NEPAL ELECTRICITY AUTHORITY
(An Undertaking of Government of Nepal)

PROJECT MANAGEMENT DIRECTORATE

SASEC Power System Expansion Project
MARSYANGDI-KATHMANDU 220kV T/L PROJECT

BIDDING DOCUMENT FOR

Procurement of Plant for Marsyangdi-Kathmandu 220 kV Transmission Line
(Design, Supply and Install)

Single-Stage, Two-Envelope
Bidding Procedure

Issued on: ....................
Invitation for Bids No.: ICB-PMD-MKTLP–072/73 - 02
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Country: Nepal

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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/Composite 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 Triple/Double 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.

1.3 Interchangeability

1.3.1 The hardware for insulator strings with disc insulators / composite 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 section–I of this Specification. The designation should be in accordance with the standard dimensions stated in IS:2486-(Part-II)/IEC:60120. The dimensions shall be checked by the appropriate gauge after galvanising 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/arching horn. All the corners and edges should be rounded off with a radius of atleast 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 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.

1.13.10 **Standard Preformed Armour Rod Set**

1.13.10.1 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.

1.13.10.2 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.

1.13.10.3 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.
1.13.10.4 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.

1.13.10.5 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.

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

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

1.13.11 Armour Grip Suspension Clamp

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

1.13.11.2 Elastomer insert shall be resistant to the effects of temperature up to 95°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.

1.13.11.3 The AGS preformed rod set shall be as detailed in clause 1.13.10.4 to 1.13.10.7 in general except for the following.

1.13.11.4 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 ‘COMPRESS FIRST’ suitably inscribed near the point on each assembly where the compression begins. If the dead end assembly is designed for intermittent die compressions it shall bear identification marks ‘COMPRESS ZONE’ AND ‘NON-COMPRESS 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 thereof 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 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 and 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)**
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of item</th>
<th>Material treatment</th>
<th>Process of Standard</th>
<th>Reference</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Security Clips</td>
<td>Stainless Steel/Phospher Bronze</td>
<td>-</td>
<td>AISI 302 or 304-L/ IS-1385</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Arcing Horn</td>
<td>Mild Steel Rod/Tube Type</td>
<td>Hot dip galvanised</td>
<td>As per IS-226 or IS-2062</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Ball Fittings, Socket, all shackles links cleves</td>
<td>Class-IV Steel</td>
<td>Drop forged &amp; normalized Hot dip galvanised</td>
<td>As per IS:2004</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Yoke Plate</td>
<td>Mild Steel</td>
<td>Hot dip galvanised</td>
<td>As per IS-226 or IS-2062</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Sag Adjustment plate</td>
<td>Mild Steel</td>
<td>Hot dip galvanised</td>
<td>As per IS-226 or IS-2062</td>
<td></td>
</tr>
<tr>
<td>6(a).</td>
<td>Corona Control ring/Grading ring</td>
<td>High Strength Al. Alloy tube</td>
<td>Heat treated Hot dip galvanised</td>
<td>ASTM-B429 or as per IS</td>
<td>Mechanical strength of welded joint shall not be less than 20 KN</td>
</tr>
<tr>
<td>6(b).</td>
<td>Supporting Brackets &amp; Mounting Bolts</td>
<td>High Strentgh Al Alloy 7061/6063/65032/63400 Type</td>
<td>Heat treated Hot dip galvanised</td>
<td>ASTM-B429 or as per IS:226 or IS:2062</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Turn Buckle</td>
<td>Class-II Steel</td>
<td>Forged hot dip galvanized</td>
<td>IS:2004</td>
<td></td>
</tr>
<tr>
<td>8(a).</td>
<td>Free centre type clamp/Envelope type Clamp: Clamp Body, Keeper Piece</td>
<td>High Strength Al. Alloy 4600/LM-6 or 6061/65032</td>
<td>Casted or forged &amp; Heat treated</td>
<td>IS:617 or ASTM-B429</td>
<td></td>
</tr>
<tr>
<td>8(b)</td>
<td>Envelope type Clamp: Cotter bolts/ Hangers, Shackles,</td>
<td>Mild Steel</td>
<td>Hot dip galvanised</td>
<td>As per IS-226 or IS-2062</td>
<td></td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Name of item</td>
<td>Material treatment</td>
<td>Process of Standard</td>
<td>Reference</td>
<td>Remarks</td>
</tr>
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<tr>
<td></td>
<td>Brackets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8(c)</td>
<td>Envelope type Clamp: U Bolts</td>
<td>Stainless Steel or High Strength Al alloy 6061/6063 or 65032/63400</td>
<td>Forged &amp; &amp; Heat treated</td>
<td>AISI 302 or 304-L ASTM-B429</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>P. A. rod</td>
<td>High strength Al alloy type 6061 or equivalent</td>
<td>Heat treatment during manufacturin g</td>
<td>ASTM:B429</td>
<td>Min. tensile strength of 35 kg/mm²</td>
</tr>
<tr>
<td>10.</td>
<td>AGS clamp</td>
<td>High strength corrosion resistant Al. alloy LM6, 4600 or equivalent 6061</td>
<td>Cast/forged heat treated.</td>
<td>IS:617 or equivalent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Supporting house</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Al insert and retaining strap</td>
<td>High strength Al alloy type 6061 or equivalent</td>
<td>Forged and Heat treated</td>
<td>ASTM:B429</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(c) Elastomer cushion</td>
<td>Moulded on Al reinforcement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11(a).</td>
<td>Dead End Assembly: Outer Sleeve</td>
<td>EC grade Al of purity not less than 99.50%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11(b).</td>
<td>Steel Sleeve</td>
<td>Mild Steel</td>
<td>Hot Dip Galvanised</td>
<td>IS:226/IS-2062</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Balancing weights</td>
<td>Cast iron MCI/ machined Mild Steel</td>
<td>Hot dip galvanised</td>
<td>IS:226/2062 or equivalent</td>
<td></td>
</tr>
</tbody>
</table>

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 be 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° 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 hardwares 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/ AACSR 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 **Vibration Damper**

2.3.1 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.

2.3.2 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.

2.3.3 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 220 kV line.

2.3.4 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.

2.3.5 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.

2.3.6 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.
2.3.7 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.

2.3.8 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:

<table>
<thead>
<tr>
<th>Sl. o.</th>
<th>Description</th>
<th>Technical particulars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Configuration</td>
<td>Two continuously steel earthwire 10.98 mm diameter in horizontal configuration. Refer to Section-I for mechanical properties of the earthwire.</td>
</tr>
<tr>
<td>2.</td>
<td>Span length in meters</td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Ruling design span</td>
<td>400 meters</td>
</tr>
<tr>
<td>ii)</td>
<td>Maximum span</td>
<td>1100 meters</td>
</tr>
<tr>
<td>iii)</td>
<td>Minimum span</td>
<td>100 meters</td>
</tr>
<tr>
<td>3.</td>
<td>Tensile load in Conductor at temperature of 0 deg. C and still air</td>
<td>As per sag tension calculations.</td>
</tr>
<tr>
<td>4.</td>
<td>Maximum permissible dynamic strain</td>
<td>+/- 150 micro strains</td>
</tr>
</tbody>
</table>

2.3.9 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.

2.3.10 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.

3.3 **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.

3.4 **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.

3.5 **Bundle Spacer**

3.5.1 Armour grip bundle spacers shall be used to maintain the spacing of 450 mm between the two sub-conductors of each bundle under all normal working conditions.

3.5.2 Spacers offering equivalent or better performance shall also be accepted provided offer meets the qualifying requirements stipulated in the Specification.

3.5.3 The offer shall include placement charts recommending the number of spacers per phase per span and the sub span lengths to be maintained between the spacers while installing on the twin bundle conductors.

3.5.3.1 The placement of spacers shall be in such a way that adjacent sub spans are sufficiently detuned and the critical wind velocity of each sub span shall be kept more than 30 km/hr and to avoid clashing of sub conductors. The placement shall ensure bundle stability under all operating conditions.

3.5.3.2 The placement chart shall be provided for spans ranging from 100 m to 1100m. The number of spacers recommended for a ruling design span of 400m shall
however be seven with no sub-span greater than 70m and no end sub-span longer than 40m.

3.5.3.3 The Bidder may offer more number of spacers per ruling design span than the specified. However, in such case, suitable price compensation shall be considered for evaluation. For the purpose of price compensation, all the spans shall be assumed to be ruling design spans.

3.5.3.4 The Bidder shall also furnish all the relevant technical documents in support of their placement charts along with the bid.

3.5.4 Jumpers at tension points shall also be fitted with spacers so as to limit the length of free conductor to 3.65 m and to maintain the sub conductor spacing of 450 mm. 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.

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

3.5.5.1 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.

3.5.5.2 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.

3.5.5.3 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 + 0.1 mm and the length of the rods shall not be less than 1100 mm.

3.5.5.4 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.

3.5.5.5 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.

3.5.5.6 Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened.
3.5.5.7 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.

3.5.5.8 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.

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

3.5.5.10 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.

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

3.5.5.12 Rigid spacers shall be acceptable only for jumpers.

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

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

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

3.5.5.16 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.

3.5.5.17 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.

3.5.5.18 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.

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

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

3.6 Rigid Spacer for Jumper for Conductor

3.6.1 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.

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

3.6.2.1 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.

3.6.2.2 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.

3.6.2.3 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 ± 0.1 mm and the length of the rods shall not be less than 1100 mm.

3.6.2.4 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.

3.6.2.5 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.

3.6.2.6 Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened.
3.6.2.7 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.

3.6.2.8 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.

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

3.6.2.10 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.

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

3.6.2.12 Rigid spacers shall be acceptable only for jumpers.

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

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

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

3.6.2.16 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 that stipulated in the Standard Technical Particulars.

3.6.2.17 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.

3.6.2.18 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.

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

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

3.7 Material and Workmanship

3.7.1 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 220 kV transmission line applications with bundle conductors and will give continued good performance.

3.7.2 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.

3.7.3 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.

3.7.4 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.

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

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

3.7.7 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.

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

3.7.9 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.

3.8 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.

3.9 Bid Drawings

3.9.1 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.

3.9.2 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

3.9.3 Placement charts for spacer and damper

3.9.4 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.
4.0 **Accessories for Earthwire**

4.1 **General**

4.1.1 This portion specify the details of the technical particulars of the accessories for Galvanised Steel Earth wire.

4.1.2 2.5% extra fasteners shall be supplied.

4.2 **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.

4.3 **Vibration Damper**

4.3.1 Vibration dampers of 4R-Stockbridge type with four (4) different frequencies spread within the specified aeolian frequency band-width corresponding to wind speed of 5 m/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.

4.3.2 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.

4.3.3 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.

4.3.4 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%
towers as suspension locations and 20% of the towers as tension locations and all the spans assumed to be ruling design spans.

4.3.5 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.

4.3.6 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.

4.3.7 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.

4.3.8 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:-

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<td>4.</td>
<td>Maximum permissible dynamic strain</td>
<td>+/- 150 micro strains</td>
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4.3.9 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.

4.3.10 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.

4.4 **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.

4.5 **Suspension Clamp**

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

4.5.2 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.

4.5.3 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.
4.5.4 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.

4.5.5 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.

4.5.6 The complete assembly shall adhere to the values stipulated in the Standard Technical Particulars.

4.6 **Tension Clamp**

4.6.1 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.

4.6.2 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.

4.6.3 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.

4.6.4 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.

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

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

4.7 **Material and Workmanship**

Same as Clause 2.7 of this section
4.8 **Compression Marking**

Same as Clause 2.8 of this section

4.9 **Bid Drawings**

Same as Clause 2.9 of this section

5.0 **Standard technical particulars**

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

**Standardised Technical Particulars**

**Hardware Fittings and Accessories for 220 kV Transmission Line**

**SUSPENSION HARDWARE FITTINGS FOR TWIN AACSR/ ACSR ‘MOOSE’ CONDUCTOR**

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single suspension Pilot Fitting with Envelope clamp</td>
</tr>
<tr>
<td>1.</td>
<td>Maximum magnetic power loss of one suspension assembly at sub-conductor current of 600 amperes</td>
<td>Watt</td>
<td>8</td>
</tr>
<tr>
<td>2.</td>
<td>Slipping strength of suspension assembly</td>
<td>KN</td>
<td>20-29</td>
</tr>
<tr>
<td>3.</td>
<td>Particulars of standard/ AGS preformed armour rod set for suspension assembly</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) No. of rods per set</td>
<td>No.</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>b) Direction of lay</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Overall length after fitting on conductor</td>
<td>mm</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>d) Diameter of each rod</td>
<td>mm</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>e) Tolerance in</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Diameter of each rod</td>
<td>±mm</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>ii) Length of each rod</td>
<td>±mm</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>iii) Difference of length between the longest and shortest rod in a set</td>
<td>±mm</td>
<td>NA</td>
</tr>
<tr>
<td>Sl.</td>
<td>Description</td>
<td>Unit</td>
<td>Single Tension</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------------------------------------------</td>
<td>------------</td>
<td>----------------</td>
</tr>
<tr>
<td>1.</td>
<td>Mechanical strength of Tension fitting(excluding dead end clamp)</td>
<td>KN</td>
<td>120</td>
</tr>
<tr>
<td>2.</td>
<td>Type of dead end assembly</td>
<td></td>
<td>Compression</td>
</tr>
<tr>
<td>3.</td>
<td>Compression pressure</td>
<td>MT</td>
<td>100</td>
</tr>
<tr>
<td>4.</td>
<td>Maximum electrical resistance of dead end assembly as a percentage of equivalent length of Conductor</td>
<td>%</td>
<td>75</td>
</tr>
<tr>
<td>5.</td>
<td>Slip strength of dead end assembly</td>
<td>KN</td>
<td>153.2</td>
</tr>
<tr>
<td>6.</td>
<td>Galvanising</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Minimum weight of Zinc coating for steel parts</td>
<td>gm/m²</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>b) Purity of Zinc used for galvanising</td>
<td>%</td>
<td>99.95 (IS 209)</td>
</tr>
<tr>
<td></td>
<td>c) Min. No. of dips in standard preece test the ferrous parts can withstand.</td>
<td>Nos.</td>
<td></td>
</tr>
<tr>
<td>Sl.</td>
<td>Description</td>
<td>Unit</td>
<td>Particulars/ Value</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------------------------------</td>
<td>------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>b) Spring washers: 3 dips of 1 minute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) all others: 6 dips of 1 minute</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Mid span compression Joint for ACSR MOOSE Conductor

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material of Joint</td>
<td></td>
<td>Aluminium of purity 99.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mild Steel(Fe-410, IS:2062)</td>
</tr>
<tr>
<td>2.</td>
<td>Range of Hardness of the steel sleeve (Brinnel hardness)</td>
<td>BHN</td>
<td>From 100 to 200</td>
</tr>
<tr>
<td>3.</td>
<td>Weight of Zinc coating for steel sleeve</td>
<td>gm/m²</td>
<td>610</td>
</tr>
<tr>
<td>4.</td>
<td>Dimension of sleeve Before compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Inside diameter</td>
<td>mm</td>
<td>34.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>ii) Outside diameter</td>
<td>mm</td>
<td>54.00 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>iii) Length</td>
<td>mm</td>
<td>735 ± 5</td>
</tr>
<tr>
<td>5.</td>
<td>Dimensions of Sleeve after compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Outside dimension(Corner to corner)</td>
<td>mm</td>
<td>53.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>ii) Outside dimension ( face to face)</td>
<td>mm</td>
<td>46.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>iii) Length</td>
<td>mm</td>
<td>785 (approx)</td>
</tr>
<tr>
<td>6.</td>
<td>Slip strength</td>
<td>KN</td>
<td>153.2</td>
</tr>
<tr>
<td>7.</td>
<td>Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.</td>
<td>%</td>
<td>75</td>
</tr>
<tr>
<td>8.</td>
<td>Minimum corona Extinction voltage kV (rms) under dry condition</td>
<td>kV</td>
<td>320</td>
</tr>
<tr>
<td>9.</td>
<td>Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition</td>
<td>Micro Volts</td>
<td>1000</td>
</tr>
</tbody>
</table>

### Repair sleeve for ACSR MOOSE Conductor

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material</td>
<td></td>
<td>Aluminium of minimum purity 99.5%</td>
</tr>
</tbody>
</table>
2. **Dimension of Aluminum sleeve Before compression**

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Particulars/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Inside diameter</td>
<td>mm</td>
<td>34.00 ± 0.5</td>
</tr>
<tr>
<td>ii) Outside diameter</td>
<td>mm</td>
<td>54.00 ± 1.0</td>
</tr>
<tr>
<td>iii) Length</td>
<td>mm</td>
<td>300.00 ± 5.0</td>
</tr>
</tbody>
</table>

3. **Dimensions of Aluminum Sleeve after compression**

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Particulars/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Outside dimension (Corner to corner)</td>
<td>mm</td>
<td>53.00 ± 0.5</td>
</tr>
<tr>
<td>ii) Outside dimension (face to face)</td>
<td>mm</td>
<td>46.00 ± 0.5</td>
</tr>
<tr>
<td>iii) Length</td>
<td>mm</td>
<td>330.00 (Approx.)</td>
</tr>
</tbody>
</table>

4. **Minimum corona Extinction voltage kV (rms) under dry condition**

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Particulars/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kV</td>
<td>320</td>
</tr>
</tbody>
</table>

5. **Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition**

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Particulars/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Micro Volts</td>
<td>1000</td>
</tr>
</tbody>
</table>

### T-connector for ACSR MOOSE Conductor

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

### VIBRATION DAMPER FOR TWIN ACSR/ AACSR MOOSE CONDUCTOR

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type of Damper</td>
<td></td>
<td>4R-Stockbridge type</td>
</tr>
<tr>
<td>2.</td>
<td>Materials of components</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**VIBRATION DAMPER FOR TWIN ACSR/ AACSR MOOSE CONDUCTOR**
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a) Damper masses</strong></td>
<td>Cast iron/mild steel/Zinc alloy duly hot dip galvanised</td>
</tr>
<tr>
<td><strong>b) Clamp</strong></td>
<td>Aluminum alloy 4600</td>
</tr>
<tr>
<td><strong>c) Messenger cable</strong></td>
<td>High tensile strength galvanized steel</td>
</tr>
<tr>
<td><strong>3. Number of strands in stranded messenger cable</strong></td>
<td>Nos. 19</td>
</tr>
<tr>
<td><strong>4. Minimum ultimate tensile strength of stranded messenger cable</strong></td>
<td>Kg/mm$^2$ 135</td>
</tr>
<tr>
<td><strong>5. Slip strength of stranded messenger cable (mass pull off)</strong></td>
<td>KN 5</td>
</tr>
<tr>
<td><strong>6. Slipping strength of damper clamp</strong></td>
<td></td>
</tr>
<tr>
<td>(a) Before fatigue test</td>
<td>KN 2.5</td>
</tr>
<tr>
<td>(b) After fatigue test</td>
<td>KN 2</td>
</tr>
<tr>
<td><strong>7. Resonance frequencies range</strong></td>
<td>Hz 5 to 40</td>
</tr>
<tr>
<td><strong>8. Maximum magnetic power loss per vibration damper watts for 600 amp, 50 Hz Alternating Current</strong></td>
<td>Watts 1</td>
</tr>
<tr>
<td><strong>9. Minimum corona Extinction voltage kV (rms) under dry condition</strong></td>
<td>kV 320</td>
</tr>
<tr>
<td><strong>10. Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition</strong></td>
<td>Micro Volts 1000</td>
</tr>
<tr>
<td><strong>11. Percentage variation in reactance after fatigue test in comparison with that before fatigue test</strong></td>
<td>% +/-40 (Maximum)</td>
</tr>
<tr>
<td><strong>12. Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test</strong></td>
<td>% +/-40 (Maximum)</td>
</tr>
<tr>
<td><strong>13. Galvanising</strong></td>
<td></td>
</tr>
<tr>
<td>a) Minimum weight of Zinc coating for steel parts</td>
<td>gm/m$^2$ 600</td>
</tr>
<tr>
<td>b) Purity of Zinc used for galvanising</td>
<td>% 99.95 (IS 209) or 98.5 (IS 13229)</td>
</tr>
<tr>
<td>c) Min. No. of dips in standard preece test the ferrous parts can withstand.</td>
<td>Nos. a) Fastenees: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute</td>
</tr>
<tr>
<td>Sl.</td>
<td>Description</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>1.</td>
<td>Type of Bundle Spacer</td>
</tr>
<tr>
<td>2.</td>
<td><strong>Insert</strong></td>
</tr>
<tr>
<td></td>
<td>(i) Materials of components</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) Manufacturing process of component</td>
</tr>
<tr>
<td></td>
<td>parts</td>
</tr>
<tr>
<td>3.</td>
<td><strong>Retaining rods (if used)</strong></td>
</tr>
<tr>
<td></td>
<td>(a) Number of retaining rods used for</td>
</tr>
<tr>
<td></td>
<td>each spacer</td>
</tr>
<tr>
<td></td>
<td>(b) Diameter</td>
</tr>
<tr>
<td></td>
<td>(c) Length</td>
</tr>
<tr>
<td></td>
<td>(d) Minimum UTS of rods</td>
</tr>
<tr>
<td>4.</td>
<td><strong>Elastomer</strong></td>
</tr>
<tr>
<td></td>
<td>(a) Type</td>
</tr>
<tr>
<td></td>
<td>(c) Moulded on insert</td>
</tr>
<tr>
<td></td>
<td>(d) Shore hardness</td>
</tr>
<tr>
<td></td>
<td>(e) Thickness on insert</td>
</tr>
<tr>
<td></td>
<td>(f) Temp. range for which designed</td>
</tr>
<tr>
<td>5.</td>
<td><strong>Minimum ultimate tensile strength of</strong></td>
</tr>
<tr>
<td></td>
<td>spacer</td>
</tr>
<tr>
<td></td>
<td>(a) Compressive load</td>
</tr>
<tr>
<td></td>
<td>(b) Tensile load</td>
</tr>
<tr>
<td>6.</td>
<td><strong>Slipping strength of spacer clamp</strong></td>
</tr>
<tr>
<td></td>
<td>a) Before vibration test</td>
</tr>
<tr>
<td></td>
<td>b) After vibration test</td>
</tr>
<tr>
<td>7.</td>
<td>Minimum corona Extinction voltage</td>
</tr>
<tr>
<td></td>
<td>kV (rms) under dry condition</td>
</tr>
<tr>
<td>8.</td>
<td>Maximum Radio Interference Voltage (RIV)</td>
</tr>
<tr>
<td></td>
<td>at 1 MHz for phase to earth voltage of</td>
</tr>
<tr>
<td></td>
<td>305 kV (rms) under dry condition</td>
</tr>
</tbody>
</table>
### Rigid Spacer for Jumper for Twin ACSR/ AACSR Moose Conductor

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type of Spacer</td>
<td>Rigid type without retaining rods</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Material of component parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Clamp</td>
<td>Aluminum alloy (4600)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Main body</td>
<td>Aluminum alloy 6063/63400 ; 6061/65032</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Manufacturing process of component parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Clamp</td>
<td>Die-casting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Main body</td>
<td>Aluminum extrusion</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Minimum ultimate tensile strength of spacer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Compressive load</td>
<td>kN 14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Tensile load</td>
<td>kN 7.0</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Slipping strength of spacer clamp</td>
<td>kN 2.5</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Maximum Magnetic power loss per spacer for 600 Amps, 50 Hz Alternating Current</td>
<td>Watts 1</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Minimum corona Extinction voltage kV (rms) under dry condition</td>
<td>kV 320</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition</td>
<td>Microvolts 1000</td>
<td></td>
</tr>
</tbody>
</table>

### Standardised Technical Particulars of Accessories of Earthwire

#### Flexible Copper Bond for GS / AACSR Earthwire

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Stranding</td>
<td>37/7/0.417</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Cross sectional area</td>
<td>Sq.mm</td>
<td>35.4</td>
</tr>
<tr>
<td>3.</td>
<td>Minimum copper equivalent area</td>
<td>Sq.mm</td>
<td>34</td>
</tr>
<tr>
<td>4.</td>
<td>Length of copper cable</td>
<td>mm</td>
<td>500 + 5</td>
</tr>
<tr>
<td>5.</td>
<td>Material of lugs</td>
<td>Tinned copper</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Bolt Size</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Diameter</td>
<td>mm</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>ii) Length</td>
<td>mm</td>
<td>40</td>
</tr>
</tbody>
</table>

#### Mid span compression Joint for GS Earthwire

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Aluminium / Filler Sleeve</td>
<td>Steel Sleeve</td>
</tr>
<tr>
<td>1.</td>
<td>Material of Joint</td>
<td>Aluminium of Mild</td>
<td></td>
</tr>
</tbody>
</table>
2. Range of Hardness of the steel sleeve (Brinell hardness)  
   BHN  
   From 100 to 200

3. Weight of Zinc coating  
   gm/m²  
   610

4. Dimension of sleeve Before compression

<table>
<thead>
<tr>
<th></th>
<th>Aluminium Sleeve</th>
<th>Steel Sleeve</th>
<th>Alu filler sleeve</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Inside diameter</td>
<td>mm 22.00 ± 0.5</td>
<td>11.05 ± 0.2</td>
<td>11.50 ± 0.2</td>
</tr>
<tr>
<td>ii) Outside diameter</td>
<td>mm 32.00 ± 0.5</td>
<td>21.00 ± 0.5</td>
<td>21.00 ± 0.5</td>
</tr>
<tr>
<td>iii) Length</td>
<td>mm 400 ± 5</td>
<td>230 ± 5</td>
<td>60 ± 5</td>
</tr>
</tbody>
</table>

5. Dimensions of Sleeve after compression

<table>
<thead>
<tr>
<th></th>
<th>Aluminium Sleeve</th>
<th>Steel Sleeve</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Outside dimension(Corner to Corner)</td>
<td>mm 29.40 ± 0.5</td>
<td>20.20 ± 0.5</td>
</tr>
<tr>
<td>ii) Outside dimension (face to face)</td>
<td>mm 25.00 ± 0.5</td>
<td>17.50 ± 0.5</td>
</tr>
<tr>
<td>iii) Length</td>
<td>mm 430 (approx)</td>
<td>265 (approx)</td>
</tr>
</tbody>
</table>

6. Slip strength

   KN 65

7. Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare Earthwire

   % 75

### Vibration Damper for GS Earthwire

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type of Damper</td>
<td>4R-Stockbridge type</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Materials of components</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Damper masses</td>
<td>Cast iron/mild steel/Zinc alloy duly hop dip galvanised</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Clamp</td>
<td>Aluminum alloy 4600</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Messenger cable</td>
<td>High tensile strength galvanized steel</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Number of strands in stranded messenger cable</td>
<td>Nos. 19</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Minimum ultimate tensile strength of stranded messenger cable</td>
<td>Kg/mm² 135</td>
<td></td>
</tr>
</tbody>
</table>
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)  

**Suspension Clamp for GS Earthwire**

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material of components</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Shackle</td>
<td></td>
<td>Forged Steel</td>
</tr>
<tr>
<td></td>
<td>(b) Clamp Body &amp; Keeper</td>
<td></td>
<td>Malleable cast iron / SGI</td>
</tr>
<tr>
<td></td>
<td>(c) U- Bolt</td>
<td></td>
<td>Mild Steel</td>
</tr>
<tr>
<td>2.</td>
<td>Total Drop (Maximum)</td>
<td>mm</td>
<td>150</td>
</tr>
<tr>
<td>3.</td>
<td>Breaking Strength (Minimum)</td>
<td>kN</td>
<td>25</td>
</tr>
<tr>
<td>4.</td>
<td>Slipping Strength</td>
<td>kN</td>
<td>12 to 17</td>
</tr>
</tbody>
</table>

**Tension Clamp for GS Earthwire**

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material of components</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(i) Anchor Shackle</td>
<td></td>
<td>Forged Steel</td>
</tr>
<tr>
<td></td>
<td>(ii) Compression Clamp</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Steel Sleeve</td>
<td></td>
<td>Mild Steel</td>
</tr>
<tr>
<td></td>
<td>b) Aluminium sleeve</td>
<td></td>
<td>Aluminium of purity 99.5%</td>
</tr>
<tr>
<td></td>
<td>c) Aluminium Filler sleeve</td>
<td></td>
<td>Aluminium of purity 99.5%</td>
</tr>
<tr>
<td>3.</td>
<td>Range of Hardness of the steel sleeve (Brinnel hardness)</td>
<td>BHN</td>
<td>120-200</td>
</tr>
<tr>
<td>4.</td>
<td>Dimension of sleeve Before compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Inside diameter</td>
<td>mm</td>
<td>22.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>ii) Outside diameter</td>
<td>mm</td>
<td>32.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>iii) Length</td>
<td>mm</td>
<td>245 ± 5</td>
</tr>
</tbody>
</table>
### 5. Dimensions of Sleeve after compression

<table>
<thead>
<tr>
<th></th>
<th>Aluminium Sleeve</th>
<th>Steel Sleeve</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Outside dimension(Corner to Corner) mm</td>
<td>29.40 ± 0.5</td>
<td>20.20 ± 0.5</td>
</tr>
<tr>
<td>ii) Outside dimension (face to face) mm</td>
<td>25.00 ± 0.5</td>
<td>17.50 ± 0.5</td>
</tr>
</tbody>
</table>

6. Slip strength KN 65

7. Minimum Breaking strength of assembly (excluding clamp) KN 70

8. Compression Pressure Ton 100

### 6.0 Tests and Standards

#### 6.1 Type Tests

#### 6.1.1 On the complete Insulator String with Hardware Fittings

<table>
<thead>
<tr>
<th>Tests</th>
<th>Ref</th>
<th>Strings on which test to be conducted*</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Power frequency voltage withstand test</td>
<td>As per IEC:60383</td>
<td>SISP(T), DT(T), TT (T)</td>
</tr>
<tr>
<td>with corona control rings/grading ring and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>arcing horns under wet condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Switching surge voltage withstand test</td>
<td>As per IEC:60383</td>
<td>SISP(T), DT(T), TT (T)</td>
</tr>
<tr>
<td>under wet condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Impulse voltage withstand test under dry condition</td>
<td>As per IEC:60383</td>
<td>SISP(T), DT(T), TT (T)</td>
</tr>
<tr>
<td>d) Impulse voltage Flashover test under dry condition</td>
<td>As per Annex-A</td>
<td>SISP(T), DT(T), TT (T)</td>
</tr>
<tr>
<td>e) Power Arc Test ( For 400kV Only)</td>
<td>As per Annex-A</td>
<td>DT(T)</td>
</tr>
<tr>
<td>f) Voltage distribution test</td>
<td>As per Annex-A</td>
<td>SISP(T), DT(T), TT (T)</td>
</tr>
<tr>
<td>g) Corona and RIV test</td>
<td>As per Annex-A</td>
<td>SISP(T), DT(T), TT (T)</td>
</tr>
</tbody>
</table>
under dry condition

h) Mechanical Strength test : As per Annex-A SISP(T), DT(T), TT (T)

i) Vibration test : As per Annex-A DT(T)

*Strings with Twin MOOSE Insulators*

- SISP(T) : Single I Suspension Pilot,
- DT (T): Double Tension
- TT(T) : Triple Tension

6.1.2 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

6.1.3 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

6.1.4 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*
6.1.5 **T-Connector for Conductor**

- 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) Axial tensile load test for welded portion  
  As per Annexure-A
- b) Corona extinction voltage test (dry)  
  As per Annexure-A
- c) Radio interference voltage test (dry)  
  As per Annexure-A

6.1.6 **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

6.1.9 **Flexible Copper Bond**

- a) Slip strength test  
  As per Annexure-A

6.1.10 **Bundle Spacer for Line**

- a) Chemical analysis of materials  
  As per Annexure-A
- b) Clamp slip test  
  As per Annexure-A
- c) Vibration test
  - (i) Vertical vibration  
    As per Annexure-A
  - (ii) Longitudinal vibration  
    As per Annexure-A
  - (iii) Sub span oscillation  
    As per Annexure-A
- d) Magnetic power loss test (if applicable)  
  As per Annexure-A
- e) Compression - Tension test  
  As per Annexure-A
- f) Corona extinction voltage test (dry)  
  As per Annexure-A
- g) Radio interference voltage test (dry)  
  As per Annexure-A
- h) Ozone test  
  As per Annexure-A

6.1.11 **Vibration Damper for ACSR/ ACSR Moose, GS & ACSR 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
g) Magnetic power loss 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

Note: Tests mentioned at (g), (h) & (i) are not applicable to Vibration Damper for earthwire

6.1.12 On Suspension clamp Assembly for GS & AACSR Earthwire

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

6.1.13 On Earthwire Tension clamp Assembly for GS & AACSR Earthwire

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

6.1.14 Type tests specified under Clause 6.1.1 to 6.1.13 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 any Utility.

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

6.2 Acceptance Tests
6.2.1 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 particle inspection for forgings/castings : As per Annexure-A

6.2.2 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
6.2.3 On Tension Hardware Fittings only
   a) Slip strength test for dead end assembly : As per IS:2486 (Part-I)
       Clause 5.4

6.2.4 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

6.2.5 T-Connector for Conductor
   a) Visual examination and dimensional verification : As per IS:2121 (Part-II),
       Clause 6.2, 6.3 7 6.7
   b) Axial tensile load test for welded portion : As per IS:2121 (Part-II),
       Clause 6.2, 6.3 7 6.7

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

6.2.8 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

6.2.9 Vibration Damper for AACSR/ ACSR MOOSE, GS & AACSR 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

6.2.9 Bundle Spacer 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

6.2.10 GS Earthwire / AACSR 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
6.2.11 **GS Earthwire / AACSR 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

6.3 **Routine Tests**

6.3.1 **For Hardware Fittings**

a) Visual examination IS:2486-(Part-I)

b) Proof Load Test : As per Annexure-A

6.3.1 **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

6.4 **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

6.5 **Testing Expenses**

6.5.1 In case of failure in any type test, the Bidder 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.

6.5.2 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.

6.5.3 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.

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

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

6.6 Sample Batch For Type Testing

6.6.1 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.

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

6.7 Schedule of Testing and Additional Tests

6.7.1 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.

6.7.2 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.

6.7.3 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.

6.8 **Co-ordination for testing**

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

6.9 **Test Reports**

6.9.1 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.

6.9.2 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.

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

6.9.4 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.

6.10 **Inspection**

6.10.1 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.

6.10.2 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.

6.10.3 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.

6.10.4 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.

6.10.5 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 material are later found to be defective.

6.11 Packing and Marking

6.11.1 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.

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

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

6.11.4 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.

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

6.11.6 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.

6.12 Standards

6.12.1 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.
6.12.2 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.

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Indian Standard</th>
<th>Title</th>
<th>International Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.</td>
<td>IS 1573</td>
<td>Electroplated Coating of Zinc on iron and Steel</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>IS : 2121 (Part-II)</td>
<td>Specification for Conductor and Earthwire Accessories for Overhead Power lines: Mid-span Joints and Repair Sleeves for Conductors</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>IS:2486 (Part-I)</td>
<td>Specification for Insulator Fittings for Overhead power Lines with Nominal Voltage greater than 1000 V: General Requirements and Tests</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>IS:2629</td>
<td>Recommended Practice for Hot Dip Galvanising of Iron and Steel</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>IS:2633</td>
<td>Method of Testing Uniformity of Coating on Zinc Coated Articles</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td>Ozone test on Elastomer</td>
<td>ASTM- D1 171</td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td>Tests on insulators of Ceramic material or glass for overhead lines with a nominal voltage greater than 1000V</td>
<td>IEC:383-1993</td>
</tr>
<tr>
<td>11.</td>
<td>IS:6745</td>
<td>Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles</td>
<td>BS:433 ISO : 1460 (E)</td>
</tr>
<tr>
<td>Sl.</td>
<td>Indian Standard</td>
<td>Title</td>
<td>International Standard</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>15.</td>
<td>IS:10162</td>
<td>Specification for Spacers Dampers for Twin Horizontal Bundle Conductors</td>
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</table>

The standards mentioned above are available from:

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

1.1 Voltage Distribution Test

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The maximum voltage across any disc shall not exceed the values specified in the standard technical particulars.

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 that stipulated in the standard Technical particulars. There shall be no evidence of corona on any part of the sample. The test shall be carried out as per IEC:61284. The atmospheric condition during testing shall be recorded and the test results; shall be accordingly corrected with suitable correction factor as stipulated in IEC:60060-1.

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 that stipulated in the standard Technical particulars. The test procedure shall be in accordance with IEC:61284.

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 sub conductors each tensioned at 25% of UTS 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 \( 1000 / f^{1.8} \) 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:

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Test</th>
<th>Percentage of insulator units to be tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Temperature cycle test followed by mechanical performance test</td>
<td>60</td>
</tr>
<tr>
<td>b)</td>
<td>Puncture test / steep wave front test (Only for glass insulators)</td>
<td>40</td>
</tr>
</tbody>
</table>

1.6 **Power Arc test (for 400 kV line only)**

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

<table>
<thead>
<tr>
<th>Test circuit</th>
<th>Short circuit current</th>
<th>Number and duration of test</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>( I_n = I_{sys} = 40 , KA )</td>
<td>Two of ( t_n = 0.2s ) and one of ( t_n = 0.5s )</td>
</tr>
</tbody>
</table>

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

2.1.1 For 220 kV line with Twin ACSR MOOSE conductor, Two hollow aluminium tubes of 32 mm diameter shall be placed 450 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**

2.9.1 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 for GS / ACSR 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 fittings 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 ACSR/ACSR Moose/ GS / ACSR 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 10 to 60 Hz for damper for earth wire. The damper assembly shall be vibrated vertically with a ± 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at ± 0.5 mm to determine following characteristics with the help of suitable recording instruments:
(i) Force Vs frequency
(ii) Phase angle Vs frequency
(iii) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the aeolian vibration frequency-band between the lower and upper dangerous frequency, limits determined by the vibration analysis of conductor/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 ACSR Moose: 0.191 f to 0.762 f
- V.D. for 7/3.66 Earth wire: 0.060 f to 0.357 f kgf/mm
- V.D. for AACSR Earth wire: 0.125 f to 0.501 f kgf/mm

Where f is frequency in Hz.

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

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

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

(b) Vibration Analysis

The vibration analysis of the 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 as per the parameters given under clause 3.3.8 of this part of the Specification. The tension shall be taken as 43 kN, 38 kN and 14 kN for ACSR Moose, AACSR Earthwire and 7/3.66 mm earth wire respectively for a span ranging from 100 m to 1100 m.
The self damping factor and flexural stiffness (EI) for earthwire shall be calculated on the basis of experimental results. The details of experimental analysis with these data should be furnished.

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

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.

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.

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 ACSR Earthwire / 7/3.66 mm earth wire shall be tensioned at 38 kN / 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 guaranteed % variation
in reactance after fatigue test in comparison with that before fatigue test
by the Contractor.

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

3.5 Spacer (for twin bundle)

(a) Vibration Tests

The test set up shall be as per Clause No.3.3(c) (i) of Annexure - A. The spacer
assembly shall be clamped to conductor. During the vibration tests the axis of the
clamp of sample shall be maintained parallel to its initial static position by applying a
tension of 25% of RTS of conductor. The spacer assembly shall be free to vibrate and
shall not be re-torqued or adjusted between the tests.

All the vibration tests mentioned hereunder shall be conducted on the samesample
on the same test span. The samples shall withstand the vibration tests without
slipping on the conductor. loosening, damage or failure of component parts. After
each vibration test, clamp slip test shall be carried out as per the procedure given in
Clause No3.5 (b) below

(i) Longitudinal Vibration Test

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

(ii) Vertical Vibration Test

The spacer/spacer damper shall be installed in the middle of the test span
and the frequency chosen so as to get an odd number of loops. The shaker
shall be positioned at least two loops away from the test specimen to allow
free movement of the conductor close to the test specimen. One conductor
shall be connected to the shaker and vibrated to an amplitude such that.
f1.8 \( Y_{\text{max}} > 1000 \text{ mm/sec.} \)
Where \( Y_{\text{max}} \) being the antinode displacement (mm) and \( f \) is the test frequency (Hz). The test frequency shall be greater than 24 Hz and the total number of cycles shall be more than 10 millions.

(iii) Sub-span Oscillation Test

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

3.6 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 as per the values stipulated in the Standard Technical Particulars.

(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.

3.7 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 1000 & up to 5000 nos.
- Additional 1 sample for every additional 1500 pieces above 5000.

The acceptance criteria will be as follows

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

(ii) If the entire individual curve for dampers is 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 characteristics 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.
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Specification for OPGW cabling & associated hardware & fittings

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Section-01
Specification for OPGW cabling and associated hardware & fittings

The broad scope of this specification include the survey, planning, design, engineering, manufacturing, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, splicing, termination, testing, demonstration for acceptance and commissioning and documentation for:

a) OPGW fibre optic cable including all associated hardware, accessories & fittings
b) Fibre Optic approach cable including installation material
c) Fibre Optic Distribution Panels (FODP) & Joint Box
d) Supply of spares
e) Supply of test equipments
f) All other associated work/items described in the technical specifications.

This section of the technical specification describes the functional and technical specifications of OPGW cabling and associated hardware and fittings.

1.0 Fibre Optic Cabling

In this section of the technical specification, the functional & technical specifications of OPGW cable, associated hardware & fittings for the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable is mentioned. Bidders shall furnish with their bids, detailed descriptions of the fibres & cable(s) proposed.

All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

1.1 Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristics :

1.1.1 Physical Characteristic

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 1-1(a).

1.1.2 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fibre attenuation characteristics specified in table 1-1 (a) shall be “guaranteed” fibre attenuation of any & every fibre reel.
The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550 nm : 0.21 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Maximum attenuation @ 1310 nm : 0.35 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

### Table 2-1(a)
#### DWSM Optical Fibre Characteristics

<table>
<thead>
<tr>
<th>Fibre Description:</th>
<th>Dual-Window Single-Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode Field Diameter:</td>
<td>8.6 to 9.5 μm (± 0.6μm )</td>
</tr>
<tr>
<td>Cladding Diameter:</td>
<td>125.0 μm ± 1 μm</td>
</tr>
<tr>
<td>Mode field concentricity error</td>
<td>≤ 0.6μm</td>
</tr>
<tr>
<td>Cladding non-circularity</td>
<td>≤ 1%</td>
</tr>
<tr>
<td>Cable Cut-off Wavelength ( \lambda_{cc} )</td>
<td>≤ 1260 nm</td>
</tr>
<tr>
<td>1550 nm loss performance</td>
<td>As per G.652 D</td>
</tr>
<tr>
<td>Proof Test Level</td>
<td>≥ 0.69 Gpa</td>
</tr>
<tr>
<td>Attenuation Coefficient:</td>
<td>@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.21 dB/km</td>
</tr>
<tr>
<td>Chromatic Dispersion; Maximum:</td>
<td>18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm</td>
</tr>
<tr>
<td>Zero Dispersion Wavelength :</td>
<td>1300 to 1324 nm</td>
</tr>
<tr>
<td>Zero Dispersion Slope :</td>
<td>0.092 ps/(nm²xkm) maximum</td>
</tr>
<tr>
<td>Polarization mode dispersion coefficient</td>
<td>≤ 0.2 ps/km²½</td>
</tr>
<tr>
<td>Temperature Dependence :</td>
<td>Induced attenuation ≤ 0.05 dB (-60°C - +85°C )</td>
</tr>
<tr>
<td>Bend Performance :</td>
<td>@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB/km @ 1550 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.10 dB/km @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB/km</td>
</tr>
</tbody>
</table>

### 1.2 Fibre Optic Cable Construction

The OPGW (Optical Ground Wire) cable is proposed to be installed on the new transmission lines along with transmission line construction. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to
be supplied shall be designed to meet the overall requirements of all the transmission lines. The Tower span details shall be collected by the contractor during survey. To meet the overall requirement of the transmission line(s), the contractor may offer more than one design without any additional cost to Employer, in case single design is not meeting the requirement. OPGW cable to be designed to meet transmission line sag-tension parameters and other details to be provided by Transmission Line contractor. Any other details, as required for cable design etc. shall be collected by the Contractor during survey.

1.2.1 Optical Fibre Cable Link Lengths

The estimated optical fibre link lengths are provided in Appendices as transmission line route length. However, the Contractor shall supply the OPGW cable as required based on the tower schedule. The Contractor shall verify the transmission line route length during the survey and the Contract price shall be adjusted accordingly.

For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths & wastage etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price Schedules shall take into account all such factors.

1.2.2 Optical Fibre Identification

All optical fibres shall be individually coated. Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme.

Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing.

Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres is included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be suitably bundled, tagged and identified at the factory by the vendor.

1.2.3 Buffer Tube

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.

1.2.4 Optical Fibre Strain & Sag-Tension chart
The OPGW cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions of transmission lines. Zero fibre strain condition shall apply even after a 25 year cable creep.

For the purpose of this specification, the following definitions shall apply:

- **Maximum Working Tension (MWT)** is defined as the maximum cable tension at which there is no fibre strain.
- The *no fibre strain* condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ETSI (FOTP) specified optical reflectometry.
- The **Cable strain margin** is defined as the maximum cable strain at which there is no fibre strain.
- The cable **Maximum Allowable Tension (MAT)** is defined as the maximum tension experienced by the Cable under the worst case loading condition.
- The cable **max strain** is defined as the maximum strain experienced by the Cable under the worst case loading condition.
- The cable **Every Day Tension (EDT)** is defined as the maximum cable tension on any span under normal conditions.
- The **Ultimate /Rated Tensile Strength (UTS/RTS/ breaking strength)** is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:

- The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.
- The 25 year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25 year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.
- The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted along with the bid under various conditions as per tower design of the transmission line.

The size of OPGW shall be selected such that max. tension and sag at specified temperature and wind condition remains within the limits of transmission line tower design.

**1.2.5 Cable Materials**

The materials used for optical fibre cable construction, shall meet the following requirements:

**1.2.5.1 Filling Materials**

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre
optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC 60794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, non-hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

1.2.5.2 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

1.2.6 Marking, Packaging and Shipping

This section describes the requirements for marking, packaging and shipping the overhead fibre optic cable.

(a) **Drum Markings:** Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Purchaser’s destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line & segment no., factory inspection stamp and date.

(b) **Cable Drums:** All optical fibre cabling shall be supplied on strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a "schedule" prepared by the Contractor and approved by the owner.

1.3. Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 2009. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.
The composite fibre optic overhead ground wire shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single buffer tube or directly in central fibre optic unit is not acceptable. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

1.3.1 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials for stranded wires and tubes are not allowed. Central fibre optic unit may be of aluminium / aluminium alloy tube. There shall be no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

1.3.2 Basic Construction

The OPGW cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 1.2(a) OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

1.3.3 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.
1.3.4 Electrical and Mechanical Requirements

Table 1-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earthwire being replaced such that there is no or minimal consequential increase in stresses on towers. OPGW installation sag & tension charts shall be as per transmission line requirement. For the OPGW cable design selection and preparation of sag tension charts, the limits specified in this section shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

**Table 1.2(a)**

**OPGW Electrical and Mechanical Requirements**

<table>
<thead>
<tr>
<th></th>
<th>Everyday Tension</th>
<th>≤ 20% of UTS of OPGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D.C. Resistance at 20ºC:</td>
<td>&lt; 1.0 ohm/Km or Employer provided values</td>
</tr>
<tr>
<td>2</td>
<td>Short Circuit Current</td>
<td>≥ 6.32 kA for 1.0 second or Employer provided values</td>
</tr>
</tbody>
</table>

Bidder may offer separate design for each short circuit rating however OPGW design with higher short circuit level shall be acceptable.

1.3.5 Operating conditions

Since OPGW shall be located at the top of the transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.

1.4 Installation Hardware

The scope of supply includes all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The quantity of hardware & fittings to meet any eventuality during site installation minimum@ 1% shall also be provided as part of set/km for each transmission line without any additional cost to Employer.

The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.
The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

(a) **Suspension Assemblies:** Preformed armour grip suspension clamps and aluminium alloy armour rods/reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25 KN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured.

The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the centre point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

(b) **Dead End Clamp Assemblies:** All dead end clamp assemblies shall preferably be of preformed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

(c) **Clamp Assembly Earthing Wire:** Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.

(d) **Structure Attachment Clamp Assemblies:** Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.

(e) **Vibration Dampers:** Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1m/s to 7 m/s, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis as specified in technical specifications.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 400 meters. For all other ruling spans, the number of vibration damper shall be based on vibration analysis.

The clamp of the vibration damper shall be made of high strength aluminum alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chaffing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the
strands or causing premature fatigue failure of the OPGW cable under the clamp. The clamp groove shall be in uniform contact with the OPGW cable over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the OPGW cable when the clamp is installed. Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanised steel/stainless steel. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS: 4826 for heavily coated wires.

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

The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

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

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

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Technical Particulars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Span Length in meters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(i) Ruling design span:</td>
<td>400 meters</td>
</tr>
<tr>
<td></td>
<td>(ii) Maximum span:</td>
<td>1100 meters</td>
</tr>
<tr>
<td></td>
<td>(iii) Minimum Span:</td>
<td>100 meters</td>
</tr>
<tr>
<td>2</td>
<td>Configuration:</td>
<td>As per Specifications</td>
</tr>
</tbody>
</table>
3  Tensile load in each:  As per sag tension calculations
4  Armour rods used:  Standard preformed armour rods/AGS
5  Maximum permissible dynamic strain:  +/- 150 micro strains

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

The damper placement charts shall include the following:

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

1.5 Fibre Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply with ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 12 fibres shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures.

Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anti-climb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

1.5.1 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

(a) All fibre splices shall be accomplished through fusion splicing.
(b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.

(c) All splices and bare fibre shall be neatly installed in covered splice trays.

(d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.

(e) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

1.6 Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices. However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

1.6.1 Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

1.6.2 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

1.6.3 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

1.7 Fibre Optic Distribution Panel

Fibre Optic Distribution Panels is required for each location for termination of fibres in a manner consistent with the following:

(a) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.

(b) FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement.
(c) All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.

1.7.1 Optical Fibre Connectors

Optical fibres shall be connectorised with FC-PC type connectors preferably. Alternatively connector with matching patch cord shall also be acceptable. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

1.8 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

(a) Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.

(b) Indoor Cable Service Loops: FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius are maintained.

(c) Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(d) Pigtail Service Loops: Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

(e) Fibre Service Loops: At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

1.9 Test Equipment

The table 1.3 below provides mandatory test equipment requirements, to be provided as applicable as per BoQ. The parameters / features of the mandatory equipments are enumerated as follows:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test equipment</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Test Equipments for OPGW cable</td>
<td></td>
</tr>
</tbody>
</table>
OTDR (Optical Time Domain Reflectometer) for 1310/1550 nm with laser source. Equivalent to Anritsu MW9076B1 or better.

2. Optical Attenuators (variable 1310/1550nm). Equivalent to JDSU OLA55 or better.

3. Optical Power meter (1310/1550nm) Equivalent to JDSU OLP55 or better

4. Optical Talk set Equivalent to JDSU OTS55 or better.

5. Optical Fibre Fusion Splicer incl. Fibre cleaver Equivalent to Sumitomo T-39-SE or better.

6. Calibrated Fibre

7. Connectorization kit FIS – FI-0053-FC-INST or equivalent

8. Splice kit FIS – FI-0053-FF or equivalent

9. Optical test accessory kit including all necessary connectors, adaptors, cables, terminations and other items required for testing FIS – FI-0053-TS-ST or equivalent

In case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for use in the high EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment from at least one customer. The Contractor shall offer only reputed make test equipment such as Acterna (JDSU)/Anritsu/Sumitomo/Agilent/EXFO etc.

2.0 Applicable Standards

The following standards and codes shall be generally applicable to the equipment and works supplied for OPGW and associated Items

(1) American Society for Testing and Materials ASTM

ASTM-B415 Standard Specification for Hard-Drawn Aluminium-Clad Steel Wire

(2) Bell Communication Research

GR-20 Generic requirements for optical fibre and optical fibre cable

(3) ITU-T/CCITT Recommendations

G.650 Definitions and test methods for the relevant parameters of single-mode fibres

G.652 Characteristics of a single-mode optical fibre cable
(4) IEEE

IEEE-1138 IEEE Standard Construction of Composite Fibre Optic Ground Wire (OPGW) for Use on Electric Utility power Lines

(5) Telecommunication Industry Association EIA/TIA

EIA/TIA-455-3 Procedure to Measure Temperature Cycling Effects on Optical Fibres, Optical Cable, and Other Passive Fiber Optic Components
EIA/TIA-455-16 Salt Spray (Corrosion) Test for Fibre Optic Components
EIA/TIA-455-20 Measurement of Change in Optical Transmittance
EIA/TIA-455-25 Repeated Impact Testing of Fibre Optic Cables and Cable Assemblies
EIA/TIA-455-32 Fibre Optic Circuit Discontinuities
EIA/TIA-455-33 Fibre Optic Cable Tensile Loading and Bending Test
EIA/TIA-455-41 Compressive Loading Resistance of Fibre Optic Cables
EIA/TIA-455-59 Measurement of Fibre Point Defects Using an OTDR
EIA/TIA-455-62 Measurement of Optical Fibre Macro bend Attenuation
EIA/TIA-455-80 Measurement of Cut-Off Wavelength of Single-Mode Fibre by Transmitted Power
EIA/TIA-455-81 Compound Flow (Drip) Test for Filled Fibre Optic Cable
EIA/TIA-455-82 Fluid Penetration Test for Fluid-Blocked Fibre optic Cable
EIA/TIA-455-91 Fibre Optic Cable Twist-Bend Test
EIA/TIA-455-164 Single-Mode Fibre, Measurement of Mode Field Diameter by Far-Field Scanning
EIA/TIA-455-167 Mode Field Diameter Measurement, Variable Aperture Method in the Far-Field
EIA/TIA-455-169 Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Phase-Shift Method
EIA/TIA-455-170 Cable Cut-off Wavelength of Single-Mode Fibre by Transmitted Power
EIA/TIA-455-174 Mode Field Diameter Measurement
EIA/TIA-455-175 Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Differential Phase-Shift Method
EIA/TIA-455-176 Method of Measuring Optical Fibre Cross-Sectional Geometry by Automated Grey-Scale Analysis
EIA/TIA-598 Optical Fibre Cable Colour Coding

(6) International Electrotechnical Commission IEC standards

IEC-60793-1 series Optical fibres – Generic & product specifications, measurement methods & test procedures specification
IEC-60794-1-1 Optical fibre cables – Generic specification
Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer’s written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

In case values indicated for certain parameters in the specifications are more stringent than those specified by the standards, the specification shall override the standards.

I.10 References

(1) CIGRE Guide for Planning of Power Utility Digital Communications Networks
(2) CIGRE Optical Fibre Planning Guide for Power Utilities
(3) CIGRE New Opportunities for Optical Fibre Technology in Electricity Utilities
(4) CIGRE guide to fittings for Optical Cables on Transmission Lines
Technical Specifications for
Optical Ground Wire (OPGW) Cable

Chapter - 02
Inspection & Testing Requirement

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Section - 02
Inspection & Testing Requirement

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory, production tests and other test during manufacture specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer’s representative.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

2.1 Testing Requirements

Following are the requirements of testing:

1. Type Testing
2. Factory Acceptance Testing
3. Site Acceptance Testing
2.3.1 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

(a) All cable & equipment being supplied shall conform to type tests as per technical specification.

(b) The test reports submitted shall be of the tests conducted within last seven (7) years for OPGW cable prior to the date of proposal/offer submitted. In case the test reports are older than seven (7) years for OPGW cable on the date of proposal/offer, the Contractor shall repeat these tests at no extra cost to the Employer.

(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer’s representatives.

In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

In case the Type Test is required to be carried out, then following shall be applicable:-

(d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

(e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.
(g) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

2.1.1 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. For optical fibres/ Fibre Optic cables, at least three reels/ drums of each type of fibre/cable proposed shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered for selection. For Splice enclosures at least three samples shall be offered for selection.

2.1.2 List of Type Tests

The type testing shall be conducted on the following items

(a) Optical fibres
(b) OPGW Cable
(c) OPGW Cable fittings
(d) Vibration Damper
(e) Splice Enclosure (Joint Box)
(f) Approach Cable

2.1.2.1 Type Tests for Optical Fibres

The type tests listed below in table 2-1 shall be conducted on DWSM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Acceptance Criteria</th>
<th>Test procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attenuation</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-40 Or EIA/TIA 455-78A</td>
</tr>
<tr>
<td>2</td>
<td>Attenuation Variation with Wavelength</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-40 Or EIA/TIA 455-78A</td>
</tr>
</tbody>
</table>
### Table 2-1
Type Tests For Optical Fibres

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Acceptance Criteria</th>
<th>Test procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Attenuation at Water Peak</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-40 Or EIA/TIA 455-78A</td>
</tr>
<tr>
<td>4</td>
<td>Temp. Cycling (Temp dependence of Attenuation)</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles</td>
</tr>
<tr>
<td>5</td>
<td>Attenuation With Bending (Bend Performance)</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-47 Or EIA/TIA 455-62A</td>
</tr>
<tr>
<td>6</td>
<td>Mode Field dia.</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-42 Or EIA/TIA 455-164A/167A/174</td>
</tr>
<tr>
<td>7</td>
<td>Chromatic Dispersion</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-20 Or EIA/TIA 455-176</td>
</tr>
<tr>
<td>8</td>
<td>Cladding Diameter</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-40 Or EIA/TIA 455-59</td>
</tr>
<tr>
<td>9</td>
<td>Point Discontinuities of attenuation</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-20 Or EIA/TIA 455-176</td>
</tr>
<tr>
<td>10</td>
<td>Core -Clad concentricity error</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-30 Or EIA/TIA 455-31B</td>
</tr>
<tr>
<td>11</td>
<td>Fibre Tensile Proof Testing</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-30 Or EIA/TIA 455-31B</td>
</tr>
</tbody>
</table>

-End Of table-

### 2.1.2.2 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 2-2 Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

### Table 2-2
Type tests for OPGW Cable

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Test Description</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water Ingress Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009 (IEC 60794-1-2 Method F5 or EIA/TIA 455-82B) : Test duration : 24 hours</td>
</tr>
</tbody>
</table>
### Table 2-2
Type tests for OPGW Cable

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Test Description</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Short Circuit Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009 Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. A suitable temperature sensor such as thermocouple shall be used to monitor and record the temperature inside the OPGW tube in addition to monitoring &amp; recording the temperatures between the strands and between optical tube and the strand as required by IEEE 1138. Test shall be conducted with the tension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test. Or IEC60794-4-10 / IEC 60794-1-2 (2003) Method H1 Initial temperature during the test shall be greater than or equal to ambient field temperature.</td>
</tr>
<tr>
<td>4</td>
<td>Aeolian Vibration Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009 Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The vibration frequency and amplitude shall be monitored and recorded continuously. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring. Test shall be conducted with the tension/suspension clamps proposed to be</td>
</tr>
</tbody>
</table>
### Table 2-2
Type tests for OPGW Cable

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Test Description</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and clamps shall be visually inspected for mechanical damage and photographed after the test. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Cable Bend Test</td>
<td>Procedure 2 in IEC 60794-1-2 Method E11</td>
<td>The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC 60794-1-2 E11 to determine the minimum acceptable radius of bending without any increase in attenuation or any other damage to the fibre optic cable core such as bird caging, deformation, kinking and crimping.</td>
</tr>
<tr>
<td>7</td>
<td>Sheave Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR IEC 60794-1-2 Method E1B</td>
<td>Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The Sheave dia. shall be based on the pulling angle and the minimum pulley dia employed during installation. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.</td>
</tr>
<tr>
<td>8</td>
<td>Crush Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009</td>
</tr>
</tbody>
</table>
|        |                  | (IEC 60794-1-2, Method E3/ | The crush test shall be carried out on a sample of approximately one (1) metre long in accordance with IEC 60794-1-2 E3. A load equal
Table 2-2
Type tests for OPGW Cable

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Test Description</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Impact Test</td>
<td>IEEE 1138-2009</td>
<td>EIA/TIA 455-41B) to 1.3 times the weight of a 400-metre length of fibre optic cable shall be applied for a period of 10 minutes. A permanent or temporarily increase in optical attenuation value greater than 0.1 dB change in sample shall constitute failure. The load shall be further increased in small increments until the measured attenuation of the optical waveguide fibres increases and the failure load recorded along with results.</td>
</tr>
<tr>
<td>10</td>
<td>Creep Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009, (IEC 60794-1-2 E4/ EIA/TIA 455-25B) The impact test shall be carried out in accordance with IEC 60794-1-2 E4. Five separate impacts of 0.1-0.3kgm shall be applied. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.</td>
</tr>
<tr>
<td>12</td>
<td>Strain Margin Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009</td>
</tr>
</tbody>
</table>
### Table 2-2
Type tests for OPGW Cable

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Test Description</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Stress strain Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009</td>
</tr>
<tr>
<td>15</td>
<td>Temperature Cycling Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009 Or IEC 60794-1-2, Method F1</td>
</tr>
<tr>
<td>16</td>
<td>Corrosion (Salt Spray) Test</td>
<td>EIA/TIA 455-16A</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Tensile Performance Test</td>
<td>IEC 60794-1-2 E1 / EIA/TIA 455-33B</td>
<td>The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 E1. The attenuation variation shall not exceed 0.05 dB/Km up to 90% of RTS of fibre optic cable. The load shall be increased at a steady rate up to rated tensile strength and held for one (1) minute. The fibre optic cable sample shall not fail during the period. The applied load shall then be increased until the failing load is reached and the value recorded.</td>
</tr>
<tr>
<td>18</td>
<td>Lightning Test</td>
<td>IEC 60794-4-10 / IEC 60794-1-2 (2003)</td>
<td>The OPGW cable construction shall be tested in accordance with IEC 60794-1-2, Method H2 for Class 1.</td>
</tr>
<tr>
<td>19</td>
<td>DC Resistance Test</td>
<td>(IEC 60228)</td>
<td>On a fibre optic cable sample of minimum 1 metre length, two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially zero metre and subsequently one metre apart. The tests shall be repeated at least five times and the average value recorded after correcting at 20°C.</td>
</tr>
</tbody>
</table>

-End Of Table-
2.1.2.3 Type Test on OPGW Cable Fittings

The type tests to be conducted on the OPGW Cable fittings and accessories are listed below:

(i) Mechanical Strength Test for Suspension/Tension Assembly


Suspension Assembly

The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:
The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16°. This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:
The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load 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 shall be documented.

Tension Assembly

The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:
The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then remove in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:
The Tension Dead-End and associated components shall then be reassembled and bolts
tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load 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 shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.
- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

(ii) Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder ‘zeroed’. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative positions between clamp body and armour rods shall be marked on the other side. After the one minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

Acceptance Criteria:

The Suspension Clamp has passed the Slip Test if the following conditions are met:

- No slippage* shall occur at or below the specified minimum slip load.

* Definition of no slippage in accordance with IEC 61284, 1997:- Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.

- Slippage shall occur between the specified maximum and minimum slip load of 12 - 17 kN.
There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.

The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.

The Armour Rods shall not be displaced from their original lay or damaged**.

** Definition of no damage in accordance with convention expressed in IEC 61284: 1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

(iii) Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on an 8 m length of fibre optic cable 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 shall gradually be applied up to 20% of the RTS of OPGW. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods and Tension Dead-End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50% of the UTS and the position scale of the recorder is zeroed. The load shall then gradually increased up to 95% of the UTS and maintained for one minute. After one minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria:

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.
- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or OPGW.

* Definition of no movement as defined in IEC 61284: Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage.

Any result outside these parameters shall constitute a failure.

(iv) Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed
including clamping compound as required on the fibre optic cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 5.5 kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also the fibre optic cable shall be checked to ensure free movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter as measured outside the clamped area.

(v) Structure Mounting Clamp Strength Test

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

2.1.2.4 Type Test on Vibration Damper

The testing standard of vibration damper for OPGW shall be as per applicable international standard i.e. IEC 61897.

(a) Dynamic Characteristic 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 Critical Aeolian Vibration frequency band ranging from 0.18/d to 1.4/d – where d is the OPGW cable diameter in meters. The damper assembly shall be vibrated vertically with a ±1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm to determine following characteristics with the help of suitable recording instruments.

(i) Force Vs frequency

(ii) Phase angle Vs frequency

(iii) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the Aeolian vibration frequency-band between the lower and upper dangerous frequency limits determined by the vibration analysis of fibre optic cable 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:

\[ V.D. \text{ for OPGW} - 0.060 \, f \text{ to } 0.357 \, f \, \text{kgf/mm}^2 \]

Where \( f \) is frequency in Hz.

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

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

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

(b) Vibration Analysis

The vibration analysis of the fibre optic cable shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

(i) The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as 25% of RTS of fibre optic cable for a span ranging from 100 m to 1100 m.

(ii) The self damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.

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

(iv) Examine the Aeolian Vibration level of the fibre optic cable 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 fibre optic cable 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 fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the fibre optic cable shall be
determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.

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

(c) Fatigue Tests

(i) Test Set Up

The fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 25% of RTS of fibre optic cable 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 fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable 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 fibre optic cable. There shall be no loose parts, such as suspension clamps, U bolts, on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) 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 herein shall be repeated after fatigue tests 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 fibre optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics 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 fibre optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

1. There shall not be any resonant frequency shift before and after the test by more than ± 20%
2. The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than ± 20%

Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Test Name</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Visual examination &amp; Dimensional and material verification</td>
<td>IEC 61897 Clause 7.1 &amp; 7.2</td>
</tr>
<tr>
<td>2</td>
<td>Clamp Slip test</td>
<td>IEC 61897 Clause 7.5</td>
</tr>
<tr>
<td>3</td>
<td>Clamp bolt tightening test</td>
<td>IEC 61897 Clause 7.7</td>
</tr>
<tr>
<td>4</td>
<td>Attachments of weights to messenger cable</td>
<td>IEC 61897 Clause 7.8</td>
</tr>
<tr>
<td>5</td>
<td>Attachment of clamps to messenger cable</td>
<td>IEC 61897 Clause 7.8</td>
</tr>
<tr>
<td>6</td>
<td>Damper effectiveness evaluation</td>
<td>IEC 61897 Clause 7.11.3.2</td>
</tr>
</tbody>
</table>

2.1.2.5 Type Tests for Splice Enclosures (Joint Box)

Following Type tests shall be demonstrated on the Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

(i) Temperature Cycling Test

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40°C to +65°C with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20 / IEC 60794-1-C10. The variation in attenuation shall be less than ±0.05dB. The final humidity level, inside the
box, shall not exceed the initial level, at the closing of the box.

(ii) Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of +55°C ±2°C with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than ±0.05dB, and the internal humidity rate measured, less than 2%.

(iii) Rain Withstand Test / Water Immersion test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60060 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than ±0.05dB.

(iv) Vibration Test

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than ±0.05dB. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

(v) Bending and Torsion test

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

a) 3 torsion cycles of ±180° shall be exercised on the cable. Each cycle shall be less than one minute.

b) 3 flexure cycles of the cable, of ±180° with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than ±0.05dB. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure

(vi) Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

(vii) Drop Test
With 2 lengths of 11 metres of cable fixed to the box, it shall be dropped five times from a height of 10 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test surface shall be carried out in accordance with IEC 60068-2-32.

### 2.1.2.6 Type Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in Table 2-3: Type Tests for Fibre Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

#### Table 2-3: Type Tests Fibre Optic Approach Cable

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>Test Name</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water Ingress Test</td>
<td>(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours</td>
</tr>
<tr>
<td>2</td>
<td>Seepage of filling compound</td>
<td>(EIA 455-81A) Preconditioning : 72 hours, Test duration : 24 hours.</td>
</tr>
<tr>
<td>3</td>
<td>Crush Test</td>
<td>(IEC 60794-1-E3/ EIA 455-41)</td>
</tr>
<tr>
<td>4</td>
<td>Impact Test</td>
<td>(IEC-60794-1-E4/ EIA 455-25A)</td>
</tr>
<tr>
<td>5</td>
<td>Stress strain Test</td>
<td>(EIA 455-33A)</td>
</tr>
<tr>
<td>6</td>
<td>Cable Cut-off wavelength Test</td>
<td>(EIA 455-170)</td>
</tr>
<tr>
<td>7</td>
<td>Temperature Cycling Test</td>
<td>(IEC60794-1-F1/EIA-455-3A) – 2 cycles</td>
</tr>
</tbody>
</table>

---

#### 2.1.2.6.1 Impact Test

The Impact test shall be carried out in accordance with IEC:60794-1-E4. Five separate impacts of 2.0 kg shall be applied at different locations. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

### 2.2 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on OPGW Cable and associated hardware & fittings, Approach Cable, Joint Box, FODP etc. and all other items for which price has been identified separately in the Bid Price Schedules.
Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer’s authorised representatives unless waiver for witnessing by Employer’s representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance tests for the supplied items shall be proposed by the Contractor in accordance with technical specifications and Contractor’s (including Sub-Contractor’s / supplier’s) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces etc.

For Test equipment FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer’s final inspection certificate/ report.

### 2.2.1 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

For the OPGW cable hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, Joint box and other similar items.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/approvals until such a report is made and remedial actions taken, as applicable.
2.2.2 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor’s standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), along with information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

2.2.3 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in the table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138/IEC 60794. The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above mentioned IEEE standards unless specified otherwise in the technical specifications.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Acceptance Criteria</th>
<th>Test procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attenuation Coefficient</td>
<td>T S, Table 1-1(a)</td>
<td>EIA/TIA 455-78A</td>
</tr>
<tr>
<td>2</td>
<td>Point Discontinuities of attenuation</td>
<td>TS, Section 1.1.2</td>
<td>EIA/TIA 455-59</td>
</tr>
<tr>
<td>3</td>
<td>Attenuation at Water Peak</td>
<td>TS, Table 2-1(a)</td>
<td>EIA/TIA 455-78A</td>
</tr>
<tr>
<td>4</td>
<td>Chromatic Dispersion</td>
<td></td>
<td>EIA/TIA 455-168A/169A/175A</td>
</tr>
<tr>
<td>5</td>
<td>Core – Clad Concentricity Error</td>
<td></td>
<td>EIA/TIA 455-176</td>
</tr>
<tr>
<td>6</td>
<td>Cladding diameter</td>
<td></td>
<td>EIA/TIA 455-176</td>
</tr>
<tr>
<td>7</td>
<td>Fibre Tensile Proof Testing</td>
<td></td>
<td>EIA/TIA 455-31B</td>
</tr>
</tbody>
</table>

The test report for the above tests for the fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

2.2.4 Factory Acceptance Test on OPGW Cable
The factory acceptance tests for OPGW cable specified below in Table follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

### Table 2-5
**Factory Acceptance Tests on OPGW**
**Applicable standard: IEEE 1138 / IEC 60794**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test on Manufactured OPGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attenuation Co-efficient at 1310 nm and 1550 nm</td>
</tr>
<tr>
<td>2</td>
<td>Point discontinuities of attenuation</td>
</tr>
<tr>
<td>3</td>
<td>Visual Material verification and dimensional checks as per approved DRS/Drawings</td>
</tr>
<tr>
<td>4</td>
<td>Rated Tensile Strength</td>
</tr>
<tr>
<td>5</td>
<td>Lay Length Measurements</td>
</tr>
</tbody>
</table>

### 2.2.5 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 2-6. The sampling plan shall be as per relevant standard:

### Table 2-6
**Factory Acceptance Tests On OPGW Fittings**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Suspension Assembly</strong></td>
</tr>
<tr>
<td>1</td>
<td>UTS/Mechanical Strength of the assembly</td>
</tr>
<tr>
<td>2</td>
<td>Clamp Slip Test</td>
</tr>
<tr>
<td>3</td>
<td>Visual Material verification and dimensional checks as per approved DRS/Drawings</td>
</tr>
<tr>
<td>4</td>
<td>Mechanical strength of each component</td>
</tr>
<tr>
<td>5</td>
<td>Galvanising test</td>
</tr>
<tr>
<td></td>
<td><strong>Tension Assembly</strong></td>
</tr>
<tr>
<td>6</td>
<td>Clamp Slip Strength test</td>
</tr>
<tr>
<td>7</td>
<td>Visual Material verification and dimensional checks as per approved DRS/Drawings</td>
</tr>
<tr>
<td>8</td>
<td>Mechanical strength of each component</td>
</tr>
<tr>
<td>9</td>
<td>Galvanising Test</td>
</tr>
</tbody>
</table>
Table 2-6
Factory Acceptance Tests On OPGW Fittings

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vibration Damper</td>
</tr>
<tr>
<td>10</td>
<td>Galvanising test on damper, masses and messenger wires</td>
</tr>
<tr>
<td>11</td>
<td>Damper response (resonant frequencies)</td>
</tr>
<tr>
<td>12</td>
<td>Clamp Slip test</td>
</tr>
<tr>
<td>13</td>
<td>Strength of messenger wires</td>
</tr>
<tr>
<td>14</td>
<td>Attachments of weights to messenger cable</td>
</tr>
<tr>
<td>15</td>
<td>Attachments of clamps to messenger cable</td>
</tr>
<tr>
<td>16</td>
<td>Clamp bolt tightening test</td>
</tr>
<tr>
<td>17</td>
<td>Clamp bolt torque test</td>
</tr>
<tr>
<td>18</td>
<td>Dynamic characteristic test</td>
</tr>
<tr>
<td>19</td>
<td>Visual Material verification and dimensional checks as per DRS/Drawings</td>
</tr>
</tbody>
</table>

Structure Mounting Clamp

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Clamp fit test</td>
</tr>
<tr>
<td>21</td>
<td>Clamp Strength test</td>
</tr>
<tr>
<td>22</td>
<td>Visual Material verification and dimensional checks as per DRS/Drawings</td>
</tr>
</tbody>
</table>

End of Table

2.2.6 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 2-7:

Table 2-7
Factory Acceptance Tests On Approach Cable

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attenuation Co-efficient at 1310 nm and 1550 nm</td>
</tr>
<tr>
<td>2</td>
<td>Point discontinuities of attenuation</td>
</tr>
<tr>
<td>3</td>
<td>Visual Material verification and dimensional checks as per approved DRS/Drawings</td>
</tr>
</tbody>
</table>
2.2.7 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below in Table: 2-8

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Visual check of Quantities and Specific Component Number for each component of Splice Enclosure/FODP and dimensional checks against the approved drawings.</td>
</tr>
</tbody>
</table>

2.2.8 Factory Acceptance Test on Test Equipment & other items

As per technical specification and approved DRS/Documents.

2.3 Site Acceptance Tests

The Contractor shall be responsible for the submission of all material & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for FO cable etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

2.3.1 Minimum Site Acceptance Testing Requirement for FO Cabling

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.
2.3.1.1 Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links.

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents.

Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be documented. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Table 2-9(a) through 2-9(c) below:

Table 2-9(a)
Fibre Optic Cable Pre-Installation Testing

<table>
<thead>
<tr>
<th>Item:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Physical Inspection of the cable assembly for damage</td>
</tr>
<tr>
<td>2.</td>
<td>Optical fibre continuity and fibre attenuation with OTDR at 1550 nm</td>
</tr>
<tr>
<td>3.</td>
<td>Fibre Optic Cable length measurement using OTDR</td>
</tr>
</tbody>
</table>

Table 2-9(b)
Fibre Optic Cable Splicing Testing

<table>
<thead>
<tr>
<th>Item:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Per splice bi-directional average attenuation with OTDR</td>
</tr>
<tr>
<td>2.</td>
<td>Physical inspection of splice box/enclosure for proper fibre / cable routing techniques</td>
</tr>
<tr>
<td>3.</td>
<td>Physical inspection of sealing techniques, weatherproofing, etc.</td>
</tr>
</tbody>
</table>

Table 2-9(c)
Fibre Optic Cable Commissioning Testing

<table>
<thead>
<tr>
<th>Item:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.</td>
</tr>
<tr>
<td>2.</td>
<td>End to End (FODP to FODP) bi-directional average attenuation of each fibre at</td>
</tr>
</tbody>
</table>
### Technical Specifications for Optical Ground Wire (OPGW) Cable

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1310 nm and 1550 nm by Power meter.</td>
</tr>
<tr>
<td>3</td>
<td>Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).</td>
</tr>
<tr>
<td>4</td>
<td>Proper termination and labelling of fibres &amp; fibre optic cables at FODP as per approved labelling plan.</td>
</tr>
</tbody>
</table>

-End of Table-

-End of this Section-
Chapter-03

Installation for OPGW Cabling

Table of Content

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Installation requirements ..................................................................</td>
<td>2</td>
</tr>
<tr>
<td>3.1.1</td>
<td>Installation of OPGW cable ................................................................</td>
<td>2</td>
</tr>
<tr>
<td>3.1.2</td>
<td>Installation Hardware fittings .....................................................</td>
<td>2</td>
</tr>
<tr>
<td>3.2</td>
<td>Installation of Approach cable ...................................................</td>
<td>2</td>
</tr>
<tr>
<td>3.3</td>
<td>Optical fibre termination and splicing ..........................................</td>
<td>3</td>
</tr>
<tr>
<td>3.4</td>
<td>Fibre Optic Distribution Panel ..................................................</td>
<td>3</td>
</tr>
<tr>
<td>3.5</td>
<td>Methodology for installation and termination ..................................</td>
<td>3</td>
</tr>
<tr>
<td>3.6</td>
<td>Cable raceways ..............................................................................</td>
<td>4</td>
</tr>
</tbody>
</table>
3.1 Installation requirements

The OPGW cable shall be installed at the top of the tower in place of earthwire (only one of the earthwire peaks in case of 400kV & above lines, if applicable) for under construction transmission lines as envisaged.

The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances, and on Employer specific approval, cable may be terminated on suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor.

For OPGW Cable to be installed on new line transmission line, the stringing shall be carried by the Transmission Line Contractor as per the stringing chart/procedure submitted by them and approved by Employer. The Contractor shall install OPGW as per approved stringing procedure.

The Contractor shall follow precautions including proper location of drum site, installation of stringing blocks/pulleys, proper sagging, proper installation of hardware, proper tension as per Sag-Tension chart, provision of service loops of OPGW in jointing locations etc.

3.1.1 Installation of OPGW cable

The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances and on Employer specific approval, cable may be terminated on Suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor. In such a case, the jointing of OPGW on suspension tower if required, shall be acceptable subject to its suitability.

3.1.2 Installation Hardware Fittings

All required hardware fittings shall be installed alongwith OPGW Cable.

3.2 Installation of Approach Cable

The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The Contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval. However, the approach cable shall be laid in the HDPE pipe in all condition.
Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable.

All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the Contractor.

### 3.3 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack/wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer’s approval.

#### 3.4 Fibre Optic Distribution Panel

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

(a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

(b) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

### 3.5 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification. The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.
Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/distribution line towers shall also be carried out by the Contractor. It shall be the Contractor's responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

3.6 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

(a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

(b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.

(c) Mechanical construction drawings of the cable raceways shall be submitted for Employer’s information & review.

........................................End of this Section........................................
APPENDIX – A

General Requirements
### Table A-1
Typical Transmission line details

<table>
<thead>
<tr>
<th>Line Voltage</th>
<th>S/C or D/C</th>
<th>Nominal Span (E/W &amp; Conductors in mtrs.)</th>
<th>Wind Zone as per IS 802</th>
<th>Design Tension at Every Day Temp (32°C) and full wind condition – Earthwire) in kg for Wind Zone</th>
<th>Wind Pressure (kg/Sq-m) considering gust factor</th>
<th>Max Sag – Ground Wire at 53°C (in mtrs)</th>
<th>UTS – Earthwire (in Kg)</th>
<th>Weight – Earth wire (in Kg/km)</th>
<th>Minimum Clearance in mtrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>220 kV</td>
<td>D/C</td>
<td>350</td>
<td>IV</td>
<td>2838</td>
<td>200</td>
<td>7.83</td>
<td>6230</td>
<td>483</td>
<td>8.4 (DA,DB &amp; DC Towers)</td>
</tr>
</tbody>
</table>

A1 Minimum clearance between conductor and ground (in meters)
B1 Minimum clearance between two phase conductors (in meters) – vertical in case of D/C towers and horizontal in case of S/C towers.
C1 Minimum clearance between conductor and earth wire (in meters)
Appendix-B

Data Requirement Sheets
Appendix-B

Data Requirement Sheets

The following sets of Data Requirement Sheets are required to be filled up by the bidders to aid in the evaluation process. The response shall be brief and to the point and shall be supported by the printed product description and other literature. The DRS duly filled and the relevant drawings shall also be submitted during the detailed engineering along with the relevant technical brochures.
**DATA REQUIREMENTS SHEETS for OVERHEAD FIBRE OPTIC CABLE**

**OPTICAL GROUND WIRE (OPGW) – 24 Fibre:**

**(if applicable)**

Manufacturer: ________________________________

Part #: ________________________________

Configuration: ________________________________

<table>
<thead>
<tr>
<th>Seq</th>
<th>Parameter:</th>
<th>As per Technical Specification</th>
<th>As per Bidder Offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>No. of Fibres</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dual Window Single-Mode:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Buffer Type:</td>
<td>Loose Tube</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Buffer Tube material</td>
<td>Non-metallic</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>No. of Buffer Tubes:</td>
<td>Minimum Two (2)</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>No. of Fibers per buffer Tube:</td>
<td>Maximum Twelve(12)</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Expected Cable Life:</td>
<td>25 Year</td>
<td></td>
</tr>
</tbody>
</table>
# Technical Specifications for Optical Ground Wire (OPGW) Cable

## DRS Form 2

**DATA REQUIREMENTS SHEETS for OPTICAL FIBRE**

**DUAL-WINDOW SINGLE MODE (DW-SM)**

### OPTICAL PARAMETERS

<table>
<thead>
<tr>
<th>Seq</th>
<th>Parameter:</th>
<th>As per Technical Specification</th>
<th>As per Bidder offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fiber manufacturer(s) / Type:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Attenuation Coefficient @ 1310 nm: @ 1550 nm:</td>
<td>≤ 0.35 dB/km</td>
<td>≤ 0.21 dB/km</td>
</tr>
<tr>
<td>3.</td>
<td>Point discontinuity @ 1310 nm: @ 1550 nm:</td>
<td>≤ 0.05 dB</td>
<td>≤ 0.05 dB</td>
</tr>
<tr>
<td>4.</td>
<td>Nominal Mode Field Diameter @ 1310 nm: @ 1550 nm:</td>
<td>8.6 to 9.5 µm (± 0.6 µm)</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Chromatic Dispersion Coefficient @ 1310 (1288-1339) nm: @ 1310 (1271-1360) nm: @ 1550 nm:</td>
<td>3.5 ps/(nm×km)</td>
<td>5.3 ps/(nm×km)</td>
</tr>
<tr>
<td>6.</td>
<td>Zero dispersion wavelength:</td>
<td>1300 to 1324 nm</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Cutoff wavelength:</td>
<td>≤ 1260 nm</td>
<td></td>
</tr>
</tbody>
</table>

### Physical and Mechanical Properties

<table>
<thead>
<tr>
<th>Seq</th>
<th>Parameter:</th>
<th>As per Technical Specification</th>
<th>As per Bidder offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td>Bend Performance: (37.5 mm radius, 100 turns) @ 1310 nm (30 mm radius, 100 turn) @ 1550 nm (16mm radius, 1 turn) @ 1550nm</td>
<td>≤ 0.05 dB</td>
<td>≤ 0.05 dB</td>
</tr>
<tr>
<td>9.</td>
<td>Cladding Diameter (nominal ± deviation):</td>
<td>125.0 µm ± 1 µm</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Polarisation mode dispersion coefficient</td>
<td>≤ 0.2 ps/km(^{1/2})</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Proof test level</td>
<td>≥ 0.69 Gpa</td>
<td></td>
</tr>
</tbody>
</table>

----------------------------------------End of the Appendix----------------------------------------
GATE DETAIL PLAN AT A-A

NOTES

1: ALL DIMENSIONS ARE IN MILLIMETERS
2: ALL HOLES ARE 17.5 MM Ø TO SUIT 16mm Ø BOLTS
3: BLANK HOLES AT GATES ARE TO RECEIVE BARBED WIRE
4: ONE 3 MM SPRING WASHER TO BE PROVIDED UNDER EACH NUT
5: BARBED WIRE SHALL CONFORM TO IS 278 (SIZE DESIGNATION A1)

FOR BID PURPOSE ONLY
NOTES

1: ALL DIM. ARE IN MM
2: M.S. PLATE 1.6 mm THICK (MIN)
3: WHITE ENAMELLED BACKGROUND AND RED ENAMELLED LETTERING
4: EQUAL NO. OF CKT. PLATE FOR EACH. CKT. ARE TO BE SUPPLIED
5: 2 NOS. 16 mm Ø H.R.H. BOLTS x35 mm LONG. TO BE SUPPLIED ALONG WITH EACH PLATE.
6: 2 NOS. 2MM THICK LEAD WASHERS TO BE PROVIDED WITH EACH PLATE
7: REAR SIDE SHOULD BE ENAMELLED BLACK.

FOR BID PURPOSE ONLY

NEPAL ELECTRICITY AUTHORITY
TRANSMISSION AND SYSTEM OPERATION
TRANSMISSION LINE /SUBSTATION CONST. DEPARTMENT
PROJECT
MARSYANGDI-KATHMANDU 220 KV T/L PROJECT
TITLE
CIRCUIT PLATE
CONSULTANT
POWERGRID CORP. OF INDIA LTD.
PREPARED BY:
SCALE: NOT TO SCALE
CHECKED BY:
DRAWING NO.: K/K/220KV/303
NOTES

1: ALL DIM. ARE IN MM
2: LETTER AND FIGURE SHALL IN RED ENAMEL & BACKGROUND SHOULD BE WHITE ENAMELLED.
3: BACK : BLACK VITREOUS ENAMEL
4: 1.6 MM THICK MS PLATE WITH THE CORNERS ROUNDED OFF.
5: DESIGN OF DANGER PLATE IS AS PER IS : 2551
6: FASTENERS & WASHERS : 2 NOS. 16 mm PER PLATE WITH FOUR NOS. 2mm THICK LEAD WASHERS
TYPICAl. D/C TOWER

GROUND LEVEL

CONCRETE LEVEL

WINDWARD SIDE
<table>
<thead>
<tr>
<th>S.NO.</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>MATERIAL</th>
<th>MIN. ULTIMATE TENSILE STRENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ANCHOR SHACKLE</td>
<td>1</td>
<td>FORGED STEEL</td>
<td>240KN</td>
</tr>
<tr>
<td>2</td>
<td>CHAIN LINK</td>
<td>1</td>
<td>MILD STEEL</td>
<td>120KN</td>
</tr>
<tr>
<td>3</td>
<td>YOKE PLATE</td>
<td>1</td>
<td>FORGED STEEL</td>
<td>114.8 KN SLIP</td>
</tr>
<tr>
<td>4</td>
<td>BALL CLEVIS</td>
<td>2</td>
<td>FORGED STEEL</td>
<td>240KN</td>
</tr>
<tr>
<td>5</td>
<td>SOCKET CLEVIS</td>
<td>2</td>
<td>MILD STEEL</td>
<td>120KN</td>
</tr>
<tr>
<td>6</td>
<td>YOKE PLATE</td>
<td>1</td>
<td>FORGED STEEL</td>
<td>120KN</td>
</tr>
<tr>
<td>7</td>
<td>ARCING HORN</td>
<td>1</td>
<td>MILD STEEL</td>
<td>120KN</td>
</tr>
<tr>
<td>8</td>
<td>CORONA CONTROL RING/PIPE</td>
<td>1</td>
<td>AL ALLOY</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

NOTES:
1. SPRING WASHERS ELECTRO GALVANISED
2. OTHER FERROUS PARTS HOT DIP GALVANISED.
3. BALL & SOCKET SIZE OF 20MM. DESIGNATION AS PER IS
4. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT AS SHOWN ARE INDICATIVE ONLY & NOT MANDATORY.
5. ALL DIMENSIONS ARE IN MM.

FOR BID PURPOSE ONLY.
<table>
<thead>
<tr>
<th>S.NO.</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>MATERIAL</th>
<th>MIN. ULTIMATE TENSILE STRENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ANCHOR SHACKLE</td>
<td>1</td>
<td>FORGED STEEL</td>
<td>240KN</td>
</tr>
<tr>
<td>2</td>
<td>CHAIN LINK</td>
<td>2</td>
<td>FORGED STEEL</td>
<td>240KN</td>
</tr>
<tr>
<td>3</td>
<td>YOKE</td>
<td>4</td>
<td>MILD STEEL</td>
<td>120KN</td>
</tr>
<tr>
<td>4</td>
<td>BALL CLEVIS</td>
<td>5</td>
<td>FORGED STEEL</td>
<td>240KN</td>
</tr>
<tr>
<td>5</td>
<td>SOCKET CLEVIS</td>
<td>7</td>
<td>MILD STEEL</td>
<td>120KN</td>
</tr>
<tr>
<td>6</td>
<td>ARCING HORN</td>
<td>6</td>
<td>FORGED STEEL</td>
<td>N.A.</td>
</tr>
<tr>
<td>7</td>
<td>YOKE</td>
<td>1</td>
<td>MILD STEEL</td>
<td>N.A.</td>
</tr>
<tr>
<td>8</td>
<td>CORONA CONTROL RING/SET ALLOY PIPE</td>
<td>9</td>
<td>AL. &amp; M.S.</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

**NOTES:**

1. SPRING WASHERS ELECTRO GALVANISED
2. OTHER FERROUS PARTS HOT DIP GALVANISED.
3. THE OVERALL MIN. & MAX. DIMENSIONS INDICATED ARE INCLUSIVE OF MAX. VARIATION IN LENGTH DUE TO:
   - A) INSULATOR DISC TOLERANCE OF + 5MM
   - B) TOLERANCE ON TOTAL LENGTH OF HARDWARE FITING OF + 2%
4. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT AS SHOWN ARE INDICATIVE ONLY & NOT MANDATORY.
5. ALL DIMENSIONS ARE IN MM.
<table>
<thead>
<tr>
<th>S.No.</th>
<th>Description</th>
<th>QTY.</th>
<th>Material</th>
<th>Min. Ultimate Tensile Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ANCHOR SHACKLE</td>
<td>1</td>
<td>FORGED STEEL</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CHAIN LINK</td>
<td>1</td>
<td>MILD STEEL</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>YOKE PLATE</td>
<td>4</td>
<td>FORGED STEEL</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>BALL CLEVIS</td>
<td>2</td>
<td>FORGED STEEL</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>SOCKET CLEVIS</td>
<td>7</td>
<td>MILD STEEL</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>ARCING HORN</td>
<td>1</td>
<td>FORGED STEEL</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>YOKE PLATE</td>
<td>1</td>
<td>MILD STEEL</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>CORONA CONTROL RING/Pipe</td>
<td>1</td>
<td>AL. &amp; M.S.</td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
1. SPRING WASHERS ELECTRO GALVANISED
2. OTHER FERROUS PARTS HOT DIP GALVANISED.
3. BALL & SOCKET SIZE OF 20MM.
4. THE OVERALL MIN. & MAX. DIMENSIONS INDICATED ARE INCLUSIVIE OF MAX. VARIATION IN LENGTH DUE TO:
   A) INSULATOR LENGTH
   B) TOLERANCE ON TOTAL LENGTH OF HARDWARE FITTING OF + 2%
   C) ADJUSTMENT OF SAG ADJUSTMENT DEVICE
   D) TOLERANCE ON TOTAL LENGTH OF HARDWARE FITTING OF ± 2%
5. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT AS SHOWN ARE INDICATIVE ONLY & NOT MANDATORY.
6. ALL DIMENSIONS ARE IN MM.

**Special Note:**
Each unit of porcelain long rod shall be 1233 mm long.

**Diagram:**
Tension insulator string (Twin ACSR Bison) with line diagram of long rod double ball insulator.
NOTE:

1. SPRING WASHERS ELECTRO GALVANIZED
2. OTHER RECURSIVE PARTS NOT GALVANIZED
3. BALL & SOCKET SIZE 16 MM. OF DESIGNATION.
4. THE OVERALL MIN. & MAX. DIMENSIONS INDICATED ARE
5. TOLERANCE ON TOTAL LENGTH OF HARDWARE FITTING OF + / - 2% INCLUSIVE OF MAX. VARIATION IN LENGTH DUE TO..  
6. ALL DIMENSIONS ARE IN MM.
7. SPRING WASHERS ELECTRO GALVANIZED
8. OTHER RECURSIVE PARTS NOT GALVANIZED
9. BALL & SOCKET SIZE 16 MM. OF DESIGNATION
10. TOLERANCE ON TOTAL LENGTH OF HARDWARE FITTING OF + / - 2% INCLUSIVE OF MAX. VARIATION IN LENGTH DUE TO..
1. All dimensions are in mm.

2. Clearances from outer surface of outer layer of conductor is at least 75mm.

3. Thickness of protective lagging should be 50mm.

4. Tolerance on dimension of wood only is equal to +3mm.

5. Standard length of conductor is equal to 10% of standard length.

6. Tolerance on length of conductor is equal to 5% of standard length.

7. Notes:
   - Inner surface of protective lagging is at least 75mm.
   - All dimensions are in mm.
   - Scale: Not to scale.
   - Date:
   - Drawing No.:

8. Table of Description:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Protective External Lagging</td>
</tr>
<tr>
<td>2</td>
<td>Flange</td>
</tr>
<tr>
<td>3</td>
<td>Barrel</td>
</tr>
<tr>
<td>4</td>
<td>Mild Steel Bush 8 Plate</td>
</tr>
<tr>
<td>5</td>
<td>Barrel Stud The Rod</td>
</tr>
<tr>
<td>6</td>
<td>Barrel Stud Support</td>
</tr>
<tr>
<td>7</td>
<td>Washer</td>
</tr>
<tr>
<td>8</td>
<td>Access for Inner EoN of Conductor</td>
</tr>
<tr>
<td>9</td>
<td>Access for Binder</td>
</tr>
</tbody>
</table>

9. Prepared By:

10. Checked By:

11. Approved By:

12. Transmission Line/Substation Const. Department

13. Nepal Electricity Authority

14. Powergrid Corp. of India Ltd.

15. For Bid Purpose Only
COUNTERPOISE EARTHING ARRANGEMENT

CONNECTED ON 3 LEGS & FOURTH LUG WILL BE CONNECTED WITH FLAT

ONE SET COMPRISING OF FOUR NUMBERS OF REQUIRED LENGTH OF COUNTERPOISE WIRE

FOUR G.S. LUG WILL BE REQUIRED PER TOWER. THREE LUGS WILL BE OTHER END FREE FOR A REQUIRED LENGTH OF COUNTERPOISE WIRE

1 : ALL DIM. ARE IN MM
2 : 10.97mm GALVINISED WIRE WITH G.S LUG FORGED AT ONE END OTHER END FREE FOR A REQUIRED LENGTH OF COUNTERPOISE WIRE
3 : FOUR G.S. LUG WILL BE REQUIRED PER TOWER. THREE LUGS WILL BE CONNECTED ON 3 LEGS & FOURTH LUG WILL BE CONNECTED WITH FLAT TYPE 'C' PROVIDED FOR PIPE TYPE EARTHING.
4 : 10.97 MM WIRE SHALL BE OUTSIDE COPPING.
5 : ONE SET COMPRISING OF FOUR NUMBERS OF REQUIRED LENGTH OF COUNTERPOISE WIRE

LIST OF BOLTS & NUTS/TOWER

<table>
<thead>
<tr>
<th>S. No</th>
<th>SIZE</th>
<th>QTY.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M16 X 45LG</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>M16 X 35LG</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3.5 THK SPG WASHER</td>
<td>4</td>
</tr>
</tbody>
</table>

NOTES

NEPAL ELECTRICITY AUTHORITY
TRANSMISSION AND SYSTEM OPERATION
TRANSMISSION LINE /SUBSTATION CONST. DEPARTMENT
PROJECT
MARSYANGDI-KATHMANDU 220 KV T/L PROJECT
TITLE
COUNTERPOISE EARTHING ARRANGEMENT
CONSULTANT
POWERGRID CORP. OF INDIA LTD.
1: ALL DIM. ARE IN MM
2: STRIP IS TO BE PROVIDED ON ONE LEG OF EACH TOWER
3: STRIP WITH PIPE EARTH ARRANGEMENT IS TO BE PROVIDED ON ONLY ONE LEG
   FOR THE LOCATION WHERE TOWER FOOTING RESISTANCE IS MORE THAN 10 OHMS
4: 17.5 MM Ø HOLES SUITABLE FOR 16MM BOLTS FOR EARTHING DEVICES
5: FOR COUNTER POISE EARTHING STRIP 'C' SHALL BE CONNECTED WITH COUNTER POISE
   WIRE THROUGH 'A' LUG

FOR BID PURPOSE ONLY

Nepal Electricity Authority
Transmission and System Operation
Transmission Line/Substation Const. Department
Project: Marsyangdi-Kathmandu 220 KV T/L Project
Title: Details of Pipe Type Earthing
Consultant: Powergrid Corp. Of India Ltd.
Prepared By: SCALE: NOT TO SCALE
Checked By: DRAWING NO.: M-K/220KV/006 (1/3)
**DETAILS FOR FLATS FOR EARTHING**

**DETAIL OF FLAT TYPE `C`**

- 2-17.5 ø HOLES
- 50 x 6 MS FLAT 851 LG.

**DETAIL OF FLAT TYPE `D`**

- 2x 17.5 ø HOLES
- 50x6 MS FLAT 3350 LG.

**NOTES**

1. ALL DIM. ARE IN MM
2. AFTER FABRICATION, BOTH FLATES ARE TO BE HOT DIP GALVINISED AS PER IS - 2629.
3. `FLAT TYPE 'C' IS TO BE PROVIDED ON ONE LEG OF EACH TOWER
4. `FLAT TYPE 'D' IS TO BE PROVIDED WITH PIPE EARTHING ARRANGEMENT AND TO BE CONNECTED WITH FLAT 'C' FOR THE LOCATION WHERE TOWER FOOTING RESISTANCE IS MORE THAN 10 OHMS

**LIST OF BOLTS & NUTS WITH SP. WASHER**

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>SIZE</th>
<th>QTY.</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M 16Ø x 45 LG.</td>
<td>2</td>
<td>PER TOWER</td>
</tr>
<tr>
<td>2</td>
<td>M 16Ø x 35 LG.</td>
<td>2</td>
<td>PER PIPE TYPE EARTHING</td>
</tr>
<tr>
<td>3</td>
<td>M 12Ø x 30 LG.</td>
<td>2</td>
<td>PER PIPE TYPE EARTHING</td>
</tr>
</tbody>
</table>
**DESCRIPTION**

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>QUANTITY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Protectite External Lagging</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>Mild Steel Bush</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>Barrel Support</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>Washer</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>BUSH PLATE</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>BARREL SUPPORT</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>TIE RODS</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>WOOD</td>
</tr>
</tbody>
</table>

**NOTES**

1. All dimensions are in mm.
2. Clearance from outer surface of outer layer of earth wire.
3. Two lengths of earth wire are wound on every drum.
4. Thickness of protective lagging should be 50 mm.
5. Standard length of earth wire 2000m +/- 5%.
6. Tolerance on wood dimension = ±3mm.

**FOR BID PURPOSE ONLY**

**SCALE: NOT TO SCALE**

**DRAWING NO.**

NEPAL ELECTRICITY AUTHORITY

MARSYANGDI-KATHMANDU 220 KV T/L PROJECT

TRANSMISSION AND SUBSTATION CONSTRUCTION 

TRANSMISSION AND SUBSTATION OPERATION

M-K/220KV/012

CHECKED BY: 

PREPARED BY:
TYP. FOUNDATION SHAPE FOR P.C.C. TYPE

TYP. FOUNDATION SHAPE FOR R.C.C. TYPE

TYP. FOUNDATION SHAPE FOR HARD ROCK

FOR BID PURPOSE ONLY

NEPAL ELECTRICITY AUTHORITY
TRANSMISSION AND SYSTEM OPERATION
TRANSMISSION LINE / SUBSTATION CONST. DEPARTMENT
PROJECT
MARSYANGDI-KATHMANDU 220 KV T/L PROJECT
TITLE
TENTATIVE SHAPE OF TOWER FOOTINGS
CONSULTANT
POWERGRID CORP. OF INDIA LTD.
PREPARED BY:
CHECKED BY:
DRAWING NO.: M-K/220KV/010
BID PURPOSE ONLY
1: ALL DIM. ARE IN MM
2: LETTER RED ENAMELLED
3: GROUND WHITE VITREOUS ENAMELLED
4: BACK: BLACK VITREOUS ENAMELLED
5: 1.6 MM THICK MS PLATE
6: 2 NOS. 2 MM THICK LEAD WASHER TO BE PROVIDED WITH EACH PLATE
7: EACH NO. WILL HAVE FOUR DIGITS AS SHOWN.
   NO TO BE STARTED FROM 1 OWNWARDS
8: TWO NO 16 MM DIA H.R.H. BOLTS x 35 MM LONG ARE TO BE SUPPLIED ALONG WITH EACH PLATE
9: ABC CODE FOR SENDING END AND DEF CODE FOR RECEIVING END.

FOR BID PURPOSE ONLY
TOWER PHASE PLATE DRAWING

QUANTITIES PER TOWER

1: ONE OF EACH COLOUR FOR DC TENSION TOWER
2: TWO NO. OF EACH COLOUR FOR D/C TOWER
3: M.S. PLATE 1.6 MM THICK
4: ALL DIM. ARE IN MM
5: NOTES

NOTES

1: ALL DIM. ARE IN MM
2: M.S. PLATE 1.6 MM THICK, PHASE PLATES TO BE ENAMELLED RED, YELLOW, AND BLUE ON FRONT AND BACK
3: 2 NO. 2MM THK. LEAD WASHERS TO BE PROVIDED WITH EACH PLATE
4: PHASE PLATES TO BE ENAMELLED RED, YELLOW
5: 1 NO. 16MM DIA BOLT FASTNERS & WASHERS PER PLATE

POWERGRID CORP. OF INDIA LTD.

APPROVED BY: CHECKED BY: PREPARED BY:

CONSULTANT

DATE: SCALE: NOT TO SCALE

DRAWING NO.:

NEPAL ELECTRICITY AUTHORITY

FOR BID PURPOSE ONLY

MARSYANGDI-KATHMANDU 220 KV T/L PROJECT

TRANSMISSION AND SYSTEM OPERATION

TRANSMISSION LINE / SUBSTATION CONST. DEPARTMENT

50 20 25

250
X = 2.5% OF LEG LOAD

REDUNDANT DESIGN LOAD FOR REDUNDANT

1. X b/a
2. X c/a
3. X b'/a'
4. X c'/a'

FOR BID PURPOSE ONLY

POWERGRID CORP. OF INDIA LTD.
1: ALL DIM. ARE IN MM UNLESS OTHERWISE SPECIFIED.

2: WEEP HOLES SHOULD BE OF SIZE 100mm x 100mm OR 150mm x 150mm INCASE OF LARGE SIZE REVETMENT.

3: WEEP HOLES SHOULD BE 2.5Mt C-C APART HORIZONTAL CENTER OF TOP MOST WEEP HOLES TO BE NOT LESS THAN 300 mm BELOW TOP.

4: CENTER OF TOP MOST WEEP HOLES TO BE NOT LESS THAN 300 mm BELOW TOPLINE. 

5: THE MIN. DEPTH OF REVETMENT WALL BELOW G.L. WILL BE 600mm.

6: DIM. 'B' ARE VALID ONLY FOR H NOT EXCEEDING 5.00 METER.

7: SIZE OF STONE FOR MASONARY WORK. 300 x 150 x 150 & BELOW.

8: THE MASONARY WORK SHOULD BE CARRIED OUT IN 1:5 CEMENT MORTAR.

9: SIZE OF STONE PACKING AT WEEP HOLE 75 mm TO 150mm.

NOTE:

1: ALL DIM. ARE IN MM UNLESS OTHERWISE SPECIFIED.

2: WEEP HOLES SHOULD BE OF SIZE 100mm x 100mm OR 150mm x 150mm INCASE OF LARGE SIZE REVETMENT.

3: WEEP HOLES SHOULD BE 2.5Mt C-C APART HORIZONTAL CENTER OF TOP MOST WEEP HOLES TO BE NOT LESS THAN 300 mm BELOW TOPLINE.

4: CENTER OF TOP MOST WEEP HOLES TO BE NOT LESS THAN 300 mm BELOW TOPLINE.

5: THE MIN. DEPTH OF REVETMENT WALL BELOW G.L. WILL BE 600mm.

6: DIM. 'B' ARE VALID ONLY FOR H NOT EXCEEDING 5.00 METER.

7: SIZE OF STONE FOR MASONARY WORK. 300 x 150 x 150 & BELOW.

8: THE MASONARY WORK SHOULD BE CARRIED OUT IN 1:5 CEMENT MORTAR.

9: SIZE OF STONE PACKING AT WEEP HOLE 75 mm TO 150mm.

H > 1000, d = 230
H < 1000, d = 150

FOR H > 1000, d = 150
FOR H < 1000, d = 230

MASONARY WORK SHOULD BE CARRIED OUT IN 1:5 CEMENT MORTAR.

SIZE OF STONE PACKING AT WEEP HOLE 75 mm TO 150mm.

SIZE OF STONE FOR MASONARY WORK. 300 x 150 x 150 & BELOW.

THE MIN. DEPTH OF REVETMENT WALL BELOW G.L. WILL BE 600mm.

CENTER OF TOP MOST WEEP HOLES TO BE NOT LESS THAN 300 mm BELOW TOPLINE.

NOTES
Outline DRG. OF SINGLE LONG ROD SUSPENSION INSULATOR STRING (TWIN BISON)

MARSYANGDI-KATHMANDU 220 KV T/L PROJECT
POWER GRID CORPORATION OF INDIA LTD.
NEPAL ELECTRICITY AUTHORITY

FOR BID PURPOSE ONLY

1. OTHER FERROUS PARTS HOT DIP GALVANISED.
2. BALL & SOCKET DESIGNATION 20mm AS PER IEC 120/IS 2486
3. ARCING HORN MILD STEEL
4. ALLOY PIPE FORGED STEEL
5. MILD STEEL FORGED STEEL
6. ALLOY

SPECIAL NOTES

1) ALL DIMENSIONS ARE IN MM
2) THE OVERALL MIN. & MAX. DIMENSIONS INDICATED ARE IN THE SCOPE OF LONG ROD INSULATOR SUPPLIER
3) THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT ARE SHOWN AS INDICATIVE ONLY & NOT MANDATORY
4) THE TOLERANCE ON TOTAL LENGTH OF HARDWARE FITTING IS +2%
5) INCLUSIVIE OF MAX. VARIATION IN LENGTH DUE TO

B) INSULATOR LENGTH

\[ \text{TENSILE STRENGTH} \]

\[
\begin{array}{|c|c|c|}
\hline
\text{S.NO.} & \text{DESCRIPTION} & \text{TENSILE STRENGTH} \\
\hline
1 & HORN SHACKLE & \text{120 K.N.} \\
2 & HORN & \text{70 K.N.} \\
3 & ANCHOR SHACKLE & \text{120 K.N.} \\
4 & SUSPENSION LAMP & \text{120 K.N.} \\
5 & CORONA CONTROL RING/GRADING RING & \text{N.A.} \\
6 & TWISTED SHACKLE & \text{120 K.N.} \\
7 & SUSPENSION LAMP & \text{120 K.N.} \\
8 & ANCHOR SHACKLE & \text{70 K.N.} \\
9 & INTERMEDIATE ARCING HORN & \text{N.A.} \\
10 & INTERMEDIATE DOUBLE BALL PIN & \text{120 K.N.} \\
\hline
\end{array}
\]

NOTES:

\[ \text{EACH UNIT OF PORCELAIN LONG ROD SHALL BE 1160 MM (NOM)} \]
NOTES:

1. SPRING WASHERS ELECTRO GALVANIZED
2. OTHER REINFORCEMENT PARTS HOT DIP GALVANIZED
3. BALL & SOCKET SIZE 16 MM OF DESIGNATION
4. THE OVERALL MIN & MAX DIMENSIONS INDICATED ARE
5. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT
6. ALL DIMENSIONS ARE IN MM
7. TOLERANCE ON TOTAL LENGTH OF HARDWARE FITTING OF +/-2%
8. INSULATOR DISC TOLERANCE OF +/ - 4 MM
9. INCLUSION OF MAX VARIATION IN LENGTH DUE TO
10. OTHER FERROUS PARTS HOT DIP GALVANIZED
11. SPRING WASHERS ELECTRO GALVANIZED
1: STEP BOLT SHALL BE HOT DIPPED GALVANISED

2: ALL DIM. ARE IN MM

3: WEIGHT / PIECE WITH TWO NUTS: 0.41 K.G.

4: THREADS TO BE UNDER CUT BY 0.3 MM

5: STEP BOLT SHALL BE CAPABLE OF WITHSTANDING A VERTICAL LOAD NOT LESS THAN 1.5 K.N.

6: SPRING WASHER SHOULD BE ELECTRO GALVANISED.

7: PROPERTY OF BOLT SHALL BE CLASS AS PER IS: 10238

8: THE STEP BOLT SHALL WITHSTAND CANTILEVER TEST AS PER IS: 10238

9: NUTS SHALL BE OF CLASS 5 CONFORMING TO IS: 967 (PART - IV)

10: THE STEP BOLT SHALL WITHSTAND CANTILEVER TEST AS PER IS: 10238

NOTES

AS PER IS: 3063
3.5 MM THICK SPRING WASHER

M - 16 HEX NUT, THREAD POSITION TO SUIT

M16 HEX NUT AS PER

IS: 1363
**NOTES:**
1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 600 m (NC), 360 m (BWC) Maximum
   200 m (NC), 100 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Bracketed figures indicate Minimum Vertical Load/Uplift Loads
5. Angle of Deviation = 2°
6. Wind Load (Full Wind) on Tower Body shall be considered in Assm. 1.
7. 75 % Wind Load on Tower Body shall be considered in Assm. 2, 3, 4, 5, 6, 4A, 5A & 6A
8. S.W. (Self Weight) of Tower shall be considered Extra.
10. Insulator Strings Weight & Wind on Strings are included in above Load.
NEPAL ELECTRICITY AUTHORITY
LOAD TREES FOR TYPE-DA

ASSM 7: SAFETY CONDITIONS (NORMAL)

NOTES:
1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 600 m (NC), 360 m (BWC) Maximum
   200 m (NC), 100 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Angle of Deviation = 2°
5. Wind Load on Tower Body need not be considered in all above assumptions.
6. S.W. (Self Weight) of Tower shall be considered Extra.
8. Insulator Strings Weight are included in above Load.

ASSM 8, 9: SAFETY CONDITION
(GW BROKEN)

ASSM 10, 11, 12, 10A, 11A, 12A: SAFETY CONDITION (COND BROKEN)
NOTES:
1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 600 m (NC), 360 m (BWC) Maximum
   -600 m (NC), -360 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Bracketed figures indicate Minimum Vertical Load/Uplift Loads
5. Angle of Deviation = 15°
6. Wind Load (Full Wind) on Tower Body shall be considered extra in all above assumptions.
7. S.W. (Self Weight) of Tower shall be considered Extra.
8. Assm. 4A, 5A & 6A indicates Right Side Conductor Broken conditions.
9. Insulator Strings Weight & Wind on Strings are included in above Load.
NOTES:
1. Wind Span 350m (NC), 210 m (BWC)
2. Weight Span 600 m (NC), 360 m (BWC) Maximum
   -600 m (NC), -360 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Angle of Deviation = 15°
5. Wind Load on Tower Body need not be considered in all above assumptions.
6. S.W. (Self Weight) of Tower shall be considered Extra.
8. Insulator Strings Weight are included in above Load.
**NOTES:**

1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 600 m (NC), 360 m (BWC) Maximum
   - 600 m (NC), -360 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Bracketed figures indicate Minimum Vertical Load/Uplift Loads
5. Angle of Deviation = 30 °
6. Wind Load (Full Wind) on Tower Body shall be considered extra in all above assumptions.
7. S.W. (Self Weight) of Tower shall be considered Extra.
8. Assm. 4A, 5A & 6A indicates Right Side Conductor Broken conditions.
9. Insulator Strings Weight & Wind on Strings are included in above Load.
NOTES:
1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 600 m (NC), 360 m (BWC) Maximum
   -600 m (NC), -360 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Angle of Deviation = 30 °
5. Wind Load on Tower Body need not be considered in all above assumptions.
6. S.W. (Self Weight) of Tower shall be considered Extra.
8. Insulator Strings Weight are included in above Load.
NOTES:
1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 1000 m (NC), 600 m (BWC) Maximum
   -1000 m (NC), -600 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Bracketed figures indicate Minimum Vertical Load/Uplift Loads
5. Angle of Deviation = 60 °
6. Wind Load (Full Wind) on Tower Body shall be considered extra in all above assumptions.
7. S.W. (Self Weight) of Tower shall be considered Extra.
8. Assm. 2A, 3A & 4A indicates Right Side GW Broken conditions.
9. Assm. 5A indicates Right Side Conductors Broken condition.
10. Insulator Strings Weight & Wind on Strings are included in above Load.
NOTES:
1. Wind Span 350 m (NC), 210 m (BWC)
2. Weight Span 1000 m (NC), 600 m (BWC) Maximum
   -1000 m (NC), -600 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Angle of Deviation = 60°
5. Wind Load on Tower Body need not be considered in all above assumptions.
6. S.W. (Self Weight) of Tower shall be considered Extra.
7. Assm. 7A, 8A & 9A indicates Right Side GW Broken conditions.
8. Assm. 10A indicates Right Side Conductor Broken condition.
9. Insulator Strings Weight are included in above Load.
NOTES:
1. Wind Span 200 m (NC), 40 m (BWC)
2. Weight Span 500 m (NC), 100 m (BWC) Maximum
   -500 m (NC), -60 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Bracketed figures indicate Minimum Vertical Load/Uplift Loads
5. Angle of Deviation = 15°
6. Wind Load (Full Wind) on Tower Body shall be considered extra in all above assumptions.
7. S.W. (Self Weight) of Tower shall be considered Extra.
9. Assm. 15A indicates Right Side Conductors Broken condition.
10. Insulator Strings Weight & Wind on Strings are included in above Load.
NOTES:
1. Wind Span 200 m (NC), 40 m (BWC)
2. Weight Span 500 m (NC), 100 m (BWC) Maximum
   -500 m (NC), -60 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Angle of Deviation = 15°
5. Wind Load on Tower Body need not be considered in all above assumptions.
6. S.W. (Self Weight) of Tower shall be considered Extra.
8. Assm. 20A indicates Right Side Conductor Broken condition.
9. Insulator Strings Weight are included in above Load.
NOTES:
1. Wind Span 300 m (NC), 210 m (BWC)
2. Weight Span 700 m (NC), 600 m (BWC) Maximum
   -700 m (NC), 0 m (BWC) Minimum
3. All ultimate loads are in kg.
4. Bracketed figures indicate Minimum Vertical Load/Uplift Loads
5. Angle of Deviation = 15° (Both on Line and Substation side).
6. Wind Load (Full Wind) on Tower Body shall be considered extra in all above assumptions.
7. S.W. (Self Weight) of Tower shall be considered Extra.
10. Insulator Strings Weight & Wind on Strings are included in above Load.
**Conductor Properties**

Conductor Name: MOOSE ACSR

- UTS (Kg): 16428
- Area of Conductor (sqmm): 597
- Wt. Of Conductor (Kg/m): 2.004
- Dia. Of Conductor (mm): 31.77
- Modulus of Elasticity (Kg/sqmm): 7034
- Coeff. Of linear Expansion (per deg C): 0.0000193

**Initial Condition**

- Normal Span (m): 350
- Wind Pressure on Cond. (Kg/sqm): 162
- Initial Cond. temp. (deg C): 32
- Initial Wind %: 0
- Thickness of ICE (mm): 0
- Initial Cond. tension at above temp, and wind condition (% of UTS OR value in Kg): 22

### Note:
The tension should be below 22% of UTS in day to day condition and should not exceed 70% of UTS in any condition.

<table>
<thead>
<tr>
<th>22% of UTS</th>
<th>70% of UTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3614.16 Kg</td>
<td>11499.6 Kg</td>
</tr>
</tbody>
</table>

#### Initial Sag, Ten at 32 deg C, 0% Wind

<table>
<thead>
<tr>
<th>Ten (% of UTS)</th>
<th>Ten (kg)</th>
<th>Sag (mts)</th>
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</thead>
<tbody>
<tr>
<td>22.00</td>
<td>3614.16</td>
<td>8.49</td>
</tr>
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</table>

### Final Conditions

<table>
<thead>
<tr>
<th>Temperature (deg C)</th>
<th>0</th>
<th>32</th>
<th>75</th>
<th>0</th>
<th>32</th>
<th>80</th>
<th>32</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (% of full wind)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>36</td>
<td>100</td>
<td>0</td>
<td>75</td>
<td>0</td>
</tr>
<tr>
<td>Thickness of ICE (mm)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Resultant Tension (Kg)</td>
<td>4291.53</td>
<td>3614.16</td>
<td>3014.12</td>
<td>5300.51</td>
<td>7792.31</td>
<td>2959.81</td>
<td>6530.66</td>
<td>3614.16</td>
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<tr>
<td>Resultant Sag (mts)</td>
<td>7.150</td>
<td>8.491</td>
<td>10.181</td>
<td>#</td>
<td>#</td>
<td>10.368</td>
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<td>8.491</td>
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Sag-Tension Calculation of Earthwire

Conductor Properties

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<th>Conductor Name</th>
<th>Earthwire</th>
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<tbody>
<tr>
<td>UTS (kg)</td>
<td>6230</td>
</tr>
<tr>
<td>Area of Conductor (sqmm)</td>
<td>61.7</td>
</tr>
<tr>
<td>Wt. Of Conductor (kg/m)</td>
<td>0.483</td>
</tr>
<tr>
<td>Dia of Conductor (mm)</td>
<td>10.05</td>
</tr>
<tr>
<td>Modulus of Elasticity (kg/sqmm)</td>
<td>19000</td>
</tr>
<tr>
<td>Coeff of linear Expansion (per deg C)</td>
<td>0.0000115</td>
</tr>
</tbody>
</table>

Initial Condition

| Normal Span (m) | 350 |
| Wind Pressure on Cond.(Kg/sqm) | 200.09 |
| Initial Cond. temp.(deg C) | 0 |
| Intial Wind % | 0 |
| Initial Cond. tension at above temp,and wind condition (% of UTS OR value in Kg) | 18.45 |

<table>
<thead>
<tr>
<th>Initial Sag, Ten at 0 deg C, 0% Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ten (% of UTS)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>18.45</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (deg C)</td>
</tr>
<tr>
<td>Pressure (% of full wind)</td>
</tr>
<tr>
<td>Resultant Tension (Kg)</td>
</tr>
<tr>
<td>Resultant Sag (mts)</td>
</tr>
</tbody>
</table>
Detailed survey of route alignment (Marsyangdi-Kathmandu 220 kV Transmission Line Alignment.) was carried out from Badbhanjyng (Kathmandu). which is about 81.6 km long. During detailed survey, strip mapping within 50 m. RoW of the proposed route was carried out for plan & profile preparation.

1.1 Objective and scope of work

The main objective of the detail survey was to carryout the survey works along the proposed route alignment recommended from reconnaissance survey and to prepare plan and profile drawing of the alignment in appropriate scale. The main objective of the survey work is as follows:

- To carry out detail survey along the proposed route alignment from the reconnaissance survey.
- To take each and every details within 25m right of way along the proposed route alignment.
- To fix concrete pillars at every angle points and permanent control points.
- To prepare plan and profile of final alignment at appropriate scale.

1.2 Control Survey

The basic control traverse was carried out from two Trig. Points 169 and 170. Then several other required control points were established by conventional traverse survey covering the entire area to mapped from AP-0 at proposed Tapping point at Badbhanjyng, Kathmandu to proposed sub-station at Markichok Tanahu. The entire traverses formed by conventional survey were closed loops or closed on existing traverse points. traverse legs were made as long as possible and fixed tripod system was used for all reflecting prisms to achieve better accuracy.

During the traverse survey, the following control points were used for UTM coordinates and msl datum.

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<tr>
<th>Station</th>
<th>X- Northing</th>
<th>Y- Easting</th>
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<th>Location</th>
<th>Remarks</th>
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For all survey works, SOKKIA SET 2B II Total Station with least cont of 1” was used for measuring horizontal & vertical angles with horizontal distance. Distances were measured in fore and back sight.
directions and mean distance adopted. All traverse survey works was connected to above Known control points. The closing errors were distributed according to common survey standards. The list of traverse points are given in the following table:

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1.3 Monumentation of Angle Points

All the major control points and angle points were made conspicuous in the field by monumentation of concrete pillars (10cm x 10cm x 60 cm) with iron pin set in the center. They are also marked by red enamel paint. All together there are 84 angle points including two dead end points from Tapping point at Bsadbhanjyang, Kathmandu to proposed sub-station at Markichok Tanahnu. Similarly at every angle point there are 3 reference points, hence all together there are 252 reference points. Description cards of all angle points with the list of reference points are given in Annex -D.

1.4 Detail Alignment Survey

All the required area (25m left and 25m right from the center line) along the proposed route alignment were fixed by number of control points. Then all the terrain features were surveyed by means of spot surveying. Spot positions and elevation were taken by tacheometric method from traverse points and off-set points. Features such as river banks, temples, trees, houses, canals, HT and LT lines, telecommunication lines, bridges, road and tracks, electric and telephone poles, were recorded. Similarly all the land types along the proposed lines were also recorded.

1.5 Description of Selected Routes

The proposed transmission line alignment will traverse through 17 VDCs (1 VDC of Tanahaun, 1 VDC of Chitwan, 1 VDC of Kathmandu, 3 VDCs of Gorkha district and 11 VDCs of Dhading district. The VDCs that encompasses the transmission line alignment are as follows; Aabhukhareni Deurali, Manakamana, Darechowk, Jogimara, Ghyalchowk, Benighat, Salang, Kumpur, Pida, Baireni, Kalleri, Goganpani, Kewalpur, Thakre, Naubise and Baadbhanjyang.

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Due consideration has been given to the following as far as possible:
- shortest possible length and straight route
- minimization or avoidance of the forest area crossings
- minimization of the structure or assets crossings
- avoidance of built up, swampy and unstable areas
- easy access for construction and maintenance works

The proposed Marsyangdi – Kathmandu 220 kV Transmission Line Project taps electric power from Abukhaireni substation. A part of the substation area has already been acquired by NEA and about 3 ha of land is under process of acquiring for the extension of the substation.

Proposed Baadbhanjyan 220 kV Tapping Point Area

Proposed Tapping Point of Baadbhanjyan is at Khatrigau, 670m Southwest from Nagdhunga, Thankot, Kathmandu. The proposed site (Tapping Point) is located just above Khatrigau area on the Thankot – Kanakot road at chainage 0+600 from Tribhuban Highway. Altitude of the center of the proposed area at AP(0)UT-3A is 1565 m. The proposed Tapping Point area is located at slope community forest terrain. According to the peoples residing at the nearby area and NEA experts, preliminary survey has been conducted for the proposed Tapping point at Baadbhanjyan.

Station AP-0 to AP-1

The alignment originates at station AP-0 located in the proposed Tapping Point site at Baadbhanjyan. From AP-0 the alignment heads northwest towards angle point AP-1, crossing two roads and two kholsi at chainage 0+276.30, 0+504.38, 0+560.43 and 0+651.37km respectively. The alignment passes over forest and cultivated land.

Station AP-1 to AP-2

From AP-1 the alignment turns by angle of 08°57'53" LEFT to AP-2. From AP-1 the alignment heads northwest towards angle point AP-2, crossing two 11 kV T/L at chainage 0+967.28km & 1+005.66. The alignment passes over cultivated terrain.

Station AP-2 to AP-3

From AP-2 the alignment turns by angle of 17°42'11" left to AP-3. From AP-2 the alignment heads west towards angle point AP-3. From AP-2 to AP-3, it passes through a cultivated land and then afterward passes to the fairly barren land by crossing kholsi, foot tracks, canal and road.
Station AP- 3 to AP- 4
From AP-3 the alignment turns by angle of 22°50'29" left to AP-4. From AP-3 the alignment heads southwest towards angle point AP-4. The alignment passes over undulating cultivated terrain and some forest.

Station AP- 4 to AP- 5
From AP-4 the alignment turns by angle of 14°51'08" right to AP-5. From AP-4 the alignment heads west towards angle point AP-5, crossing three house at around chainage 3+608.94km and crossing T/L at chainage 3+940.39 km. The alignment passes over undulating cultivated and forest terrain.

Station AP- 5 to AP- 6
From AP-5 the alignment turns by angle of 27°56'08" right to AP-6. From AP-5 the alignment heads northwest towards angle point AP-6 by crossing T/L line at chainage 5+131.67and Khola at chainage 4+918.62 km. The alignment passes over mainly cultivated terrain.

Station AP- 6 to AP- 7
From AP-6 the alignment turns by angle of 10°19'01" left to AP-7. From AP-6 the alignment heads northwest towards angle point AP-7, crossing road at chainage 5+191.32 km. crossing Foot Track at chainage 5+420.27 km. The alignment passes through a undulating cultivated land.

Station AP- 7 to AP- 8
From AP-7 the alignment turns by angle of 17°29'02" right to AP-8. From AP-7 the alignment heads northwest towards angle point AP-8 by crossing roads at chainage 6+096 km, 6+121.92 km and 6+163.04 & Kholsi at chainage 6+521.62 km , 6+787.32 km and 7+066.08 km Similarly its also crosses Highway at chainage 7+271.99 km & Ganes Khola At chainage 7+339.26 km. The alignment passes over undulating barren land, forest area and some cultivated terrain with some houses.

Station AP- 8 to AP- 8A
From AP-8 the alignment turns by angle of 28°00'03" right to AP-8A. From AP-8 the alignment heads northwest towards angle point AP-8A by crossing road at chainage 8+293.21 km & Kholsi at chainage 7+601.12km , 7+682.54km and 7+726.52km Similarly its also crosses 11 kV Line at chainage 8+175.69 km. It passes through an undulating terrain.

Station AP- 8A to AP- 8B
From AP-8A the alignment turns by angle of 32°21'50" right to AP-8B. From AP-8A the alignment heads north towards angle point AP-8B by crossing 132 kV T/L at chainage 8+491.43 km & 11 kV T/L...
at chainage 8+540.13 km, it passes through an undulating terrain and then afterward passes to the forest area covering some houses.

**Station AP-8B to AP-9**
From AP-8B the alignment turns by angle of 29°53'39" left to AP-9. From AP-8B the alignment heads northwest towards angle point AP-9 by crossing road at chainage 8+890.45 km & kholsi at chainage 8+913.32 km, it passes through forest area and then afterward passes to the undulating terrain

**Station AP-9 to AP-10**
From AP-9 the alignment turns by angle of 06°57'32" left to AP-10. From AP-9 the alignment heads northeast towards angle point AP-10. The alignment passes over plane cultivated terrain.

**Station AP-10 to AP-11**
From AP-10 the alignment turns by angle of 14°32'44" left to AP-11. From AP-10 the alignment heads north towards angle point AP-11. At chainage 9+192.81 km it crosses T/L 220 V, at chainage 9+215.34 km it crosses a house, at chainage 9+242.55 km the alignment passes through Mahesh khola and similarly at chainage 9+200 km, it passes through highway and then afterward passes to the cultivated land.

**Station AP-11 to AP-12**
From AP-11 the alignment turns by angle of 40°02'37" left to AP-12. From AP-11 the alignment heads northwest towards angle point AP-12, crossing a T/L at chainage 10+937.96 km, crossing canal at chainage 10+061.63 km and then afterward passes to the cultivated land.

**Station AP-12 to AP-13**
From AP-12 the alignment turns by angle of 35°20'50" left to AP-13. From AP-12 the alignment heads west towards angle point AP-13 crossing small streams then the alignment passes through undulating cultivated terrain. In this alignment there is no any major crossing.

**Station AP-13 to AP-14**
From AP-13 the alignment turns by angle of 15°20'09" right to AP-14. From AP-13 the alignment heads west towards angle point AP-14, crossing houses at chainage 12+604.71 km, 12+973.68km & 13+392.83 and crossing five T/L at different chainages. The alignment passes over undulating forest, cultivated and barren terrain.

**Station AP-14 to AP-15**
From AP-14 the alignment turns by angle of 30°36'51" right to AP-15. From AP-14 the alignment heads northwest towards angle point AP-15 crossing a house at chainage 15+227.88 km and crossing some kholsi at different chainages. The alignment passes over undulating forest & bushes terrain.

**Station AP-15 to AP-16**

From AP-15 the alignment turns by angle of 42°25'41" left to AP-16. From AP-15 the alignment heads west towards angle point AP-16, in this alignment there is no major crossing beside a road at chainage 15+871.32 km and a house at 15+900 km. The alignment passes over undulating barren then cultivated and lastly the forest terrain.

**Station AP-16 to AP-17**

From AP-16 the alignment turns by angle of 19°27'17" right to AP-17. From AP-16 the alignment heads northwest towards angle point AP-17, crossing a T/L at chainage 16+811.14 km, crosses roads at chainage 17+386.73 km and 17+450.00 km. The alignment passes over undulating forest terrain and some cultivated land.

**Station AP-17 to AP-18**

From AP-17 the alignment turns by angle of 18°16'48" right to AP-18. From AP-17 the alignment heads northwest towards angle point AP-18, crossing a foot-tracks at chainage 18+621.06 and Sati khola at 18+713.76 km. It passes through fairly undulating forest terrain.

**Station AP-18 to AP-19**

From AP-18 the alignment turns by angle of 12°56'34" left to AP-19. From AP-18 the alignment heads north-west towards angle point AP-19 by crossing some streams at different chainages, crossing a roads at chainage 20+188.72 km and crossing a Mahesh Khola at chainage 20+950.00 km. The alignment passes through some cultivated land then undulating forest terrain.

**Station AP-19 to AP-20**

From AP-19 the alignment turns by angle of 32°24'55" right to AP-20. From AP-19 the alignment heads northwest towards angle point AP-20 by crossing a kholsi at chainage 22+134.60 km, Mahesh khola at chainage 22+492.88 km and crossing Jyamire kholsi at chainage 22+746.26 km. The alignment passes through totally undulating forest and barren terrain.

**Station AP-20 to AP-21**

From AP-20 the alignment turns by angle of 13°55'09" left to AP-21. From AP-20 the alignment heads northwest towards angle point AP-21, crossing Mahesh khola at chainage 23+378.23 km and 23+600.00. At chainage 23+951.06 km it crosses 33 kV TL, at chainage 24+391.48 km & 24+500 it
crosses two houses, at chainage 24+087.69 km the alignment passes through Trishuli river and similarly at chainage 24+218.85 km, it passes over Suspension Bridge and then afterward passes to the cultivated land.

**Station AP- 21 to AP- 22**
From AP-21 the alignment turns by angle of 45°46'50" left to AP-22. From AP-21 the alignment heads west towards angle point AP-22, crossing Trishuli river three times at chainage 25+453.96 km, 25+842.74 km, 27+164.69 km respectively and Belkhu khola at chainage 29+284.05 km. The alignment also crossing over 11 kv T/L, 33 Kv T/L, road, Highway and two houses The alignment passes over forest with some cultivated terrain.

**Station AP- 22 to AP- 23**
From AP-22the alignment turns by angle of 18°39'01" left to AP-23. From AP-22 the alignment heads west towards angle point AP-23, crossing rosds at chainage 29+735.84 km and at chainage 30+047.11 km. The alignment passes through a forest terrain.

**Station AP- 23 to AP- 24**
From AP-23 the alignment turns by angle of 33°50'16" right to AP-24. From AP-23 the alignment heads northwest towards angle point AP-24, crossing roads at chainage 30+222.29km, 30+566.18 km, 31+089.73 km. respectively, Its also crosses Trishuli river at chainage 30+841.91 and 33 kV T/L two times. The alignment passes over mostly forest terrain.

**Station AP- 24 to AP- 24A**
From AP-24 the alignment turns by angle of 03°21'06" left to AP-24A. From AP-24 the alignment heads west towards angle point AP-24A, crossing three timesroads at chainage 31+232.65km, 32+756.48 km, & 33+445.42 km. respectively. The alignment alos crosses T/L and 33 kV T/L at chainage 33+226.3 km and 33+551.55 km. Some different kholsis also crosses the alignment.The alignment passes over forest then cultivated terrain.

**Station AP- 24A to AP- 24B**
From AP-24A the alignment turns by angle of 02°33'36" left to AP-24B. From AP-24A the alignment heads west towards angle point AP-24B, crossing a T/L at chainage 34+048.55km and road at chainage 34+059.35 km. The alignment passes over cultivated terrain.

**Station AP- 24B to AP- 25**
From AP-24B the alignment turns by angle of 04°27'41" right to AP-25. From AP-24A the alignment heads northwest towards angle point AP-25. The alignment passes over a cultivated terrain by
crossing two kholsi at chainage 34+542.55 km and 34+686.55 km. Then its passes over a 33 kV T/L at chainage at 34+947.09 km and a house at chainage 35+064.81 km.

Station AP- 25 to AP- 26
From AP-25 the alignment turns by angle of 14°16'40" left to AP-26. From AP-25 the alignment heads west towards angle point AP-26, crossing a 33 kV T/L at chainage 35+301.84 km and Kholsi at chainage 36+503.55 km it passes through undulating forest land and then afterward passes to cultivated land.

Station AP- 26 to AP- 27
From AP-26 the alignment turns by angle of 09°03'14" right to AP-27. From AP-26 the alignment heads west towards angle point AP-27 by crossing a some kholsi. It passes through bushes and then afterward passes to barren land.

Station AP- 27 to AP- 28
From AP-27 the alignment turns by angle of 05°37'55" left to AP-28. From AP-27 the alignment heads west towards angle point AP-28, by crossing a kholsi at chainage 38+244.2 km and a village road at chainage 39+706.73 km. It passes through bushes area then afterward passes to cultivated land and then afterward passes through forest area.

Station AP- 28 to AP- 29
From AP-28 the alignment turns by angle of 00°29'02" right to AP-29. From AP-28 the alignment heads west towards angle point AP-29 by crossing a kholsi at chainage 40+105.61 km and two roads at chainage 40+275.74 km & 40+375.98 km. The alignment passes through an undulating barren terrain and cultivated land.

Station AP- 29 to AP- 30
From AP-29 the alignment turns by angle of 16°22'00" right to AP-30. From AP-29 the alignment heads northwest towards angle point AP-30, at chainage 40+720.462 km the route crosses a pond and at chainage 40+840.22 km the route crosses a Thopal khola. It passes through a plane cultivated land and then afterward passes over Trishuli river at chainage at 40+903.812 km.

Station AP- 30 to AP- 31
From AP-30 the alignment turns by angle of 06°16'48" left to AP-31 at Risinchautara village From AP-30 the alignment heads north-west towards angle point AP-31. From chainage 41+965.062 to 42+119.88 km. it passes through a Trishuli river. The alignment also cross some roads at chainage
41+732.75 km, 41+813.03km, 41+918.78 km respectively. This alignment passes through cultivated land then bushes area.

**Station AP- 31 to AP- 31A**
From AP-31 the alignment turns by angle of 02°57'23" right to AP-31A. From AP-31 the alignment heads north-west towards angle point AP-31A by crossing a road at chainage 42+438.61 km. The route also crosses two kholsi at chainage 42+688.43 km and 42+688.43. It passes through a undulating bushes land and then afterward passes to forest land.

**Station AP- 31A to AP- 32**
From AP-31A the alignment turns by angle of 31°59'58" left to AP-32. From AP-31A the alignment heads southwest towards angle point AP-32 by crossing a Khosli at chainage 43+694.21 km. The route crosses some houses at different chainage. It passes through a plane cultivated land.

**Station AP- 32 to AP- 33**
From AP-32 the alignment turns by angle of 13°52'27" left to AP-33. From AP-32 the alignment heads southwest towards angle point AP-33 by crossing a some house at different chainage. It passes through plane cultivated land.

**Station AP- 33 to AP- 34**
From AP-33 the alignment turns by angle of 17°27'40" right to AP-34. From AP-33 the alignment heads southwest towards angle point AP-34 by crossing T/L line at chainage 45+149.56 km. It passes through plane cultivated land (Mostly paddy field).

**Station AP- 34 to AP- 35**
From AP-34 the alignment turns by angle of 32°00'54" right to AP-35. From AP-34 the alignment heads north-west towards angle point AP-35. In this route there is no any major crossing. It passes through cultivated land and then afterward passes to forest land.

**Station AP- 35 to AP- 35A**
From AP-35 the alignment turns by angle of 00°00'55" right to AP-35A. From AP-35 the alignment heads north-west towards angle point AP-35A, by crossing Budhigandaki river at chainage from 46+672.11 km to 46+917.34 km and crossing a road at chainage 47+004.13 km. It passes through bushes and then afterward passes to forest land.
Station AP-35A to AP-36
From AP-35A the alignment turns by angle of 39°41'29" left to AP-36. From AP-35A the alignment heads west towards angle point AP-36 by crossing roads three times at chainage 47+191.80 km, 47+252.12 km, 47+381.78 km respectively. Then again it crosses a T/L line at chainage 47+331.73 km and forward the route crossing a foot track at chainage 47+459.09 km. It passes through a sloppy cultivated and then afterward passes to undulating bushes terrain.

Station AP-36 to AP-37
From AP-36 the alignment turns by angle of 09°32'57" right to AP-37. From AP-36 the alignment heads west towards angle point AP-37, by crossing the Trishuli river at chainage 47+862.44 to 48+038.73 km and before Trishuli river crossing a village road also crosses the route at chainage 47+802.08 km. It passes through an undulating forest terrain and then afterward passes to bushes area and cultivated land.

Station AP-37 to AP-38
From AP-37 the alignment turns by angle of 02°12'39" left to AP-38. From AP-37 the alignment heads west towards angle point AP-38 by crossing the Trishuli river at chainage 48+643.15 km to 48+949.58 km and crossing a road twice at chainage 49+341.15 km and 49+689.34 km. The route also crosses a Lambu khola at chainage 49+550 km. It passes through a cultivated land terrain.

Station AP-38 to AP-39
From AP-38 the alignment turns by angle of 05°53'30" left to AP-39. From AP-38 the alignment heads west towards angle point AP-39, by crossing some kholsi at different chainage, the major D hobadi khola crosses at chainage 51+100.01 km and by crossing some houses at different chainage this alignment forward to cross T/L Line at chainage 50+678.52 km. It passes through mostly plane cultivated land terrain.

Station AP-39 to AP-40
From AP-39 the alignment turns by angle of 13°08'06" right to AP-40. From AP-39 the alignment heads west towards angle point AP-40, by crossing a road twice at chainage 51+602.46 km and 51+789.46 km. The route also crosses some houses at different chainage and three times T/L Line at chainage 51+674.57 km. 51+688.64 km and 51+789.46 km. The line crossing a khosli at chainage 51+504.94 km and 52+006.90 km. It passes through bushes and then afterward passes to cultivated land.

Station AP-40 to AP-41
From AP-40 the alignment turns by angle of 06°02'47" left to AP-41. From AP-40 the alignment heads west towards angle point AP-41, by crossing a road at chainage 52+396.30 km and crossing T/L line at
chainage 52+417.44 km. The line crosses a kholsi at chainage 53+005.59 km. In this segment no. of foot tracks and houses are also crossed by the alignment. This alignment passes through cultivated and then afterward passes to bushes land.

**Station AP- 41 to AP- 42**

From AP-41 the alignment turns by angle of 25°22'14" left to AP-42. From AP-41 the alignment heads south-west towards angle point AP-42, by crossing a three houses at chainage 53+222 km, 53+258 km and 53+313 km. The line also cross a 132 kV Line at chainage 53+165.10 kV and a kholsi at chainage 53+637.12 km. This alignment passes through cultivated land, barren and then afterward passes to forestland.

**Station AP- 42 to AP- 43**

From AP-42 the alignment turns by angle of 07°26'23" right to AP-43. From AP-42 the alignment heads south-west towards angle point AP-43, by crossing three houses at chainage 53+450 km, 53+477 km and 53+486 km. The line also cross a T/L Line at chainage 53+566.472km. This alignment passes through plane cultivated land.

**Station AP- 43 to AP- 44**

From AP-43 the alignment turns by angle of 14°56'52" right to AP-44. From AP-43 the alignment heads south towards angle point AP-44, by crossing the Trishuli River at chainage 53+987 km to 54+085 and crossing roads five times at different chainages. The line also crosses a T/L Line at chainage 53+566 km and Highway at chainage 54+166 km . In this segment no. of houses fall down in the 25m. RoW. This alignment passes through barren and then afterward passes through to bushes land and cultivated land.

**Station AP- 44 to AP- 45**

From AP-44 the alignment turns by angle of 06°31'17" right to AP-45. From AP-44 the alignment heads west towards angle point AP-45, by crossing a Hudgi khola at chainage 55+237km to 55+261 km . The line crosses a village road two times at chainage 54+906 km & 55+382 km. This alignment passes through forestland and then afterward passes through to bushes land.

**Station AP- 45 to AP- 46**

From AP-45 the alignment turns by angle of 04°57'20" right to AP-46. From AP-45 the alignment heads west towards angle point AP-46, by crossing roads at chainage 55+495km, 55+524 km and 55+937km respectively . The alignment passes over undulating barren and bushes terrain.
**Station AP-46 to AP-47**
From AP-46 the alignment turns by angle of 19°19'59" right to AP-47. From AP-46 the alignment heads west towards angle point AP-47, by crossing T/L line at chainage 56+421 km, 57+545 km and 57+608 km respectively. In this segment no. of foot tracks fall down in the 25m. RoW. It passes through an undulating cultivated area.

**Station AP-47 to AP-48**
From AP-47 the alignment turns by angle of 45°48'14" right to AP-48. From AP-47 the alignment heads north-west towards angle point AP-48, crossing T/L line two times at chainage 57+947 km & 58+024 km and kholsi at chainage 59+488 km. The line cross rosd two times at chainage 57+919 km & 58+783 km. The line also crosses Jobang khola at chainage 58+797 km. In this segment no. of houses fall down in the 25m. RoW. This alignment passes through cultivated land and then afterward passes through to bushes and forest land.

**Station AP-48 to AP-49**
From AP-48 the alignment turns by angle of 01°22'45" right to AP-49. From AP-48 the alignment heads north-west towards angle point AP-49 by crossing foot track at chainage 59+705 km. The line cross rosd two times at chainage 59+753 km & 60+010 km. The line also crosses Mauwa khola at chainage 60+250 km. In this segment a house fall down in the 25m. RoW. This alignment passes through cultivated land and then afterward passes through to bushes and forest land.

**Station AP-49 to AP-50**
From AP-49 the alignment turns by angle of 03°44'19" left to AP-50. From AP-49 the alignment heads north-west towards angle point AP-50, crossing a kholsi at chainage 61+189 km. This alignment passes through forest land and then afterward passes through to cultivated land.

**Station AP-50 to AP-51**
From AP-50 the alignment turns by angle of 13°43'14" right to AP-51. From AP-50 the alignment heads north towards angle point AP-51. In this segment there is no any major crossing. This alignment passes through only forest area.

**Stations AP-51 to AP-52**
From angle point AP-51, the alignment bears to the 13°52'46" left slightly ascends to angle point AP-52 at chainage 63+278 km. The alignment runs over bushes on Tokdan and Dhap village and the other patch of cultivated land before AP-52. Its run by crossing 11 kV T/L line at chainage 62+186 km. The line cross rosd three times at chainage 62+203km, 62+244 km & 62+320km. The line also crosses T/L line at chainage 62+967km. In this segment no. of foot track fall down in the 25m. RoW.
Stations AP-52 to AP-53
At angle point AP-52, the alignment turns by 09°37'14" left to the AP-53 at the chainage 64+668 km and runs over small part of cultivated land and crossing kholsi. This angle point is accessible from existing access road from Prithvi highway.

Stations AP-53 to AP-54
From angle point AP-53, the alignment bears to the left at an angle of 05°34'39" and rapidly descends to angle point AP-54 at Bunge Danda village of Chitwan district at chainage 65+382 km. Mostly forest area lies on the both side of the alignment. The alignment also crosses Kuching khola at chainage 65+152 km.

Stations AP-54 to AP-55
At AP-54, the alignment deviates left by at an angle of 18°58'50" and travels over undulating terrain covered with forest area along the alignment. The alignment heads towards AP-55 to the north west, crosses the two village road and Barban khola at chainage 65+970. In this segment no. of house fall down in the 25m. RoW. The chainage of AP-55 is 66+356 km.

Stations AP-55 to AP-56
From angle point AP-55, the alignment deviates left by a small angle of 02°18'28" and passes over undulating terrain covered with forest area and reaches the angle point AP-56 at chainage 66+953 km. The terrain in this region is covered with forest land by crossing some kholsi.

Stations AP-56 to AP-57
From angle point AP-56, the line runs right at an angle of 08°56'31" crosses small patch of cultivated land to reach AP-57 at chainage 67+236. Similarly the line also passes over cultivated land and crosses a house at chainage 67+100 km. The government forest area lies on the frist half of the alignment and cultivated land lies on the rest of the alignment.

Stations AP-57 to AP-58
At AP-57, the alignment turns left by a quite large angle of 22°14'53" and heads towards angle point AP-58 at chainage 68+163 km, Lewatar village. The alignment crosses Dalima Hotel at chainage 67+590 km. On the way to AP-58, the alignment crosses government forest on the both side of the alignment and also crosses a Kholsi.
Stations AP-58 to AP-59
From AP-58, the alignment makes an angle of 13°37'15" to the right and leaving Kharka village on its left towards angle point AP-59 at chainage 69+389 km. The lines runs over smooth terrain of government forest with bushes and crosses no. of kholsi.

Stations AP-59 to AP-60
From AP-59, the alignment heads towards AP-60 at Cheres Village of Chitwan district makes an angle of 05°12'33" to the right and crossing existing tracks and Forest. The alignment runs through government forest in close proximity with the Prithvi Highway. The chainage of AP-60 is 69+845 km.

Stations AP-60 to AP-61
From AP-60, the alignment heads towards AP-61 at Chumtar Village of Gorkha district makes an angle of 17°38'48" to the left and crossing Trishuli river at chainage 70+169 km to 70+217 km, which is also a district border of Chitawan and Gorkha district. The alignment runs by crossing Prithvi Highway and covered by forest on both banks of Trishuli River. The chainage of AP-61 is 70+674 km.

Stations AP-61 to AP-62
From AP-61, the alignment heads towards AP-62 at Gyaja Dada Village makes an angle of 03°15'39" to the left and crossing existing two foot tracks and Kholsi. The alignment runs through some forest then mostly cultivated land. The chainage of AP-62 is 71+881 km.

Stations AP-62 to AP-63
From AP-62, the alignment heads towards AP-63 at Manakamana VDC, ward no 8 makes an angle of 05°48'46" to the right and there is no any major crossing. The alignment runs through mostly cultivated area. The chainage of AP-63 is 72+391 km.

Stations AP-63 to AP-64
From AP-63, the alignment heads towards AP-64 at Darsin Village of Manakamana VDC ward no 7 makes an angle of 28°42'26" to the right and crossing existing 132 kV T/L line at chainage 72+455 km and a kholsi. The alignment runs through cultivated land and few bushes area. The chainage of AP-64 is 72+710 km.

Stations AP-64 to AP-65
From AP-64, the alignment heads towards AP-65 at Darsin Village of Manakamana VDC ward no 5, Gorkha district makes an angle of 44°27'06" to the right and crossing existing 11 kV T/L line at chainage 72+876 km and a main road to the Manakamana temple at chainage 72+906 km. The alignment runs through forest area. The chainage of AP-65 is 72+943 km.
Stations AP-65 to AP-66
From AP-65, the alignment heads towards AP-66 at Jhyapi Village, Manakamana VDC, ward no.5 makes an angle of 28°18'28" to the left and crossing a kholsi at chainage 73+709 km. The alignment runs through mostly cultivated land. The chainage of AP-66 is 73+808 km.

Stations AP-66 to AP-67
At AP-66, the alignment makes an angle of 37°38'54" right and gently descends towards heads angle point AP-67, which is in Simle village, Manakamana VDC ward no.7, Gorkha district. The chainage of AP-67 is 74+163 km. The alignment crosses shed at chainage 73+843 km, road at chainage 73+856 km and T/L line at chainage 73+905 km. The alignment runs through totally cultivated land.

Stations AP-67 to AP-68
From AP-67, the alignment heads towards AP-68 at Banauti Village of Manakamana VDC, ward no.6, Gorkha district makes an angle of 24°52'02" to the left and crossing existing road at chainage 75+266 km and Silin khola at chainage 74+715. In this segment two house are fall down in the 25m. RoW. The alignment runs through rice field up to Silin khola then it pass over forest land. The chainage of AP-68 is 75+288 km.

Stations AP-68 to AP-69
From AP-68, the alignment heads towards AP-69 at Keureni Village of Manakamana VDC ward no.6, Gorkha district makes an angle of 17°46'05" to the right and it crosses some kholsi at different chainage and two T/L lines at chainage 75+298 km & 75+301 km. The alignment runs through forest area. The chainage of AP-69 is 75+878km.

Stations AP-69 to AP-69A
At AP-69, the alignment makes an angle of 28°23'51" left and gently descends towards heads angle point AP-69A, which is at kalleri Village of Manakamana VDC ward no.5, Gorkha district. The alignment crosses Daraudi river two times at chainage 76+096 km to 76+130.959 km and 76+404 km to 76+432 km. The chainage of AP-69A is 76+743 km. The alignment runs over cultivated land then over river & forest and again its runs over cultivated land.

Stations AP-69A to AP-70
At AP-69A, the alignment makes an angle of 17°57'04" left and gently descends towards heads angle point AP-70, which is at Majhuwa Village of Deurali VDC ward no.5, Gorkha district. The alignment again crosses the Daraudi river at chainage 76+831 km to 76+894 km. The chainage of AP-70 is 77+344 km. The alignment also crosses 11 kV T/L, T/L Line, Gorkha-Dumre highway and 33 kV T/L.
line at chainage 76+949 km, 77+048 km, 77+060 km & 77+311 km respectively. The alignment runs over cultivated land then over river & forest and again its runs over cultivated land.

**Stations AP-70 to AP-71**
At AP-70, the alignment makes an angle of 22°46'10" left and gently descends towards heads angle point AP-71, which at Sera Village of Deurali VDC ward no. 6, Gorkha district. This segment crosses some kholsi at different chainage and it also crosses a 11 kV T/L lines at chainage 77+558 km & a road at chainage 78+106 km. The chainage of AP-71 is 78+425 km. The alignment runs over Chanaute khola and passes through along the forest area.

**Stations AP-71 to AP-72**
At AP-71, the alignment makes an angle of 27°03'20" left and gently descends towards heads angle point AP-72, which is at Simle phant Village of Deurali VDC ward no. 7, Gorkha district. The chainage of AP-73 is 78+940 km. The alignment runs over cultivated land in left side and forest area in the right side from the center line and crosses T/L line at chainage 78+451 km.

**Stations AP-72 to AP-73**
At AP-72, the alignment makes an angle of 21°49'02" right and gently descends towards heads angle point AP-73, which is at Yankot Village of Deurali VDC ward no. 4, Gorkha district. The chainage of AP-73 is 79+649 km. In this segment so many house fall down in the 25m. RoW. The alignment runs over cultivated land and crosses T/L line at chainage 79+339 km.

**Stations AP-73 to AP-74**
At AP-73, the alignment makes an angle of 32°00'00" left and gently descends towards heads angle point AP-74, which is forest area at Thimure, Yankot phant Village of Deurali VDC ward no. 4, Gorkha district. In this segment also there is so many house fall down in the 25m. RoW. The chainage of AP-74 is 80+099 km. The alignment runs over mostly cultivated land.

**Stations AP-74 to AP-75**
At AP-74, the alignment makes an angle of 08°11'24" right and gently descends towards heads angle point AP-75, which is at Yankot Village of Deurali VDC ward no. 4, Gorkha district. The chainage of AP-75 is 80+761 km. In this segment also no. of house fall down in the 25m. RoW. The alignment crosses a T/L line at chainage 80+497 km. The alignment runs over mostly cultivated land.
Stations AP-75 to AP-76 (S/S)

At AP-75, the alignment makes an angle of 21°59'53" right and gently descends towards heads angle point AP-76, which is at Markichok Village of Abu Khaireni VDC ward no. 3, Tanahu district. The chainage of AP-76 is 81+604 km. The alignment crosses the Marsyangdi river at chainage 80+938 km to 80+970 km, which is also the district boarder of Gorkha and Tanahu district.

Proposed Markichok 220 kV Sub-station Area

Proposed sub-station of Markichok is at Abu Khaireni VDC ward no. 3, Tanahu district, is close to Prithvi highway. It is located at the right bank of Marsyandi River, which is about 5.5 km upstream from the Abu Khaireni bazaar at Tanahu district and is accessible from Prithvi Highway along the right bank of Marsyandi River. There is sufficient space for the proposed sub-station and accessible from the Prithvi highway. Altitude of the center of the proposed area is about RL 371 m. The proposed sub-station area is plane terrain land belongs to NEA.
CHAPTER II: MAJOR CROSSINGS

During detailed survey all the major crossings like river, Highway, Khola, LT and HT lines, foot tracks, permanent features, etc were recorded along the alignment. The alignment crosses major highway & roads at 7 different locations. Major roads are Prithvi Rajmarga, Mahendra Rajmarga, Road to Gorkha etc. It also crosses 6 rivers & streams along the alignment. Among which, Mahesh khola, Trishuli River, Hugdi Khola, Budhi Gandaki River, Mauwa Khola & Daraudi rivers are the major ones. Similarly it also crosses existing LT & HT lines at different locations along the route alignment. It three times crosses existing 132 kV line from Marshyangdi HEP. Altogether there are 116 households falls within 25m RoW along the route alignment & 67 households falls within 15m RoW along the route alignment . The summary of major crossings along the proposed route alignment is given in the following table:

Table: 2.1 List of Major Crossing

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<td>Abu</td>
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CHAPTER III : SUMMARY OF ANGLE POINTS

Altogether there are 83 angle points with two dead end points along the alignment. All the angle points are located in geologically stable and accessible from the nearest road or existing foot track. The list of all angle points with their description cards are given in Annex-C and the summary of angle points are given as follows:

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<th>S. No.</th>
<th>Deflection Angle</th>
<th>No. of Angle Points</th>
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<td>3</td>
<td>10° - 20°</td>
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<td>20° - 30°</td>
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Table 3.1: Summary of Angle Points

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Project Development Department
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During detailed survey, all the angle points, in particular, have been fixed close to the road to facilitate transport of conductor drums and hardware during construction. For the future reference, three reference points are fixed around each angle point. These reference points are fixed in permanent boulders, trees or electric pole around the angle point. All list of these reference points are given in the following table:

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CHAPTER IV : PLAN & PROFILE

All the survey data were computed in the field as well as in the Kathmandu office. Similarly, some field data were evaluated and easting, northing and elevation of each spot height were calculated with respect to given control points established by NG, Survey Department. Then DTM, Softwel software was used for data analysis and generation of plan and profile. Finally, a plan and profile of the entire alignment was prepared with all the relevant details within 25 meters corridor in required scale. The plan and profile drawings are generated under the following format and scale required for tower spotting and sag calculation of each tower.

Profile Scale:
- Vertical: 1:1000
- Horizontal: 1:4000

Plan Scale:
- Horizontal: 1:4000

Format:
- Plan & Profile drawing size: A3
- Length per sheet: 1.3km
- Total no. of sheets: 63 sheets

All the plan and profile drawings are also presented in AutoCAD 2007 format with required scale for tower spotting and sag calculation. All the plan & profile drawings are given in Annex-B.
CHAPTER V: MAJOR CHARACTERISTICS OF THE ROUTE

The final route alignment of the transmission line number of important characteristics which makes it technically, economically and environmentally attractive. These characteristics are listed below:

- As far as possible, the alignment has kept in close proximity to existing road. The angle points, in particular, have been fixed close to the road to facilitate transport of conductor drums and hardware during construction.

- During the river crossing along different streams like Mahesh Khola, Trishuli River, Budhi Gandaki River, Hugdi Khola, Mauwa Khola & Daraudi River all the angle points have been located in geographically stable regions of river banks.

- Wherever possible, the transmission line has been aligning over barren and cultivated lands in order to avoid major forest clearance.

- Because of the relatively sparse settlement in route, it has been possible to keep the alignment clear of major housing areas.

- The selected alignment does not have large angles of deviation. The deviation angles at angle point have been kept well below the permissible of 60°.

- This alignment link will gave the way for interconnection of candidate hydropower projects within vicinity of central river basin.
CHAPTER VI : CONCLUSION & RECOMMENDATION

Based on the detailed survey carried out in this study and existing topographical condition of the proposed route alignment, it is fair to recommend that the selected transmission line alignment satisfies the essential requirements set forth for the line at the outset of this study. Preliminary observation along this transmission line also considers least impact on political, physical, biological and social environments. It is recommended that the transmission line route selected in this study is fair enough to proceed for project development by full feeling statutory requirements. The information provided in this report is adequate to proceed environmental study and preliminary design for project development. This report is adequate to determine tower types and tower optimization. In order to utilize optimized design considerations of the towers, the uneconomic spans can be modified by altering some angle points which might require modifications for optimum use of tower structures and minimization of the road and river crossings. Such minor modification may be considered during check survey time prior to tower spotting during construction period.

All the maps, plan, profiles and photographs taken during the detailed survey are given in following Annexes:

Annex A: Project Location Map
Annex B: Route Alignment Map
Annex C: Plan & Profile Drawings
Marsyangdi-Kathmandu 220 kV Transmission Line Project

Project Location

Legend:
- Project Affected Districts
- National Boundary
- Regional Boundary
- District Boundary
Title: Marsyangdi-Kathmandu 220 kV Transmission Line Project

Date: December, 2014

Sheet No.: 23/63

SCALE: 1:4000
SCALE V: 1:400

NEPAL ELECTRICITY AUTHORITY
Durbar Marg, Kathmandu (Nepal)

ENGINEERING SERVICES DIRECTORATE
PROJECT DEVELOPMENT DEPARTMENT

PLAN AND PROFILE
PLAN AND PROFILE

Marsyangdi-Kathmandu 220 kV Transmission Line Project

NEPAL ELECTRICITY AUTHORITY
Durbar Marg, Kathmandu (Nepal)
ENGINEERING SERVICES DIRECTORATE
PROJECT DEVELOPMENT DEPARTMENT

Title

Date: December, 2014

Sheet No. 29/63

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