SECTION-VI

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TECHNICAL SPECIFICATION

SECTION - VI

1.0 **Technical Description of Hardware Fittings**

1.1 **Details of Hardware Fittings**

1.1.1 The hardware fittings shall be suitable for use with Disc insulators and /or porcelain long rod insulators having ball and socket fittings. The hardware fittings shall be as per the specification drawings enclosed with the section of drawing of the specification. Each hardware fitting shall be supplied complete in all respects and shall include the following hardware parts :

1.1.2 Suitable arcing horn as specified in clause 1.8 hereinafter.

1.1.3 Suitable yoke plates complying with the specifications given hereinafter.

1.1.4 Corona control rings/grading ring with fittings for attachment to line side yoke plate.

1.1.5 Sag adjustment plate for Double / Quadruple tension hardware fittings and turn buckle for single tension hardware fittings.

1.1.6 Suspension and dead end assembly to suit conductor size as detailed in clause 1.13, 1.14 and 1.15 hereinafter.

1.1.7 Provisions for attaching balancing weights on the line side yoke plate of single suspension pilot hardware fittings.

1.1.8 Other necessary fittings viz D-shackles, eye links, extension links, ball clevis, socket clevis, clevis eye, U clevis and chain link etc. to make the hardware fittings complete.

1.1.9 2.5% extra fasteners .

1.2 **Dimensions of Insulator String Along with Hardware Fitting**

The various limiting dimensions of the insulator strings along with hardware fittings shall be as per the specification drawings enclosed in section of drawings of this specification.

1.2.1 For every set of quad-tension hardware fittings, one number 250mm rigid spacer suitable for twin ACSR MOOSE conductor shall also be provided to ensure that there is no fouling of conductors or any component of the fittings while bringing down top two conductors through bottom two conductors of quad bundle, at the jumper connection.

1.3 Interchangeability

1.3.1 The hardware for insulator strings with disc insulators / porcelain long rod insulators together with ball and socket fittings shall be of standard design, so that these hardware are inter- changeable with each other and suitable for use with insulators of any make conforming to relevant Indian/International Standard.

1.4 **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

Contractor must give suitable assurance about the satisfactory corona and radio interference performance of the materials offered by him.

1.5 **Maintenance**

1.5.1 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. The Bidder should clearly establish in the bid, the suitability of his fittings for hot line maintenance.

1.5.2 The line side yoke plate shall have a notch & a working hole of suitable size. The design of corona control rings/grading ring shall be such that it can be easily replaced by employing hot line maintenance technique.

1.6 **Designation**

1.6.1 Ball and Socket Designation

The dimensions of the ball and socket are furnished in other sections of this Specification. The designation should be in accordance with the standard dimensions stated in IS:2486-(Part-II)/IEC:120. The dimensions shall be checked by the appropriate gauge after galvanizing only.

1.7 **Security Clips and Split Pins**

1.7.1 Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking of the coupling as per IS:2486-(Part-III)/ IEC : 372. The legs of the security clips shall be spread after assembly in the works to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall the locking devices allow, separation of fittings.

1.7.2 The hole for the security clip shall be countersunk and the clip should be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energised conditions. The force required to pull the security clip into its unlocked position shall not be less than 50 N (5 kg) or more than 500 N (50 kg).

1.7.3 Split pins shall be used with bolts & nuts.

1.8 **Arcing Horn/Intermediate Arcing Horn**

1.8.1 The arcing horn / Intermediate Arcing Horn shall be either ball ended rod type or tubular type.

1.8.2 The arcing horn shall be provided as shown on the drawing of the hardware fittings, in this specification.

1.8.3 The air gap shall be so adjusted to ensure effective operation under actual field conditions.

1.9 **Yoke Plates**

The strength of yoke plates shall be adequate to withstand the minimum ultimate tensile strength as specified in the bid drawings.

The plates shall be either triangular or rectangular in shape as may be necessary. The design of yoke plate shall take into account the most unfavorable loading conditions likely to be experienced as a result of dimensional tolerances for disc insulators as well as components of hardware fittings within the specified range. The plates shall have suitable holes for fixing corona control rings/grading ring/arcing horn. All the corners and edges should be rounded off with a radius of at least 3 mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the bidder. The holes provided for bolts in the yoke plate should satisfy shear edge condition as per Clause No. 8.10 of IS:800-1984..

1.10 **Corona Control Rings/Grading Ring**

1.10.1 The Corona control rings/grading ring shall be provided with hardware fittings and shall be of such design that it should cover at least one disc insulator in disc insulator strings so that they will reduce the voltage across the insulator units. It shall also improve corona and radio interference performance of the complete insulator string along with hardware fittings.

1.10.2 The corona control rings/grading ring shall be made of high strength heat treated aluminium alloy tube of minimum 2.5 mm wall thickness. If mild steel brackets are used then the brackets shall not be welded to the pipe but shall be fixed by means of bolts and nuts on a small aluminium plate attachment welded to the pipe. The welded center of the corona control ring/grading ring shall be grinded

before buffing. Alternately, Aluminium tube/flats of suitable dimensions welded to the corona control rings/grading rings may be used for connection to yoke plate.

1.10.3 The Corona control rings/grading ring should have a brushed satin finish and not a bright glossy surface. No blemish should be seen or felt when rubbing a hand over the metal.

1.10.4 The limiting dimensions of corona control ring shall be as per the specification drawings.

1.10.5 Bidder may quote for grading ring with armour grip suspension assembly. The grading ring shall be of open type design with a gap of 125 mm. The open ends shall be suitably terminated. The outside diameter of the tube shall be 60 mm. The ends of grading ring tube shall be sealed with welded aluminium cap duly buffed.

1.11 **Sag Adjustment Plate**

1.11.1 The sag-adjustment plate to be provided with the Double Tension / Quad tension hardware fitting shall be of three plate type. The sag adjustment plate shall be provided with a safety locking arrangement. The device shall be of such design that the adjustment is done with ease, speed and safety.

1.11.2 The maximum length of the sag adjustment plate from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible and the steps of adjustment shall be clearly indicated in the drawing. An adjustment of 150 mm minimum at the interval of 6 mm shall be possible with the sag adjustment plate.

1.11.3 Design calculations for deciding the dimensions of sag adjustment plate shall be furnished by bidder. The hole provided for bolts should satisfy shear edge condition as per Clause No.8.10 of IS:800-1984.

1.12 **Turn Buckle**

1.12.1 The turn buckle is to be provided with single tension hardware fitting. The threads shall be of sufficient strength to remain unaffected under the specified tensile load.

1.12.2 The maximum length of the turn buckle from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible shall be clearly indicated in the drawing. An adjustment of 150 mm minimum shall be possible with turn buckle.

1.13 **Suspension Assembly**

1.13.1 The suspension assembly shall be suitable for the specific conductor as given in Section–I of this Specification.

1.13.2 The suspension assembly shall include free center 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.

1.13.3 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.

1.13.4 The suspension clamp along with standard preformed armour rods/armour grip suspension clamp set shall have the slip strength not less than that specified in the Standard Technical Particulars.

1.13.5 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.

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

1.13.7 The magnetic power loss shall not be more than that stipulated in the Standard Technical Particulars.

1.13.8 **Free Center Type Suspension Clamp**

For the Free Center 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.

1.13.9 **Standard Preformed Armour Rod Set**

1.13.9.1 The Preformed Armour Rods Set, suitable for specific Conductor, 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.

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

1.13.9.3 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.

1.13.9.4 The length of each rod along with permissible tolerances shall be as stipulated in the Standard Technical Particulars. The end of armour rod shall be parrot billed.

1.13.9.5 The number of armour rods in each set shall as stipulated in the Standard Technical Particulars. Each rod shall be marked in the middle with paint for easy application on the line.

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

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

1.13.10 **Armour Grip Suspension Clamp**

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

1.13.10.2 Elastomer insert shall be resistant to the effects of temperature up to $95^{O}C$, 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.

1.13.10.3 The AGS preformed rod set shall be as detailed in clause 1.13.9.4 to 1.13.9.7 in general except for the following.

1.13.10.4 The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength as detailed under clause 1.13.4 and shall not introduce unfavorable stress on the conductor under all operating conditions. However the length of AGS preformed rods shall not be less than that stipulated in the Standard Technical Particulars.

1.14 **Envelope Type Suspension Clamp**

1.14.1 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.

1.15 **Dead end Assembly**

1.15.1 The dead end assembly shall be suitable for specific Conductor.

1.15.2 The dead end assembly shall be compression type with provision for comprising jumper terminal at one end. The angle of jumper terminal to be mounted should be 30° with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I^2R losses. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

1.15.3 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 dimensional tolerances of the cross section of aluminium and steel dead end; for dead end assembly for the specific conductor shall be as stipulated in the Standard Technical Particulars.

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

1.16 **Balancing Weights**

For holding the single suspension pilot insulator string used for jumper connections at the transposition towers from excessive deflection, suitable balancing weights, weighing 200 kg. are to be suspended through the line side yoke plate. It shall consist of four weights, each weighing 50 Kgs. and shall be connected to the yoke plate by means of eye bolt and shackle arrangement. The bottom weight shall be provided with recess to shield the ends of eye bolts. The same shall be suitable for use on specific transmission lines.

1.17 **Fasteners : Bolts, Nuts and Washers**

1.17.1 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.

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

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

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

1.17.5 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.

1.17.6 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:2016-1967.

1.17.7 The Bidder shall furnish bolt schedules giving thickness of components connected, the nut and the washer, the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.

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

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

1.17.10 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-.14000 services Quality System standard.

1.17.11 Fasteners of grade higher than 8.8 are not to be used.

1.18 **Materials**

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

1.18.1 The details of materials for different component are listed as in Table-I

TABLE-1 : (Details of Materials)

Sl. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks
1.	Security Clips	Stainless Steel/ Phospher Bronze	-	AISI 302 or 304-L/ IS-1385	
2.	Arcing Horn	Mild Steel Rod/ Tube Type	Hot dip galvanised	As per IS-226 or IS-2062	
3.	Ball Fittings, Socket, all shackles links cleves	Class-IV Steel	Drop forged & normalized Hot dip galvanised	As per IS: 2004	
4.	Yoke Plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
5.	Sag Adjustment plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
6(a).	Corona Control ring/ Grading ring	High Strength Al. Alloy tube (6061/ 6063/1100 type or 65032/ 63400 Type)	Heat treated Hot dip galvanized	ASTM-B429 or as per IS	Mechanical strength of welded joint shall not be less than 20 KN
6(b).	Supporting Brackets & Mounting Bolts	High Strentgth Al Alloy 7061/ 6063/ 65032/ 63400 Type) or Mild Steel	Heat treated Hot dip galvanized	ASTM-B429 or as per IS:226 or IS:2062	
7.	Turn Buckle	Class-II Steel	Forged hot dip galvanized	IS:2004	
8(a).	Free centre type clamp/ Envelope type Clamp: Clamp Body, Keeper Piece	High Strength Al. Alloy 4600/ LM-6 or 6061/ 65032	Casted or forged & Heat treated	IS:617 or ASTM-B429	
8(b)	Envelope type Clamp: Cotter bolts/ Hangers, Shackles, Brackets	Mild Steel	Hot dip galvanised	As per IS-226 or IS-2062	

Sl. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks
8(c)	Envelope type Clamp: U Bolts	Stainless Steel or High Strength Al alloy 6061/ 6063 or 65032/ 63400	Forged & & Heat treated	AISI 302 or 304-L ASTM-B429	
9.	P. A. rod	High strength Al alloy type 6061 or equivalent	Heat treatment during manufacturing	ASTM:B429	Min. tensile strength of 35 kg/mm2
10.	AGS clamp (a) Supporting house	High strength corrosion resistant Al. alloy LM6, 4600 or equivalent 6061	Cast/forged heat treated.	IS:617 or equivalent	
	(b) Al insert and retaining strap	High strength Al alloy type 6061 or equivalent	Forged and Heat treated	ASTM:B429	
	(c) Elastomer cushion	Moulded on Al reinforcement			
11(a).	Dead End Assembly: Outer Sleeve	EC grade Al of purity not less than 99.50%			
11(b).	Steel Sleeve	Mild Steel	Hot Dip Galvanised	IS:226/IS-2062	
12.	Balancing weights	Cast iron MCI/ machined Mild Steel	Hot dip galvanised	IS:226/2062 or equivalent	

Note : Alternate materials conforming to other national standards of other countries also may be offered provided the properties and compositions of these are close to the properties and compositions of material specified. Bidder should furnish the details of comparision of material offered vis a vis specified in the bid or else the bids are liable to be rejected.

1.19 Workmanship

1.19.1 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 rated transmission lines and will give continued good performance.

1.19.2 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.

1.19.3 All ferrous parts including fasteners shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised. The bolt threads shall be undercut to take care of the increase in diameter due to galvanising. Galvanising shall he done in accordance with IS 2629 :1985/ IS 1367 (Part 13) and shall satisfy the tests mentioned in IS 2633: 1986.

1.19.4 Before ball fittings are galvanised. all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the dimensions below the design requirements.

1.19.5 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 Zinc of any grade in IS 209:1992 ingot (fourth revision) or IS 13229:1991.

1.19.6 Pin balls shall be checked with the applicable "GO" gauges in at least two directions. One of which shall be across the line of die flashing, and the other 90^{o} to this line. "NO GO" gauges shall not pass in any direction.

1.19.7 Socket ends, before galvanising, shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions of high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS: 2486/IEC : 120.

The axis of the bearing surfaces of socket ends shall be coaxial with the axis of the fittings. There shall be no noticeable tilting of the bearing surfaces with the axis of the fittings.

1.19.8 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.

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

1.19.10 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.

1.19.11 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.

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

1.19.13 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.

1.20 **Bid Drawings**

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

1.20.2 Fully dimensioned drawings of the complete insulator string hard wares and their component parts showing clearly the following arrangements shall be furnished along with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

(i) Attachment of the hanger or strain plate.

(ii) Suspension or dead end assembly.

(iii) Arcing horn attachment to the string as specified in clause 1.8 of this technical Specification.

(iv) Yoke plates

(v) Hardware fittings of ball and socket type for inter connecting units to the top and bottom Yoke plates.

(vi) Corona control rings/grading ring attachment to conductor and other small accessories.

(vii) Links with suitable fittings.

(viii) Details of balancing weights and arrangements for their attachment in the single suspension pilot insulator string.

1.20.3 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.

1.20.4 After placement of award, the Contractor shall submit fully dimensioned drawing including all the components in four (4) copies to the Owner for approval. After getting approval from the Owner and successful completion of all the type tests, the Contractor shall submit thirty (30) more copies of the same drawings to the Owner for further distribution and field use at Owner's end.

2.0 Accessories for ACSR Moose Conductor

2.1 General

2.1.1 This portion (under clause 2.0) details the technical particulars of the accessories for Conductor.

2.1.2 2.5% extra fasteners and retaining rods shall be provided.

2.2 Mid Span Compression Joint

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

2.2.2 The joint shall be made of steel and aluminium sleeves for jointing the steel core and aluminium wires respectively. The steel sleeve should not crack or fail during compression. The steel sleeve shall be hot dip galvanised. The aluminium sleeve shall have aluminium of purity not less than 99.5%. The dimensions and dimensional tolerances of mid span compression joint shall be as per Standard Technical Particulars.

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 and shall be strong enough to withstand normal working loads. The T-connector shall have a resistivity across jumper less than 75% resistivity 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 and dimensional tolerances of T-connector shall be as per Standard Technical Particulars.

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 and shall have a smooth surface. 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 and dimensional tolerances of repair sleeve shall be as per Standard Technical Particulars.

2.5 Spacer Damper

2.5.1 Suitable spacer dampers for four bundle ACSR MOOSE conductor for 400 kV (Quad) line shall be offered. The spacer damper covered by this specification shall be designed to maintain the bundle spacing of 457 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.

2.5.2 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.

2.5.3 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. A vibration performance test shall be carried out on an experimental test line. The systems tested should be those specified by the Supplier for the 400 kV line conditions. Only systems satisfying the performance criteria under Annexure-A shall be submitted by Bidder along with bid.

The test line selected for the performance evaluation shall have been designed for that purpose, be adequately exposed to wind and properly instrumented.

Sl.	Description	Technical Particulars
1.	Configuration	**Double circuit for 400 kV line:** Four ACSR MOOSE Quad conductor bundle per phase and all three phases in vertical configuration. Refer section–I for mechanical properties of conductor
2.	Span length in metres	
	i) Ruling design span	400 metres
	ii) Maximum span	1100 metres
	iii) Minimum Span	100 metres
3.	Tensile load in each sub-conductor	As per sag tension calculations.
4.	Armour rods used	Yes
5.	Maximum permissible dynamic strains	± 150 micro strains

2.5.4 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.

2.5.5 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.

2.5.6 The spacer damper shall consist of a rigid central body called the frame linked to the conductor by four 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.

2.5.7 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.

2.5.8 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.

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

2.5.10 Where elastomer surfaced clamps are used, the elastomer elements shall be firmly fixed to the clamp. The insert should be forged from aluminium alloy of type 6061 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.

2.5.11 If clamps involving preformed rods are used, these rods shall be designed for specific conductor size. They shall be made of high strength aluminium alloy of type 6061 or equivalent aluminium alloy having a minimum tensile strength of 35 kg/mm3. The rods shall be ball 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.

2.5.12 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.

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

2.5.14 The rubber components used shall have good resistance to the effects of temperature up to 95°C and to ultraviolet radiation, ozone and other atmospheric contaminants. The rubber shall have good wear and fatigue resistance and shall be electrically semi-conductive.

2.5.15 The spacer damper involving ferrous material shall not have magnetic power loss more than that stipulated in the Standard Technical Particulars at 600 A, 50 Hz alternating current per sub-conductor.

2.5.16 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.

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

2.5.18 The spacer damper assembly shall be capable of being installed and removed from the energized line by means of hot line techniques. The Bidder shall supply with the bid the complete description of the installation, removal and reinstallation procedure.

2.5.19 The Bidder shall recommend the staggering scheme for installation of spacer dampers on the line which shall ensure most satisfactory fatigue performance of the line as specified. The scheme shall indicate the number of spacer dampers per phase per span and the sub span lengths to be maintained between spacer dampers while installing on the four bundle conductors.

2.5.20 The staggering scheme shall be provided for spans ranging from 100 m to 1100 m. The number of spacer dampers for a nominal ruling span of 400 m shall not be less than six.

2.5.21 No sub span shall be greater than 70 m and no end sub span shall be longer than 40 m.

2.5.22 The staggering scheme shall be such that the spacer dampers be unequally distributed along the span to achieve sufficient detuning of adjacent subs pans for oscillations of sub span mode and to ensure bundle stability for wind speeds up to 60 km/hr.

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

2.6 Rigid Spacer for Jumper for Quad Conductor

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 457 mm. Bidder shall quote for rigid spacer for jumper. 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 For spacer requiring retaining rods, the retaining rods shall be designed for the specified conductor size. The preformed rods shall be made of high strength, special aluminium alloy of type 6061/65032 and shall have minimum tensile strength of 35 kg/sq.mm. The ends of retaining rods should be ball ended. The rods shall be heat-treated to achieve specified mechanical properties and give proper resilience and retain the same during service.

2.6.2.3 Four number of rods shall be applied on each clamps to hold the clamp in position. The minimum diameter of the rods shall be 7.87 $\pm$ 0.1 mm and the length of the rods shall not be less than 1100 mm.

2.6.2.4 Where elastomer surfaced clamp grooves are used, the elastomer shall be firmly fixed to the clamp. The insert should be forged from aluminium alloy of type 6061/65032. The insert shall be duly heat treated and aged to retain its consistent characteristics during service.

2.6.2.5 Any nut used shall be locked in an approved manner to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded.

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

2.6.2.7 The clam 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.

2.6.2.8 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.

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

2.6.2.10 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.

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

2.6.2.12 Rigid spacers shall be acceptable only for jumpers.

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

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

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

2.6.2.16 The spacer tube shall be made of aluminium alloy of type 6061/65032. If fasteners of ferrous material are used, they shall conform to and be galvanised conforming to relevant Indian Standards. The spacer involving ferrous fasteners shall not have magnetic power loss more than one watt at 600 Amps 50 Hz alternating current per sub conductor.

2.6.2.17 Elastomer, if used, shall be resistant to the effects of temperature up to 95 deg.C, 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 of approved standard.

2.6.2.18 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.

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

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

2.7 Material and Workmanship

2.7.1 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 400 kV transmission line application with bundle conductors and will give continued good performance.

2.7.2 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.

2.7.3 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-1573-1970. 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 overall coating of Zinc equivalent to 600 gm/sq.m and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanising unless otherwise specified.

2.7.4 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.

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

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

2.7.7 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.

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

2.7.9 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.

2.8 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.

2.9 Bid Drawings

2.9.1 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.

2.9.2 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

2.9.3 Placement charts for spacer and damper

2.9.4 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 Purchaser for approval. After Purchaser's approval and successful completion of all type tests, 10 (ten) more sets of drawings shall be submitted to Purchaser for further distribution and field use at Purchaser's end.

3.0 G.S. Earth wire Accessories

3.1 General

3.1.1 This portion Specify the details of the technical particulars of the accessories for Galvanised Steel Earth wire.

3.1.2 2.5% extra fasteners shall be supplied.

3.2 Mid Span Compression Joint

Mid Span Compression Joint shall be used for joining two lengths of earth wire. The joint shall be made of mild steel with aluminium encasing. The steel sleeve should not crack or fail during compression. The Brinnel Hardness of steel should not exceed the value as stipulated in the Standard Technical Particulars. The steel sleeve shall be hot dip galvanised. The aluminium sleeve shall have aluminium of purity not less than that stipulated in the Standard Technical Particulars. Filler aluminium sleeve shall also be provided at the both ends. The joints shall not permit slipping off, damage to or failure of the complete earth wire or any part thereof at a load not less than 95% of the ultimate tensile strength of the earth wire. The joint shall have resistivity less than 75% of resistivity of equivalent length of earth wire. The dimensions and the dimensional tolerances of the joint shall be as stipulated in the Standard Technical Particulars.

3.3 Vibration Damper

3.3.1 Vibration dampers of 4R-Stockbridge type with four (4) different frequencies spread within the specified Aeolian frequency band-width corresponding to wind speed of 5m/s to 7 m/s shall be used for suspension and tension points on each earth wire in each span to damp out Aeolian vibrations as mentioned herein after.

3.3.2 Alternate damping systems or "Dogbone" dampers offering equivalent or better performance also shall be acceptable provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid.

3.3.3 One damper minimum on each side per earth wire at suspension points and two dampers on each side per earth wire at tension points shall be used for ruling design span of 400 meters for 400 kV line.

3.3.4 The Bidder may offer damping system involving more number of dampers per ruling design span than the specified. However suitable price compensation shall be considered for evaluation. For the purpose of price compensation 80% of

towers as suspension locations and 20% of the towers as tension locations and all the spans assumed to be ruling design spans.

3.3.5 The clamp of the vibration damper shall be made of aluminium alloy. It shall be capable of supporting the damper during installation and prevent damage or chaffing of the earth wire during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the earth wire without damaging the strands or causing premature fatigue failure of the earth wire under the clamp. The clamp groove shall be in uniform contact with the earth wire 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 materials which could cause damage to the earth wire when the clamp is installed. Clamping bolts shall be provided with self locking nuts designed to prevent corrosion of the threads or loosening during service.

3.3.6 The messenger cable shall be made of high strength galvanised steel/stainless steel with a minimum strength of 135 Kg/sq.mm. It shall be of preformed and post formed quality in order to prevent subsequent droop of weights and to maintain consistent flexural stiffness of the cable in service. The number of standards in the messenger cable shall be 19. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion.

3.3.7 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, shrinkages, inclusions and blow holes etc. The inside and outside surfaces of the damper masses shall be smooth.

3.3.8 The vibration analysis of the system, with and without damper, dynamic characteristic of the damper as detailed under Annexure-A, shall have to be submitted by the Bidder along with his bid. The technical particulars for vibration analysis and damping design of the system are as follows:-

Sl. o.	Description	Technical particulars
1.	Configuration	Two continuously steel earthwire 10.98 mm diameter in horizontal configuration. Refer to Section-I for mechanical properties of the earthwire.
2.	Span length in meters	
i)	Ruling design span	400 meters
ii)	Maximum span	1100 meters
iii)	Minimum span	100 meters

3.	Tensile load in Conductor at temperature of 0 deg. C and still air	As per sag tension calculations.
4.	Maximum permissible dynamic strain	+/- 150 micro strains

3.3.9 The damper placement chart for spans ranging from 100 m to 1100 m shall be submitted by the Bidder. All the placement charts should be duly supported by relevant technical documents.

3.3.10 The damper placement charts shall include the following :

(1) Location of the dampers for various combinations of spans and line tensions clearly indicating number of dampers to be installed per earth wire per span.

(2) Placement distances clearly identifying the extremities between which the distances are to be measured.

(3) Placement recommendation depending upon type of suspension clamps (viz, free center type/trunion type etc.)

(4) The influence of mid span compression joints in the placement of dampers.

3.4 **Flexible Copper Bond**

The flexible copper bond shall be circular in cross-section of minimum 34 sq.mm equivalent copper area and not less than 500 mm in length. It shall consist of 259 wires of 0.417 mm dia. tinned copper conductor. It shall be laid up as 7 stranded ropes, each of 37 bunched wires. The tinning shall be as per relevant Indian Standard. Two tinned copper connecting lugs shall be press jointed to either ends of the flexible copper cable. One lug shall be suitable for 12 mm, dia. bolt and the other for 16 mm dia bolt. The complete assembly shall also include one 16 mm dia., 40 mm long HRH MS Bolt hot dip galvanised with nut and lock washer.

3.5 **Suspension Clamp**

3.5.1 Standard anchor shackle/twisted shackle for earth wire suspension clamp shall be supplied for attaching to the hanger plate of tower.

3.5.2 At all suspension towers, suitable suspension clamps shall be used to support the required earth wire. The clamps shall be of either free center type or trunion type and shall provide adequate area of support to the earth wire. The groove of the clamp shall be smooth, finished in an uniform circular or oval shape and shall slope downwards in a smooth curve to avoid edge support and hence to reduce the intensity of bending moment on earth wire.

3.5.3 There shall be no sharp point in the clamps coming in contact with earth wire. There shall not be any displacement in the configuration of the earth wire strands

nor shall the strands be unduly stressed in final assembly during working conditions.

3.5.4 The clamping piece and the clamp body shall be clamped by at least two U-bolts of size not less than 10 mm diameter having one nut and one 3 mm thick lock nut with washer on each of its limbs. Suspension clamps shall be provided with inverted type U-bolts. One limb of the U-bolt shall be long enough to accommodate the lug of the flexible copper bond.

3.5.5 The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pin etc. The total drop of the suspension assembly from the center point of the attachment to the center point of the earth wire shall not exceed 150 mm. The design of the assembly shall be such that the direction of run of the earth wire shall be same as that of the conductor.

3.5.6 The complete assembly shall be guaranteed for slip strength of not less than 12 KN and not more than 17 kN. The breaking strength of the assembly shall not be less than 25 kN.

3.6 Tension Clamp

3.6.1 At all tension towers suitable compression type tension clamps shall be used to hold the required galvanised steel earth wire. Anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plates.

3.6.2 The clamps shall have adequate area of bearing surface to ensure positive electrical and mechanical contact and shall not permit any slip to the earth wire under working tension and vibration conditions. The angle of jumper terminal to be mounted should be 30 deg. with respect to the vertical line.

3.6.3 The clamps shall be made of mild steel with aluminium encasing. The steel should not crack or fail during compression. The Brinnel hardness of steel sleeve shall not exceed 200. The steel sleeve shall be hot dip galvanised. The aluminium encasing shall have aluminium of purity not less than 99.5%. Filler aluminium sleeve shall also be provided at the end.

3.6.4 The complete assembly shall be so designed as to avoid undue bending in any part of the clamp and shall not produce any hindrance to the movements of the clamps in horizontal or vertical directions.

3.6.5 The slip strength of the assembly shall not be less than 95% of the ultimate strength of the earth wire.

3.6.6 The clamps shall be complete with all the components including anchor shackle, bolts, nuts, washers, split pin, jumper arrangement etc.

3.7 Material and Workmanship

Same as Clause 2.7 of this section

3.8 **Compression Marking**

Same as Clause 2.8 of this section

3.9 **Bid Drawings**

Same as Clause 2.9 of this section

4.0 Standard technical particulars

4.1 The Standard technical particulars to adhered by the contractor / manufacturer are furnished below:

Standardised Technical Particulars of Hardware Fittings and Accessories of Quad ACSR MOOSE conductor for 400 kV Transmission Line

1.	**SUSPENSION HARDWARE FITTINGS FOR QUAD ACSR 'MOOSE' CONDUCTOR**				
Sl.	**Description**	**Unit**	**Particulars / Value**		
			Double 'I'		**Single 'I' Pilot**
			AGS clamp	**Free centre clamp**	**Envelope clamp**
1.	Maximum magnetic power loss of suspension assembly at sub conductor current of 600 amperes, 50Hz AC	Watt	4		8
2.	Slipping strength of suspension assembly(clamp torque Vs slip curve shall be enclosed)	kN	20-29		
3.	Particulars of standard/AGS Standard / AGS preformed armour rod set for suspension assembly				
	a) No. of rods per set	No.	12		NA
	b) Direction of lay		Right Hand		NA
	c) Overall length after fitting on conductor	mm	2235	2540	NA
	d) Diameter of each rod	mm	9.27		NA
	e) Tolerance in				NA
	i) Diameter of each rod	±mm	0.10		NA
	ii) Length of each rod	±mm	25		NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13		NA
	g) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032		NA
	h) UTS of each rod	Kg/mm^2 (Min)	35		NA
4.	**Particulars of Elastomer (For AGS Clamp only)**				
	a) Type of elastomer		Chloropren e / Neoprene	NA	NA
	b) Shore hardness of elastomer		65 - 80	NA	NA
	c) Temperature range for which elastomer is designed	°C	Upto 95°C	NA	NA
	d) Moulded on insert		Yes	NA	NA
5.	Mechanical Strength of Suspension fitting (excluding suspension clamp)	KN	240		120
6.	Mechanical Strength of suspension clamp.		70	70	70
7.	Purity of Zinc used for galvanising	%	As per IS:209 / IS 13229		
8.	Min. No. of dips in standard preece test the	No	a) Fasteners : 4 dips of 1 min		

	ferrous parts can withstand		b) Spring washers : 3 dips of 1 min c) All others : 6 dips of 1 min

2.	**TENSION HARDWARE FITTINGS QUAD ACSR MOOSE CONDUCTOR**			
Sl.	**Description**	**Unit**	**Particulars / Value**	
			Single Tension	**Quad Tension**
1.	Mechanical Strength of Tension fittings (excluding dead end clamp)	kN	120	640
2.	Type of Dead End assembly		Compression	
3.	Compression Pressure	MT	100	
4.	Maximum electrical resistance of dead end assembly as a percentage of equivalent length of Conductor	%	75	
5.	Slip strength of dead end assembly	kN	153.2	
6.	Purity of Zinc used for galvanising	%	As per IS:209 / IS 13229	
7.	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos	a) Fasteners : 4 dips of 1 min b) Spring washers : 3 dips of 1 min c) All others : 6 dips of 1 min	

Mid span compression Joint for ACSR MOOSE Conductor				
Sl.	**Description**	**Unit**	**Particulars/ Value**	
			Aluminium Sleeve	Steel Sleeve
1.	**Material of Joint**		Aluminium of purity 99.5%	Mild Steel(Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200	
3.	Weight of Zinc coating for steel sleeve	gm/m²	610	
4.	**Dimension of sleeve Before compression**		Aluminum sleeve	Steel sleeve
i)	Inside diameter	mm	34.00 ± 0.5	11.10 ± 0.2
ii)	Outside diameter	mm	54.00 ± 1.0	21.00 ± 0.5
iii)	Length	mm	735 ± 5	250 ± 5
5.	**Dimensions of Sleeve after compression**		Aluminum sleeve	Steel sleeve
i)	Outside dimension(Corner to corner)	mm	53.00 ± 0.5	20.20 ± 0.5
ii)	Outside dimension (face to face)	mm	46.00 ± 0.5	17.50 ± 0.5
iii)	Length	mm	785 (approx)	286 (approx)
6.	Slip strength	KN	153.2	

7.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75
8.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
9.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

Repair sleeve for ACSR MOOSE Conductor			
Sl.	**Description**	**Unit**	**Particulars/ Value**
1.	**Material**		Aluminium of minimum purity 99.5%
2.	**Dimension of Aluminum sleeve Before compression**		
i)	Inside diameter	mm	34.00 ± 0.5
ii)	Outside diameter	mm	54.00 ± 1.0
iii)	Length	mm	300.00 ± 5.0
3.	**Dimensions of Aluminum Sleeve after compression**		
i)	Outside dimension(Corner to corner)	mm	53.00 ± 0.5
ii)	Outside dimension (face to face)	mm	46.00 ± 0.5
iii)	Length	mm	330.00(Approx.)
4.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
5.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

QUAD SPACER DAMPER FOR QUAD ACSR MOOSE CONDUCTOR			
Sl.	**Description**	**Unit**	**Particulars / Value**
1.	Type of Clamps		Bolted / Nut cracker / Hinged open / Boltless / Preformed rods.
2.	Type of Damping element		Spring / Elastomer / EPDM
3.	Material of		
	(a) Clamp		Al Alloy IS:4600 or Equivalent
	(b) Body		Galvanised Steel / Al Alloy 4600 or Equivalent
4.	Elastomer (*if used*)		
	(a) Shore hardness		50 - 80
	(b) Temp. range for which designed	°C	Upto 95°C
5.	Minimum ultimate tensile strength of spacer		

	(a) Compressive load	kN	14		
	(b) Tensile load	kN	7.0		
6.	Slipping strength of spacer clamp				
	(a) Before vibration test	kN	**Clamp type**	**Longitudnal Load (kN)**	**Maxm Slip permitted (mm)**
			Metal – Metal Bolted	6.5	1
			Rubber loaded	2.5	2.5
			Preformed rods	2.5	12
	(b) After vibration test	kN	80% of the above values		
7.	Maximum magnetic power loss of at sub conductor current of 600 amperes, 50Hz AC	Watt	Below 1 watt.		
8.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320		
9.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) Microvolts under dry condition	μV	Below 1000		

QUAD RIGID SPACER FOR QUAD ACSR MOOSE CONDUCTOR					
Sl.	**Description**	**Unit**	**Particulars / Value**		
1.	Material of				
	(a) Clamp		Al Alloy IS:4600 or Equivalent		
	(b) Body		Galvanised Steel / Al Alloy 4600 or Equivalent		
2.	Elastomer (*if used*)				
	(a) Shore hardness		65 - 80		
	(b) Temp. range for which designed	°C	Upto 95°C		
3.	Minimum ultimate tensile strength of spacer				
	(a) Compressive load	kN	14		
	(b) Tensile load	kN	7.0		
4.	Slipping strength of spacer clamp	kN	**Clamp type**	**Longitudinal Load (kN)**	**Maxm Slip permitted (mm)**
			Metal – Metal Bolted	6.5	1
			Rubber	2.5	2.5

			loaded		
			Preformed rod	2.5	12
5.	Maximum magnetic power loss of at sub conductor current of 600 amperes, 50Hz AC	Watts	Below 1 watt.		
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320		
7.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) Microvolts under dry condition	μV	Below 1000		

T-connector for ACSR MOOSE Conductor			
Sl.	**Description**	**Unit**	**Particulars/ Value**
1.	**Material**		Aluminium of purity 99.5%
2.	**Dimension of Aluminum sleeve Before compression**		
	i) Inside diameter	mm	34.00 ± 0.5
	ii) Outside diameter	mm	54.00 ± 1.0
	iii) Length	mm	400.00 ± 5.0
3.	**Dimensions of Aluminum Sleeve after compression**		
	i) Outside dimension(Corner to corner)	mm	53.00 ± 0.5
	ii) Outside dimension (face to face)	mm	46.00 ± 0.5
4.	Axial tensile strength of welded portion of T-connector	KN	30
5.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
7.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

Standardised Technical Particulars of Accessories of 7/3.66mm GS Earthwire

1. MID SPAN COMPRESSION JOINT FOR 7/3.66 MM GS EARTHWIRE

Sl.	Description	Unit	Particulars/ Value		
			Aluminium / Filler Sleeve	Steel Sleeve	
1.	**Material of Joint**		Aluminium of minimum purity 99.5%	Mild Steel(Fe-410, IS:2062)	
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200		
3.	**Dimension of sleeve Before compression**				
			Aluminium Sleeve	Steel Sleeve	Alu filler sleeve
i)	Inside diameter	mm	22.00 ± 0.5	**11.50** ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	**30.00** ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	400 ± 5	230 ± 5	60 ± 5
4.	**Dimensions of Sleeve after compression**				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension(Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
iii)	Length	mm	430 (approx)	265 (approx)	
5.	Slip strength	KN	65		
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare Earthwire	%	75		
7.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m2	600		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5(IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	6 dips of 1 minute		

2. FLEXIBLE COPPER BOND FOR 7/3.66 MM GS EARTHWIRE

Sl.	Description	Unit	Particulars/ Value
1.	Stranding		37/7/0.417
2.	Cross sectional area	Sq.mm	35.4
3.	Minimum copper equivalent area	Sq.mm	34
4.	Length of copper cable	mm	500 + 5
5.	Material of lugs		Tinned copper

6.	Bolt Size		
	i) Diameter	mm	16
	ii) Length	mm	40
7.	Slip Strength	kN	3

3. VIBRATION DAMPER FOR 7/3.66 MM GS EARTHWIRE

Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/mild steel/Zinc alloy duly hop dip galvanised
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm^2	135
5.	Slip strength of stranded messenger cable (mass pull off)	kN	2.5
6.	Slipping strength of damper clamp		
	(a) Before fatigue test	kN	2.5
	(b) After fatigue test	kN	2
7.	Resonance frequencies range	Hz	10 to 60
8.	Percentage variation in reactance after fatigue test in comparison with that . before fatigue test	%	+/-40 (Maximum)
9.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
10.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5(IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

4. SUSPENSION CLAMP FOR 7/3.66 MM GS EARTHWIRE

Sl.	Description	Unit	Particulars/ Value
1.	**Material of components**		
	(a) Shackle		Forged Steel
	(b) Clamp Body & Keeper		Malleable cast iron / SGI / **Al Alloy 4600**
	(c) U- Bolt		Mild Steel
2.	Total Drop (Maximum)	mm	150
3.	Breaking Strength (Minimum)	kN	25
4.	Slipping Strength	kN	12 to 17
5.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5(IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

5. TENSION CLAMP FOR 7/3.66 MM GS EARTHWIRE

Sl.	Description	Unit	Particulars/ Value		
1.	**Material of components**				
	(i) Anchor Shackle		Forged Steel		
	(ii) Compression Clamp				
	a) Steel Sleeve		Mild Steel		
	b) Aluminium sleeve		Aluminium of purity 99.5%		
	c) Aluminium Filler sleeve		Aluminium of purity 99.5%		
3.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	120-200		
4.	**Dimension of sleeve Before compression**				
			Aluminium Sleeve	Steel Sleeve	Alu filler sleeve
i)	Inside diameter	mm	22.00 ± 0.5	**11.50** ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	**30.00** ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	245 ± 5	205 ± 5	25 .0
5.	**Dimensions of Sleeve after compression**				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension(Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
6.	Slip strength	KN	65		
7.	Minimum Breaking strength of assembly	KN	70		

	(excluding clamp)		
8.	Compression Pressure	Ton	100
9.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5(IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

5.0	**Tests and Standards**		
5.1	**Type Tests**		
5.1.1	**On the complete Insulator String with Hardware Fittings**		
5.1.1.1	**On the complete Disc Insulator String with Hardware Fittings**		
	a)	Power frequency voltage withstand test with corona control rings/grading ring and arcing horns under wet condition	: As per IEC:383
	b)	Switching surge voltage withstand test under wet condition	: As per IEC:383
	c)	Impulse voltage withstand test under dry condition	: As per IEC:383
	d)	Impulse voltage flashover test under dry condition	: As per IEC:383
	e)	Voltage distribution test	: As per Annexure-A
	f)	Corona and RIV test under dry condition	: As per Annexure-A
	g)	Mechanical Strength test	: As per Annexure-A
	h)	Vibration test	: As per Annexure-A
	i)	Power Arc Test (for 400 kV only)	: As per Annexure-A
5.1.1.2	**On the complete Porcelain long rod Insulator string with Hardware Fittings**		
	a)	Power frequency voltage withstand test with corona control rings/grading ring and arcing horns under wet condition	: As per IEC:383
	b)	Switching surge voltage withstand test under wet condition	: As per IEC:383
	c)	Impulse voltage withstand test under dry condition	: As per IEC:383
	d)	Impulse voltage flashover test under dry condition	: As per IEC:383
	e)	Corona and RIV test under dry condition	: As per Annexure-A
	f)	Mechanical Strength test	: As per Annexure-A
	g)	Vibration test	: As per Annexure-A
	h)	Power Arc Test	: As per Annexure-A

5.1.2 On Suspension Hardware Fitting only

a)	Magnetic power loss test for suspension assembly	: As per Annexure-A
b)	Clamp slip strength Vs torque test for suspension clamp	: As per Annexure-A
c)	Mechanical strength Test	: As per Annexure-A
d)	Ozone Test on elastomer	: As per Annexure-A

5.1.3 On Tension Hardware Fitting only

a)	Electrical resistance test for dead end Assembly	: As per IS:2486 (Part-I)
b)	Heating cycle test for for dead end Assembly	: As per IS:2486 (Part-I)
c)	Slip strength test for dead end assembly	: As per IS:2486 (Part-I)
d)	Mechanical strength test	: As per Annexure-A

5.1.4 Mid Span Compression Joint for Conductor and Earthwire

a)	Chemical analysis of materials	: As per Annexure-A
b)	Electrical resistance test	:As per IS:2121 (Part-II)
c)	Heat cycle test	:As per IS:2121 (Part-II)
d)	Slip strength test	: As per Annexure-A
e)	Corona Extinction Voltage (Dry)	: As per Annexure-A
f)	Radio Interference Voltage (dry)	: As per Annexure-A

Note : Tests mentioned at (c), (e) & (f) are not applicable to mid span compression joints for earthwire

5.1.5 Repair Sleeve for Conductor

a)	Chemical analysis of materials	: As per Annexure-A
b)	Corona extinction voltage test (dry)	: As per Annexure-A
c)	Radio interference voltage test (dry)	: As per Annexure-A

5.1.6 T-Connector for Conductor

a)	Chemical analysis of materials	: As per Annexure-A

	b)	Electrical resistance test	:As per IS:2121 (Part-II), Clause 6.5 & 6.6
	c)	Heating cycle test	:As per IS:2121 (Part-II)
	d)	Axial tensile load test on welded portion	: As per Annexure-A
	e)	Corona extinction voltage test (dry)	: As per Annexure-A
	f)	Radio interference voltage test (dry)	: As per Annexure-A
5.1.7	**Flexible Copper Bond**		
	a)	Slip strength test	: As per Annexure-A
5.1.8	**Vibration Damper for Earthwire**		
	a)	Chemical analysis of materials	: As per Annexure-A
	b)	Dynamic characteristics test	: As per Annexure-A
	c)	Vibration analysis	: As per Annexure-A
	d)	Clamp slip test	: As per Annexure-A
	e)	Fatigue tests	: As per Annexure-A
	f)	Damper efficiency test	: As per IS:9708
5.1.9	**Quad Spacer Damper for Conductor**		
	a)	Chemical analysis of materials	: As per Annexure-A
	b)	Clamp slip test	: As per Annexure-A
	c)	Performance test	: As per Annexure-A
		i) Aeolian	
		ii) sub span oscillations	
	d)	Magnetic power loss test (if applicable)	: As per Annexure-A
	e)	Dynamic Characteristic test	
	f)	Fatigue test	
	g)	Tension-compression Test	: As per Annexure-A
	h)	Corona extinction voltage test (dry)	: As per Annexure-A
	i)	Radio interference voltage test (dry)	: As per Annexure-A

	j)	Ozone test on elastomer	: As per Annexure-A
5.1.11	**Rigid Spacer for jumper**		
	a)	Chemical analysis of materials	: As per Annexure-A
	b)	Clamp slip test	: As per Annexure-A
	c)	Magnetic power loss test (if applicable)	: As per Annexure-A
	d)	Tension-compression Test	: As per Annexure-A
	e)	Corona extinction voltage test (dry)	: As per Annexure-A
	f)	Radio interference voltage test (dry)	: As per Annexure-A
5.1.12	**On Earthwire Suspension clamp Assembly**		
	a)	Chemical analysis of materials	: As per Annexure-A
	b)	Clamp slip strength Vs torque test for suspension clamp	: As per Annexure-A
	c)	Mechanical strength Test	: As per Annexure-A
5.1.13	**On Earthwire Tension clamp Assembly**		
	a)	Chemical analysis of materials	: As per Annexure-A
	b)	Mechanical strength test (excluding clamp)	: As per Annexure-A
	c)	Slip strength test for tension assembly	: As per Annexure-A
	d)	Electrical resistance test for tension clamp	: As per Annexure-A

5.1.14 All the type tests given under clause no. 5.1.1 above shall be conducted on Double 'I' suspension and Quadruple tension insulator string along with hardware fittings for 400 kV lines with Quad ACSR Moose conductor.

5.1.15 The tests specified under Clause No. 5.1.1.1 (a) to (g)/5.1.1.2 (a) to (f) shall be conducted on Single 'I' suspension pilot & single tension insulator string along with hardware fittings for 400 kV lines with Quad ACSR MOOSE conductor.

5.1.16 Heating cycle test on dead end assembly, mid span compression joint for Conductor and T – connector and performance test for Quad spacer damper shall not be required to be carried out if a valid test certificate is available for a similar

design, i.e., test conducted earlier should have been conducted in accredited laboratory (accredited based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation body of the country where laboratory is located) or witnessed by the representative (s) of OWNER or Utility. The test reports submitted shall be for the tests conducted within the last 5 (five) years prior to the date of Bid opening.

In case the tests have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test report not applicable due to any design / manufacturing change including substitution of components or due to non compliance with the requirement stipulated in the Technical Specification) the tests shall be conducted by the Contractor at no extra cost to the Owner.

5.1.17 Type tests specified under Clause 5.1.1.1 (a) to (d) /5.1.1.2 (a) to (d) shall not be required to be carried out if a valid test certificate is available for a similar design, i.e., tests conducted earlier should have been conducted in accredited laboratory (accredited based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation body of the country where laboratory is located) or witnessed by the representative (s) of OWNER or Utility. The test reports submitted shall be for the tests conducted within the last 5 (five) years prior to the date of Bid opening.

In case the tests have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test report not applicable due to any design / manufacturing change including substitution of components or due to non compliance with the requirement stipulated in the Technical Specification) the tests shall be conducted by the Contractor at no extra cost to the Owner.

5.2 **Acceptance Tests**

5.2.1 **On Both Suspension and Tension Hardware Fittings**

a)	Visual Examination	: As per IS:2486-(Part-I)
b)	Verification of dimensions	: As per IS:2486-(Part-I)
c)	Galvanising/Electroplating test	: As per IS:2486-(Part-I)
d)	Mechanical strength test of each component (excluding corona control rings grading ring and arcing horn)	: As per Annexure-A
e)	Mechanical Strength test of welded joint	: As per Annexure-A

f)	Mechanical strength test for corona control ring/ grading ring and arcing horn	BS:3288 - (Part-I)
g)	Test on locking device for ball and socket coupling	: As per IEC:372 (2)
h)	Chemical analysis, hardness tests, grain size, inclusion rating & magnetic paricle inspection for forgings/castings	: As per Annexure-A

5.2.2 **On Suspension Hardware Fittings only**

a)	Clamp Slip strength Vs Torque test for suspension clamp	: As per Annexure-A
b)	Shore hardness test of elastomer cushion for AG suspension clamp	: As per Annexure-A
c)	Bend test for armour rod set	: As per IS:2121(Part-I), Clause 7.5,7,10 & 7.11
d)	Resilience test for armour rod set	: As per IS:2121(Part-I), Clause 7.5,7,10 & 7.11
e)	Conductivity test for armour rods set	: As per IS:2121(Part-I), Clause 7.5,7,10 & 7.11

5.2.3 **On Tension Hardware Fittings only**

a)	Slip strength test for dead end assembly	: As per IS:2486 (Part-I) Clause 5.4

5.2.4 **On Mid Span Compression Joint for Conductor and Earthwire**

a)	Visual examination and dimensional verification	: As per IS:2121 (Part-II), Clause 6.2, 6.3 7 6.7
b)	Galvanising test	: As per Annexure-B
c)	Hardness test	: As per Annexure-B

5.2.5 **T-Connector for Conductor**

a)	Visual examination and dimensional verification	: As per IS:2121 (Part-II)
b)	Axial tensile load test for welded portion	: As per Annexure-A

5.2.6 **Repair Sleeve for Conductor**

a)	Visual examination and dimensional verification	: As per IS:2121(Part-II) Clause 6.2, 6.3

5.2.7 **Flexible Copper Bond**

a)	Visual examination and dimensional verification	: As per IS:2121(Part-II) Clause 6.2, 6.3
b)	Slip strength test	: As per annexure-A

5.2.8 **Vibration Damper for Earthwire**

a)	Visual examination and dimensional verification	: As per IS:2121(Part-II) Clause 6.2, 6.3 7 6.7
b)	Galvanising test	: As per Annexure-B
	(i) On damper masses	: As per Annexure-B
	ii) On messenger cable	: As per Annexure-B
c)	Verification of resonance frequencies	: As per Annexure-B
d)	Clamp slip test	: As per Annexure-B
e)	Clamp bolt torque test	: As per Annexure-B
f)	Strength of the messenger cable	: As per Annexure-B
g)	Mass pull off test	: As per Annexure-B
h)	Dynamic characteristics test	: As per Annexure-B

5.2.9 **Quad Spacer Damper for line / Rigid spacer for Jumper**

a)	Visual examination and dimensional verification	: As per IS:2121(Part-II) Clause 6.2, 6.3 7 6.7
b)	Galvanising test	: As per Annexure-B
c)	Movement test (except for spacer jumpers)	: As per Annexure-B
d)	Clamp slip test	: As per Annexure-B
e)	Clamp bolt torque test	: As per Annexure-B
f)	Compression-tension test	: As per Annexure-B
g)	Assembly torque test	: As per Annexure-B

	h)	Hardness test for elastomer (if applicable)	: As per Annexure-B

5.2.10 **Earthwire Tension Clamp Assembly**

	a)	Visual examination and dimensional verification	: As per IS:2121(Part-II)
	b)	Galvanising test	: As per Annexure-A
	c)	Slip strength test for tension clamp	: As per Annexure-A
	d)	Mechanical strength test on each component (excluding clamp)	: As per Annexure-A
	e)	Hardness test	: As per Annexure-A

5.2.11 **Earthwire Suspension Clamp Assembly**

	a)	Visual examination and dimensional verification	: As per IS:2121(Part-II)
	b)	Galvanising test	: As per Annexure-A
	c)	Clamp slip strength test	: As per Annexure-A
	d)	Mechanical strength test on each component (excluding clamp)	: As per Annexure-A

5.3 **Routine Tests**

5.3.1 **For Hardware Fittings**

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

5.3.1 **For conductor and earthwire accessories**

	a)	Visual examination and dimensional verification	: As per IS:2121(Part-II) Clause 6.2, 6.3 7 6.7

5.4 **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	: As per Annexure-A
c)	Chemical analysis, hardness tests and magnetic particle inspection for forging	: As per Annexure-A

5.5 Testing Expenses

5.5.1 Testing charges for the type test specified shall be indicated separately in the prescribed schedule.

5.5.2 Bidder shall indicate charges for all type tests covered under Clause No. 5.1.2 to 5.1.12 separately. The charges for each type test shall be separately indicated.

5.5.3 Testing charges for all type tests specified under clause no. 5.1.1 shall be indicated only by insulator Supplier's as the charges for these tests shall be paid to them duly by the Owner to avoid duplication and shall not be indicated by the hardware Supplier's.

5.5.4 For type tests which involve the tests on the complete insulator string with hardware fittings, the Contractor of hardware fittings shall supply the necessary number of sets of hardware fittings at the place of testing free of cost.

5.5.5 In case of failure in any type test, the Bidder whose material has failed is either required to modify the design of the material & successfully carryout all the type tests as has been detailed out in Clause 5.1 of this specification or to repeat that particular type test at least three times successfully at his own expenses. In case of failure of the complete string in any type test, the manufacturer whose product has failed in the test shall get the test repeated at his cost. The Supplier whose material has not failed in the test shall be required to supply the requisite quantity of material (that is, insulator discs or hardware fittings as the case may be) required for repeat testing at the place of testing and the cost of supply shall be borne by the Contractor whose material has failed in testing.

5.5.6 Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities for conducting the tests are available in the laboratory and the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule.

5.5.7 The entire cost of testing for acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/CIF Price.

5.5.8 In case of failure in any type test, repeat type tests are required to be conducted, then, all the expenses for deputation of Inspector Owner's representative shall be deducted from the contract price. Also if on receipt of the Contractor's notice of testing, the Owner's representative/Inspector does not find 'plant' to be ready for testing the expenses incurred by the Owner for re-deputation shall be deducted from contract price.

5.5.9 The Contractor shall intimate the Owner about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of Domestic Contractor and at least 6 weeks advance in case of Foreign Contractor) of the scheduled date of testing during which the Owner will arrange to depute his representative to be present at the time of carrying out the tests.

5.6 **Sample Batch For Type Testing**

5.6.1 The Contractor shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Owner. 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 Owner.

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

5.7 **Schedule of Testing and Additional Tests**

5.7.1 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.

5.7.2 The Owner 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 comply with the specifications.

5.7.3 The Owner 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 center. 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 Owner.

5.8 **Co-ordination for testing**

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

5.9 **Test Reports**

5.9.1 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 Owner, only after which the commercial production of the concerned material shall start.

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

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

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

5.10 **Inspection**

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

5.10.2 The material for final inspection shall be offered by the Contractor only under packed condition as detailed in clause 5.11 of this part of the Specification. The engineer shall select samples at random from the packed lot for carrying out acceptance tests.

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

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

5.10.5 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.

5.11 **Packing and Marking**

5.11.1 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.

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

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

5.11.4 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.

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

5.11.6 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 despatched 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.

5.12 **Standards**

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

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

Sl.	Indian Standard	Title	International Standard
1.	IS: 209-1992	Specification for zinc	BS:3436-1986
2.	IS:398-1992 Part-V	Aluminum Conductor Galvanised Steel-Reinforced For Extra High Voltage (400 KV) and above	IEC:1089-1991 BS:215-1970
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.		Ozone test on Elastomer	ASTM- D1 171
9.		Tests on insulators of Ceramic material or glass for overhead lines with a nominal voltage greater than 1000V	IEC:383-1993
10.	IS:4826	Galvanised Coating on Round Steel Wires	ASTM A472-729 BS:443-1969
11.	IS:6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433 ISO : 1460 (E)
12.	IS:8263	Method of Radio Interference Tests on High Voltage Insulators	IEC:437 NEMA:107 CISPR
13.	IS:6639	Hexagonal Bolts for Steel Structures	ISO/R-272
14.	IS:9708	Specification for Stock Bridge Vibration Dampers for Overhead Power Lines	
15.	IS:10162	Specification for Spacers Dampers for Twin Horizontal Bundle Conductors	

The standards mentioned above are available from:

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

1.0 Tests on Complete Strings with Hardware Fittings

1.1 Voltage Distribution Test (For Insulator String with Disc Insulators)

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 9% for suspension insulator strings and 10% for tension insulator strings for 400 kV line.

1.2 Corona Extinction Voltage Test (Dry)

The sample assembly when subjected to power frequency voltage shall have a corona Extinction voltage of not less than 320 kV (rms) line to ground for 400 kV lines 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 IEC: 60383.

1.3 RIV Test (Dry)

Under the conditions as specified under (1.2) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 1000 micro volts at one MHz when subjected to 50 Hz AC voltage of 305 kV line to ground under dry condition for 400 kV line. The test procedure shall be in accordance with IS: 8263/IEC:437.

1.4 Mechanical Strength Test

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of 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. After removal of the load, the string components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.5 **Vibration Test**

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 meters. In the case of suspension string a load equal to 600 kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and two/four sub conductors each tensioned at 43 KN shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductors throughout the duration of the test. Vibration dampers shall not be used on the test span. Both the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators string (more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement in mm of vibration at the antinode point nearest to the string shall be measured and the same shall not be less than $1000/f^{18}$ where f is the frequency of vibration in cycles/sec. The insulator string shall be vibrated for not less than 10 million cycles without any failure. After the test the disc insulators shall be examined for looseness of pins and cap or any crack in the cement. The hardware shall be examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and disc insulators after the vibration test. The disc insulators shall be subjected to the following, tests as per relevant standards :

Sl.	**Test**	**Percentage of insulator units to be tested**	
		Disc Insulators	**Long Rod Insulators**
a)	Temperature cycle test followed by mechanical performance test	60	100
b)	Puncture test/steep wave front test (Only for glass insulators)	40	-

1.6 **Power Arc test**

This test shall be performed on the complete string in accordance with IEC Technical Report IEC : 61467-1997 with the following test series :

Test circuit	**Short circuit current**	**Number and duration of test**
B	$I_n = I_{sys} = 40$ KA	Two of $t_n = 0.2$s and one of $t_n = 0.5$s

The acceptance criteria after the completion of test series shall be following.

a) Insulator separation not permitted.

b) Burning/melting of metal components, breaking of insulator sheds, glaze removal are permitted.

c) The complete insulator string along with its hardware fittings including arcing horn, corona control ring/grading ring shall withstand 80% of UTS.

1.7 **Assembly Test**

This test shall be carried out to ensure that the cotter pins, bolts, clamps etc., fit freely and properly.

2.0 **Tests on Hardware Fittings**

2.1 **Magnetic Power Loss Test for Suspension Assembly**

For 400 kV line with Quad ACSR MOOSE conductor, four hollow aluminium tubes of 32 mm diameter shall be placed 457 mm apart. An alternating current over the range of 400 to 800 Amps for shall be passed through each tube. The reading of the wattmeter with and without two suspension assemblies along with line side yoke plate, clevis eye shall be recorded. Not less than three suspension assemblies shall be tested. The average power loss for suspension assembly. shall be plotted for each value of current. The value of the loss corresponding to 600 amperes shall be read off from the graph.

2.2 **Galvanising/Electroplating Test**

The test shall be carried out as per Clause no. 5.9 of IS:2486-(Part-1) - 1972 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.

2.3 **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.

2.4 **Mechanical Strength Test of Welded Joint**

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

2.5 **Clamp Slip Strength Vs Torque Test for Suspension Clamp**

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

2.6 **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.

2.7 **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.

2.8 **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.

2.9 **Mechanical Strength Test for Suspension/Tension Hardware Fittings**

The complete string without insulators excluding arcing horn, corona control rings/grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. This load shall be held for five minutes and then removed. After removal of the load, the string component shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached and held for the one

minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

2.10 **Ozone Test for Elastomer**

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

3.0 Tests on Conductor and Earth wire Accessories

3.1 **Mid Span Compression Joint for Conductor and Earth wire**

(a) Slip Strength Test

The fitting compressed on conductor/earth wire shall not be less than one meter in length. 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/earth wire and retained for one minute at this load. There shall be no movement of the conductor/ earth wire relative to the fittings and no failure of the fit tings during this one minute period.

3.2 **T-Connector for Conductor**

Axial Tensile Load Test for Welded Portion

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

3.3 **Flexible Copper Bond**

Slip Strength Test

On applying a load of 3 kN between the two ends, stranded flexible copper cable shall not come out of the connecting lugs and none of its strands shall be damaged. After the test, the lugs shall be cut open to ascertain that the gripping of cable has not been affected.

3.4 **Vibration Damper for Earth wire**

(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 5 to 40

Hz for damper for ACSR MOOSE Conductor and from 10 to 60 Hz for damper for earth wire. The damper assembly shall be vibrated vertically with a $\pm$ 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at ± 0.5mm to determine following characteristics with the help of suitable recording instruments:

(i) Force Vs frequency

(ii) Phase angle Vs frequency

(iii) Power dissipation Vs frequency

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

Acceptance criteria for vibration damper.

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

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

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

V.D. for MOOSE : 0.191 f to 0.762 f gf/mm

V.D. for 7/3.66Earth wire : 0.060 f to 0.357 f gf/mm

Where f is frequency in Hz.

(iv) The above mean phase angle response curve shall be between 25^{o} to 130^{o} 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 earthwire shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis :

(i) The analysis shall be borne for single conductor / earthwire without armour rods.. The tension shall be taken as 43 kN and 14 kN for ACSR MOOSE conductor and 7/3.66 mm earth wire respectively for a span ranging from 100 m to 1100 m.

(ii) The self damping factor and flexural stiffness (El) for earthwire shall be calculated on the basis of experimental results. The details of 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 earthwire 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 earthwire without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the aeolian vibration levels exceed the specified limits shall be determined.

(vi) From vibration analysis of earthwire with damper/dampers installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment point and the antinodes on the earthwire shall be determined. In addition to above damper clamp vibration amplitude and antinode 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 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 7/3.66 mm earth wire shall be subjected to a tension at 14 kN 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 earthwire has been tensioned, clamps shall be installed to support the earthwire 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 earthwire. 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.

(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 earthwire for a minimum duration of one minute shall not slip i.e. the permanent displacement between earthwire 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 torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ± 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 retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from conductor/earthwire 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/earthwire under clamp shall also be free from any damage.

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

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

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

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

3.5 Spacer Damper

(a) Performance Test

One very important quality of a spacer damper is its ability to control Aeolian vibrations and sub-span oscillations within acceptable limits. Performance testing shall be carried out on an experimental test line, as described in Clause 2.5.3, Section-VI. After testing, there shall not be any slippage greater than 3mm on conductors, loosening of components or damage to conductors or spacer damper components.

i) Aeolian Vibrations

Under the specified operating conditions, the spacer damper shall control Aeolian vibrations in order to prevent damage to conductors either at suspensions clamp or at the spacer damper clamps.

For measurements and evaluation purpose, the following criteria shall apply:

- The peak to peak amplitude of any vibration cycle shall never exceed 1.5 Yb, where Yb is the safe "Bending Amplitude".
- The RMS value of any vibration measurement sample shall be lower than 0.6 Yb/2, at 89mm from last point of contact with suspension or spacer clamp.

ii) Sub-span Oscillations

The spacer damper system shall control subspan oscillations in order to prevent conductor damage due to clashing or to severe bending stresses at the spacer damper clamp, and avoid wear of spacer dampers elements.

In order to achieve that performance level, subspan oscillation shall be controlled within the following limits, for any wind speed below 60 km/hr.

- In any individual subspan, the peak to peak amplitude of each subconductor shall never exceed 350mm.
- In any individual subspan, the RMS value (Y rms) of each oscillation measurement sample shall be such that:

  f.Yrms < 80 mm/sec.

  Where

  Y (rms) = antinode amplitude (mm)

  f = frequency of the oscillation (cycle/sec.)

  f = (1/2L) sqrt (T/m)

  L = subspan length (m)

  T = Conductor tension (N)

  m = conductor mass (kg/m)

  For any set of 10 or more measurement samples associated with a given wind sector and a given subspan, the Y rms value shall be such that:

  f. Yrms <70 mm/sec.

  The wind sector is defined as a combination of 5 km/hr wind speed range and 10^{o} wind direction range.

  Each measurement sample shall be at least one (1) minute long.

(b) Clamp Slip Test (for spacer for jumper also)

The spacer damper assembly shall be installed on a four conductors bundle string at a tension of 43 kN. 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 Clamp using	2.5	2.5
Preformed rods	2.5	12

In order to determine the effect of conductor creep with the spacer dampers only, the conductor shall be retensioned to 68 kN without further tightening the spacer damper clamps and the clamp slip test shall be re-performed. The minimum slip under longitudinal loads shall not be less than 80% of the values given in the above table.

Similar testing shall be performed of the other clamps of the same sample. For spacer dampers only, such clamp slip tests shall also be conducted after each of the vibration tests mentioned in Clause 3.5 (a) but under longitudinal loading corresponding to 80% of the values given in the above table.

c) Dynamic Characteristic Test for Spacer Damper

The purpose of this test is to obtain quantitative information regarding the dynamic characteristic 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 to the spacer damper articulation and measurement of the force (F), displacement (X) and phase angle (Ø) between these two. From these values, the stiffness (K) and damping faction (n) shall be calculated as:

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.

In case of spacer dampers with a single articulation for each arm, the central body shall be applied between two arms corresponding to a horizontal pair of conductors. In this case, one spacer clamp may be fixed and the other displaced in its direction, the central body being free to move.

a) Fatigue Test for Spacer Damper

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 300N;
- 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. The test shall be performed at two amplitudes, 10% and 60% of the maximum displacement.

The spacer damper shall show no signs of cracks or detoriation, loosening of bolts or abnormal wear.

The dynamic characteristics (k and n) shall not be less than 75% of the values measured before the fatigue test. The test shall be performed on three samples which have been previously subjected to dynamic characteristics test. Motion shall be as described in Dynamic Characteristic Test.

b) Ozone Test

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

c) Compression and Tensile Tests

Three samples of spacer dampers shall be subjected to a tension compression test. The load shall be applied between each pair of diagonally opposed conductors. Under the compressive load, the arms shall be allowed to rotate until they reach their mechanical stops. A compressive load of 15 kN shall first be applied and held for five minutes. Then a tensile load of 5 kN shall be applied on the same pair of arms. The test shall be repeated on the other pair of arms. After the test, the spacer damper must be dismantled and the components examined. There should not be any failure of components or damage impairing

the reusability of the spacer damper such as permanent deformation. The spacer geometry shall be maintained within 5% of the original dimensions.

3.6 Magnetic Power Loss Test for Spacer Damper/Spacer for jumper

The sample involving ferrous parts shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave. The test should be carried out at various currents ranging from 400 amperes to 800 amperes for 400 kV line and the magnetic power loss at various currents should be specified in tabulated graphical form. The difference between the power losses without and with sample at room temperature shall be limited to 1 watt for 600 amperes current (rms) for ACSR MOOSE Conductor. The losses shall be determined by averaging the observations obtained from at least four samples.

3.7 Mechanical Strength Test for Earthwire Suspension/Tension Clamp

(a) The suspension assembly/tension assembly (excluding tension clamp) shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. This load shall be held for five minutes and then removed. After removal of the load, the components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to loosen the nuts initially. The assembly shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

(b) Clamp Slip Strength Vs Torque Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length of Earthwire shall be fixed in the clamps. The clamp slip strength at various tightening torques shall be obtained by gradually applying the load at one end of the earthwire. The clamp slip strength Vs torque curve shall be drawn. The clamp slip strength at the recommended tightening torque shall be more than 12 kN but less than 17 kN for 7/3.66 mm earthwire.

(c) Slip Strength Test of Tension Clamp

Tension clamps shall be compressed on a 5 m length of earthwire on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load of 50% of the specified breaking load of the earthwire shall be applied & the sample shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of

the fitting, the load shall be steadily increased to 95% of the specified breaking load and maintained for one minute. There shall be no movement of the earthwire relative to the fitting during this one minute period and no failure of the fitting also.

(d) Electrical Resistance Test of Tension Clamp

The tension clamp and the jumper shall be compressed on two suitable lengths of earthwire. The electrical resistance shall be measured between points on earthwire near the clamp and near the jumper mouth keeping 25 mm clearance of the fitting and should not exceed 75% of the measured resistance of equivalent length of earthwire. The test shall be conducted with direct current. The current connections shall be at a distance not less than 50 times the diameter of earthwire from the fitting and shall be made so that effective contact is ensured with all those strands of the earth wire which would be taken into account in calculating its equivalent resistance. The test shall be repeated with the polarity reversed and the average of the two results considered as the measured value.

3.8 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 for 400 kV lines under dry condition for 400 kV line. 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.

3.9 Radio Interference Voltage Test (Dry)

Under the conditions as specified under (3.8) above, the sample shall have a radio interference voltage level below 1000 micro volts at one MHz when subjected to 50 Hz AC voltage of 305 kV rms line to ground under dry condition for 400 kV line. The test procedure shall be in accordance with IS:8263.

3.10 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.

4.0 Tests on All components (As applicable)

4.1 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%.

4.2 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 Purchaser in Quality Assurance Programme.

4.3 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 Purchaser in Quality Assurance Programme.

ANNEXURE-B

Acceptance Tests

1 **Mid Span Compression Joint for Conductor and Earthwire**

(a) Hardness Test

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

2. **T-Connector for Conductor**

(a) Axial Tensile Load Test for Welded Portion

Same as clause 3.2 of Annexure-A .

3. **Flexible Copper Bond**

(a) Slip Strength Test

Same as clause 3.3 of Annexure - A.

4. **Vibration Damper for Conductor & Earthwire**

(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 3.4 (c) (ii) of Annexure - A.

(c) Clamp Bolt Torque Test

The clamp shall be attached to a section of the earthwire. A torque of 150 percent of the manufacturer's specified torque shall be applied to the bolt. There shall be no failure of component parts. The test set up is as described in Clause 3.4 (c) (i), Annexure-A.

(d) Strength of the Messenger Cable

The messenger cable shall be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. Alternatively, each strand of message caste 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 caste. The load shall be not less than the value guaranteed by the Contractor

(e) Mass Pull off Test

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

(f) Dynamic Characteristics Test

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

Vibration Damper:

- 1 Sample for 1000 Nos. & below Conductor
- 3 Samples for lot above 1 000 & up to 5000 nos.
- Additional 1 sample for every additional 1500 pieces above 5000.

The acceptance criteria will be as follows

(i) The above dynamic characteristics curve for reactance & phase angle will be done for frequency range of 10 Hz to 60 Hz for vibration damper for 7/3.66 mm earth wire.

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

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

(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.

5. Spacer Damper/ Spacer for jumper

(a) Dynamic charactics Test

The test shall be carried out as per clause 3.5 (c) of Annexure-A.

(b) Movement Test

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

(i)	Longitudinal movement parallel to the conductor	± 50 mm
(ii)	Vertical movement in a vertical direction at right angle to the conductor	± 25 mm
(iii)	Torsional movement/angular movement in a vertical plane parallel to the conductor	± 5 deg.

(c) Compressive and Tensile Test

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

(d) Clamp Slip Test

Same as clause 3.5(b) of Annexure-A.

(e) Clamp Bolt Torque Test

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

(f) Assembly Torque Test

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

(g) Hardness test for Elastomer

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

(h) UTS of Retaining Rods

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