

SECTION-VI B

CLAMP FITTINGS AND ACCESSORIES FOR HTLS CONDUCTOR

TECHNICAL SPECIFICATIONS

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CONTENTS

Clause No.	Description	Page No.
1.0	Technical Description of Clamp Fittings for HTLS Conductor	1
2.0	Technical Description of Accessories for HTLS Conductor	12
3.0	Tests and Standards	22
Annexure-A	Type Test Procedure for Clamp Fittings and Accessories for HTLS Conductor	36
Annexure-B	Acceptance Test Procedure for Clamp Fittings and Accessories for HTLS Conductor	48

TECHNICAL SPECIFICATIONS

SECTION- VI B

CLAMP FITTINGS AND ACCESSORIES FOR HTLS CONDUCTOR

1.0 Technical Description of Clamp Fittings for HTLS Conductor

1.1 General

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

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

In case, some special arrangement viz. semi-strain assembly is required to maintain low sag behavior of offered HTLS conductor in longer spans, supply & installation of such arrangements shall be in the scope of the Contractor. Documentary evidence regarding contractor/ supplier's previous experience of using such arrangements along with exact number of such arrangements required to be used in longer sections shall be submitted during post award engineering activities. Cost of supply and installation of required number of such arrangements shall be deemed to be included in the total quoted price.

1.3 Corona and RI Performance

Sharp edges and scratches on all the hardware fittings shall be avoided. All surfaces must be clean, smooth, without cuts and abrasions or projections. The

Supplier shall be responsible for satisfactory corona and radio interference performance of the materials offered by him.

1.4 Maintenance

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

1.5 Split Pins

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

1.6 Suspension Assembly

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

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

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

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

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

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

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

1.7 Free Centre Type Suspension Clamp

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

1.7.1 Standard Preformed Armour Rod Set

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

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

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

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

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

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

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

1.8 Armour Grip Suspension Clamp

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

- 1.8.2 Elastomer insert shall be resistant to the effects of temperature up to designed maximum conductor temperature guaranteed by the bidder corresponding to peak current, Ozone, ultraviolet radiations and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS performed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene insert.
- 1.8.3 The supplier shall submit relevant type/ performance test certificates as per applicable standard/product specifications for elastomer to confirm suitability of the offered elastomer for the specified application.
- 1.8.4 The AGS preformed rod set shall be as detailed in clause 1.7.1.4 to 1.7.1.7 in general except for the following.
- 1.8.5 The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength as detailed under clause 1.6.7 and shall not introduce unfavourable stress on the conductor under all operating conditions. The length of the AGS preformed rods shall be indicated in the GTP.
- 1.9 **Envelope Type Suspension Clamp**
- 1.9.1 The seat of the envelope type suspension clamp shall be smoothly rounded & suitably curved at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together. Hexagonal bolts and nuts with split-pins shall be used for attachment of the clamp.
- 1.10 **Dead end Assembly**
- 1.10.1 The dead-end assembly shall be suitable for the offered HTLS Conductor.
- 1.10.2 The dead-end assembly shall be of compression type with provision for compressing jumper terminal at one end. The angle of jumper terminal to be mounted (including angle of pad) should be 30° with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I^2R losses. The resistance of the clamp when compressed on HTLS conductor shall not be more than 75% of the resistance of equivalent length of HTLS conductor.
- 1.10.3 Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions and shall bear the words 'COM PRESS FIRST' suitably inscribed near the point on each assembly where the compression begins. If the dead-end assembly is designed for intermittent die compressions it shall bear identification marks 'COMPRESSION ZONE' AND 'NON-COMPRESSION ZONE' distinctly with arrow marks showing the direction

of compressions and knurling marks showing the end of the zones. The letters, number and other markings on the finished clamp shall be distinct and legible. The dimensions of dead-end assembly before & after compression along with tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification. These shall be guaranteed in the relevant schedules of bid.

- 1.10.4 The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.
- 1.10.5 Jumper bolting arrangement between jumper terminal/cone and terminal pad/plate of dead-end assembly of tension hardware fittings shall be designed to suit the ampacity at continuous operating conductor temperature as specified in Section-I of this specification and shall conform to the relevant Indian/International standards
- 1.10.6 For composite core HTLS conductor, dead end assembly may inter-alia include collets, collet housing, inner sleeve etc., suitable for the offered design of HTLS conductor
- 1.11 **Fasteners: Bolts, Nuts and Washers**
 - 1.11.1 All bolts and nuts shall conform to IS 6639. All bolts and nuts shall be galvanised as per IS 1367 (Part-13)/ IS 2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.
 - 1.11.2 Bolts upto M16 and having length upto 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS 12427. Bolts should be provided with washer face in accordance with IS 1363 (Part-1) to ensure proper bearing.
 - 1.11.3 Nuts should be double chamfered as per the requirement of IS 1363 Part-III 1984. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4 mm oversize on effective diameter for size upto M16.
 - 1.11.4 Fully threaded bolts shall not be used for parts/components requiring shear/tensile strength. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts. Bolts & Nuts for these parts/components shall be of minimum 5.6 grade conforming to IS 1367 or equivalent International standards.
 - 1.11.4.1 For parts/ components requiring grip strength viz. arcing horn, corona rings & dead-end jumper assembly, fully threaded bolts can be used as an alternative.

Bolts & nuts for these parts/ components shall be of minimum 4.6 grade conforming to IS 6639 or equivalent International standards

- 1.11.4.2 In case of fasteners of other materials viz. stainless steel, aluminium alloy, etc. are proposed to be used by the supplier, these shall conform to relevant Indian/International standards and complete details shall be submitted by the supplier for review & approval by the Employer.
- 1.11.5 All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but no further. It shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.
- 1.11.6 Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanised. The thickness of washers shall conform to IS 2016.
- 1.11.7 The Supplier shall indicate required size & length of various bolts in the drawings based on thickness of components connected, the nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.
- 1.11.8 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three times its diameter.
- 1.11.9 Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.
- 1.11.10 To ensure effective in-process Quality control it is essential that the manufacturer should have all the testing facilities for tests like weight of zinc coating, shear strength, other testing facilities etc, in-house. The manufacturer should also have proper Quality Assurance system which should be in line with the requirement of this specification and IS 9001 services Quality System standards.
- 1.11.11 Fasteners of grade higher than 8.8 are not to be used and minimum grade for bolt shall be 5.6.

1.12 Materials

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

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

1.13 Workmanship

- 1.13.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for the applicable voltage level of transmission lines and will give continued good performance. For Employer's review of the offered design of clamps/ fittings, the supplier shall submit document/ design details of similar type of clamps/ fittings used in past for similar type of HTLS conductor application.
- 1.13.3 The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and corners to limit corona and radio-interference, best resistance to corrosion and a good finish.
- 1.13.4 All ferrous parts including fasteners shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised. The bolt threads shall be undercut to take care of the increase in diameter due to galvanising. Galvanising shall be done in accordance with IS 2629/ IS 1367 (Part-13) and shall satisfy the tests mentioned in IS 2633. Fasteners shall withstand four dips while spring washers shall withstand three dips of one minute duration in the standard Preece test. Other galvanised materials shall have a minimum average coating of zinc equivalent to 600 gm/sqm, shall be guaranteed to withstand at least six successive dips each lasting one (1) minute under the standard preece test for galvanising.
- 1.13.5 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash rust, stains, bulky white deposits and blisters. The zinc used for galvanising shall be grade Zn 99.95 as per IS:209.
- 1.13.6 In case of casting, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm.
- 1.13.7 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localized heating phenomenon is averted.
- 1.13.8 No equipment shall have sharp ends or edges, abrasions or projections and cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under service conditions.

- 1.13.9 All the holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of the holes shall be free from burrs.
- 1.13.10 The fasteners shall conform to the requirements of IS:6639. All fasteners shall have suitable corona free locking arrangement to guard against vibration loosening.
- 1.13.11 Welding of aluminium shall be by inert gas shielded 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.

1.14 Bid Drawings

- 1.14.1 The Bidder shall furnish full description and illustrations of materials offered.
- 1.14.2 Fully dimensioned drawings of the hardware and their component parts shall be furnished along with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

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

The drawings shall include:

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

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

TABLE-1
(Details of Materials)

Sl. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks
1.	Security Clips	Stainless Steel/ Phosphor Bronze	-	AISI 304 IS7811	
2.	For Free Centre /Envelope type clamps				
(a)	Clamp Body, Keeper Piece	Al. Alloy 4600	Casted & Heat treated	IS 617	
		Al. Alloy 65032	Forged & Heat treated	IS 733	
		Al Alloy ENAW6082	Forged & Heat treated	EN 573-3	
(b)	Cotter bolts	Mild Steel	Hot dip galvanised	IS-2062	
(c)	Shackles	Forged Steel (Class-IV)	Hot dip galvanised	IS-2004	
(d)	U Bolts	Stainless Steel		AISI 304 IS7811	
		Al alloy 65032	Forged & Heat treated	IS 733	
(e)	P. A. Rod	Al. Alloy 65032	Extruded & Heat treated	IS 733	
3.	For AGS type clamp				
(a)	Supporting House	Al. Alloy 4600	Casted & Heat treated	IS:617	
		Al alloy 65032	Forged & Heat treated	IS 733	
(b)	Al insert & Retaining strap	Al. Alloy 4600	Casted & Heat treated	IS:617	
		Al alloy 65032	Forged & Heat treated	IS 733	
(c)	Elastomer	Moulded on Al. reinforcement			
4.	For Dead End Assembly & Mid Span Compression Joint				
(a)	Outer Sleeve (for	Al Alloy 19500	Extruded	IS 733	

	Annealed Aluminium Conductor)				
(b)	Outer Sleeve (for Aluminium alloy Conductor)	Al Alloy 19500	Extruded	IS 733	
		Al Alloy 63400	Extruded & heat treated	IS 733	
		Al Alloy 6060		EN 573-3	
(c)	Steel Sleeve	Mild Steel	Hot Dip Galvanised	IS-2062	
		Forged Steel (Class-II)		IS-2004	
5	For Repair Sleeve				
(a)		Al Alloy 19500	Extruded	IS 733	
6	For T-Connector				
		Al Alloy 19500	Extruded	IS 733	
		Al Alloy 63400	Extruded & heat treated	IS 733	
		Al Alloy 6060		EN 573-3	
7	For Rigid Spacer				
	Clamp Body, Keeper Piece, Frame	Al. Alloy 4600	Casted & Heat treated	IS 617	
		Al. Alloy 65032	Forged & Heat treated	IS 733	
		Al Alloy ENAW6082	Forged & Heat treated	EN 573-3	
	Al Tube	Al Alloy 63400	Extruded & heat treated	IS 733	
		Al. Alloy 65032		IS 733	
8	For Spacer Damper				
(a)	Clamp Body, Keeper Piece, Frame & Al Insert	Al. Alloy 4600	Casted & Heat treated	IS 617	
		Al. Alloy 65032	Extruded/Forged & Heat treated	IS 733	
		Al Alloy ENAW6082	Forged & Heat treated	EN 573-3	
		Al Alloy 63400	Extruded & Heat treated	IS 733	
9	For Vibration Damper				
(a)	Clamp Body, Keeper Piece	Al. Alloy 4600	Casted & Heat treated	IS 617	
(b)	Damper Mass	Cast Iron/Steel			
(c)	Messenger Cable	High strength galvanised			

		steel/stain less steel			
10.	Yoke Plate	Mild Steel	Hot dip galvanized	IS-2062	
11 (a)	Corona Control ring/ Grading ring	Al. Alloy 65032	Extruded & Heat treated	IS 733	Mechanical strength of welded joint shall not be less than 20 KN
		Al. Alloy 63400	Extruded & Heat treated	IS 733	
		Al. Alloy 63401	Extruded & Heat treated	IS 5082	
11 (b)	Supporting Brackets & Mounting Bolts	Al Alloy 65032/63400	Heat treated	IS 733	
		Mild Steel	Hot dip galvanized	IS 2062	

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

2.0 Accessories for the HTLS Conductor

2.1 General

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

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

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

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

2.2 Mid Span Compression Joint

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

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

2.3 T-Connector

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

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

2.4 Repair Sleeve

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

2.5 Vibration Damper

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

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

vibration dampers shall exceed the wind power so that the vibration level on the conductor is reduced below its endurance limit i.e. 150 micro strain.

- 2.5.3 The clamp of the vibration damper shall be made of high strength aluminium alloy grade 4600. It shall be capable of supporting the damper and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the conductor without damaging the strands or causing premature fatigue failure of the conductor under the clamp. The clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the conductor when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and designed to prevent corrosion of threads or loosening in service.
- 2.5.4 The messenger cable shall be made of high strength galvanised steel/stain less steel with a minimum strength of 135 kg/mm^2 . It shall be of preformed and post-formed quality in order to prevent subsequent drop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in the messenger cable shall be 19. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS 4826 for heavily coated wires.
- 2.5.5 The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blowholes etc. The surface of the damper masses shall be smooth.
- 2.5.6 The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.
- 2.5.7 The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.
- 2.5.8 The vibration damper shall be capable of being installed and removed from energised line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the conductor at the designated torque without shearing or damaging of fasteners.

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

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

Sl. No.	Description	Technical particulars
1	Span length in meters	
	i) Ruling design span	As per Section-I
	ii) Maximum span	1100 meters
	iii) Minimum span	100 meters
2	Configuration	As per section – I.
3	Tensile load in Conductor	25% of UTS of offered HTLS Conductor
4	Armour rods used	Standard preformed armour rods/AGS
5	Maximum permissible dynamic strain i.e. endurance limit.	+/- 150 micro strains

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

2.5.15 The damper placement charts shall include the following

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

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

2.6.1 Jumpers at tension points shall be fitted with spacers so as to limit the length of free conductor to 3.65 m and to maintain the sub conductor spacing of 450 mm for twin bundle conductors. It shall meet all the requirements of spacer

used in line except for its vibration performance. Spacers requiring retaining rods shall not be quoted for jumpers.

- 2.6.2 The spacer offered by the Bidder shall satisfy the following requirements.
- 2.6.2.1 Spacer shall restore normal spacing of the sub-conductors after displacement by wind, electromagnetic and the electrostatic forces under all operating conditions including the specified short circuit level without permanent deformation damage either to conductor or to the assembly itself. They shall have uniform grip on the conductor
- 2.6.2.2 Where elastomer lined clamp grooves are used, the elastomer shall be firmly fixed to the clamp.
- 2.6.2.3 Any nut used shall be locked in such a manner so as to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded.
- 2.6.2.4 Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened.
- 2.6.2.5 The clamp grooves shall be in uniform contact with the conductor over the entire surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, grit or other material which cause damage to the conductor when the clamp is installed.
- 2.6.2.6 For the spacer involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.
- 2.6.2.7 Universal type bolted clamps, covering a range of conductor sizes, will not be permitted.
- 2.6.2.8 No rubbing, other than that of the conductor clamp hinges or clamp swing bolts, shall take place between any parts of the spacer. Joint incorporating a flexible medium shall be such that there is no relative slip between them.
- 2.6.2.9 The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service.
- 2.6.2.10 The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance.
- 2.6.2.11 The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep.

- 2.6.2.12 The spacer assembly shall not have any projections, cuts, abrasions etc. or chattering parts which might cause corona or RIV.
- 2.6.2.13 The spacer tube shall be made of aluminium alloy 65032/63400. If fasteners of ferrous material are used, they shall conform to and be galvanised conforming to relevant Indian Standards.
- 2.6.2.14 Elastomer, if used, shall be resistant to the effects of temperature upto the designed maximum temperature specified for the conductor, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be as per relevant Indian/International standard. The supplier shall submit relevant type/ performance test certificate as per applicable standard/ product specification for elastomer to confirm suitability of the offered elastomer for the specified application.
- 2.6.2.15 The spacer assembly shall have electrical continuity. The electrical resistance between the sub-conductor across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.
- 2.5.2.16 The spacer assembly shall have complete ease of installation and shall be capable of removal/ reinstallation without any damage.
- 2.6.2.17 The spacer assembly shall be capable of being installed and removed from the energized line by means of hot line technique.
- 2.7 Spacer Damper (For 400 KV line with twin HTLS Conductor only)**
- 2.7.1 The spacer damper covered by this specification shall be designed to maintain the bundle spacing of 450 mm under all normal operating conditions and to effectively control Aeolian vibrations as well as sub span oscillation and to restore conductor spacing after release of any external extraordinary load. The nominal sub conductor spacing shall be maintained within ± 5 mm.
- 2.7.2 The spacer damper shall restore the normal sub-conductor spacing due to displacement by wind, electromagnetic and electrostatic forces including the specified short circuit level without permanent deformation or damage either to bundle conductors or to spacer damper itself.
- 2.7.3 The design offered shall be presented as a system consisting of spacer dampers and their staggering scheme for spans ranging from 100 m to 1100 m.
- 2.7.4 Under the operating conditions specified, the spacer damper system shall adequately control Aeolian vibrations throughout the life of the transmission line with wind velocity ranging from 0 to 30 km per hour in order to prevent

damage to conductor at suspension clamps, dead end clamps and spacer damper clamps.

- 2.7.5 The spacer damper system shall also control the sub-span oscillations in order to prevent conductor damage due to chaffing and severe bending stresses at the spacer damper clamps as well as suspension and dead end clamps and to avoid wear to spacer damper components.
- 2.7.6 The spacer damper shall consist of a rigid central body called the frame linked to the conductor by two articulated arms terminated by suitable clamping system. The articulation shall be designed to provide elastic and damping forces under angular movement of the arms. The dynamic characteristics of the articulations shall be maintained for the whole life of the transmission line.
- 2.7.7 The clamping system shall be designed to provide firm but gentle and permanent grip while protecting the conductor against local static or dynamic stresses expected during normal operating conditions. The clamping system shall be designed to compensate for any reduction of conductor diameter due to creep.
- 2.7.8 Bolted type clamps shall allow installation without removal of the bolts or the clamps from clamp body. Locking mechanism shall be suitable to prevent bolt loosening. Clamp locking devices with small loose components shall not be accepted. Nut cracker, hinged open or boltless type clamps are acceptable provided adequate grip can be maintained on the conductor.
- 2.7.9 Bolts and nuts shall be of mild steel, stainless steel, or high strength steel in accordance with the design of the spacer damper.
- 2.7.10 Where elastomer lined clamps are used, the elastomer elements shall be firmly fixed to the clamp. In case of elastomer covered clamps, the insert should be forged from aluminium alloy 65032 or equivalent aluminium alloy having minimum tensile strength of 25 kg/mm². The insert shall be moulded on the insert surface. The insert shall be duly heat treated and aged to retain its consistent characteristics during service. The grain flow of the forged insert shall be in the direction of the maximum tension and compression loads experienced.
- 2.7.11 In case of Spacer dampers with pre-formed rods, the articulated arms shall be terminated by elastomer lined or elastomer covered clamps and securely held by pre-formed retaining helical, factory formed rods. Minimum four (4) no. of rods shall be applied on each clamp to hold the clamp in position., These rods shall be designed for specific conductor size & shall be made of high strength aluminium alloy 65032 or equivalent having a minimum tensile strength of 35 kg/mm². The rods shall be parrot bill ended. The rods shall be heat treated

and aged to achieve specified mechanical properties and to retain the same during service. The length of the rods shall be such that the ends fall inside the imaginary square whose sides are vertical and horizontal outer tangents to the conductor sections.

- 2.7.12 The spacer damper body shall be cast/ forged from suitable high strength corrosion resistant aluminum alloy. The aluminium alloy shall be chosen in relation with the process used.
- 2.7.13 The rubber components involved in the design such as damping elements shall be made with rubber compound selected specifically for that particular application. The Contractor shall submit a complete list of physical and mechanical properties of the elastomer used. This list shall make reference to all applicable Indian/International standards.
- 2.7.14 The rubber components used shall have good resistance to the effects of temperature up to the designed maximum temperature of the conductor and to ultraviolet radiation, ozone and other atmospheric contaminants. The rubber shall have good wear and fatigue resistance and shall be electrically semi-conductive.
- 2.7.15 The spacer damper assembly shall have electrical continuity. The electrical resistance between the sub-conductors across the assembly in case of spacer damper involving elastomer surfaced clamps shall be suitably selected by the manufacturer to ensure satisfactory electrical performance and avoid deterioration of elastomer under service conditions.
- 2.7.16 The spacer damper assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.
- 2.7.17 The spacer damper assembly shall be capable of being installed and removed from the energized line by means of hot line techniques. The Supplier shall furnish the complete description of the installation, removal and reinstallation procedure.
- 2.7.18 A typical placement chart of spacer dampers for spans ranging from 100m to 1100m is indicated in table at Annexure-D. Sub span spacing indicated in Annexure-D may be varied by the manufacturer as per requirement, provided total no. of Spacer Damper in sub-span shall not be less than indicated in table at Annexure-D. In case of tension towers, one additional Spacer Damper shall be placed within 10m of dead end clamp.

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

- 2.7.19 The staggering scheme shall be such that no sub span shall be greater than 65 m and no end sub span shall be longer than 40 m & the spacer dampers be unequally distributed along the span to achieve sufficient detuning of adjacent sub spans for oscillations of sub span mode and to ensure bundle stability for wind speeds up to 60 km/hr.
- 2.7.20 In case of Spacer Damper with bolted clamps, the manufacturer/ supplier shall supply free of cost 25 number fixed setting torque wrench (of torque as per spacer damper design) along with 1st batch of supply of spacer dampers for installation of spacer damper on the line by the tower contractors.
- 2.7.21 The Bidder shall furnish all the relevant technical documents in supports of the staggering scheme recommended for the spacer damper.
- 2.8 **Material and Workmanship**
- 2.8.1 All the equipment shall be of the latest proven design and conform to the best modern practice adopted in the extra high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for intended voltage level of transmission line application and will give continued good performance at all service conditions. For employer's review of the offered design of accessories, the supplier shall submit document/ design details of similar type of accessories used in past for similar type of HTLS conductor application.
- 2.8.2 The design, manufacturing process and quality control of all the materials shall be such as to achieve requisite factor of safety for maximum working load, highest mobility, elimination of sharp edges and corners, best resistance to corrosion and a good finish.
- 2.8.3 All ferrous parts shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised as per grade 4 of IS 1573. The bolt threads shall be undercut to take care of increase in diameter due to galvanising. Galvanising shall be done in accordance with IS 2629/ IS 1367 (Part-13) and satisfy the tests mentioned in IS 2633. Fasteners shall withstand four dips while spring washers shall withstand three dips. Other galvanised materials shall have a minimum average coating of Zinc equivalent to 600 gm/sqm and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanising unless otherwise specified.
- 2.8.4 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The zinc used for galvanising shall be of grade Zn 99.95 as per IS 209.

- 2.8.5 In case of castings, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc.
- 2.8.6 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localised heating phenomenon is averted.
- 2.8.7 No equipment shall have sharp ends or edges, abrasions or projections and shall not cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under all service conditions.
- 2.8.8 Particular care shall be taken during manufacture and subsequent handling to ensure smooth surface free from abrasion or cuts.
- 2.8.9 The fasteners shall conform to the requirements of IS 6639. All fasteners and clamps shall have corona free locking arrangement to guard against vibration loosening.
- 2.9 **Compression Markings**
- Die compression areas shall be clearly marked on each equipment designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' suitably inscribed on each equipment where the compression begins. If the equipment is designed for intermittent die compressions, it shall bear the identification marks 'COMPRESSION ZONE' and 'NON-COMPRESSION ZONE' distinctly with arrow marks showing the direction of compression and knurling marks showing the end of the zones. The letters, number and other markings on finished equipment shall be distinct and legible.
- 2.10 **Bid Drawings**
- 2.10.1 The Bidder shall furnish detailed dimensioned drawings of the equipments and all component parts. Each drawing shall be identified by a drawing number and Contract number. All drawings shall be neatly arranged. All drafting and lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions and dimensional tolerances shall be mentioned in mm.
- 2.10.2 The drawings shall include
- (i) Dimensions and dimensional tolerances
 - (ii) Material. fabrication details including any weld details and any specified finishes and coatings. Regarding material, designations and reference of standards are to be indicated.
 - (iii) Catalogue No.
 - (iv) Marking
 - (v) Weight of assembly

- (vi) Installation instructions
- (vii) Design installation torque for the bolt or cap screw
- (viii) Withstand torque that may be applied to the bolt or cap screw without failure of component parts
- (ix) The compression die number with recommended compression pressure.
- (x) All other relevant technical details

2.10.3 Placement charts for spacer/spacer damper and damper

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

3.0 Tests and Standards

3.1 Type Tests

3.1.1 On Suspension Clamp for HTLS Conductor

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

3.1.2 On Dead end Tension Assembly for HTLS Conductor

a)	Visual Examination	IS 2486 (Part-1)
b)	Verification of Dimensions	IS 2486 (Part-1)
c)	Chemical analysis of materials	Annexure-A

d)	Electrical resistance test for dead end Assembly	IS 2486-(Part-I)
e)	Heating cycle test for dead end Assembly	Annexure-A
f)	Slip strength test for dead end assembly	Annexure-A
g)	Ageing test on filler (if applicable)	Annexure-A
h)	Thermal Profile test	Annexure-A
i)	Galvanising/Electroplating test	Annexure-A

3.1.3 On Mid Span Compression Joint for HTLS Conductor

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

3.1.4 T-Connector for HTLS Conductor

a)	Visual Examination	IS 2121 (Part-IV)
b)	Verification of Dimensions	IS 2121 (Part-IV)
c)	Chemical analysis of materials	Annexure-A
d)	Electrical resistance test	IS 2121 (Part-II)
e)	Heating cycle test	Annexure-A

f)	Axial tensile load test on welded portion	Annexure-A
g)	Tensile Test	IEC61284, Clause 11.6.2
h)	Thermal Profile test	Annexure-A
i)	Corona extinction voltage test (dry) (for 400 kV and above voltage level only)	Annexure-A
j)	Radio interference voltage test (dry) (for 400 kV and above voltage level only)	Annexure-A
k)	Galvanizing test	Annexure-A

3.1.5 Repair Sleeve for HTLS Conductor

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

3.1.6 Vibration Damper for HTLS Conductor

a)	Visual Examination	IS 9708
b)	Dimensional Verification	IS 9708
c)	Verification of Resonance Frequencies	Annexure-B
d)	Mass pull off test	IS 9708
e)	Chemical analysis of materials	Annexure-A
f)	Dynamic characteristics test*	Annexure-A
g)	Vibration analysis	Annexure-A
h)	Clamp slip test	Annexure-A
i)	Clamp bolt torque test	IS 9708

j)	Fatigue tests	Annexure-A
k)	Magnetic power loss test	Annexure-A
l)	Thermal Profile test	Annexure-A
m)	Corona extinction voltage test (dry) <i>(for 400 kV and above voltage level only)</i>	Annexure-A
n)	Radio interference voltage test (dry) <i>(for 400 kV and above voltage level only)</i>	Annexure-A
o)	Damper efficiency test	IS 9708
p)	Galvanising/Electroplating test	Annexure-A
* Applicable for 4 R stockbridge dampers. For alternate type of vibration dampers (permitted as per clause 2.5.2), as an alternative to dynamic characteristic test, damper efficiency test as per IEEE-664 Power Manual may be proposed/ carried out by the supplier.		

3.1.7

Rigid Spacer for jumper for twin HTLS Conductor

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

3.1.8 Spacer Damper for twin HTLS Conductor

a)	Visual Examination	IS 10162
b)	Dimensional Verification	IS 10162
c)	Movement Test	IS 10162
d)	Resilience Test (if applicable)	IS 10162
e)	Clamp bolt torque test	IS 10162
f)	Assembly Torque test	IS 10162
g)	Chemical analysis of materials	Annexure-A
h)	Clamp slip test	Annexure-A
i)	Vibration Test	Annexure-A
	(i) Vertical Vibration	IS 10162
	(ii) Longitudinal Vibration	IS 10162
	(iii) Sub-span oscillation	IS 10162
j)	Dynamic characteristics test	Annexure-A
k)	Fatigue tests	Annexure-A
l)	Magnetic power loss test (if applicable)	Annexure-A
m)	Compressive and tension Test	Annexure-A
n)	Thermal Profile test	Annexure-A
o)	Corona extinction voltage test (dry) <i>(for 400 kV and above voltage level only)</i>	Annexure-A
p)	Radio interference voltage test (dry) <i>(for 400 kV and above voltage level only)</i>	Annexure-A
q)	Ozone test on elastomer	Clause 7.6.3, IEC 61854
r)	Log decrement test	Annexure-A
s)	Galvanising Test	Annexure-A

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

- i) Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/ IEC vide 25/ 17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of POWERGRID or utility and
- ii) Type test reports contain valid Calibration reports of the relevant testing equipment and information pertaining to ratings, the relevant drawings, model number, test circuit, calculations (if any), photos, acceptance criteria/ values specified in Technical Specification/ relevant standards (IS/ IEC) and compliance to the same and
- iii) Tests should have been conducted on the samples of clamps & accessories for HTLS conductor manufactured from same manufacturing works within last 7 (seven) years as on the date of NOA.

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

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

3.2 Acceptance Tests

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

a)	Visual Examination	IS 2486-(Part-I)
b)	Verification of dimensions	IS 2486-(Part-I)
c)	Galvanising/ Electroplating test	Annexure-A
d)	Mechanical strength test of each component	Annexure-A
e)	Mechanical Strength test of welded joint	Annexure-A

f)	Chemical analysis, hardness tests, grain size, inclusion rating & magnetic particle inspection for forgings/castings	Annexure-A
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3.2.2 On Suspension Clamp fitting for HTLS Conductor

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

3.2.3 On Tension Clamp Fitting for HTLS Conductor

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

3.2.4 On Mid Span Compression Joint for HTLS Conductor

a)	Visual examination and dimensional verification	IS 2121 (Part-II), Clause 6.2, 6.3 & 6.7
b)	Chemical analysis of materials	Annexure-A
c)	Galvanising test	Annexure-A
d)	Hardness test	Annexure-B
e)	Ageing test on filler (if applicable)	Annexure-A

3.2.5 On T-Connector for HTLS Conductor

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

3.2.6 On Repair Sleeve for HTLS Conductor

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

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

a)	Visual examination and dimensional verification	IS 10162
b)	Chemical analysis of materials	Annexure-A
c)	Galvanising test	Annexure-A
d)	Movement test (except for rigid spacers)	IS 10162
e)	Clamp slip test	Annexure-B
f)	Clamp bolt torque test	IS 10162
g)	Compression-tension test	Annexure-B
h)	Assembly torque test	IS 10162
i)	Hardness test for elastomer (if applicable)	Annexure-B

3.2.8 On Vibration Damper for HTLS conductor

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

3.3 Routine Tests

3.3.1 For Hardware Fittings

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

3.3.2 For conductor accessories

a)	Visual examination and dimensional verification	IS 2121(Part-II)/ IS 2121 (Part IV)/ IS 9708/ IS 10162 as applicable
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3.4 Tests During Manufacture on all components as applicable

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

3.5 Testing Expenses

3.5.1 In the event of type testing, Bidder shall ensure that adequate facilities are available in the proposed laboratories and the tests can be completed in these laboratories within the time schedule.

3.5.2 In case of failure in any type test, the supplier is either required to modify the design of the material & repeat all the type tests once or to repeat that particular type test at least three times successfully at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

If repeat type tests are required to be conducted, then, all the expenses for deputation of Inspector/ Employer's representative shall be deducted from the contract price. Also, if on receipt of the Contractor's notice of testing, the Employer's representative/ Inspector does not find material & facilities to be ready for testing the expenses incurred by the Employer's for re-deputation shall be deducted from contract price.

- 3.5.3 The Contractor shall intimate the Employer about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of testing in India and at least 6 weeks advance in case of testing abroad) of the scheduled date of testing during which the Employer will arrange to depute his representative to be present at the time of carrying out the tests.
- 3.5.4 The entire cost of type tests, acceptance and routine tests and tests during manufacturing specified herein shall be treated as included in the quoted Ex-works, except for the expenses of the inspector/ Purchaser's representative.
- 3.6 **Sample Batch For Type Testing**
- 3.6.1 The Contractor shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Employer. The Contractor shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Employer.
- 3.6.2 Before sample selection for type testing the Contractor shall be required to conduct all the acceptance tests successfully in presence of Employer's representative.
- 3.7 **Schedule of Testing and Additional Tests**
- 3.7.1 The Bidder has to indicate the schedule of following activities in their bids
- (a) Submission of drawing for approval.
 - (b) Submission of Quality Assurance programme for approval.
 - (c) Offering of material for sample selection for type tests.
 - (d) Type testing.
- 3.7.2 The Employer reserves the right of having at his own expense any other test(s) of reasonable nature carried out at Contractor's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material complies with the specifications.
- 3.7.3 The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Contractor's premises or at any other test centre. In case of evidence of non-compliance, it shall be binding on the part of Contractor to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items, all without any extra cost to the Employer.

3.8 Test Reports

- 3.8.1 Copies of type test reports shall be furnished in at least six copies along with one original. One copy shall be returned duly certified by the Employer, only after which the commercial production of the concerned material shall start.
- 3.8.2 Copies of acceptance test report shall be furnished in at least six copies. One copy shall be returned, duly certified by the Employer, only after which the materials will be dispatched.
- 3.8.3 Record of routine test report shall be maintained by the Contractor at his works for periodic inspection by the Employer's representative.
- 3.8.4 Test certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Employer.

3.9 Inspection

- 3.9.1 The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where the material and/ or its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Contractor's, sub-Contractor's works, raw materials. Manufacturer's of all the material and for conducting necessary tests as detailed herein.
- 3.9.2 The material for final inspection shall be offered by the Contractor only under packed condition as detailed in clause 4.11 of this part of the Specification. The engineer shall select samples at random from the packed lot for carrying out acceptance tests.
- 3.9.3 The Contractor shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of material in its various stages so that arrangements could be made for inspection.
- 3.9.4 Material shall not be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Employer in writing. In the latter case also the material shall be dispatched only after all tests specified herein have been satisfactorily completed.
- 3.9.5 The acceptance of any quantity of material shall in no way relieve the Contractor of his responsibility for meeting all the requirements of the Specification, and shall not prevent subsequent rejection, if such materials are later found to be defective.

3.10 Packing and Marking

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

- 3.10.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.
- 3.10.3 Suitable cushioning, protective padding, dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.
- 3.10.4 Bolts, nuts, washers, cotter pins, security clips and split pins etc. shall be packed duly installed and assembled with the respective parts and suitable measures shall be used to prevent their loss.
- 3.10.5 Each component part shall be legibly and indelibly marked with trade mark of the manufacturer and year of manufacture. However, in such type of component/ item, which consists of many parts and are being supplied in assembled condition (suspension clamp, rigid spacer, spacer damper etc.), the complete assembly shall be legibly and indelibly marked on main body/on one of the parts. The symbol ☂ / alongwith the word 'TOP' shall be marked on the main body of the spacer damper for installing spacer damper in correct position.
- 3.10.6 All the packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each wooden case/crate shall have all the markings stenciled on it in indelible ink.
- 3.11 **Standards**
- 3.11.1 The clamp fitting and accessories shall conform to the following Indian/ International Standards which shall mean latest revisions, with amendments/ changes adopted and published, unless specifically stated otherwise in the Specification.
- 3.11.2 In the event of the supply of clamp fitting and accessories conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the Standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

Sl. No.	Indian Standard	Title	International Standard
1	IS 209	Specification for zinc	
2	IS 398 (Part-V)	Aluminum Conductor Galvanised Steel- Reinforced For Extra High Voltage (400 KV) and above	
3	IS 1573	Electroplated Coating of Zinc on iron and Steel	

4	IS 2121 (Part-II)	Specification for Conductor and Earthwire Accessories for Overhead Power lines: Mid-span Joints and Repair Sleeves for Conductors	
5	IS 2486 (Part-I)	Specification for Insulator Fittings for Overhead power Lines with Nominal Voltage greater than 1000 V: General Requirements and Tests	
6	IS 2629	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
7	IS 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
8	IS 4826	Galvanised Coating on Round Steel Wires	
9	IS 6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	
10	IS 8263	Method of Radio Interference Tests on High Voltage Insulators	
11	IS 6639	Hexagonal Bolts for Steel Structures	
12	IS 10162	Specification for Spacers & Spacers Dampers for Twin Horizontal Bundle Conductors	
13	IS 9708	Stockbridge Vibration Damper for Overhead Power Lines- Specification	
14		Overhead Lines-Requirements and tests for Spacers	IEC 61854
15		Overhead Lines-Requirements and tests for fittings	IEC 61284

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BS	British Standards, British Standards Institution 101, Pentonville Road, N - 19-ND UK
IEC/CISPR	International Electro technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de verembe, Geneva SWITZERLAND
BIS/IS	Beureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA
ISO	International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK.
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017 U.S.A.

Annexue-A

1.0 Tests on Hardware Fittings

1.1 Magnetic Power Loss Test for Suspension Assembly

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

1.2 Mechanical Strength Test of Each Component

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

1.3 Mechanical Strength Test of Welded Joint

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

1.4 Slip Strength Test for Suspension Clamp

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

1.5 Heating Cycle Test

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

- i) Temperature of conductor during each cycle: 40 deg. C above designed maximum operating temperature of the conductor but not exceeding maximum permissible conductor temperature for short term operation guaranteed in the GTP.
- ii) Number of cycles: 100
- iii) Slip strength test shall also be carried out after heating cycle test.

1.6 Slip strength test for dead end assembly

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

1.7 Shore Hardness Test for Elastomer Cushion for AG Suspension Assembly

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

1.8 Proof Load Test

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

1.9 Tests for Forging Casting and Fabricated Hardware

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

1.10 Resilience test for armour rod set

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

2.0 Slip Strength Test on Mid Span Compression Joint

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

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

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

- i) Temperature of conductor during each cycle: 40 deg. C above designed maximum operating temperature of the conductor but not exceeding maximum permissible conductor temperature for short term operation guaranteed in the GTP by the contractor/supplier.
- ii) Number of cycles: 100
- iii) Slip strength test shall also be carried out after heating cycle test.

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

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

2.3 **Vibration Damper**

(a) **Dynamic Characteristics, Test**

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

- (i) Force Vs frequency
- (ii) Phase angle Vs frequency
- (iii) Power dissipation Vs frequency

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

Acceptance criteria for vibration damper.

- (i) The above dynamic characteristics test on five dampers shall be conducted.
- (ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.

- (iii) The above mean reactance response curve should lie within following limits:

For ACSR Zebra equivalent HTLS Conductor: $0.135 f$ to $0.54 f$ Kgf/mm, where f is frequency in Hz.

For ACSR Panther equivalent HTLS Conductor: $0.0991 f$ to $0.495 f$, where f is frequency in Hz.

- (iv) The above mean phase angle response curve shall be between 25° to 130° within the frequency range of interest.
- (v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
- (vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

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

- (i) The analysis shall be done for single conductor without armour rods as per the parameters given under clause 2.5.13 of this part of the Specification. The tension corresponding to 25% of UTS of the HTLS conductor shall be taken for a span ranging from 100 m to 1100.
- (ii) The self-damping factor and flexural stiffness (EI) for HTLS conductor shall be calculated on the basis of experimental results. The details for experimental analysis with these data should be furnished.
- (iii) The power dissipation curve obtained from Dynamic Characteristics Test shall be used for analysis with damper.
- (iv) Examine the aeolian vibration level of the conductor with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.
- (v) From vibration analysis of conductor without damper, anti-node vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.

- (vi) From vibration analysis of conductor with damper/ dampers installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment points and the antinodes on the conductor shall be determined. In addition to above damper clamp vibration amplitude and anti-node vibration amplitudes shall also be examined.

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

- (c) Clamp Slip and Fatigue Tests

- (i) Test Set Up

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

- (ii) Clamp Slip test

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

(iii) Fatigue Test

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

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

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

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

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

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

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

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

2.4 Spacer/ Spacer Damper

(a) Vibration Tests (for Spacer Damper only)

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

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

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

(i) Longitudinal Vibration Test

The stationary conductor and the vibrating conductor/equivalent diameter of aluminium alloy tube shall be restrained by fixed clamps. The displacement of the vibrating conductor shall be 25 mm minimum

on either side. The longitudinal movement shall be parallel to the conductor at frequency not less than 2 Hz for minimum one million cycles.

(ii) Vertical Vibration Test

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

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

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.

(iii) Sub-span Oscillation Test

The test shall be conducted for oscillation in horizontal plane at frequency higher than 3 Hz for minimum one million cycles. The amplitude for oscillation shall be kept equivalent to an amplitude of 150 mm for a full sub-span of 80m. Both the conductor shall be vibrated 180 deg. out of phase with the above minimum amplitude.

b) Clamp Slip Test

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

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

c) Compressive and tensile test

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

d) Dynamic Characteristic Test (for Spacer Damper only)

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

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

$$K = \frac{F}{X} \times \cos \phi; n = \tan \phi$$

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

The test shall be performed on three samples.

e) Fatigue Test (for Spacer Damper only)

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

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

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

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

f) Log Decrement test (for spacer damper only)

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

The log decrement test shall be made with initial peak to peak amplitude of four to six times the conductor diameter in the middle of the sub-span being considered. The conductor shall be excited in a horizontal one loop per sub-span resonant mode with a slow and steady build up of amplitude that minimises harmonics and other 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 amplitude of half of the conductor diameter. The logarithmic (log) decrement shall be the value for a minimum reduction of 80 % in amplitude. The minimum acceptable log decrement average for five or more excitation shall be 0.04 based upon the following formula for decay.

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

Where A_0 is the initial amplitude and A_n is the amplitude 'n' cycles later

2.5 Magnetic Power Loss Test

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

2.6 Thermal Profile test

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

2.7 Ageing Test on Filler (if applicable)

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

2.8 Corona Extinction Voltage Test (Dry)

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

2.9 Radio Interference Voltage Test (Dry)

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

2.10 Chemical Analysis Test

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

2.11 Galvanising/ Electroplating Test

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

3.0 Tests on All components (As applicable)

3.1 Chemical Analysis of Zinc used for Galvanizing

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

3.2 Tests for Forgings

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

3.3 Tests on Castings

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

Annexure-B

Acceptance Tests

1. Mid Span Compression Joint

(a) Hardness Test

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

2. T-Connector

(a) Axial Tensile Load Test for Welded Portion

Same as clause 2.2 of Annexure-A.

3. Vibration Damper

(a) Verification of Resonance Frequencies

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

(b) Clamp Slip Test

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

(c) Strength of the Messenger Cable

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

(d) Mass Pull off Test

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

(e) **Dynamic Characteristics Test**

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

- (i) 1 Sample for 1 000 Nos. & below
- (ii) 3 Samples for lot above 1 000 & up to 5000 nos.
- (iii) Additional 1 sample for every additional 1500 pieces 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 $0.18/d$ Hz to $1.4/d$ Hz (where d is conductor diameter in meter).
- (ii) If all the individual curves for dampers are within the envelope as already mentioned for type test for reactance & phase angle, the lot passes the test.
- (iii) If individual results do not fall within the envelope, averaging of characteristics shall be done.
 - (a) Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.
 - (b) Similar averaging shall be done for phase angle.
 - (c) Average force Vs frequency and average phase Vs frequency curves shall be plotted on graph paper. Curves of best fit shall be drawn for the entire frequency range.
 - (d) The above curves shall be within the envelope specified.

4. **Spacer/ Spacer Damper**

(a) **Test Set up**

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

(b) **Compressive and Tensile Test**

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

hand pressure. There shall be no deformation or damage to the spacer assembly which would impair its function of maintaining the normal spacing.

(c) **Clamp Slip Test**

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

(d) **Hardness test for Elastomer**

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

(e) **UTS of Retaining Rods**

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