolts and nuts shall be galvanized 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.

ii. Bolts up to M16 and having length up to 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.

iii. 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 up to M16.

iv. Fully threaded bolts shall not be used. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts.

v. 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.

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

vii. The Contractor shall furnish bolt schedules giving thickness of components connected, nuts, washer, length of shank, threaded portion of bolts, size of holes and any other special details of this nature.

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

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

x. 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-.14000 services Quality System standard.

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

3. 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 fittings stating clearly the class, grade or alloy designation of the material, manufacturing process & heat treatment details and the reference standards.

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

4. Workmanship

i. 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 132 kV transmission lines and will give continued good performance.

ii. High current, heat rise test shall be conducted by the supplier to determine the maximum temperature achieved in different components of fittings under simulated service condition corresponding to continuous operation of conductor at rated maximum temperature. The material of the components should be suitable for continued good performance corresponding to these maximum temperatures. The supplier shall submit relevant type/performance test certificates as per applicable standards/product specifications to confirm suitability of the offered material.

iii. 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.

iv. All ferrous parts including fasteners shall be hot dip galvanized, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanizing and the threads oiled. Spring washers shall be electro galvanized. The bolt threads shall be undercut to take care of the increase in diameter due to galvanizing. Galvanizing 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 galvanized materials shall have a minimum average coating of zinc equivalent to 600 gm/sq.m. shall be guaranteed to withstand at least six successive dips each lasting one minute under the standard preece test for galvanizing.

v. 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 galvanizing shall be grade Zn 99.95 as per IS:209.

vi. 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.

vii. All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum.

viii. 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.

ix. 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.

x. All fasteners shall have suitable corona free locking arrangement to guard against vibration loosening.

xi. Welding of aluminium shall be by inert gas shielded tungsten 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.

5. Bid Drawings

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

Fully dimensioned drawings of the hardware and their component parts shall be furnished in three (3) copies 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:

a. Dimensions and dimensional tolerance.
b. Material, fabrication details including any weld details & any specified finishes & coatings. Regarding material designation & reference of standards are to be indicated.
c. Catalogue No.
d. Marking
e. Weight of assembly
f. Installation instructions
g. Design installation torque for the bolt or cap screw.
h. Withstand torque that may be applied to the bolt or cap screw without failure of component parts.
i. The compression die number with recommended compression pressure.
j. All other relevant terminal details.

After placement of award, the Contractor shall submit fully dimensioned drawing including all the components in three (3) copies to the Owner for approval. After getting approval from the Owner and successful completion of all the type tests, the Contractor shall submit ten (10) more copies of the same drawings to the Owner for further distribution and field use at Owner'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 302 or 304-L/ IS-1385	
2.	Arcing Horn	Mild Steel Rod/ Tube Type	Hot dip galvanised	As per IS-226 or IS-2062	
3.	Ball Fittings, Socket, all shackles links cleves	Class-IV Steel	Drop forged & normalized Hot dip galvanised	As per IS: 2004	
4.	Yoke Plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
5.	Sag Adjustment plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
6(a).	Corona Control ring/ Grading ring	High Strength Al. Alloy tube (6061/ 6063/1100 type or 65032/ 63400 Type)	Heat treated Hot dip galvanized	ASTM-B429 or as per IS	Mechanical strength of welded joint shall not be less than 20 KN

6(b).	Supporting Brackets & Mounting Bolts	High Strength Al Alloy 7061/ 6063/ 65032/63400 Type) or Mild Steel	Heat treated Hot dip galvanized	ASTM-B429 or as per IS:226 or IS:2062	
7(a).	Dead End Assembly: Outer Sleeve	EC grade Al of purity not less than 99.50%			
7(b).	Steel Sleeve	Mild Steel	Hot Dip Galvanised	IS:226/ IS-2062	

Note : Alternate materials conforming to other 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 viz a viz specified in the bid or else the bids are liable to be rejected.

B. ACCESSORIES FOR THE HTLS CONDUCTOR

1. General

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

2.5% extra fasteners, filler plugs and retaining rods shall be provided.

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

2. Accessories

a. Mid Span Compression Joint

Mid Span Compression Joint shall be used for joining two lengths of conductor. The design of the tension hardware shall be such that *uniform pressure is applied to the core as well as conductor to avoid any kind of damage to the core or deformation of the conductor itself.*

The joint shall have a resistively less than 75% of the resistivity 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. It must be able to withstand the continuous design temperature of conductor.

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.

b. Connector

Connector of compression type shall be used for jumper connection at tension 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 connector shall have a resistivity across jumper less than 75% resistivity of equivalent length of conductor. The 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 connector should be kept at an angle of 15 deg. from vertical and horizontal plane of the conductor in

order to minimize jumper pull at the welded portion. The dimensions of connector along with tolerances shall be 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.

c. 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 continuous 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 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.

d. Vibration Damper

i. 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 along with bundle spacers to damp out Aeolian vibration as well as sub- span oscillations,. One damper minimum on each side per sub-conductor for suspension points and two dampers minimum on each side per sub-conductor for tension points has been used.

ii. The bidder shall offer damping system including Stockbridge type dampers and bundle spacers for HTLS conductor for its protection from wind induced vibrations which could cause conductor fatigue /strand breakage near a hardware attachment, such as suspension clamps. Alternate damping systems with proven design offering equivalent or better performance also shall be accepted provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents including type test reports to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid.

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 a wide frequency range (depending upon conductor dia) or wind velocity range specified above. 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. The bidder shall clearly indicate the method for evaluating performance of dampers including analytical and laboratory test methods. The bidder shall indicate the type tests to evaluate the performance of offered damping system.

iii. The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or 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.

iv. The messenger cable shall be made of high strength galvanized steel/stain less steel with a minimum strength of 135 kg/sq.mm. 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 messenger cable other than stainless steel shall be hot dip galvanized in accordance with the recommendations of IS: 4826 for heavily coated wires.

v. The damper mass shall be made of hot dip galvanized 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.

vi. 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.

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

viii. The vibration damper shall be capable of being installed and removed from energized 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.

ix. 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.

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

Sl. No.	**Description**	**Technical particulars**
1.	Span length in meters	400KV/220KV/132KV
i)	Ruling design span	400/350/300 meters
ii)	Maximum span	600/525/400 meters
iii)	Minimum span	100/100/50 meters
2.	Configuration	Double / Single Circuit conductor per phase in vertical configuration.

3.	Armour rods used	Standard preformed armour rods/AGS
4.	Maximum permissible dynamic strain i.e. endurance limit.	+/- 150 micro strains

xi. The damper placement chart shall be submitted for spans ranging from 50 m to 600/525/400 m. Placement charts should be duly supported with relevant technical documents and sample calculations.

xii. 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 center type/Armour grip type etc.)

(4) The influence of mid span compression joints, repair sleeves & armour rods (standard & AGS) in the placement of dampers.

e. Material and Workmanship

i. 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 the required transmission line (KV) application with HTLS conductors and will give continued good performance at all service conditions.

ii. 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.

iii. High current, heat rise test shall be conducted by the supplier to determine the maximum temperature achieved in different components of fittings under simulated service condition corresponding to continuous operation of conductor at rated

maximum temperature. The material of the components should be suitable for continued good performance corresponding to these maximum temperatures. The supplier shall submit relevant type/ performance test certificates as per applicable standards/product specifications to confirm suitability of the offered material.

iv. All ferrous parts shall be hot dip galvanized, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanizing and the threads oiled. Spring washers shall be electro galvanized as per grade 4 of IS-1573. The bolt threads shall be undercut to take care of increase in diameter due to galvanizing. Galvanizing 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 galvanized materials shall have a minimum average coating of Zinc equivalent to 600 gm/sq. and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanizing unless otherwise specified.

v. 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 galvanizing shall be of grade Zn 99.95 as per IS: 209.

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

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

viii. 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.

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

x. The fasteners shall conform to the requirements of IS: 6639-1972. All fasteners and clamps shall have corona free locking arrangement to guard against vibration loosening.

f. 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.

3. Bid Drawings

The Bidder shall furnish detailed dimensioned drawings of the equipment 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.

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
(xi) Placement charts for spacer/spacer damper and damper

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 three copies

to the Owner for approval. After Owner's approval and successful completion of all type tests, more sets (as per OPTCL requirement) of drawings shall be submitted to Owner for further distribution and field use at Owner's end.

B. Tests and Standard

<u>Type Tests</u> (Type tests should have been completed during last seven years)

Type tests conducted beyond seven years shall not be accepted.

a. On Suspension Clamp
- i. Magnetic power loss test
- ii. Clamp slip strength vs torque test
- iii. Ozone test on elastomer

b. On dead end Tension assembly
- i. Electrical resistance test for dead end Assembly
- ii. Heating cycle test for dead end Assembly
- iii. Slip strength test for dead end assembly
- iv. Ageing test on filler (if applicable)

c. Mid span compression joint for HTLS conductor
- i. Chemical analysis of materials
- ii. Electrical resistance test
- iii. Heating cycle test
- iv. Slip strength test
- v. Corona extinction voltage test (dry)
- vi. Radio interference voltage test (dry)

d. Repair Sleeve for Conductor
- i. Chemical analysis of materials
- ii. Corona extinction voltage test (dry)
- iii. Radio interference voltage test (dry)

e. Connector for Conductor
- i. Chemical analysis of materials
- ii. Electrical resistance test
- iii. Heating cycle test
- iv. Axial tensile load test on welded portion
- v. Corona extinction voltage test (dry)
- vi. Radio interference voltage test (dry)

f. Vibration Damper for Conductor
- i. Chemical analysis of materials
- ii. Dynamic characteristics test*
- iii. Vibration analysis
- iv. Clamp slip test

v. Fatigue tests
vi. Magnetic power loss test
vii. Corona extinction voltage test (dry)
viii. Radio interference voltage test (dry)
ix. Damper efficiency test

* Applicable for 4 R stock bridge 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.

Acceptance Tests

a. On both Suspension Clamp and Tension Assembly
   i. Visual Examination
   ii. Verification of dimensions
   iii. Galvanizing/Electroplating test
   iv. Mechanical strength test of each component
   v. Mechanical Strength test of welded joint
   vi. Chemical analysis, hardness tests, grain size, inclusion rating & magnetic particle inspection for forgings/castings
b. **On Suspension Clamp only**
   i. Clamp Slip strength vs. Torque test for suspension clamp
   ii. Shore hardness test of elastomer cushion for AG suspension clamp
   iii. Bend test for armour rod set
   iv. Resilience test for armour rod set
   v. Conductivity test for armour rods set
c. **On Tension Hardware Fittings only**
   i. Slip strength test for dead end assembly
   ii. Ageing test on filler (if applicable)
d. **On Mid Span Compression Joint for Conductor**
   i. Visual examination and dimensional verification
   ii. Galvanizing test
   iii. Hardness test
   iv. Ageing test on filler (if applicable)
e. **Connector for Conductor**
   i. Visual examination and dimensional verification
   ii. Axial tensile load test for welded portion
f. **Repair Sleeve for Conductor**
   i. Visual examination and dimensional verification
g. **Vibration Damper for Conductor**
   i. Visual examination and dimensional verification

ii. Galvanizing test
    a. On damper masses
    b. On messenger cable
iii. Verification of resonance frequencies
iv. Clamp slip test
v. Clamp bolt torque test
vi. Strength of the messenger cable
vii. Mass pull off test
viii. Dynamic characteristics test

C. Co-ordination for testing

The Contractors shall have to co-ordinate testing of their hardware fittings with insulators to be supplied by other Supplier to the *Owner* and shall have to also guarantee overall satisfactory performance of the hardware fittings with the insulators.

D. Inspection

i. The Owner'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 material manufacturers of all the material and for conducting necessary tests as detailed herein.

ii. 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.

iii. The Contractor shall keep the Owner 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.

iv. 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 Owner in writing. In the latter case also the material shall be dispatched only after all tests specified herein have been satisfactorily completed.

v. 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 material are later found to be defective.

E. Packing and Marking

i. 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.

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

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

iv. 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.

v. Each component part shall be legibly and indelibly marked with trade mark of the manufacturer and year of manufacture.

vi. 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.

F. Standards

The Hardware fittings; conductor and earth wire 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.

In the event of the supply of hardware fittings; conductor and earth wire 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: 209-1992	Specification for zinc	BS:3436-1986
2.	IS 1573	Electroplated Coating of Zinc on iron and Steel	

3.	IS : 2121 (Part-II)	Specification for Conductor and Earth wire Accessories for Overhead Power lines: Mid-span Joints and Repair Sleeves for Conductors	
4.	IS:2486 (Part-I)	Specification for Insulator Fittings for Overhead power Lines with Nominal Voltage greater than 1000 V: General Requirements and Tests	
5.	IS:2629	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
6.	IS:2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
7.		Ozone test on Elastomer	ASTM- D1 171
8.		Tests on insulators of Ceramic material or glass for overhead lines with a nominal voltage greater than 1000V	IEC:383-1993
9.	IS:4826	Galvanized Coating on Round Steel Wires	ASTM A472729 BS:443-1969
10.	IS:6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433 ISO : 1460 (E)
11.	IS:8263	Method of Radio Interference Tests on High Voltage Insulators	IEC:437 NEMA:107 CISPR
12.	IS:6639	Hexagonal Bolts for Steel Structures	ISO/R-272
13.	IS:9708	Specification for Stock Bridge Vibration Dampers for Overhead Power Lines	
14.	IS:10162	Specification for Spacers Dampers for Twin Horizontal Bundle Conductors	

GUARANTEED TECHNICAL PARTICULARS

The bidder shall fill in the guaranteed technical particulars in the Performa below and submit the same with his tender, without which bid will not be considered.

GUARANTEED TECHNICAL PARTICULARS OF HTLS CONDUCTOR

Sl No	Description	Unit	Value guaranteed by Bidder
1	Name of Manufacturer		
2	Address of Manufacturer		
3	Name of the conductor		
4	Construction of conductor/ Designation of conductor as per IEC:61089		
5	Particulars of Raw Material		
5.1	Outer Layers		
a	Type of conductor strand.		
b	Chemical composition of Conductor strand i. _____ ii. _____ iii. _____ iv. _____ v. _____ …	 % % % % %	
5.2	Inner Core		
a	Material of core		
b	Chemical composition of Core i. _____ ii. _____ iii. _____ iv. _____ v. _____ …	 % % % % %	
6	Outer Aluminium Strands after stranding		

6.1	Number of outer layers	Nos	
6.2	Diameter		
a	Nominal	mm	
b	Maximum	mm	
c	Minimum	mm	
6.3	Minimum Breaking load of strand		
a	Before stranding	KN	
b	After stranding	KN	
6.4	Resistance of 1m length of strand at 20 deg. C.	Ohm	
6.5	Modulus of elasticity		
a	At 32°C	kg/mm^2	
b	Below Knee point	kg/mm^2	
c	Above Knee point	kg/mm^2	
d	At maximum operating tempt.	kg/mm^2	
6.6	Co-efficient of linear expansion		
a	At 32°C	/ °C	
b	Below Knee point	/ °C	
c	Above Knee point	/ °C	
d	At maximum operating tempt.	/ °C	
7	Inner core strands/inner core after stranding		
7.1	Number of layers in inner core	Nos	
7.2	Diameter		
a	Nominal	mm	

b	Maximum	mm	
c	Minimum	mm	
7.3	Minimum Breaking load of strand		
a	Before stranding	KN	
b	After stranding	KN	
7.4	Min. no. of twists which a single strand shall withstand during torsion test for a length equal to 100times dia of wire after stranding.	Nos	
7.5	Modulus of elasticity		
a	At 32°C	kg/mm^2	
b	Below Knee point	kg/mm^2	
c	Above Knee point	kg/mm^2	
d	At maximum operating tempt.	kg/mm^2	
7.6	Co-efficient of linear expansion		
a	At 32°C	/ °C	
b	Below Knee point	/ °C	
c	Above Knee point	/ °C	
d	At maximum operating tempt.	/ °C	
8	Complete Conductor		
8.1	Diameter		
a	Nominal	mm	
b	Maximum	mm	
c	Minimum	mm	
8.2	Area of conductor		
a	Total cross sectional area		

b	Effective aluminium area		
c	Effective core area		
8.3	Modulus of elasticity		
a	At 32°C	kg/mm^2	
b	Below Knee point	kg/mm^2	
c	Above Knee point	kg/mm^2	
d	At maximum operating tempt.	kg/mm^2	
8.4	Co-efficient of linear expansion		
a	At 32°C	/ °C	
b	Below Knee point	/ °C	
c	Above Knee point	/ °C	
d	At maximum operating tempt.	/ °C	
8.5	UTS of conductor	KN	
8.6	Lay ratio of conductor		
a	1st Layer (Outermost Layer) (Max/Min)		
b	2nd Layer (Max/Min)		
c	3rd Layer (Max/Min)		
d	4th Layer (Max/Min)		
8.7	Maximum permissible conductor temperature for continuous operation	^{0}C	
8.8	Maximum permissible conductor temperature for short term operation	^{0}C	
8.9	Permissible duration of above short term operation	Hr/year	
8.10	Steady state conductor temperature at conductor current of min.1400/1200/800 A at 50ºC ambient conditions & zero wind	^{0}C	
8.11	DC resistance of conductor at 20ºC	Ohm/Km	

8.12	AC resistance at maximum continuous operating temperature corresponding to specified maximum operating current (Minimum 1400/1200/800 A under maximum ambient conditions and zero wind	Ohm/Km	
8.13	Conductivity of Aluminium	% IACS	
8.14	Details of Creep characteristic for conductor submitted (as per Technical Specification)	Yes/No	
8.15	Sag Tension Calculation		
a	Sag Tension Calculation enclosed	Yes/No	
b	Sag & tension at 32 deg. C & no wind	Mtrs & KN	
c	Sag & tension at 32 deg. C & full wind	Mtrs & KN	
e	Sag & tension at 05 deg. C & 2/3rd wind	Mtrs & KN	
f	Sag & tension at 65 deg. C & no wind	Mtrs & KN	
g	Sag & tension at continuous current 1400/1200/800A. C & no wind. (The corresponding temperature to be mentioned)	Mtrs & KN	
h	Sag & tension at maximum operating temperature & no wind	Mtrs & KN	
i	Sag & tension at emergency temperature & no wind	Mtrs & KN	
8.16	Standard length of conductor	KM	
8.17	Maximum length of conductor that can be offered as single length	KM	
8.18	Tolerance on standard length of conductor	%	
8.19	Direction of lay for outside layer		
8.20	Linear mass of the Conductor		
A	Standard	Kg/Km	
B	Minimum	Kg/Km	
C	Maximum	Kg/Km	

9	Drum is as per specification	Yes/No	
10	Accessories as per specification/standards	Yes/No	
11	Submission of List of Type Tests conducted on conductor And hardware & accessories as per the format attached in Annexure-D	Yes/No	

Date: (Signature).....
Place: (Printed Name).....
(Designation).....
(Company Seal).....

ANNEXURE-A

Tests on Conductor

1. UTS Test on Stranded Conductor

a. 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 5 m length between fixing arrangement suitably fixed by appropriate fittings on a tensile testing machine. The load shall be increased at a steady rate up to 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.

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

b. UTS Test on Stranded Conductor at elevated temperature

UTS Test on Stranded Conductor shall be conducted as per clause no. 1(a) specified above keeping conductor temperature at the designed maximum temperature.

2. **D.C. 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 meter and subsequently one meter 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 20^0C as per IS:398-(Part-IV)/(Part-V). The resistance corrected at 20^0C shall conform to the requirements of this Specification.

3. **Stress-strain test at elevated temperature**

Stress-strain test as per IEC-1089 shall be conducted keeping conductor temperature at designed maximum temperature. Rated Tensile strength for this test shall be 70% of the UTS guaranteed in GTP.

4. High Temperature endurance & creep test

Two 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 samples shall be subjected to tests as indicated below:

On one of the conductor samples, the conductor temperature shall be maintained at 20 deg 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 up to 1000 hours time period.

On other conductor sample, the conductor temperature shall be increased to design maximum temperature in steps of 20 deg. C and thermal elongation of the conductor sample shall be measured & recorded at each step. The temperature shall be held at each step for sufficient duration for stabilization of temperature. Further, the temperature of the conductor shall be maintained at designed maximum temperature (+10 Deg. C) for 1000 hours. The elongation/creep strain of the conductor during this period shall be measured and recorded at end of 1hour, 10hour, 100hour and subsequently every100 hour up to 1000 hours' time period. After completion of the above, the core of the conductor sample shall be subjected to UTS test as mentioned above at clause 1-(a) of Annexure-A, above. The conductor core shall withstand a load equivalent to 95 % of UTS. In case of polymer composite core conductor, the flexural strength & glass transition temperature of the core shall also be evaluated and the same shall not be degraded by more than 10 % over the value guaranteed in GTP. The supplier shall plot the thermal elongation with temperature.

The supplier shall furnish details of creep characteristic in respect of the conductor based on laboratory test and other laboratory investigations/ experimental conducted on similar type of conductor and shall indicate creep strain values corresponding to 1 month, 6-month, 1 year, 10 year & 20 year creep at everyday tension & designed maximum temperature as well as room temperature.

5. Sheaves Test

The conductor sample of minimum length of 35 meter shall be tensioned at 25 % of the UTS and shall be passed through pulleys having diameter of 32 times that of the conductor with angle of 20 deg. between the pulleys. The conductor shall be passed over the pulleys 36 times a speed of 2 m/sec. After this test UTS test on the conductor shall be carried out as mentioned above at clause 1-(a). In case of polymer composite core conductors, the core shall be inspected for any sign of damage or cracking through dye penetration test as per ASTM B987 and relevant standards.

6. Axial Impact Test

The conductor sample shall be suspended vertically and load applied by dropping a 650 kgs from an elevation of 4 meters above the sample. The impact velocity shall not be less than8 m/sec. with HTLS Conductor &Hardware initial pre-tension of 200 kgs. The curve for load vs time shall be recorded and recorded load of failure for core shall not be less than UTS of core.

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 shall be subsequently disassembled and tensile tested. Core shall exhibit full strength retention.

8. Torsional Ductility Test

The conductor sample of at least 1500 time the core dia shall be loaded to 20% of UTS and then rotated in increasing steps of +/-180 deg. The entire conductor shall withstand at least 16 such rotation and there shall not be any damage to Aluminium 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 up to 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 (anti node) 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 at the anti node 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 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: -

- 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 + 2.5 deg. C for 5 minutes.

- After the above mentioned 100 cycle, Mechanical tension shall be increased up 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 is applied at the end of the test.

Conductor strength has to be higher than 95 % UTS.

- In case of polymer composites, the flexural strength should not degrade by more than 10 % of value guaranteed in GTP and the Glass Transition temperature shall not degrade by more than 10% of value guaranteed in GTP after thermal cycling. Flexural strength shall be obtained on the basis of test procedure indicated below.

11. Corona Extinction Voltage Test [for 400kV]

For 220KV, one sample of conductor of 5m length shall be strung. In case of 400KV, two samples of conductor of minimum 5 m length each shall be strung in horizontal twin bundle configuration with spacing of 450 mm between sub-conductors at a height not exceeding 8.84m above ground. The twin bundle assembly when subjected to 50 hz power frequency voltage shall have a corona extinction voltage of not less than 320 kV (rms) line to ground under dry condition for 220KV/400KV system respectively. 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 voltage should be corrected for standard atmospheric conditions.

12. Radio Interference Voltage Test [for 400kV]

Under the conditions as specified under (1.2) above, the conductor samples shall have radio interference voltage level below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 305 kV line to ground under dry conditions for 220KV/400KV system respectively. This test may be carried out with corona control rings and arcing horns.

13. Visual and Dimensional Check on Drums

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

14. Visual Check for Joints, Scratches etc.

Conductor drums shall be rewound in the presence of the Owner. The Owner 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 Owner's representative.

15. Dimensional Check on Core and Aluminium Strands

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this Specification.

16. 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.

17. Torsion and Elongation Tests on Core

The test procedures for Torsion and Elongation Tests on Core shall be as per clause No. 6.3.3 and 6.3.2 b) of IEC 61232 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. A sample length that is 170 times the diameter of the composite core being tested is mounted in the gripping fixtures. 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.

18. Breaking load test on Aluminium & Core and D.C Resistance test on Aluminium wire

The above tests shall be carried out as per IEC: 888/889 and the results shall meet the requirements of the specification.

For composite core, the test shall be carried out as per ASTM B987.

19. Wrap test on Aluminium strand

The wrap test on Aluminium strands shall be meeting the requirements of IEC: 888. The strands shall be wrapped around a mandrel of diameter of five times that of the strand to form a helix of eight turns. The strand shall be unwrapped. No breakage of strand shall occur.

26. **Chemical Analysis of Aluminium**

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

27. Bending test on polymer composite core (Acceptance test):

Bending test on polymer composite core (CFC) shall be performed as per ASTM B987/B987M-20 on polymer 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 CFC – 60 times the diameter of CFC
2) For Extra high strength grade CFC – 70 times the diameter of CFC

Annexure-B

1.0 Tests on Hardware Fittings

a. Magnetic Power Loss Test for Suspension Assembly

Two hollow aluminium tubes of 32 mm diameter for the conductor shall be placed 450 mm (for 400KV) apart respectively. An alternating current over the range of 1200 to 1800 amps shall be passed through each tube. For 220KV & 132KV, one tube of appropriate dia shall be used and required AC current shall be passed through it. The reading of the wattmeter with and without suspension assemblies along with line side yoke plate, clevis eye shall be recorded. Not less than three suspension assemblies shall be tested. The average power loss for suspension assembly shall be plotted for each value of current. The value of the loss corresponding to the applied current at the steady state conductor temperature shall be read off from the graph and the same shall not be more than the value guaranteed by the supplier.

b. Galvanizing/Electroplating Test

The test shall be carried out as per Clause no. 5.9 of IS: 2486-(Part-1) except that both uniformity of zinc coating and standard preecee test shall be carried out and the results obtained shall satisfy the requirements of this specification.

c. 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.

d. Mechanical Strength Test of Welded Joint

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

e. Clamp Slip Strength Vs Torque Test for Suspension Clamp

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length of conductor shall be fixed in the clamp. The clamp slip strength at various tightening torques shall be obtained by gradually applying the load at one end of the conductor. The Clamp slip strength vs torque curve shall be drawn. The above procedure is applicable only for free centre type suspension clamp. For AG suspension clamp only clamp slip strength after assembly shall be found out. The clamp slip strength at the recommended tightening torque shall be as indicated in the GTP.

f. 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 no to exceed the maximum use temperature of the conductor.

ii) Number of cycle: 100

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

g. 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/earth wire and retained for one minute at this load.

h. Ageing Test on Filler (if applicable)

The test shall be done in accordance with Grease drop point test method. The specimen should be 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.

i. 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.

j. 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.

k. 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 recognized 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 program.

l. Ozone Test for Elastomer

This test shall be performed in accordance with ASTM D-1171 by the Ozone chamber exposure method (method B). The test duration shall be 500 hours and the ozone concentration 50 PPHM. At the test completion, there shall be no visible crack under a 2 x magnification.

2.0 Tests on Accessories for Conductor

a. Mid Span Compression Joint for Conductor and Earth wire

(ii) Slip Strength Test

The fitting compressed on conductor shall not be less than one meter in length. The test shall be carried out as per IS:2121 (Part-ii)-1981 clause 6-4 except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor/earth wire and retained for one minute at this load. There shall be no movement of the conductor/ earth wire relative to the fittings and no failure of the fit tings during this one minute period.

(iii) Heating Cycle Test

Heating cycle test shall be performed in accordance with IS 2121 (Part-II-1981) with following modifications:-

a. Temperature of conductor during each cycle: 40 deg. C above designed maximum operating temperature of the conductor.
b. Number of cycle: 100

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

b. Connector for Conductor

Axial Tensile Load Test for Welded Portion

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.

c. Vibration damper for conductor.
(i) 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 to 1.4/d where d is the conductor diameter in meters. The damper assembly shall be vibrated vertically with a + 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at ± 0.5mm 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 damper 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 0.191 f to 0.762 f Kgf/mm limits where f is frequency in Hz.
(iv) The above mean phase angle response curve shall be between 25^{0} to 130^{0} 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 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 taken into account for the purpose of analysis:

i. The analysis shall be done for single conductor without armour rods as per the parameters given in the Specification. The tension shall be taken from Sag & Tension calculation (0 deg. C & no wind condition and ruling span) for a span ranging from 100 m to 600 m.
ii. The self-damping factor and flexural stiffness (El) for 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 point 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.

d. 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 0 deg & no wind condition and ruling span 400 from sag –tension calculation 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 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.

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

II. 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.

III. 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.

e. Spacer/ Spacer Damper

(i) Vibration Tests

The test set up shall be as per Clause No. 2-(d)-(i) of Annexure-B. The spacer/spacer damper assembly shall be clamped to conductor. During the vibration tests the axis of the clamp of sample shall be maintained parallel to its initial static position by applying a tension (Tension form sag-tension calculation at minimum temperature & no wind condition and 400 m ruling

span). 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 2.4 (b) below:

(ii) 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.

(iii) 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

$f^{1.8}Y_{max} > 1000$ mm/sec.

Where Y_{max} 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.

(iv) 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.

(v) Clamp Slip Test

The spacer assembly shall be installed on test span of twin conductor bundle string at a tension of tension at 0 deg. C & No wind. 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

(vi) 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.

(vii) 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.

$K = -F/X - \text{Cos } Ø$; $n = \text{Tan } Ø$

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.

(viii) 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 :

I. The load applied on the spacer damper clamp shall not be less than ± 300 N.

II. The clamp displacement under the applied load shall not be less than 60% of the maximum displacement permitted by the design.

III. 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.

IV. 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.

V. 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.

(i) Ozone Test

The test shall be performed in accordance with ASTM D-1171 by the ozone chamber exposure method (method B). The test duration shall be 500 hours and the ozone concentration 50 PPHM. At the test completion, there shall be no visible crack under a 2xmagnification.

(j) 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 and 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 fist sample. The log decrement test shall be made with an 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 l per sub-span resonant mode with a slow and steady build up of amplitude that minimizes harmonics and other distortions. 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 an 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.

$$\text{Log}_e\ (A_n/A_{n+1}) = (1/n)\ \text{Log}_e\ (A_0/A)$$

Where A0 is the initial amplitude and Anis the amplitude 'n' cycles later.

(k) Magnetic Power Loss Test for Spacer

The sample involving ferrous parts shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave. The test should be carried out at various currents ranging from 1200 to 1800 amperes per sub-conductor (for 400kV) the magnetic power loss at various currents should be specified in tabulated graphical form. The difference between the power losses without and with sample at room temperature shall be limited to value guaranteed by the supplier for rated current (rms) at steady state conductor temperature. The losses shall be determined by averaging the observations obtained from at least four samples.

(l) Corona Extinction Voltage Test (Dry) [for 400kV]

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.

(m) Radio Interference Voltage Test (Dry) [for 400kV]

Under the conditions as specified under (3.8) 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.

(n) 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.

3.0 Tests on All components (As applicable)

a. 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%.

b. Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized 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 Owner in Quality Assurance Program.

c. Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic particle inspection for castings will be as per the internationally recognized 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 Owner in Quality Assurance Program.

ANNEXURE-C

Acceptance Tests

1 Mid Span Compression Joint for Conductor

(a) Hardness Test

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

2. Connector for Conductor

(a) Axial Tensile Load Test for Welded Portion
Same as clause 2(b) of Annexure - B.

3. Vibration Damper for Conductor

(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(d) (ii) of Annexure - B.

(c) Clamp Bolt Torque Test

The clamp shall be attached to a section of the conductor/earth wire. A torque of 150 percent of the manufacturer's specified torque shall be applied to the bolt. There shall be no failure of component parts. The test set up is as described in Clause 2(d)(i), Annexure-B.

(d) 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

(e) 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.

(f) Dynamic Characteristics Test

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

Vibration Damper :

- 1 Sample for lot of 1000 Nos. & below
- Samples for lot above 1000 & up to 5000 nos.
- Additional 1 sample for every additional 1500 pieces above 5000.

The acceptance criteria will be as follows:

i. The above dynamic characteristics curve for reactance & phase angle will be done for frequency range of 5 Hz to 40 Hz.
ii. If all the individual curve 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.
iv. Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.
v. Similar averaging shall be done for phase angle.
vi. 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.
vii. The above curves shall be within the envelope specified.

3. Spacer/ Spacer Damper

(a) Test Set up

The test set up for the test described hereunder shall be as per clause 2-(d)-(i) of Annexure-B.

(b) Movement Test

The spacer assembly shall be capable of the following movements without damaging the conductor, assuming one conductor is fixed and the other moving:

(i) Longitudinal movement ± 50 mm parallel to the conductor

(ii) Vertical movement in a ± 25 mm vertical direction at right angle to the conductor

(iii) Torsional movement/angular ± 5 deg movement in a vertical plane parallel to the conductor

(c) 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 center 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.

(d) Clamp Slip Test

Same as clause 2-(e)-(v) of Annexure-B.

(e) Clamp Bolt Torque Test

The spacer assembly shall be attached to conductor. A torque of 150 per cent of the manufacturer's specified tightening torque shall be applied to the clamp bolts or cap screws. There shall be no failure of the component parts.

(f) Assembly Torque Test

The spacer assembly shall be installed on conductor. The same shall not rotate on either clamp on applying a torque of 0.04 kN in clockwise or anti-clockwise direction.

(g) 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. They shall lie between 65 to 80.

(h) UTS of Retaining Rods

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

(i) Ageing Test on filler (if applicable)

Same as clause 1-(h) of Annexure-B.

Annexure-D

List of Type Tests Conducted on Conductor

Sl No	Name of the Test	Name of the Lab	Date of Test	Ref Standard (#)
1				
2				
3				
4				

List of Type Tests Conducted on Core

Sl No	Name of the Test	Name of the Lab	Date of Test	Ref Standard(#)
1				
2				
3				
4				

List of Type Tests Conducted on Conductor Hardware/Accessories

Sl No	Name of the Test	Name of the Lab	Date of Test	Ref Standard (#)
1				
2				
3				
4				

(#) - Attach copy of the extract from the standard

Signature of the Manufacturer
Stamp of the Manufacturer