

Technical Specifications

(VOLUME -II)

Strikeout whichever is not Applicable

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SECTION-1

SCOPE

1.0 INTENT OF THE SPECIFICATION

- 1.0.1 This volume of the specification deals with the general technical information regarding diversion, & erection of 132 KV transmission line of Power grid corporation of India Ltd in Badarpur Bypass Project package -3 Of NHIDCL under PMU Silchar at Silchar in the state of Assam which involves Planning, Design, Engineering, Dismantling and transportation of materials, supply, erection, stringing, commissioning of Transmission lines of PGCIL on supervision basis of PGCIL.
- 1.0.2 Diversion of 132 KV D/C Badarpur- Khliehriat Transmission line of PGCIL on Badarpur bypasses Project of NHIDCL at Silchar.
- 1.0.3 The provisions of this section shall supplement all the detailed Technical Specifications and requirements brought out herein. The CONTRACTOR's proposal shall be based on the use of materials complying fully with the requirements specified herein.

1.0.4 SCOPE

- 1.0.5 The work involves design, engineering, manufacture, assembly, inspection, testing at manufacturer's works before dispatch, packing, supply, including insurance during transit, delivery at site, subsequent storage and erection & commissioning at site of 132 KV Towers and materials including associated works and civil foundations for Towers/ equipment along with Dismantling of Towers as specified in subsequent Clauses and Sections. The dismantled material shall belong to the Contractor.
- 1.0.6 It is not the intent to specify completely herein all details of design and construction of the equipment and accessories. However, the equipment and accessories shall conform in all respects to high standards of engineering, design and workmanship and be capable of performing in continuous operation up to the bidder's guarantees in a manner acceptable to the Purchaser. The Purchaser will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material, which in his judgment is not in full accordance therewith.
- 1.0.7 The major items of works included in the scope of this specification are listed below: -
- 1.0.7.1 Design & supply of all materials as per this bidding document percentage BOQ.
 - 1.0.7.2 Installation and commissioning services including civil works as specified in BoQ.
 - 1.0.7.3 Other associated works as specified in BoQ.
- 1.0.8 The various items of supply are described very briefly in the percentage BOQ schedule.. The various items as defined in these schedules shall be read in conjunction with the corresponding section in the technical specifications including amendments and, additions if any.
- 1.0.9 The bidder is required to fill up the percentage BOQ wherein the bidding is on percentage basis on entire tender cost price as given in the e-tendering portal.
- 1.0.10 The bidder has to note since the transmission line where shifting and erection shall take place belongs to utility owing agency Power grid corporation of India Ltd, and work of shifting and erection of line is under the supervision of PGCIL, hence all the

specifications and guidelines of PGCIL are to be followed.

- 1.0.11 The tower schedules, Tower spotting Data, the location of Towers which needs to be bypassed by erection of new towers are indicated in the survey and route alignment drawing of Power Grid attached with the Bid. The bidder has to minutely go through details before understanding the scope of Work.

2.0.0 DESIGN IMPROVEMENTS

- 2.0.1 The Employer or the Contractor may propose changes in the specification and if the parties agree upon any such changes and the cost implication, the specification shall be modified accordingly.
- 2.0.2 *Design and Drawings*
- 2.0.3 The relevant drawings for all the towers and their extensions shall be furnished to the Contractor by the PGCIL which shall include structural drawings/erection drawings and / or shop fabrication drawings, Bill of Materials for all the towers and their extensions as well as construction drawings for foundations.
- 2.0.4 The tower members can be directly fabricated from the structural/erection drawings wherever the required fabrication details are provided on the same or shop fabrication drawings. However, if the contractor is required to prepare shop fabrication drawings, of their own, in addition to the structural/ erection drawings with required fabrication details, they may prepare the same without any additional financial implication to Employer.

Proto Assembly:

- (i) Contractors, who have not done the proto-assembly of the towers / tower extensions or have not supplied the same towers / tower extensions against any earlier POWERGRID's project, shall before taking up mass fabrication, the Contractor shall arrange for one number proto assembly for each type of towers and extensions. POWERGRID reserves the right to get the same witnessed by their representative. After proto-assembly, the contractors, shall incorporate revisions in the drawings / documents if any on account of proto corrections, and make necessary endorsement with reference to the respective packages / Letter of Awards. The revised drawing/documents shall be submitted in 3 (three) copies for final approval by the Employer.
- (ii) The contractors who have already done the proto-assembly of the towers / tower extensions or have supplied the same towers / tower extensions against any earlier POWERGRID's project need not do the proto assembly. They shall submit documentary evidence viz. proto-inspection reports, supply records etc. in its support. However, they may do the proto-assembly for their verification and satisfaction. Further, they shall submit 10 copies of the structural drawings and

BOM of tower / tower extensions after endorsing the projects name for further distribution by Employer.

No payment shall be made to the contractor on the account of proto-assembly in either of the cases mentioned at (i) or (ii).

In any case, the onus of correct fabrication / fitment of tower parts shall lie with contractor. Any defect, if found during erection at site, the same has to be rectified by the contractor without any additional financial implication to POWERGRID.

- 2.0.5 All the drawings shall have a proper name plate clearly displaying the name of POWERGRID on right hand bottom corner. The exact format of the nameplate shall be handed over to the successful bidder for incorporation of the same on all the drawings. Also all the drawings shall carry the following statement and shall be displayed conspicuously on the drawing:

WARNING: THIS IS PROPRIETARY ITEM AND DESIGN RIGHT IS STRICTLY RESERVED WITH POWERGRID. UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM THE OWNER IN WRITING.

- 2.0.6 While submitting the structural drawings, bill of materials, shop drawings and any other drawings pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing POWERGRID Specification No., Name of the specific Transmission line and project, letter reference no. and date on which the submission are made. The same practice is also to be followed while submitting distribution copies.
- 2.0.7 The tower accessories drawings like Number plate, Danger plate, phase plate, Circuit Plate, Step Bolt, Anti-climbing device, pole plate and Earthing Arrangement have been standardized (except Bird guard) are enclosed in drawing section of this specification. The contractor is required to submit distribution copies of the above drawings after endorsing the name of the projects. However drawing of Bird Guard, D-shackle etc. shall be prepared by the Contractor and shall be submitted to the Employer, in three (3) copies for approval. This drawing shall be prepared in A4 size only
- 2.0.8 The drawings submitted by the Contractor shall be approved/commented by the Employer/ PGCIL engineer I/C as the case may be within fifteen (15) days of receipt of drawings in his office. If the designs/drawings are commented by the PGCIL, the Contractor shall submit revised design/drawings duly incorporating all comments within fifteen (15) days of date of issue of comments. The Contractor shall submit 15 copies of all tower accessories for further distribution by the Employer.

The mass fabrication shall be taken up from the standard shop drawings. The overall responsibility of fabricating tower members correctly lies with the

Contractor only and the Contractor shall ensure that all the tower members can be assembled/ fitted while erecting without any undue strain on them.

- 2.0.9 Other than the items indicated above some other drawings and documents, such as BOM, Shop drawings, structural drawings for towers/extensions based on single line diagram given by the PGCIL, which are required for the project, shall also be developed by the Contractor. However, no extra cost on this account shall be payable to the Contractor.

3.0.0 PACKING

3.0.1 All the materials shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. The CONTRACTOR shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.

- 3.0.2 The CONTRACTOR shall include and provide for securely protecting and packing the materials so as to avoid loss or damage during transport by air, sea, rail and road.
- 3.0.3 All packing shall allow for easy removal and checking at site. Wherever necessary, proper arrangement for attaching slings for lifting shall be provided. All packages shall be clearly marked for with signs showing 'up' and 'down' on the sides of boxes, and handling and unpacking instructions as considered necessary. Special precaution shall be taken to prevent rusting of steel and iron parts during transit by sea.
- 3.0.4 The cases containing easily damageable material shall be very carefully packed and marked with appropriate caution symbols, i.e., fragile, handle with care, use no hook etc. wherever applicable.
- 3.0.5 Each package shall be legibly marked by the-CONTRACTOR at his expenses showing the details such as description and quantity of contents, the name of the consignee and address, the gross and net weights of the package, the name of the CONTRACTOR etc.
- 3.0.6 All materials shall be procured from the Power Grid approved firms which meet respective qualifying requirements. The contractor shall finalize their Sub vendors/ manufactures for supply of various line materials from amongst qualified firms within two month from date of LOA and submit the details in support of their meeting the stipulated qualification requirements.
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SECTION-2

General TECHNICAL

SPECIFICATIONS

SECTION-II

GENERAL TECHNICAL CONDITIONS

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**TECHNICAL
SPECIFICATIONS
SECTION-II**

GENERAL TECHNICAL CONDITIONS

1.1 General Technical Conditions

1.1 General

The following provisions shall supplement all the detailed technical specifications and requirements brought out herein. The contractor's submission shall be based on the use of materials complying fully with the requirements specified herein.

1.2 Drawings

- 1.2.1 All relevant standard drawings for all the towers/ stubs and their extensions shall be furnished to the Contractor by the PGCIL which shall include structural drawings/erection drawings and/ or shop fabrication drawings, Bill of Materials for all the towers and their extensions as well as construction drawings for foundations.
- 1.2.2 The tower members can be directly fabricated from the structural/erection drawings wherever the required fabrication details are provided on the same or shop fabrication drawings. However, if the contractor is required to prepare shop fabrication drawings, of their own, in addition to the structural/ erection drawings with required fabrication details, they may prepare the same without any additional financial implication to Employer.
- 1.2.3 Apart from the standard drawings mentioned above, some other drawings and documents, such as BOM, Shop drawings, structural drawings for towers/extensions may need to be developed based on single line diagram given by the Employer/ PGCIL, which are required for the project. These drawings, BOM, shop sketches shall be developed by the Contractor. However, no extra cost on this account shall be payable to the Contractor.
- 1.2.4 After development, these drawing shall be submitted to the Employer in triplicate for approval. In ordinary circumstances, the contractor should submit these drawings for approval within 15 days of receipt of the single line drawing from the employer.
- 1.2.5 Such drawings/ documents developed by the Contractor shall necessarily have sufficient detail to indicate the type, size, arrangement, dimensions, material description, Bill of Materials, weight of each component break- up for packing and shipment, fixing arrangement required, the dimensions

Required for installation and any other information specifically requested in the specifications.

- 1.2.6 Each drawing developed by the Contractor shall be clearly marked with the name of the Employer/PGCIL, the specification title, the specification number and the name of the Project. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be to the scale and in S.I. units.
- 1.2.7 The drawings submitted by the Contractor shall be reviewed by the Employer/ PGCIL as far as practicable within 15 days and shall be modified by the Contractor if any modifications and/or corrections are required by the Employer/ PGCIL. The Contractor shall incorporate such modifications and/or corrections and submit the final drawings for approval. Any delays arising out of failure by the Contractor to rectify the drawings in good time shall not alter the contract completion date.
- 1.2.8 The drawings submitted for approval to the Employer/ PGCIL shall be in triplicate. One print of such drawings shall be returned to the Contractor by the Employer/ PGCIL marked "approved/ approved with corrections". The contractor shall there upon furnish the Employer additional prints as may be required along with soft copy (in PDF/AutoCAD format) of the drawings after incorporating all corrections.
- 1.2.9 The work shall be performed by the Contractor strictly in accordance with the standard/approved drawings and no deviation shall be permitted without the written approval of the PGCIL, if so required.
- 1.2.10 All manufacturing, fabrication work under the scope of Contractor, prior to the approval of the drawings shall be at the Contractor's risk. The contractor may incorporate any changes in the design, which are necessary to conform to the provisions and intent of the contract and such changes will again be subject to approval by the Employer/ PGCIL..
- 1.2.11 The approval of the documents and drawings by the Employer/ PGCIL shall mean that the Employer/ PGCIL is satisfied that:
 - (a) The Contractor has completed the part of the Works covered by the subject document (i.e. confirmation of progress of work).
 - (b) The Works appear to comply with requirements of Specifications.

In no case the approval by the Employer of any document does imply compliance with all technical requirements or the absence of errors in such documents.

If errors are discovered any time during the validity of the contract, then the Contractor shall be responsible for consequences.

- 1.2.12 All drawings shall be prepared using AutoCAD software version 2000 or later only. Drawings, which are not compatible to AutoCAD software version 2000 or later, shall not be accepted. After final approval all the drawings (structural drawings, BOMs and shop sketches shall be submitted to the Employer/ PGCIL in CDs.

A copy of each drawing reviewed will be returned to the Contractor as stipulated herein.

- 1.2.13 Copies of drawings returned to the Contractor will be in the form of a print with the Employer's/ PGCIL marking, or a print made from a microfilm of the marked-up drawing.

- 1.2.14 The following is the general list of the documents and drawings that are to be approved by the Employer/ PGCIL.

- a) Work Schedule (Master Network) Plan.
- b) Detailed survey report and profile drawings showing ground clearance and tower locations (as applicable).
- c) Tower schedule and foundation classification for individual tower locations.
- d) All drawings/ documents which are developed by the contractor based upon the single line drawing given by the Employer.
- e) Soil Investigation report.
- g) Tower footing earthing drawing.
- i) Stringing procedure.
- j) Tower accessories drawings like danger plate, name plate etc.
- k) Quality plans for fabrication and site activities including Quality System.
- l) Sub-vendors approval.
- m) Line material drawings.
- n) Type test report for line materials.

- 1.2.15 All rights of the design/ drawing for all types of towers shall be strictly reserved with the Employer/ PGCIL only and any designs/ drawings/ data sheets submitted by the contractor from time to time shall become the property of the Employer/PGCIL. Under no circumstances, the Contractor shall be allowed to user/ offer above designs/ drawings/ data sheets to any other authority Without prior written permission of the Employer. Any deviation to above is not acceptable and may be a cause for rejection of the bid.

1.3 Design Improvements

The Employer or the Contractor may propose changes in the specification and if the parties agree upon any such changes and the cost implication, the specification shall be modified accordingly.

1.4 Design Co-ordination

Wherever, the design is in the scope of Contractor, the Contractor shall be responsible for the selection and design of appropriate material/item to provide the best coordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

1.5 Design Review Meeting

The contractor may be called upon to attend design review meetings with the Employer/PGCIL, and the consultants of the PGCIL/employer during the period of Contract. The contractor shall attend such meetings at his own cost at the Corporate Office of the Employer/PGCIL or at mutually agreed venue as and when required.

1.6 Engineering Data

1.6.1 The furnishing of engineering data by the Contractor shall be in accordance with the Schedule as specified in the Bidding Document. The review of these data by the Employer will cover only general conformance of the data to the specifications and not a thorough review of all dimensions, quantities and details of the materials, or items indicated or the accuracy of the information submitted. This review by the PGCIL shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications.

1.6.2 All engineering data submitted by the Contractor after review by the Employer/PGCIL shall form part of the contract document.

1.7 Quality Assurance programme

1.7.1 To ensure that the equipment and services under the scope of this Contract, whether manufactured or performed within the Contractor's Works or at his Sub-Contractor's premises or at the Employer's site or at any other place of Work as applicable, are in accordance with the specifications, the Contractor shall ensure suitable quality assurance programme to control such activities at all points necessary. A quality assurance programme of the Contractor shall be in line with ISO requirements & shall generally cover the following:

- a) The organisation structure for the management and implementation of the proposed quality assurance programme.

- b) System for Document and Data Control.
- c) Qualification and Experience data of Bidder's key personnel.
- d) The procedure for purchases of materials, parts, components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
- e) System for shop manufacturing and site erection controls including process controls, fabrication and assembly control.
- f) System for Control of non-conforming products including deviation dispositioning, if any and system for corrective and preventive actions based on the feedback received from the Customers and also internally documented system for Customer complaints.
- g) Inspection and test procedure both for manufacture and field activities.
- h) System for Control of calibration of testing and measuring equipment and the indication of calibration status on the instruments.
- i) System for indication and appraisal of inspection status.
- j) System of Internal Quality Audits, Management review and initiation of corrective and Preventive actions based on the above.
- k) System for authorizing release of manufactured product to the Employer/PGCIL.
- l) System for maintenance of records.
- m) System for handling, storage and delivery.
- n) A quality plan detailing out the specific quality control measures and procedure adopted for controlling the quality characteristics relevant to each item of equipment furnished and /or service rendered.
- o) System for various field activities i.e. unloading, receipt at site, proper storage, erection, testing and commissioning of various equipment and maintenance of records. In this regard, the Employer has already prepared Standard Field Quality Plan for transmission line/ substation equipments as applicable, Civil/ erection Works which is required to be followed for associated works.

The Employer or his duly authorized representative of PGCIL reserves the right to carry out quality audit and quality surveillance of the system and procedure of the Contractor/ his vendor's quality management and control activities.

1.7.1.1 Quality Assurance Documents

The Contractor shall ensure availability of the following Quality Assurance Documents:

- a) All Non-Destructive Examination procedures, stress relief and weld repair procedure actually used during fabrication, and reports including radiography interpretation reports.
- b) Welder and welding operator qualification certificates.
- c) Welder's identification list, welding operator's qualification procedure and welding identification symbols.
- d) Raw Material test reports on components as specified by the specification and in the quality plan.
- e) The Manufacturing Quality Plan (MQP) indicating Customer Inspection Points (CIPs) at various stages of manufacturing and methods used to verify that the inspection and testing points in the quality plan were performed satisfactorily.
- f) Factory test results for testing required as per applicable quality plan/technical specifications/GTP/Drawings etc.
- g) Stress relief time temperature charts/oil impregnation time temperature charts, wherever applicable.

1.7.2 (PGCIL) Supervision

1.7.2.1 To eliminate delays and avoid disputes and litigation to the Contract, all matters and questions shall be resolved in accordance with the provisions of this document.

1.7.2.2 The manufacturing of the product shall be carried out in accordance with the specifications. The scope of the duties of the Employer/ PGCIL, pursuant to the contract, will include but not be limited to the following:

- a) Interpretation of all the terms and conditions of these Documents and Specifications.
- b) Review and interpretation of all the Contractor's drawings, engineering data etc.
- c) Witness or authorize his representative to witness tests at the manufacturer's works or at site, or at any place where work is performed under the contract.
- d) Inspect, accept or reject any equipment, material and work under the Contract, in accordance with the Specifications.

- e) Issue certificate of acceptance and/or progressive payment and final payment certificate.
- f) Review and suggest modification and improvement in completion schedules from time to time, and
- g) Supervise the Quality Assurance Programme implementation at all stages of the works.

1.8 Inspection, Testing & Inspection Certificate

- 1.8.1.1 Contractor shall procure bought out items from sub-vendors as per the list in “Compendium of Vendors” available on POWERGRID website www.powergrid.in after ensuring compliance to the requirements/ conditions mentioned therein. Contractor shall explore first the possibilities of procuring the bought-out items from POWERGRID approved existing vendors. In case of their unavailability/ non-response, Contractor may approach POWERGRID for additional sub-vendor approval. In that case, the assessment report of proposed sub vendor by Contractor along with the enclosures as per Annexure-I shall be submitted within 60 days of the award. The proposal shall be reviewed and approval will be accorded based on the verification of the document submitted and/or after the physical assessment of the works, as the case may be. If proposal for sub-vendor is submitted after 60 days, the Contractor’s proposal normally will not be considered for current LOA. However, POWERGRID/ NHIDCL may process the case for developing more vendors for referred items, if found relevant. In all cases, it is the responsibility of the Contractor that Project activities do not suffer on account of delay in approval/non-approval of a new sub-vendor.

The responsibility and the basis of inspection for various items & equipment is placed at Annexure-II along with the requirement of MQP (Manufacturing Quality Plan), ITP (Inspection & Test Plan), FAT (Factory Acceptance Test) which should be valid & POWERGRID approved and Level of inspection envisaged against each item.

Contractor shall ensure that order for items where MQP/ ITP/ FAT is required will be placed only on vendors having valid MQP/ITP/FAT and where the supplier’s MQP/ITP/FAT is either not valid or has not been approved by POWERGRID, MQP shall be generally submitted as per POWERGRID format before placing order. A Copy of MQP format is placed at ***Annexure-III***.

Items not covered under MQP/ITP/FAT shall be offered for inspection as per NHIDCL LOA/ technical Specifications/ POWERGRID approved data sheets/ POWERGRID approved drawings and relevant Indian/ International standards.

Inspection Levels: PGCIL being an utility owing agency and works are under their supervision; For implementation of projects in a time bound

manner and to avoid any delay in deputation of POWERGRID or its authorized representative, involvement of POWERGRID for inspection of various items / equipment will be based on the level below:

Level-I: Contractor to raise all inspection calls and review the report of tests carried out by the manufacturer, on his own, as per applicable standards/ POWERGRID specification, and submit to concerned POWERGRID inspection office/Inspection Engineer. CIP/MICC will be issued by POWERGRID based on review of test reports/certificates of manufacturers. The contractor shall intimate employer also.

Level-II: Contractor to raise all inspection calls and carry out the inspection on behalf of POWERGRID on the proposed date of inspection as per applicable standards/ specification. However, in case POWERGRID wishes to associate itself during inspection, the same would be intimated to Contractor and CIP/MICC will be issued by POWERGRID. Else, Contractor would submit their test reports/ certificates to POWERGRID. CIP/ MICC will be issued by POWERGRID based on review of test reports/ certificates. The contractor to intimate employer also.

Level-III: Contractor to raise inspection calls for both, stage (as applicable) & final inspection and carry out the stage inspections (if applicable) on behalf of POWERGRID on the proposed date of inspection as per applicable standards/ specification. However, in case POWERGRID wishes to associate itself during stage inspection, the same would be intimated to Contractor and CIP will be issued by POWERGRID. Else, Contractor would submit the test reports/ certificates of stage inspection after their own review and CIP will be issued by POWERGRID based on review of test reports/ certificates. Final inspection will be carried out by POWERGRID and CIP/MICC will be issued by POWERGRID with intimation to NHIDCL also.

Level-IV: Contractor to raise inspection calls for both, stage (as applicable) & final inspections. POWERGRID will carry out the inspection for both stage & final inspection as per applicable standards/ specification and CIP/MICC will be issued by POWERGRID.

- 1.8.1.2 Contractor shall ensure that to implement the above inspection levels, particularly for the quality control and inspection at sub-vendor's works, they would depute sufficient qualified & experienced manpower in their Quality Control and Inspection department. Further, to assure quality of construction, Contractor shall have a separate workforce having appropriate qualification & experience and deploy suitable tools and plant for maintaining quality requirement during construction in line with applicable Field Quality Plan (FQP).
- 1.8.1.3 The Employer, his duly authorized representative of PGCIL and/or outside inspection agency acting on behalf of the Employer shall have at all reasonable times access to the Contractor's premises or Works and shall have the power at all reasonable times to ensure that proper Quality Management practices/ norms are

adhered to, inspect and examine the materials & workmanship of the Works, to carry out Quality/ Surveillance Audit during manufacture or erection and if part of the Works is being manufactured or assembled at other premises or works. The Contractor shall obtain for the Employer and for his duly authorized representative of PGCIL permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works. The item/ equipment, if found unsatisfactory with respect to workmanship or material is liable to be rejected. The observations for improvements during product/ process inspection by POWERGRID shall be recorded in Quality Improvement Register (available & maintained at works) for review & timely compliance of observations.

~~1.8.1.4 Contractor shall submit inspection calls over internet emails or as deemed suitable by PGCIL Engineer I/C. The required vendor code and password to enable raising inspection call will be furnished to the main Contractor with in 30 days of award of contract on submission of documents by Contractor. After raising the inspection calls, Contractor shall then proceed as per the message of that particular call which is available on the message board.~~

1.8.1.5 The Employer/ PGCIL reserves the right to witness any or all type, acceptance and routine tests specified for which the Contractor shall give the Employer/ Inspector of PGCIL Twenty-one (21) days written notice of any material being ready for testing for each stage of testing as identified in the approved quality plan as customer inspection point (CIP) for indigenous inspections. All inspection calls for overseas material shall be given at least forty-five (45) days in advance. Such tests shall be to the Contractor's account. The Employer/or inspector of PGCIL, unless witnessing of the tests is waived by Employer, will attend such tests within Twenty one (21) days of the date of which the equipment is notified as being ready for test/ inspection, failing which the Contractor may proceed with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector three copies of tests, duly certified. Contractor shall ensure, before giving notice for type test, that all drawings and quality plans have been got approved. The equipment shall be dispatched to site only after approval of Routine and Acceptance test results and Issuance of Dispatch Clearance in writing by the PGCIL. CIP/Material Inspection clearance certificate (MICC) shall be issued by the PGCIL after inspection of the equipment or review of test reports as applicable. PGCIL/Employer may waive off the presence of Employer's/ PGCIL inspecting engineer. In that case test will be carried out as per approved QP and test certificate will be furnished by the supplier for approval. CIP/MICC will be issued only after review and approval of the test reports.

- 1.8.1.6 Contractor shall generally offer material for inspection as per supply bar chart approved by POWERGRID/ Employer and not before 30 days from schedule indicated in the bar chart. In case Contractor offers material(s) for inspection prior to 30 days from the scheduled date with necessary approval of POWERGRID, POWERGRID shall inspect the material and issue CIP only. However, in such an exceptional case, MICC shall be issued only as per provision of original/ revised approved supply schedule.
- 1.8.1.7 Contractor shall minimize the number of inspection calls by offering optimum quantities in each inspection call at the respective manufacturer's works.
- 1.8.8.8 Contractor shall inspect the material themselves and only after they are fully convinced about the Quality, they shall offer the material for POWERGRID/ Employer inspection and shall also ensure that relevant portion of LOA
Approved drawing and data sheets along with applicable Quality Plans are available at the works of Contractor or their Sub-vendor before the material is offered for inspection.
- 1.8.8.9 Contractor shall ensure that material which has been cleared for dispatch after inspection will be dispatched within 30 days in case of domestic supplies and within 60 days in case of Off-shore supplies from the date of issuance of CIP. Material which is not dispatched within stipulated time as above will be reoffered for POWERGRID inspection or specific approval of POWERGRID QA&I shall be obtained for delayed dispatch.
- 1.8.8.10 The Employer or IE of PGCIL shall give notice in writing to the Contractor, of any objection either to conformance to any drawings or to any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Employer/ Inspection Engineer giving reasons therein, that no modifications are necessary to comply with the Contract.
- 1.8.1.11 All Test Reports and documents to be submitted in English during final inspection of equipment by POWERGRID or as and when required for submission.
- 1.8.1.12 When the factory tests have been completed at the Contractor's or Sub- Contractor's works, the Employer/ Inspection Engineer (IE) of PGCIL shall issue a certificate to this effect within fifteen (15) days after completion of tests & submission of documents by Contractor/ manufacturer but if the tests are not witnessed by the Employer/ IE, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Employer/IE. Contractor

shall, on completion of all tests, submit test reports within Ten (10) days to POWERGRID IE. Failure of the Employer/IE to issue such a certificate shall not prevent the Contractor from proceeding with the Works. The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract.

- 1.8.1.13 In all cases, where the Contract provides for tests whether at the premises or works of the Contractor or of any Sub- Contractor, the Contractor, except where otherwise specified, shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer/ Inspector of PGCIL or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Employer/ Inspection Engineer or to his authorised representative to accomplish testing.
- 1.8.1.14 The inspection and acceptance by Employer/ PGCIL engineer I/C and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed quality assurance programme forming a part of the Contract, or if such equipment is found to be defective at a later stage.
- 1.8.1.15 The Employer will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material complies with the specification.
- 1.8.1.16 The Employer reserves the right for getting any additional field tests conducted on the completely assembled equipment at site to satisfy that material complies with specifications.
- 1.8.1.17 Re-work/ Re-engineering, if any, on any item/ equipment shall be carried out only after mutual discussions and in accordance with mutually agreed procedure. Contractor shall submit Joint Inspection Report of equipment's under Re-Work/ Re-Engineering along with procedure for the same to POWERGRID for approval, before taking up the Re-Work/ Re-Engineering, failing which POWERGRID reserves the right to reject the equipment.
- 1.8.1.18 Contractor may establish a field test Laboratory to execute Civil Construction testing requirements at site with the condition that all testing equipment shall be calibrated from POWERGRID approved accredited Testing laboratories, with calibration certificates kept available at site and all testing personnel employed in the Field-Testing Laboratories to be qualified and experienced Engineers or testing to be carried out at POWERGRID approved Third Party

Laboratories.

- 1.8.1.19 Contractor shall ensure that all possible steps are taken to avoid damages to the equipment during transport, storage and erection.
- 1.8.1.20 The Employer/ PGCIL reserves the right to increase or decrease their involvement in inspections at Contractor's Works or at his Sub-Contractor's premises or at the Employer's site or at any other place of Work based on performance of Contractor/ Sub Contractor.
- 1.8.1.21 Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be concluded so as not to interfere unnecessarily with the operation of the work.
- 1.8.1.22 Should any item being supplied be found not to comply with the supplied design, it shall be liable to rejection. No item once rejected shall be resubmitted for inspection, except in cases where the Employer or his authorized representative of PGCIL considers that the defects can be rectified. All rejected material shall be disposed-off/ destroyed under intimation to Employer QA&I representative as per laid down procedures.
- 1.8.1.23 The specified grade and quality of material from approved source shall be used by the Contractor. To ascertain the quality of material used, the inspector may at his discretion get the material tested at an approved laboratory.
- 1.8.2 **Tests**
 - 1.8.2.1 The type, acceptance and routine tests and tests during manufacture shall be carried-out on the material and shall mean as follows:
 - 1.8.2.2 **Type Tests** shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to this Specification. These tests shall be carried out on samples prior to commencement of commercial production against the order.
 - 1.8.2.3 **Acceptance Tests** shall mean those tests which are to be carried out on samples taken from each lot offered for pre-dispatch inspection, for the purposes of acceptance of that lot.
 - 1.8.2.4 **Routine Tests** shall mean those tests, which are to be carried out on the material to check requirements which are likely to vary during production.
 - 1.8.2.5 **Tests during Manufacture** shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the Contractor to ensure the desired quality of the end product to be supplied.

- 1.8.2.6 The norms and procedure of sampling for these tests will be as per the Quality Assurance Programme to be mutually agreed to by the Contractor and the Employer.
- 1.8.2.7 The standards and norms to which these tests will be carried out are listed against them. Where a particular test is a specific requirement of this Specification, the norms and procedure of the test shall be as specified in ***Annexure-A*** or as mutually agreed to between the Contractor and the Employer/ PGCIL in the Quality Assurance Programme.
- 1.8.2.8 For all type and acceptance tests, the acceptance values shall be the values specified in this Specification or guaranteed by the Bidder, as applicable.
- 1.8.2.9 In case of any failure or defect/ deficiency observed in material supplied Employer reserves the right to carry out any tests on the material supplied to site, if required to prove conformity of material to the specification for which testing charges shall be borne by contractor/ manufacturer.

1.9 **Standard Technical Particulars**

- 1.9.1 The Standard Technical Particulars of the various items are given in the relevant schedule of the specification; the bidder is required to comply with the same.

1.10 **Packing**

- 1.10.1 All the materials shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.
- 1.10.2 The Contractor shall include and provide for securely protecting and packing the materials so as to avoid loss or damage during transport by air, sea, rail and road.
- 1.10.3 All packing shall allow for easy removal and checking at site. Wherever necessary, proper arrangement for attaching slings for lifting shall be provided. All packages shall be clearly marked for with signs showing 'up' and 'down' on the sides of boxes, and handling and unpacking instructions as considered necessary. Special precaution shall be taken to prevent rusting of steel and iron parts during transit by sea.
- 1.10.4 The cases containing easily damageable material shall be very carefully packed and marked with appropriate caution symbols, i.e. fragile, handle with care, use no hook etc. wherever applicable.
- 1.10.5 Each package shall be legibly marked by the Contractor at his expenses showing the details such as description and quantity of contents, the name of the consignee and address, the gross and

net weights of the package, the name of the Contractor etc.

- 1.10.6 Angle section shall be wire bundled.
- 1.10.7 Cleat angles, gusset plates, brackets, fillet plate, hanger and similar loose pieces shall be tested and bolted together in multiples or securely wired through holes.
- 1.10.8 Bolts, nuts washers and other attachments shall be packed in double gunny bags accurately tagged in accordance with the contents.
- 1.10.9 The packing shall be properly done to avoid losses & damages during transit. Each bundle or package shall be appropriately marked.

1.11 Storage of Material under Transmission Line Package

Brief guidelines including typical drawing for storage of different type of construction material used in the transmission line projects are as under:

1.11.1.1 Cement Storage

Cement received at site should be stored in a building or shed which is dry, leak proof and moisture proof. The building should have minimum numbers of windows. Cement bags stored and stacked off the floor on wooden planks in such a way so as to keep about 150 mm to 200 mm clearance from the ground. The floor may be of lean cement concrete or two layers of dry bricks laid on well consolidated earth. A minimum space of 600 mm shall be kept around and between the exterior walls and the stacks. In stacks, bags shall be kept close together to reduce air circulation. The height of the stack shall not be more than 12 bags and the width of the stack shall not be more than four bags or 3 meters. For extra safety during monsoon, or when it is expected to store for an unusually long period, the stack shall be completely enclosed by a waterproofing membrane such as polyethylene etc. Different type and make of cement shall be stacked and stored separately.

1.11.2 Aggregates

Aggregates shall be stored at site on a hard dry and level patch of ground. If such a surface is not available, a platform of planks or old corrugated iron sheets, or floor bricks or a thin layer of lean concrete shall be made so as to prevent contamination with clay, dust, vegetable and other foreign matter.

The stacks of fine and coarse aggregates shall be kept in separate stock piles sufficiently removed from each other to prevent the material at the edges of the piles from getting intermixed. Fine aggregate shall be stacked in a place where loss due to the effect of wind is minimum.

1.11.3.1 Reinforcement Steel

For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colors. Steel reinforcement shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting in case of storage time exceeding one month. In store, reinforcement bars shall be stacked above ground level by at least 150 mm either

on brick/ cement/ stone platform or concrete/bricks planks.

1.11.4 Structural Steel for Tower Parts

The structural steel of different classification, sizes and lengths shall be stored separately. These shall be stored above ground level at least 150 mm upon platforms, skids or any other suitable supports to avoid any distortion of sections. Also, in order to prevent white rust formation sufficient care should be exercised while storing, handling and transporting galvanized products. The structural steel/ tower parts shall be stored in an adequately ventilated area. The article shall be stored with spacers in between them and kept at an inclination to facilitate easy drainage of any water collected on the structural steel/ tower parts.

1.11.5 Conductor & Earthwire Drums

It is essential to save the conductor drums from damage during storage and transportation and the wooden battens and main wheel should be intact so that same can be successfully mounted on the conductor jacks to release the conductor during stringing. All the conductor and earthwire drums should be stored on a proper hard platform above ground to avoid deterioration of the drum and further avoiding the damage of conductor. The conductor & earthwire drums should be stored in such a manner that each drum can be accessed at any time for inspection purposes.

1.11.6 Hardware fitting, Accessories & Insulators

All the hardware fittings, accessories and insulators should be stored on raised platform above ground so as not to damage the packaging and to avoid further damage or denting on the fittings and chipping of insulators. All the aluminum parts should be stored on a plain/ raised platform under a cover shed in such a way that the aluminum fittings cannot be distorted during storage.

2.0 Employer's Environment and Social Policy and its Implementation

2.1 Development and growth of mankind through Industrialization and unwarranted use of natural resources has inflicted considerable impact on Environment and Society. As a result, Environmental and Social issues have emerged as the focal point of global debate.

Employer's activities by their inherent nature and flexibility have negligible impacts on environmental and social attributes. In order to address these issues and to match the rising expectations of a cleaner, safer and healthier environment, Employer has evolved its Environmental and Social Policy and Procedures (ESPP). The key principles of Employer's Environmental and Social Policy are: -

- i) Avoidance of environmentally and socially sensitive areas while planning project activities.
- ii) Minimisation of impacts when project activities occur in environmentally and socially sensitive areas.
- iii) Mitigation of any unavoidable adverse impacts arising out of its projects.

2.2 Basic issues to be kept in mind while carrying out construction activities are to

- i) Avoid socially sensitive areas with regard to human habitations and areas of cultural significance.
- ii) Secure the interest of people affected by Employer's projects.
- iii) Involve local people affected by transmission line projects as per requirement and suitability.
- iv) Consult affected people in decisions having implication to them if considered necessary.
- v) Apply, efficient and safe technology/ practices.
- vi) Keep abreast of all potential dangers to people's health, occupational safety and safety of environment and the respective mitigatory measures.
- vii) Establish preventive mechanisms to guarantee safety.
- viii) Mitigation measures in case of accidents.
- ix) Avoid unwarranted cutting of trees in forest area.

- 2.3 While constructing the lines through forest stretches the contractor will provide alternate fuel to its employee e.g. working labours/ supervisors etc. in order to avoid cutting of forest woods.
- 2.4 Contractor will ensure safety to the wild life, during working/ camping near to the National park.
- 2.5 Contractor during construction of lines in agricultural fields will ensure minimum damages to the crops, trees, bunds, irrigation etc. If the same is un-avoidable, the decision of Engineer- in-charge shall be final.
- 2.6 The waste/ excess material/ debris should be removed from the construction site including agricultural field, forest stretches, river etc. immediately after construction work.
- 2.7 The Contractor will ensure least disturbance to the hill slope and natural drainage so as to avoid soil erosion. Natural drainage in plain area if disturbed is to be trained to the satisfaction of Engineer- in-charge.
- 2.8 As far as possible existing path/ kutchha road/ approach shall be used for the construction.
- 2.9 The Contractor will ensure supply of stone chips/sand from authorised/ approved quarry areas.
- 2.10 Proper documentation of above, if any.
- 2.11 The Environment & Social Policy and Procedures (ESPP) evolved by POWERGRID is available at the POWERGRID's website, www.powergrid.in, which shall be referred by the Bidder for further information.
- 2.12 Facilities to be incorporated for labourers**

The Contractor shall, on their own cost, provide his/ their laborer with sufficient number of the following facilities with the indicated specifications:

A) Tents:

- i) Tent should be with double layer canvas, outer layer being water- proof. The size/ number should be sufficient to accommodate required number of people comfortably.
- ii) The preferred size of tent should be 20ft x 20ft with Centre height of 7 ft and side height of 2.5 ft.
- iii) Tent windows should have arrangement for mosquito net with waterproof outer covering.
- iv) Doors of the tents shall have Velcro or any other closing system.
- v) The site selected for the camp shall be on high ground, removed from Jungle.
- vi) Efficient arrangement for draining away stagnant water should be provided so as to keep the camp neat and tidy.
- vii) The tents should have illumination at night by providing battery operated LED lanterns or equivalent lighting system.

B) Portable (tyre- mounted) Bio toilet

- i) The toilet seats should be 'Indian'.
- ii) The number of Toilets should be not less than 2 per 50 laborers with separate.
- iii) toilets for female laborers.
- iv) Bio-tank should be of sufficient capacity to allow bacteria present to decompose.
- v) the excreta and only waste water (odourless and harmless) gets discharged out of the toilet through a sewerage channel away from the tent areas and working areas.
- vi) Water tank of adequate capacity should be installed with the Portable Toilet.

Assessment report from Contractor for proposed sub-vendor along with following enclosures (to the extent available):

1. Registration / License of the works
2. Organization chart with name and qualification of key persons
3. List of Plant and Machinery.
4. List of testing equipment with their calibration status.
5. List of Raw material, bought out items with sourcing details
6. List of out-sourced services with sourcing details.
7. List of supply in last three years.
8. Third party approval, if any (viz. ISO, BIS),
9. Pollution clearance wherever applicable
10. Energy Conservation & Efficiency report (Applicable to industries having contract load more than 100 KVA)
11. Formats for RM, in process and acceptance testing
12. Type test approvals conducted in last 5 years, if applicable
13. Performance Certificates from customers
14. Photographs of factory, plant and machinery & testing facilities

Annexure-II

MQP & INSPECTION LEVEL REQUIREMENT

Sl. No.	Item / Equipment	Requirement of MQP/ITP/FAT	Inspection Level
N.28	Fibre Optic Cable	MQP	III
N.29	Hardware Fittings for Fibre Optic Cable	MQP	III
O.01	Re-rollers of MS/ HT Angle Section and galvanized tower parts	MQP	IV
O.02	Conductor	MQP	IV
O.03	Hardware Fittings and Accessories for Conductor and Earthwire	MQP	IV
O.04	Earthwire	MQP	IV
O.05	Insulator	MQP	IV
O.06	Bolts & Nuts of Grade 8.8/8	MQP	IV
O.07	Mono Pole	POWERGRID TS	IV
O.08	Foundation Bolts & Anchor Bolts	MQP	III
O.09	D-Shackle/ Hanger/ Links and associated Special bolts & Nuts	MQP	III
O.10	Span Marker, Obstruction Light and Wind Measuring Equipment	POWERGRID TS	III
O.11	MS Rod rolled by Approved Re-Roller of POWERGRID	MQP	III
O.12	MS Rod rolled by Approved steel producers of POWERGRID	POWERGRID TS	I
O.13	Spring Washers & Pack Washers	POWERGRID TS	II
O.14	Bolts & Nuts Grade upto 5.6/5	POWERGRID TS	II
O.15	ACD & barbed wire of ACD/ Bird Guard	POWERGRID TS	II
O.16	Danger Plate/ Phase Plate/ Number Plate/ Circuit plate	POWERGRID TS	I
O.17	Sub-station Structure (Lattice/pipe type)	MQP	III
O.18	Clamps & Connectors (including equipment connectors)	MQP	III
O.19	MS/ GI F/at, rod type, pipe type and other earthing material	POWERGRID TS	II
O.20	Aluminium Tube & Busbar materials	POWERGRID TS	II
O.21	Pipe Type & Counter Poise Earthing	POWERGRID TS	II

Note: For Equipment where requirement of MQP is envisaged, ITP/FAT will be followed If sourced from off shore. For items required in S/S or T/L or TELECOM/LD&C , same inspection level as specified shall be followed for all the cases.

MANUFACTURING QUALITY PLAN

	Manufacturers Details (Name, Works Address etc.)	Customer PGCIL/NHIDCL S-V 1 project.	Vendor's Code:	Item:	Q.P. No.	Valid From:
					Rev. No. Date:	

Sr. No.	Components / Operations & Description of Test	Type of check	Quantum of Check / Sampling with basis	Reference document for Testing	Acceptance Norms	Format of Record	Applicable Codes						Remarks
							1	2	3	4	5	6	

[illegible]

Code 1	Indicates place where testing is planned to be performed i.e. Inspection location			Code 2	Indicates who has to perform the tests i.e. Testing Agency						
A	At Equipment Manufacturer's works			J	The Equipment Manufacturer						
B	At Component Manufacturer's works			K	The Component Manufacturer						
C	At Authorised Distributor's place			L	The Third Party						
D	At Independent Lab			M	The Turnkey Contractor						
E	At Turn Key Contractor's location										
F	Not specified										
Code 3	Indicates who shall witness the tests i.e. Witnessing Agency			Code 4	Review of Test Reports/ Certificates						
P	Component Manufacturer itself			W	By Equipment manufacturer during raw material/bought out component inspection.						
Q	Component Manufacturer and Equipment Manufacturer			X	By Contractor during product/process inspection						
R	Component Manufacturer, Equipment Manufacturer and Contractor			Y	By POWERGRID during product/process inspection						
S	Equipment Manufacturer itself			Z	By Contractor and/or POWERGRID during product/process inspection						
T	Equipment Manufacturer and Contractor										
U	Equipment Manufacturer, Contractor and POWERGRID										
V	Third Party itself										
Code 5	Whether specific approval of sub-vendor / Component make is envisaged?			Code 6	Whether test records required to be submitted after final inspection for issuance of CIP/MICC						
E	Envisaged			Y	Yes						
	Not Envisaged			N	No						

**TECHNICAL
SPECIFICATIONS
SECTION-III
SURVEY & SOIL INVESTIGATION**

CONTENTS

Clause No.	Description
1.0	General information & Scope of Work
2.0	Route Alignment
3.0	Detailed Survey
4.0	Geotechnical Investigations
5.0	Statutory Regulations and Standards

(Strikeout/Delete whichever is not Applicable)

**TECHNICAL
SPECIFICATIONS**

SECTION- III

SURVEY & SOIL INVESTIGATION

1. General Information & Scope of Work

- 1.1 The technical specifications cover detailed survey including route alignment, profiling, tower spotting, optimization of locations, check survey, contouring, for the transmission lines/ part of the transmission lines covered under this specification as included in the bid document.
- 1.1.1 The scope of work inter-alia shall include the following: -
- a) Detailed Survey using Total Work stations or alternatively using ALTM (Airborne Laser Terrain Modeling) techniques, inter-alia including:
 - i) Digitised profiling along the selected route along with plan details.
 - ii) Computer aided tower spotting & optimization
 - iii) Soil resistivity measurement along the route
 - b) Check survey including digitized contouring at undulated / hilly tower locations.
 - c) Soil Investigation
 - d) Preparation of Survey reports including estimation of Bill of Quantities, identification and explanation of route constraints (like Forest, Animal/ Bird sanctuary, reserve coal belt areas, oil pipe line/ underground inflammable pipe lines etc.), infrastructure details available en-route etc.
- 1.2 The Provisional quantities for the scope of work are indicated in relevant Price Schedules of Percentage BOQ. The final quantities for route alignment, detailed survey and check survey (quantities in “kms” unit) shall be as approved by Site Engineer-in-charge/ Nodal officer of PGCIL and shall be along the approved route alignment. For contouring at undulated/hilly tower locations and soil investigations (quantities in “Locs.” unit), the actual quantities to be executed shall be decided by Site Engineer-in-charge during execution stage and the final quantities shall be as approved by Site Engineer-in-charge (PGCIL). The route alignment, detailed survey, including profiling & tower spotting, contouring, soil investigation, check survey etc. shall be carried out by the Contractor as per the technical specifications stipulated herein. Contractor shall indemnify the Employer for any loss or damage to properties, trees etc. during the survey work.
- 1.3 The Contractor should note that Employer will not furnish topographical maps prepared by survey of India but will make available assistance that may be required in obtaining these by providing letters of recommendation to the concerned authorities. Further, in case the contractor opts for use of ALTM techniques for detailed survey, he shall be responsible for obtaining necessary clearances/ permissions, as may be required from concerned authorities. The Employer will provide assistance that may be required in obtaining these clearances / permissions by providing letters of

recommendation to the concerned authorities.

- 1.4 The work shall be carried out by the contractor using modern surveying techniques. The bidder shall indicate in his offer, the detailed description of the procedure to be deployed. The details of the equipment & facilities including software for image processing, computer aided tower spotting etc. available with the bidder or his associates shall also be furnished with the bid.
- 1.5 The Contractor shall also engage services of a reputed geo-technical consultant or experts from independent educational/ research institutions for examining stability aspects of the selected transmission line route/ locations in hilly terrain wherever required.
- 1.6 After carrying out the detailed survey and soil investigations, the contractor shall submit, Tower schedule, Profiles, Survey reports and other details as per technical specification requirements to the Employer/ PGCIL Nodal officer.

2. Route Alignment

- 2.1 The route Alignment shall be carried out by the contractor using Survey of India topographical maps.

2.2 Requirement of Transmission Line Routing

- 2.2.1 The Re-alignment/ routing, if any required, of the transmission line shall be most economical from the point of view of construction and maintenance. The contractor shall identify & examine alternative route alignments and suggest to the Employer the optimal route alignment.
- 2.2.2 Routing/ Re-routing of transmission line through protected/reserved forest area should be avoided. In case it is not possible to avoid the forests or areas having large trees completely, then keeping in view of the overall economy, the route should be aligned in such a way that involvement of forest area and cutting of trees is minimum.
- 2.2.3 The route should have minimum crossings of Highways/ Major Rivers etc overhead EHV power line and communication lines.
- 2.2.4 The number of angle points shall be kept to minimum.
- 2.2.5 The distance between the terminal points specified shall be kept shortest possible, consistent with the terrain that is encountered.
- 2.2.6 Marshy and low-lying areas, river beds and earth slip zones shall be avoided to minimize risk to the foundations.
- 2.2.7 It would be preferable to utilize level ground for the alignment.
- 2.2.8 Crossing of power lines shall be minimum. Alignment of a transmission line with respect to existing line will be kept considering ROW and tower falling distance.
- 2.2.9 Crossing of communication line shall be minimized and it shall be preferably at right angle. Proximity and parallelism with telecom lines shall be eliminated to avoid danger of induction to them.

- 2.2.10 Areas subjected to flooding such as nalah shall be avoided.
- 2.2.11 Restricted areas such as civil and military airfield shall be avoided. Care shall also be taken to avoid aircraft landing approaches.
- 2.2.12 All alignment should be easily accessible both in dry and rainy seasons to enable maintenance throughout the year.
- 2.2.13 Certain areas such as quarry sites, tea, tobacco and saffron fields and rich plantations, gardens & nurseries which will present the Employer problems in acquisition of right of way and way leave clearance during construction and maintenance should be avoided.
- 2.2.14 Angle points during survey should be selected such that shifting of the point within 100 m radius is possible at the time of construction of the line.
- 2.2.15 The line routing should avoid large habitations, densely populated areas, Forest, Animal/Bird sanctuary, reserve coal belt areas, oil pipe line/underground inflammable pipe lines etc. to the extent possible.
- 2.2.16 The areas requiring special foundations and those prone to flooding should be avoided.
- 2.3 For examination of the alternatives & identification of the most appropriate route, besides making use of information/ data/ details available/ extracted through Survey of India Topographical maps, the contractor shall also carryout reconnaissance/ preliminary survey as may be required for verification & collection of additional information/ data/ details.
- 2.4 The contractor shall submit his preliminary observations & suggestions along with various information/ data /details collected, topographical map data marked with the alternative routes etc. The final evaluation of the alternative routes shall be conducted by the contractor in consultation with Employer's representatives and optimal route alignment shall be proposed by the contractor. Site visit and field verification shall be conducted by the contractor jointly with the Employer's representative for the proposed route alignment.
- 2.5 Final route alignment drawing with latest topographical and other details/ features including all rivers, railway lines, canals, roads etc. up to 8 km on both sides of selected route alignment shall be submitted by the contractor for Employer's approval along with report containing other information/details as mentioned above.
- 2.6 Changes in the route alignment, if any, during detail survey, shall be incorporated in the final route alignment drawings.
- 2.7 However PGCIL have done preliminary Survey and Route alignment of the line , which shall also be taken in view by the bidder.

3. Detailed Survey

- 3.1 The detailed survey shall be carried out using Total stations etc. along the approved route alignment. As an alternative, the contractor may also use ALTM (Airborne LaserTerrain Modeling) techniques of equal or better accuracy for the detailed survey.

- 3.2 Soil resistivity, along the route alignment shall be measured in dry weather by four electrode method keeping inter-electrode spacing of 50 meters. For calculating soil resistivity formula $2\pi ar$ (Where $a=50$ m and r = megger reading in ohms) shall be adopted. Measurement shall be made at every 2 to 3 km along the length of the route. In case soil characteristics changes within 2 to 3 km, values shall have to be measured at intermediate locations also. Megger reading and soil characteristics should also be indicated in the soil resistivity results.

3.3 Route Marking

- 3.3.1 The route of the transmission line shall be recorded using GPS/ DGPS of positional accuracy less than 3m.
- 3.3.2 The co-ordinates of all the angle points as well as other important crossings, landmarks etc. shall be recorded using GPS for easy relocating.
- 3.3.3 At the starting point of the commencement of route survey a suitable peg/spike shall be driven firmly into the ground to indicate location of the survey instrument. The co-ordinates of the location of the survey instrument shall also be recorded. Further, the co-ordinates at prominent position at intervals of not more than 750 meters along the transmission line to be surveyed up to the next angle point shall also be recorded. Wooden peg of 50x50x650mm size shall also be driven at prominent position at intervals of not more than 750 meters along the transmission line to be surveyed up to the next angle point. Wire nails of 50 mm length should be fixed on the top of these pegs to show the location of instrument. The pegs shall be driven firmly into the ground to project 100 mm only above ground level. Wherever the line alignment crosses the EHT line, Railway line, P&T line or roads, the contractor shall record co-ordinates on the points of crossing. Wherever line route alignment passes over permanent land marks such as rock, boulders, culverts etc. suitable white paint marks with directional and POWERGRID markings shall be made and co-ordinates recorded. At angle positions stone/ concrete pillars of 150x150x1000mm in size with POWERGRID marked on them shall be embedded into the ground for easy identification.

3.4 Profiling

- 3.4.1 The complete profiling along the route shall be carried out using modern surveying equipment viz. total stations. Reference levels at every 20 meters along the route are to be recorded. RLs at other undulations along the route as well as in the route plan and other En-route details viz. crossings, building & structures, trees & other infrastructure etc. shall also be recorded. Areas along the route, which in the view of the contractor, are not suitable for tower spotting, shall also be marked in profile. Any undulation keeping conductor location as reference may also be indicated as dotted line in profile.
- 3.4.2 The complete profiling details shall be digitized and the data shall be prepared & stored in the format compatible to computer-aided tower spotting software.
- 3.4.3 A printed/ plotted output of the digitized profiling shall be submitted by the contractor to Employer's site-in-charge for review before taking up computer-aided tower spotting.

3.4.4 ~~For reconductoring packages, the Contractor shall then plot the profile of the HTLS Conductor under hot and cold conditions using the above ground profile & existing tower details, verify the various statutory electrical clearances & span limitations on the profile using sag tension calculations of the HTLS Conductor.~~

3.5 Optimisation of Tower Location/ Tower Spotting

3.5.1 Optimisation of tower locations including profiling shall be done by the contractor using computer-aided tower spotting software - PLSCADD and shall furnish sample calculations and manual tower spotting drawings for some typical sections.

3.5.2 The sag-tension characteristics of the conductor as well as tower spotting data shall be furnished by the Employer to the contractor during execution stage. Sag template curves, if any required for tower spotting, shall be prepared by the contractor and two sets of sag-template curves shall be given to POWERGRID for checking of profile.

3.5.3 General description of towers is indicated in ~~Section-I~~ of this specification for information of the Bidders.

3.5.4 Tower Spotting

While profiling & spotting the towers, the following shall be borne in mind:

a) Span

The number of consecutive spans between the section points shall not exceed 15 spans or 5 km in plain terrain and 10 spans or 3km in hilly terrain. A section point shall comprise of tension point with B/DB/QB type or C/DC/QC type or D/DD/QD type towers as applicable.

b) Extension/Truncation

An individual span shall be as near to the normal design span as possible. In case an individual span becomes too short with normal supports on account of undulations in ground profile, one or both the supports of the span may be extended by inserting standard body/ leg extension. In case of locations where the ground clearance is available, truncated towers may be spotted. The provisions kept in the design of towers w.r.t. body/ leg extensions, truncations shall be intimated to the contractor by the Employer during execution stage.

c) Loading

There shall not be any upward force on suspension towers under normal working conditions and the suspension towers shall support at least the minimum weight span as provided in the designs. In case uplift is unavoidable, it shall be examined if the same can be overcome by adding standard body extensions to the towers failing which tension towers designed for the purpose shall be deployed at such positions.

d) Road Crossing

At all important road crossings, the tower shall be fitted with normal suspension and tension insulator strings depending on the type of tower, but the ground clearance at the roads under maximum temperature and in still air shall be such that even with conductor broken in adjacent span, ground clearance of the conductor from the road surfaces will not

be less than specified minimum ground clearances. At all national highways, D/DD/QD type towers tension insulator strings shall be used and crossing span will not be more than 250 meters, unless higher span is permitted by national highways authority in case of highways having more lanes.

e) Railway Crossings

All the railway crossings coming En-route the transmission line shall be identified by the Contractor. At the time of detailed survey, the railway crossings shall be finalised based on the following and also confirming to the regulation laid down by the Railway Authorities.

- i) The crossings shall be supported on D/DD/QD type tower on either side.
- ii) The crossing shall normally be at right angle to the railway track.
- iii) The minimum horizontal distance measured at right angles from the center of nearest track to any part of a structure (all structures shall be rigid and well founded), carrying electrical conductors crossing a railway shall be equal to the height of the structure in meters above normal ground level plus 6 meters.
- iv) No crossing shall be located over a booster transformer, traction switching station, traction sub-station, Overlap Section or a track cabin location in an electrified area.
- v) The crossing span will be limited to 300 meters or 80 % of the normal span for which the structure is designed whichever is less.
- vi) Minimum ground clearance between crossing conductor under condition of maximum sag and railway line shall maximum of following:

(I) Vertical Clearance for OHE (other than high rise OHE):

Sl.	Transmission line	Minimum clearances from Rail Level
No.	voltage level	New Power Line Crossing or Crossing Planned for Alteration
1	Above 66 kV & upto 132 kV	15.56 m
2	Above 132 kV & upto 220 kV	16.46 m
3	Above 220 kV & upto 400 kV	18.26 m
4	Above 400 kV & upto 500 kV	19.16 m
5	Above 500 kV & upto 800 kV	21.86 m

(II) Vertical Clearance for high rise OHE:

Sl. No.	Transmission line voltage level	Minimum clearances from Rail Level
		New Power Line Crossing or Crossing Planned for Alteration
1	Above 66 kV & upto 132 kV	17.56 m
2	Above 132 kV & upto 220 kV	18.46 m
3	Above 220 kV & upto 400 kV	20.26 m
4	Above 400 kV & upto 500 kV	21.16 m
5	Above 500 kV & upto 800 kV	23.86 m

Note: Applicable only for electrification of routes where double stack container having maximum height of 6809mm is plying.

(III) Minimum Clearances between Highest Traction Conductor & Lowest Crossing Conductor

1	Above 66 kV & upto 132 kV	3.05 m
2	Above 132 kV & upto 220 kV	4.58 m
3	Above 220 kV & upto 400 kV	5.49 m
4	Above 400 kV & upto 500 kV	7.94 m
5	Above 500 kV & upto 800 kV	7.94 m

f) River Crossings

In case of major river crossing, river crossing towers shall be of suspension type alongwith anchor towers of D/DD/QD type tower on either side of the main river crossing. Alternately on the basis of economics and / or site/ execution constraints crossing of rivers using normal extended angle towers (+18/+25/+30M Extensions) also shall be considered. For navigable rivers, clearance required by navigation authority shall be provided. For non-navigable river, clearance shall be reckoned with respect to highest flood level (HFL).

g) Power line Crossings

Where the line is to cross over another line, towers with suitable extensions may be used, depending upon the merit of the prevailing site condition.

For power line crossing of 400 kV or above voltage level, large angle & dead-end towers (i.e. D/DD/QD) shall be used on either side of power line crossing (i.e. D/DD/QD -

D/DD/QD arrangement).

For power line crossing of 132 kV and 220 kV voltage level, angle towers (B/C/D/DB/DC/DD/ QB/QC/QD) shall be used on either side of power line crossing depending upon the merit of the prevailing site condition and line deviation requirement.

For power line crossing of 66 kV and below voltage level, suspension/ tension towers shall be provided on either side of power line crossing depending upon the merit of the prevailing site condition and line deviation requirement.

In case of crossing with B/C/DB/DC/QB/QC towers proper guying shall be provided to facilitate stringing of the power line crossing sections separately on obtaining line shutdowns.

Clearance between lines crossing each other shall be kept in accordance with the CEA (Measures Relating to Safety and Electric Supply) Regulations, 2010 as amended up-to-date. In order to reduce the height of the crossing towers, it may be advantageous to remove the ground-wire of the line to be crossed (if this is possible and permitted by the Employer of the line to be crossed).

Minimum clearance in meters between lines when crossing each other:

Sl. No.	Nominal	110-132 kV	220 kV	400 kV	765 kV	500 kV HVDC	800 kV HVDC	1200 kV
1	110-132KV	3.05	4.58	5.49	7.94	6.86	9.04	10.44
2	220KV	4.58	4.58	5.49	7.94	6.86	9.04	10.44
3	400KV	5.49	5.49	5.49	7.94	6.86	9.04	10.44
4	765KV	7.94	7.94	7.94	7.94	7.94	9.04	10.44
5	500KV HVDC	6.86	6.86	6.86	7.94	7.94	9.04	10.44
6	800KV HVDC	9.04	9.04	9.04	9.04	9.04	9.04	10.44
7	1200 KV	10.44	10.44	10.44	10.44	10.44	10.44	10.44

h) Telecommunication Line Crossings

The angle of crossing shall be as near to 90 degree possible. However, deviation to the extent of 30 degree may be permitted under exceptionally difficult situations.

When the angle of crossing has to be below 60 degree, the matter will be referred to the authority in charge of the telecommunication System. On a request from the Contractor, the permission of the telecommunication authority may be obtained by the Employer.

Also, in the crossing span, power line support will be as near the telecommunication line as possible, to obtain increased vertical clearance between the wires.

i) Oil Pipe-Line Crossings

Wherever transmission line crosses an oil/ gas pipeline, the angle of crossing shall be as near to 90 degree possible. Further, a minimum separation of 3 m should be maintained between pipe line and transmission line footings & pipe/ counterpoise earthing.

j) Details En-route

All topographical details, permanent features, such as trees, building etc. within following distance on either side of the alignment shall be detailed on the profile plan: -

1	1200 kV Single Circuit	44.5 m
2	765 kV Double Circuit	33.5 m
3	765kV Single Circuit Delta	32 m
4	765kV Single Circuit Horizontal	42.5 m
5	+800 kV HVDC	34.5 m
6	400kV Single Circuit	26.0 m
7	400kV Double Circuit	23.0 m
8	+500 kV HVDC	26.0 m
9	220 kV	17.5 m
10	132 kV	13.5 m

3.6 Clearance from Ground, Building, Trees etc.

Clearance from ground, buildings, trees and telephone lines shall be provided in conformity with the CEA's Regulations 2010 (Measures relating to Safety and Electric Supply).

It may be noted, that the Contractor shall intimate to the NHIDCL the date of carrying Route survey in writing, so that team of NHIDCL and survey team of contractor shall carry the counting of the trees, bushes, LA process as described below for providing ROW to the Contractor, since ROW clearance is in the scope of NHIDCL. No extra cost shall be paid to the contractor on assisting in ROW clearance process by the employer.

- 3.6.1 The Contractor shall count, mark and put proper numbers with suitable quality of paint at his own cost on all the trees that are to be cut by the Employer at the time of actual execution of the work as detailed below. Contractor may please note that Employer shall not pay any compensation for any loss or damage to the properties or for tree cutting due to Contractor's work.
- 3.6.2 To evaluate and tabulate the trees and bushes coming within following distance on either side of the central line alignment the trees will be numbered and marked with quality paint serially from angle point 1 (I) onwards and the corresponding number will be painted on the stem of trees at a height of 1 meter from ground level.

1	1200 kV Single Circuit	44.5 m
2	765 kV Double Circuit	33.5 m

3	765kV Single Circuit Delta	32 m
4	765kV Single Circuit Horizontal	42.5 m
5	± 800 kV HVDC	34.5 m
6	400kV Single Circuit	26.0 m
7	400kV Double Circuit	23.0 m
8	± 500 kV HVDC	26.0 m
9	220 kV	17.5 m
10	132 kV	13.5 m

The trees list should contain the following:

- Girth (circumstances) measured at a height of 1 meter from ground level.
- Approximate height of the tree with an accuracy of +2 meters.
- Name of the type of the species/ tree.
- The bushy and under growth encountered within following distance should also be evaluated with its type, height, girth and area in square meters, clearly indicating the growth in the tree/bush statement: -

1	1200 kV Single Circuit	89 m
2	765 kV Double Circuit	67 m
3	765kV Single Circuit Delta	64 m
4	765kV Single Circuit Horizontal	85 m
5	± 800 kV HVDC	67 m
6	400kV Single Circuit	52 m
7	400kV Double Circuit	46 m
8	± 500 kV HVDC	52 m
9	220 kV	35 m
10	132 kV	27 m

3.6.3 The contractor shall also intimate the Employer, his assessment about the likely amount of tree & crop compensation etc. required to be paid by the Employer during execution stage. This assessment shall be done considering prevailing practices/guidelines, local regulations and other enquiries from local

authorities.

3.6.3.1 The contractor shall also collect data/ details of ownership of land within the line corridor and tower base from the concerned revenue/ local authorities and submit the same to owner as per format enclosed with this technical specification at Annexure-E.

3.6.4 The Contractor shall also identify the forest/ non-forest areas involved duly authenticated by concerned authorities.

- a) A statement of forest areas with survey/ compartment Number (all type of forest RF/ PF / Acquired forest/ Revenue forest/ Private forest/ Forest as per dictionary meaning of forest etc.)
- b) A statement of non-forest areas with survey/ compartment nos.
- c) Tree cutting details (Girth wise & specie wise)
- d) Marking of forest areas with category on topo sheets 1:2,50,000 showing complete line route, boundaries of various forest divisions and their areas involved.
- e) Village forest maps of affected line and affected forest area and marking of the same.
- f) Forest division map showing line and affected forest area.

3.6.5 The Contractor shall finalize the forest clearance proposal on the prescribed format,

3.6.6 as per requirements of the state/ MOE & F, duly completed in all respects for submission by the Employer to the Forest Department

3.7 Preliminary Schedule

The profile sheets showing the locations of the towers together with preliminary schedules of quantities indicating tower types, wind & weight spans, angle of deviation, crossing & other details etc. shall be submitted by the contractor for review & approval by Employer's site-in-charge.

3.8 Check Survey of Tower Locations

- 3.8.1 The check survey shall be conducted to locate tower locations on ground conforming to the approved profile and tower schedule.
- 3.8.2 The co-ordinates of all the tower locations shall also be recorded using GPS / DGPS of positional accuracy less than 3m for easy relocating. The position of all tower locations shall be marked in the final digitized route alignment drawing with relative distances from any permanent bench mark area.
- 3.8.3 The contractor shall also collect required data at each tower location in respect of soil strata, ground water level, history of water table in adjacent areas/surface water, distance from permanent bench mark (these details to be furnished in a tabulated form) and classify the suitable type of foundation at each tower location based on the data collected at each location and detailed soil investigations carried out at selected locations etc.

3.9 Contouring at hilly/ undulated locations

- 3.9.1 The levels up or down of each pit centre with respect to centre of tower location shall be recorded at intervals of 2m using total stations/ GPS/ digital theodolite and digitized contour plans shall be made. Based on the digitized elevation plans, the quantities of benching & protection work vis-à-vis possible unequal leg extensions shall be optimized using suitable computer-aided techniques/ software or manual method. Required tower and foundation details, cost data for comparative valuation for benching & protection work vis-à-vis unequal leg extensions shall be provided by the Employer to the Contractor during execution stage.
- 3.10 The changes desired by the Employer in the preliminary tower schedule or as may be required based on detailed survey of tower locations & contouring by the contractor, shall be carried out by the contractor and the final tower schedule shall be submitted for approval of Employer. The tower schedule shall show position of all type of towers, span length, type of foundation for each tower, benching & revetment requirement, unequal leg extensions, deviation at all angles, crossings & other details etc.

3.11 Survey Methodology & Precision

- 3.11.1 All elevations shall be referenced to benchmarks established by the survey of India. Survey operations shall begin and end at benchmarks approved by the Employer.
- 3.11.2 During the leveling of the profile, check surveys will be affected at intervals not exceeding 50 km with benchmarks of known elevations. The difference in elevations as surveyed by the contractor and as declared by Survey of India for these benchmarks shall not exceed the precision required for 3rd order

surveys $e \leq 24k$, where k is the distance between benchmarks in km and e is the difference between elevations in mm.

3.11.3 In the absence of suitable benchmarks, the leveling shall be done by two independent leveling parties working in opposite directions along the same line. The difference in elevations between the two surveys shall not exceed the precision required for 3rd order surveys as stated above.

3.11.4 All-important objects and features along the transmission line centerline (railways, highways, roads, canals, rivers, transmission lines, distribution lines, telephone lines etc.) shall be surveyed and located with a positional accuracy of 1:2000 between points of known horizontal position.

3.12 Survey Report

3.12.1 Complete BOQ of the transmission lines shall be furnished in the survey report by the selected bidder.

3.12.2 Each angle point locations shall be shown with detailed sketches showing existing close by permanent land marks such as specific tree(s), cattle shed, homes, tube wells, temples, electric pole/ tower, telephone pole, canal, roads, railway lines etc. The relative distance of land marks from the angle points and their bearings shall be indicated in the sketch. These details shall be included in the survey report.

3.12.3 Information w.r.t infrastructure details available en-route, identification and explanation of route constraints, etc. shall also be furnished in the Survey report and shall inter-alia include the following:

3.12.3.1 Information regarding infrastructural facilities available along the final route alignment like access to roads, railway stations, construction material sources (like quarry points for stone, sand and availability of construction water), labour, existing transport facilities, fuel availability etc. shall be furnished in the survey report.

3.12.3.2 All observations which the Contractor thinks would be useful to the construction of the transmission lines mentioned under scope of work are to be reported.

3.12.3.3 Suggestions regarding the number of convenient zones (line segments/ portions) in which the entire alignment can be divided keeping in view the convenience of construction/project implementation are to be given.

3.12.3.4 Suggestions regarding location for setting up stores during line construction in consultation with Employer's representative shall also be provided by the contractor.

3.12.3.5 Working months available during various seasons along the final route alignment, with period, time of sowing & harvesting of different type of crops and the importance attached to the crops particularly in the context of way leave problems and compensation payable shall be stated by the Contractor.

3.12.3.6 Some portions of the line may require clearance from various authorities. The Contractor shall indicate the portion of the line so affected, the nature of clearance required and the name of concerned organizations such as local bodies, municipalities, P&T (name of circle), Inland navigation, Irrigation Department, Electricity Boards and Zonal railways, Divisional Forest Authorities etc.

- 3.12.4 All the requisite data for processing the case for statutory clearances such as PTCC, Forest and Railway shall be provided along with the report.
- 3.12.5 The contractor shall also collect & report (as per Formats of PGCIL details pertaining to pollution levels envisaged along the transmission line.
- 3.12.6 Four copies of survey reports shall be furnished by the contractor to the Employer and to PGCIL.

4. Geotechnical Investigations

4.1 General

- 4.1.1 Employer requires that a detailed Geotechnical investigation be carried out at various tower locations to provide the designer with sufficiently accurate information, both general and specific, about the substrata profile and relevant soil and rock parameters at site on the basis of which the foundation of transmission line towers can be classified and designed rationally.
- 4.1.2 These specifications provide general guidelines for geotechnical investigation of normal soils. Cases of marshy locations and locations affected by salt water or saltpeter shall be treated as special locations and the corresponding description in these specifications shall apply. Any other information required for such locations shall be obtained by Contractor and furnished to Employer/ PGCIL.

4.2 Scope

- 4.2.1 The scope of work includes detail soil investigations and furnishing bore log data at various tower locations. Detailed soil investigations shall be carried out at least at one location for every five-kilometer line stretch besides critical locations like railway crossing, river crossing etc. However, during actual execution of work, the quantities shall be decided by the Engineer - in - Charge,/ PGCIL depending upon the soil strata and terrain. Based on the bore log data/ soil parameter/ soil investigation results, the Contractor shall recommend the type of foundations suitable for each location and the same shall be got approved by the Employer/ PGCIL. For other locations, trial pit is to be done in every location for foundation classification up to foundation depth. No separate payment for trial pit shall be done.
- 4.2.2 These specifications cover the technical requirements for a detailed Geotechnical investigation and submission of a detailed Geotechnical Report. The work shall include mobilization of all necessary tools and equipment, provision of necessary engineering supervision and technical personnel, skilled and unskilled labour, etc. as required carrying out the entire field investigation as well as laboratory tests, analysis and interpretation of data collected and preparation of the Geotechnical Report. Contractor shall also collect data regarding variation of subsoil water table along the proposed line route. The aforementioned work shall be supervised by a graduate in Civil Engineering having at least 5 years of site experience in geotechnical investigation work.
- 4.2.3 Contractor shall make his own arrangements to establish the co-ordinate system required to position boreholes, tests pits and other field test locations as per the drawings/ sketches supplied by Employer. Contractor shall determine the reduced levels (RL's) at these locations with respect to benchmarks used in the detailed survey. Two reference lines shall be established based on survey

data/details. Contractor shall provide at site all required survey instruments to the satisfactions of the Employer so that the work can be carried out accurately according to specifications and drawings. Contractor shall arrange to collect the data regarding change of course of rivers, major natural streams and nalas, etc., encountered along the transmission line route from the best available sources and shall furnish complete hydrological details at the tower location including maximum velocity discharge, highest flood level (H.F.L), scour depth etc. of the concerned rivers, major streams and nalas (canals).

- 4.2.4 The field and laboratory data shall be recorded on the proforma recommended in relevant Indian Standards. Contractor shall submit to Employer two copies of field bore logs (one copy each to Employer site and Corporate Office) and all the field records (countersigned by the Employer) soon after the completion of each boreholes/ test.
- 4.2.5 Whenever Contractor is unable to extract undisturbed samples, he shall immediately inform the Employer. Payment for boring charges shall be subject to Employer being satisfied that adequate effort has been made to extract undisturbed samples. Special care shall be taken for locations where marshy soils are encountered and Contractor in such cases shall ensure that specified numbers of vane shear tests are performed and the results correlated with other soil parameters.
- 4.2.6 One copy of all field records and laboratory test results along with soil investigation report shall be sent to Employer. Employer may observe, at the laboratory testing procedures.
- 4.2.7 The Contractor shall interact with the Employer to get acquainted with the different types of structures envisaged and in assessing the load intensities on the foundation for the various types of towers in order to enable him to make specific recommendation for the depth, founding strata, type of foundation and the allowable bearing pressure.
- 4.2.8 After reviewing Contractor's geotechnical investigation draft report, Employer will call for discussions, to be held normally within one week at Employers site Office, in order to comment on the report in the presence of Contractor's Geotechnical Engineer. Any expenditure associated with the redrafting and finalising the report, traveling etc. shall be deemed included in the rates quoted for the geotechnical investigations.
- 4.2.9 Contractor shall carry out all work expressed and implied in these specifications in accordance with requirements of the specification.
- 4.2.10 The contractor shall prepare and submit soil profile along the transmission line route (in digitized form, with digitized route alignment drawing as base) indicating salient soil characteristics/ features, water table etc. based on detailed soil investigations and other details/ information collected during detailed survey.

4.3 General Requirements

- 4.3.1 Wherever possible, Contractor shall research and review existing local knowledge, records of test pits, boreholes, etc., types of foundations adopted and the behavior of existing structures, particularly those similar to the present project.

- 4.3.2 Contractor shall make use of information gathered from nearby quarries, unlined wells excavation etc. Study of the general topography of the surrounding areas will often help in the delineation of different soil types.
- 4.3.3 Contractor shall gather data regarding the removal of overburden at the tower location area either by performing test excavations, or by observing soil erosion or land slide in order to estimate reconsolidation of the soil strata. Similarly, data regarding recent landfills shall be studied to determine the characteristics of such land fill as well as the original soil strata.
- 4.3.4 The water level in neighboring streams and water courses shall be noted. Contractor shall make enquiries and shall verify whether there are abandoned underground works e.g. worked out ballast pits, quarries, old brick fields, mines, mineral workings etc.
- 4.3.5 It is essential that equipment and instruments be properly calibrated at the commencement of the work. If the Employer so desires. Contractor shall arrange for having the instruments tested at an approved laboratory at its cost and shall submit the test reports to the Employer. If the Employer desires to witness such tests, Contractor shall arrange for the same.
- 4.4 Codes and Standards for Geotechnical Investigations**
- 4.4.1 All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of conflict between the present specifications and those referred to herein, the former shall prevail. Internationally accepted standards which ensure equal or higher performance than those specified shall also be accepted.
- 4.4.2 All work shall be carried out in accordance with the following Indian Standards and Codes:

Indian Standards	Title	International Standard
IS 1080	Codes of Practice for Design and Construction of Shallow Foundations on soils (other than Raft, Ring & Shell)	
IS1498	Classification and Identification of Soils for General Engineering purposes.	ASTM D 2487 ASTM D2488
IS 1892	Code of Practice for Subsurface Investigation for Foundation	
IS 1904	Code of Practice for Design and Construction of foundation in Soils: General Requirements.	
IS 2131	Method of Standard Penetration Test for Soils	ASTM D 1586

IS 2132	Code of Practice for Thin Walled Tube Sampling of Soils	ASTM D 1587
IS 2720 (Part 1-39) (relevant parts)	Method of Test for Soils (Relevant Parts)	
IS 2809	Glossary of Terms and symbols Relating to Soil Engineering	ASTM D 653-14
IS 2911 (Part I-VI)	Code of Practice for Design and construction of Pile Foundations (Relevant Parts)	
IS 3043	Code of Practice for Earthing	
IS 4078	Code of Practice for Indexing and Storage of Drill Cores.	
IS 4091	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles	
IS 4434	Code of Practice for In-situ Vane Shear Test for Soils	ASTM D 2573(M)-15 ASTM D 4648(M)-16
IS 4453	Code of Practice for Sub-Surface Exploration by Pits, Trenches, Drifts and Shafts	
IS 4464	Code of Practice for Presentation of Drilling information and core description in Foundation investigation	
IS 4968(Part-II)	Method for Subsurface sounding for soils, dynamic method using cone and Bentonite slurry	
IS 5313	Guide for Core Drilling observations	
IS 6403	Code of Practice for Determination of Bearing Capacity of Shallow Foundation	
IS 6926	Code of Practice for Diamond Core Drilling for Site Investigation for River Valley Projects	

IS 6935	Method of Determination of Water level in a Bore Hole	
IS 2809	Glossary of Terms and symbols Relating to Soil Engineering	ASTM D 653-14
IS 2911 (Part I-VI)	Code of Practice for Design and construction of Pile Foundations (Relevant Parts)	

IS 3043	Code of Practice for Earthing	
IS 4078	Code of Practice for Indexing and Storage of Drill Cores	
IS 4091	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles	
IS 4434	Code of Practice for In-situ Vane Shear Test for Soils	ASTM D2573 (M)-15 ASTM D4648 (M)-16
IS 4453	Code of Practice for Sub-Surface Exploration by Pits, Trenches, Drifts and Shafts	
IS 4464	Code of Practice for Presentation of Drilling information and core description in Foundation investigation	
IS 4968 (Part-II)	Method for Subsurface sounding for soils, dynamic method using cone and Bentonite slurry	
IS 5313	Guide for Core Drilling observations.	
IS 6403	Code of Practice for Determination of Bearing Capacity of Shallow Foundation	
IS 6926	Code of Practice for Diamond Core Drilling for Site Investigation for River Valley Projects	
IS 6935	Method of Determination of Water level in a Bore Hole	
IS 7422 Part (I- V)	Symbols and Abbreviations for use in Geological Maps Sections and subsurface Exploratory Logs (Relevant parts).	
IS 8009 (Part-I)	Code of Practice for Calculation of Settlements of Foundations (Shallow Foundations subjected to symmetrical Vertical Loads).	
IS 8764	Method of Determination of Point Load Strength Index of Rocks.	
IS 9143	Method of Determination of Unconfined Compressive Strength of Rock Materials	ASTM D 7012-14e1
IS 9179	Method of Preparation of Rock Specimen for Laboratory Testing	
IS 9259	Specification for Liquid Limit Apparatus	ASTM D4318-17
IS 9640	Specification for Split Spoon Sampler	ASTM D1586-11
IS 10050	Method of Determination of Slake Durability Index of Rocks.	ASTM D4644-16

IS 11315 (Part 1-12)	Method for the Quantitative Description of discontinuities in Rock Mass	

4.5 Field Investigation for Soils

Tentative numbers of detailed soil investigation to be done is given in BOQ Sheet.

4.5.1 Boring

Boreholes are required for detailed soil investigations.

4.5.1.1 General Requirements

- a) Boreholes shall be made to obtain information about the subsoil profile, its nature and strength and to collect soil samples for strata identification and for conducting laboratory tests. The minimum diameter of the borehole shall be 150mm and boring shall be carried out in accordance with the provisions of IS 1892 and the present specification.
- b) All boreholes shall be 10m deep for normal soil conditions. The depth of boreholes at river crossings and special locations shall be 40m. If a strata is encountered where the Standard Penetration Test Records N values greater than 100, with characteristics of rock, the borehole shall be advanced by coring at least 3m further in normal locations and at least 7m further for the case of river crossing locations with prior approval of the Employer. When the boreholes are to be terminated in soil strata an additional Standard Penetration Test shall be carried out at the termination depth. No extra payment shall be made for carrying out Standard Penetration Tests.
- c) Casing pipe shall be used when collapse of a borehole wall is probable. The bottom of the casing pipe shall at all times be above the test of sampling level but not more than 15 cm above the borehole bottom. In case of cohesionless soils, the advancement of the casing pipe shall be such that it does not disturb the soil to be tested or sampled. The casing shall preferably be advanced by slowly rotating the casing pipe and not by driving.
- d) In-situ tests shall be conducted and undisturbed samples shall be obtained in the boreholes at intervals specified hereafter. Representative disturbed samples shall be preserved for conducting various identification tests in the laboratory. Water table in the bore hole shall be carefully recorded and reported following IS 6935. No water or drilling mud shall be used while boring above ground water table. For cohesion less soil below water table, the water level in the borehole shall at all times be maintained slightly above the water table.
- e) The borehole shall be cleaned using suitable tools to the depth of testing or sampling, ensuring least or minimum disturbance of the soil at the bottom of the borehole. The process of jetting through an open tube sampler shall not be permitted. In cohesive soils, the borehole may be cleaned by using a bailer with a flap valve. Gentle circulation of drilling fluid shall be done when rotary mud circulation boring is adopted.
- f) On completion of the drilling, Contractor shall backfill all boreholes as directed by the Employer.

4.5.1.2 Auger Boring

Auger boring may be employed in soft to stiff cohesive soils above the water table. Augers shall be of helical or post hole type and the cuttings brought up by the auger shall be carefully examined in the field and the description of all strata shall be duly recorded in the field bore log as per IS 1498. No water shall be introduced from the top while conducting auger boring.

4.5.1.3 Shell and Auger Boring

4.5.1.3.1 Shell and auger boring may be used in all types of soil which are free from boulders. For cohesion less soil below ground water table, the water level in the borehole shall always be maintained at or above ground water level. The use of chisel bits shall be permitted in hard strata having SPT-N value greater than 100. Chisel bits may also be used to extend the bore hole through local obstructions such as old construction. Boulders rocky formations, etc. The requirements in **Clause 4.5.1.2** shall apply for this type of boring also.

4.5.1.3.2 Rotary method may be used in all types of soil below water table. In this method the boring is carried out by rotating the bit fixed at the lower end of the drill rod. Proper care shall be taken to maintain firm contact between the bit and the bottom of the borehole. Bentonite or drilling mud shall be used as drilling fluid to stabilise and protect the inside surface of the borehole. Use of percussion tools shall be permitted in hard clays and in dense sandy deposits.

4.5.2 Standard Penetration Test (SPT)

4.5.2.1 This test shall be conducted in all types of soil deposits encountered within a borehole, to find the variation in the soil stratification by correlating with the number of blows required for unit penetration of a standard penetrometer. Structure sensitive engineering properties of cohesive soils and silts such as strength and compressibility shall not be inferred based on SPT values.

4.5.2.2 The test shall be conducted at every change of stratum or at interval of not more than 1.5 m whichever is less as per IS 2131, for a depth up to 10 m in case of normal soils and 40 m in case of special locations.

4.5.2.3 The Equipment, accessories and procedures for conducting the test shall conform to IS 2131 and IS 9640. The test shall be conducted immediately after reaching to the test depth and cleaning of bore hole.

4.5.2.4 The test shall be carried out by driving a standard split spoon sampler in the bore hole by means of hammer of standard weight as specified in IS 2131, having a free fall of 750 mm. The sample shall be driven using the hammer for 450 mm recording the number of blows for every 150 mm. The number of blows for the last 300 mm drive shall be reported as N value.

4.5.2.5 This test shall be discontinued when the blow count is equal to 100 or the penetration is less than 25 mm for 50 blows. At the level where the test is discontinued, the number of blows and the corresponding penetration shall be reported. Sufficient quantity of disturbed soil samples shall be collected from the split spoon sampler for identification and laboratory testing. The sample shall be visually classified and recorded at the site as well as properly preserved without loss of moisture content and labeled.

4.5.3 Sampling

4.5.3.1 General

- a) Sufficient number of soil samples shall be collected. Disturbed soil samples shall be collected for soil identification and for conducting tests such as sieve analysis, index properties, specific gravity, chemical analysis etc. Undisturbed samples shall be collected to estimate the physical bearing capacity and settlement properties of the soil.
- b) All accessories and sampling methods shall conform to IS 2132. all disturbed and undisturbed samples collected in the field shall be classified as per IS 1498.
- c) All samples shall be identified with date, borehole or test pit number, depth of sampling, etc. The top surface of the sample in-situ shall also be marked. Care shall be taken to keep the core and box samples vertical, with the mark directing upwards. The tube samples shall be properly trimmed at one end and suitably capped and sealed with molten paraffin wax. The Contractor shall be responsible for packing, storing in a cool place and transporting all the samples from site to the laboratory within seven days after sampling with probe, protection against loss and damage.

4.5.3.2 Disturbed Samples

- a) Disturbed soil samples shall be collected in boreholes at regular intervals. The weight of sample as per table 2 of IS 1892 shall be collected at 0.5 m intervals starting from a depth of 0.5 m below ground level and at every identifiable change of strata to supplement the boring records. Samples shall be stored immediately in air tight jars which shall be filled to capacity as much as possible.
- b) In designated borrow areas, bulk samples, from a depth of about 0.5 m below ground level shall be collected to establish the required properties for use as a fill material. Disturbed samples weighing about 25 kg (250 N) shall be collected at shallow depths and immediately stored in polythene bags as per IS 1892. The bags shall be sealed properly to preserve the natural moisture content of the sample and placed in wooden boxes for transportation.

4.5.3.3 Undisturbed Samples

In each borehole undisturbed samples shall be collected at every change in stratum or at intervals not more than 1.5 m, whichever is less as per IS 2132, for a depth up to 10 m in case of normal soils and 40 m in case of special locations.

- 4.5.3.3.1 The spacing between the top levels of undisturbed sampling and standard penetration testing shall not be less than 1.0 m. Undisturbed samples shall be of 100 mm diameter and 450 mm in length. Samples shall be collected in a manner to preserve the structure and moisture content of the soil. Accessories and sampling procedures shall conform to IS 1892 and IS 2132

- a) Undisturbed sampling in cohesive soil:

Undisturbed samples in soft to stiff cohesive soils shall be obtained using a thin walled sampler. In order to reduce the wall friction, suitable precautions, such as oiling the surfaces shall be taken. The sampling tube shall have a smooth finish on both surfaces and a minimum effective length of 450 mm.

The area ratio of sampling tubes shall be less than 12.5%. However, in case of very stiff soils area ratio up to 20% shall be permitted.

- b) Undisturbed sampling in very loose, saturated, sandy and silty soils and very soft clays:

Samples shall be obtained using a piston sampler consisting of a cylinder and piston system. In soft clays and silty clays, with water standing in the casing pipe, piston sampler shall be used to collect undisturbed samples in the presence of expert supervision.

Accurate measurements of the sampling depth, dimensions of sampler, stroke and length of sample recovery shall be recorded. After the sampler is pushed to the required depth, the cylinder and piston system shall be drawn up together, preventing disturbance and changes in moisture content of the sample;

- c) Undisturbed sampling in cohesion less soils

Undisturbed samples in cohesion less soils shall be obtained in accordance with IS 8763. Sampler operated by compressed air shall be used to sample cohesion less soils below ground water table.

4.5.4 **Ground Water**

- 4.5.4.1 One of the following methods shall be adopted for determining the elevation of ground water table in boreholes as per IS 6935 and the instructions of the Employer:

- a) In permeable soils, the water level in the borehole shall be allowed to stabilize after depressing it adequately by bailing before recording its level. Stability of sides and bottom of the boreholes shall be ensured at all times.

- b) For both permeable and impermeable soils, the following method shall be suitable. The borehole shall be filled with water and then bailed out to various depths. Observations on the rise or fall of water level shall be made at each depth. The level at which neither fall nor rise is observed shall be considered the water table elevation and confirmed by three successive readings of water level taken at two hours interval.

4.5.4.2 If any variation of the ground water level is observed in any specific boreholes, the water level in these boreholes shall be recorded during the course of the field investigation. Levels in nearby wells, streams, etc., if any, shall also be noted in parallel.

4.5.4.3 Subsoil water samples

- a) Subsoil water samples shall be collected for performing chemical analysis. Representative ground water samples shall be collected when first encountered in boreholes and before the addition of water to aid boring or drilling.
- b) Chemical analysis of water samples shall include determination of pH value, turbidity, sulphate, carbonate, nitrate and chloride contents, presence of organic matter and suspended solids. Chemical preservatives may be added to the sample for cases as specified in the test methods or in applicable Indian Standards. This shall only be done if analysis cannot be conducted within an hour of collection and shall have the prior written permission and approval of the Employer.

4.5.5 Dynamic Cone Penetration Test (only at Special locations)

- a) With bentonite slurry

Dynamic cone penetration test shall be conducted to predict stratification, density, bearing capacity of granular soils, etc. The test shall be conducted to the specified depth or refusal, whichever comes first. Refusal shall be considered when the blow count exceeds 100 for 300mm penetration.

Equipment, accessories test procedures, field observations and reporting of results shall conform to IS 4968 (Part-II). The driving system shall comprise of hammer of standard weight as specified in IS 4968 (Part-II), having a free fall of 750mm. The cone shall be of 60° and of 62.5mm diameter provided with vents for continuous flow of bentonite slurry through the cone and rods in order to avoid friction between the rods and soil. On completion of the test the results shall be presented as a continuous record of the number of blows required for every 300mm penetration of the cone into the soil in a suitable chart supplemented by a graphical plot of blow count for 300mm penetration vs. depth. On completion of the test, the results shall be presented on the proforma approved by the Employer/ Nodal officer of PGCIL.

- b) Without bentonite slurry

This test shall be conducted with 50mm diameter 60° cone fitted loosely to the driving rod through a cone adapter. The cone shall be driven in to the soil by allowing hammer of standard weight as specified in IS 4968 (Part-II), having a free fall of 750mm. The number of blows for every 100mm

penetrations shall be recorded. The process shall be repeated till the cone is driven to the required depth. The penetration depth shall be limited to 5m in cohesion less soil and 10m in mixed soil with some binding material. The cone driving rods, driving head, hoisting equipment shall conform to IS 10589. The test report should be prepared as per guidelines of IS 4968 (Part I).

4.5.6 Vane Shear Test. (required for boreholes where UDS is not possible) (Only at Special Locations)

Field vane shear test shall be performed inside the borehole to determine the shear strength and bearing capacity of cohesive soils, especially of soft and sensitive clays, which are highly susceptible to sampling disturbance. Equipment, accessories, test procedures, field observations shall correspond to IS 4434. Tests may also be conducted by direct penetration from ground surface. If the cuttings at the test depth in the borehole show any presence of gravel, sand shells, decomposed wood, etc., which are likely to influence the test results substantially, the test at that particular depth may be omitted with the permission of the Employer. However, the test shall be conducted at a depth where these obstructions cease to occur. On completion of the test, the results shall be reported in an approved proforma as specified in IS 4434, Appendix-A.

4.6 Field Investigation for Rock

4.6.1 Rock Drilling

- 4.6.1.1 If, during the investigations, large hard fragments or natural rock beds are encountered, work shall proceed with core drilling methods. The equipment and procedures for this operation shall conform to IS 1892. The starting depth of drilling in rock shall be certified by the Employer. At the end of the investigation, the hole drilled in rock shall be backfilled with grout consisting of 1-part cement and 3-parts sand by weight.
- 4.6.1.2 Drilling shall be carried out with NX size tungsten carbide (TC) or diamond tipped drill bits, depending on the type of rock and according to IS 6926. Suitable type of drill bit (TC/Diamond) and core catchers shall be used to ensure continuous and good core recovery. Core barrels and core catchers shall be used for breaking off the core and retaining it when the rods are withdrawn. Double tube core barrels shall be used to ensure better core recovery and to retrieve cores from layers of bedrock. Water shall be circulated continuously in the hollow rods and the sludge conveying the rock cuttings to the surface shall be collected. A very high core recovery ratio shall be aimed at in order to obtain a satisfactory undisturbed sample. Attempt shall be made to recover cores of 1.5 m in length. Normally TC bit shall be used. Change over to a diamond bit shall require the specific written approval of the Employer, and his decision as to whether a TC or a diamond bit is to be used shall be final and binding on Contractor.
- 4.6.1.3 No drilling run shall exceed 1.5 m in depth. if the core recovery is less than 80% in any run, the length of the subsequent run shall be reduced to 0.75 m. During drilling operations observations on return water, rate of penetration etc. shall be made recorded and recorded as per IS 5313.
 - a) The colour of return water at regular intervals, the depth at which any change of colour of return water is observed, the depth of occurrence and amount of

flow of hot water, if encountered, shall be recorded.

- b) The depth through which a uniform rate of penetration was maintained, the depth at which marked change in rate of penetration or sudden fail on drill rod occurs, the depth at which any blockage of drill bit causing core loss, if any, shall be recorded.
- c) Any heavy vibration or torque noticed during the drilling should be recorded together with the depth of occurrence.
- d) Special conditions like the depth at which grouting was done during, drilling, presence of artesian conditions, loss of drilling fluid, observations of gas discharge with return water, etc., shall also be observed and recorded.
- e) All the observations and other details shall be recorded as per daily drill and reported in a proforma as given in IS 5313, Appendix-A.

4.6.2 Core Sampling

- 4.6.2.1 Core samples shall be extracted by the application of a continuous pressure at one end of the core with the barrel held horizontally without vibration. Friable cores shall be extracted from the barrel directly into a suitably sized half round plastic channel section. Care shall be taken to extrude the samples in the direction of coring to avoid stress reversal.
- 4.6.2.2 Immediately after withdrawal from the core barrel, the cores shall be placed in a tray and transferred to boxes specially prepared for this purpose. The boxes shall be made from seasoned timber or any other durably material and shall be indexed on top of the lid according to IS 4078. The cores shall be numbered serially and arranged in the boxes in a sequential order. The description of the core samples shall be recorded as instructed in IS 4464. Where no core is recovered, it shall be recorded as specified in the standard. Continuous record of core recovery and rock quality designation (RD/DD/QD) is to be mentioned in the bore log in accordance with IS 11315 (Part-II).

4.7 Laboratory Testing

4.7.1 Essential Requirements

- a) Depending on the types of substrata encountered, appropriate laboratory tests shall be conducted on soil and rock samples collected in the field. Laboratory tests shall be scheduled and performed by qualified and experienced personnel who are thoroughly conversant with the work. Tests indicated in the schedule of items shall be performed on soil, water and rock samples as per relevant IS codes. One copy of all laboratory test data records shall be submitted to Employer progressively every week. Laboratory tests shall be carried out concurrently with the field investigations as initial laboratory test results could be useful in planning the later stages of field work. A schedule of laboratory tests shall be established by Contractor to the satisfaction of the Employer within one week of completion of the first bore hole;
- b) Laboratory tests shall be conducted using approved apparatus complying with the requirements and specification of Indian Standards or other approved standards for this type of work. It shall be checked that the apparatus is in good working condition before starting the laboratory tests. Calibration of all the instruments and their accessories shall be done

carefully and precisely at an approved laboratory.

- c) All samples, whether undisturbed or disturbed shall be extracted, prepared and examined by competent personnel properly trained and experienced in soil sampling. examination, testing and in using the apparatus in conformance with the specified standards;
- d) Undisturbed soil samples retained in liners or seamless tube samplers shall be removed, without causing any disturbance to the samples, using suitably designed extruders just prior to actual testing. If the extruder is horizontal, proper support shall be provided to prevent the sample from breaking. For screwtube extruders, the pushing head shall be free from the screw shaft so that no torque is applied to the soil sample in contact with the pushing head. For soft clay samples, the sample tube shall be cut by means of a high-speed hacksaw to proper test length and placed over the mould before pushing the sample into it with a suitable piston;
- e) While extracting a sample from a liner or tube, care shall be taken to assure that its direction of movement is the same as that during sampling to avoid stress reversal;

4.7.2 Tests

4.7.2.1 Tests as indicated in these specifications and as may be requested by the Employer, shall be conducted. These tests shall include but may not be limited to the following: -

- a) Tests of undisturbed and disturbed samples
 - Visual and engineering classification;
 - Sieve analysis and hydrometric analysis;
 - Liquid, plastic and shrinkage limits;
 - Specific gravity;
 - Chemical analysis;
 - Swell pressure and free swell index determination;
 - Proctor compaction test.
- b) Tests of undisturbed samples:
 - Bulk density and moisture content;
 - Relative density (for sand),
 - Unconfined compression test;
 - Box shear test (for sand);
 - Triaxial shear tests (depending on the type of soil and field conditions on undisturbed or remoulded samples):
 - i) Unconsolidated undrained;
 - ii) Consolidated drained test;

- Consolidation
- c) Tests on rock samples
- Visual classification;
 - Moisture content, porosity and density;
 - Specific gravity;
 - Hardness
 - Stake durability
 - Unconfined compression test (both saturated and at in-situ water content);
 - Point load strength index;
 - Deformability test (both saturated and dry samples).
- d) Chemical analysis of sub soil water.

4.7.3 Salient Test Requirement

- a) Triaxial shear tests shall be conducted on undisturbed soil samples, saturated by the application of back pressure. Only if the water table is at sufficient depth so that chances of its rising to the base of the footing are small or nil, the triaxial tests shall be performed on specimens at natural moisture content. Each test shall be carried out on a set of three test specimens from one sample at cell pressures equal to 100, 200 and 300 KPa respectively or as required depending on the soil conditions:
- b) Direct shear test shall be conducted on undisturbed soil samples. The three normal vertical stresses for each test shall be 100, 200 and 300 KPa or as required for the soil conditions;
- c) Consolidation test shall have loading stages of 10, 25, 50, 75, 100, 200, 400 and 800 KPa. Rebound curve shall be recorded for all samples by unloading the specimen at its in-situ stress. Additional rebound curves shall also be recorded wherever desired by the Employer;
- d) Chemical analysis of subsoil shall include determination of PH value, carbonate, sulphate (both SO₃ and SO₄), chloride and nitrate contents, organic matter, salinity and any other chemicals which may be harmful to the foundation material. Their contents in the soil shall be indicated as percentage (%);
- e) Chemical analysis of subsoil water samples shall include the determination of properties such as colour, odour, turbidity, PH value and specific conductivity, the last two chlorides, nitrates, organic matter and any other chemical harmful to the foundation material. The chemical contents shall be indicated as parts per million (PPM) based on weight.

4.8 Geotechnical Investigation Report

4.8.1 General

Contractor shall submit a formal report containing geological information of the region, procedures adopted for geotechnical investigation, field observations, summarised test data, conclusions and recommendations. The report shall also include detailed bore logs, subsoil sections, field test results, laboratory observations and test results both in tabular as well as graphical form, practical and theoretical considerations for the interpretation of test results, supporting calculations for the conclusions drawn, etc. Initially, Contractor shall submit three copies of the report in draft form for Employer's review;

- a) Contractor's Geotechnical engineer shall visit Employer's Office for a detailed review based on Employer's comments in order to discuss the nature of modifications, if any, to be done in the draft report. Contractor shall incorporate in the report the agreed modifications and resubmit the revised draft report for approval. Ten copies of the detailed final approved report shall be submitted to Employer together with one set of reproducible of the graphs, tables etc.
- b) The detailed final report based on field observations, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different types of structures.

4.8.2 Data to be furnished

4.8.2.1 The report shall also include the following

- a) A plot plan/ location plan showing the locations and reduced levels of all field test e.g. boreholes, trial pits, static cone penetration tests, dynamic cone penetration tests, etc., properly drawn to scale and dimensioned with reference to the established grid lines;
- b) A true cross section of all individual boreholes and test pits with reduced levels and co-ordinates showing the classification and thickness of individual stratum, position of ground water table, various in-situ tests conducted, samples collected at different depths and the rock stratum, if encountered;
- c) Geological information of the area including geomorphology, geological structure, lithology, stratigraphy and tectonics, core recovery and rock quality designation (RD/DD/QD), etc.,
- d) Observations and data regarding change of course of rivers, velocity, scour depths, silt factor, etc., and history of flood details for mid-stream and river bank locations;
- e) Past observations and historical data, if available, for the area or for other areas with similar soil profile, or with similar structures in the surrounding areas;
- f) Plot of Standard Penetration Test (uncorrected and corrected N values) with depth for each test site;
- g) Results of all laboratory test summarised according to Table 4.0 (i) for each sample as well as (ii) for each layer, along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative rock cores,
- h) For all triaxial shear tests, stress vs. strain diagrams as well as Mohr's circle

envelopes shall be furnished. If back pressure is applied for saturation, the magnitude of the same shall be indicated. The value of modulus of elasticity (E) shall be furnished for all tests along with relevant calculations;

i) For all consolidation tests, the following curves shall be furnished

- i) e vs. $\log p$;
- ii) e vs. p ;
- iii) Compression vs $\log t$ or vs $\sqrt{t}$

depending upon the shape of the plot, for proper determination of coefficient of consolidation. The point showing the initial condition (e_0 , p_0) of the soil shall be marked on the curves;

j) The procedure adopted for calculating the compression index from the field curve and settlement of soil strata shall be clearly specified. The time required for 50% and 90% primary consolidation along with secondary settlements, if significant, shall also be calculated.

**STANDARD SPECIFICATION OF
TRANSMISSION LINE (SECTION-SURVEY &
SOIL INVESTIGATION)**

Table 4.0

A) SUMMARY OF RESULTS OF LABORATORY TESTS ON SOIL

Date of Boring:						Name of the Project:										Bore hole no.:								
Ground elevation: (R.L. in m.)						Co-ordinates:						Termination Depth:				Water table:								
Soil details							Grain Size Distribution			Atterberg limits			Soil Density (kg / m³)				Moisture content		Triaxial / Direct shear Test		Remarks			
Depth	Sample nos. & type	IS Classification of soil	Description of layers	N - Value (observed)	N - Value (corrected)	Specific Gravity	Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity index	Bulk / Natural Density	Dry Density	Submerged Density	Proctor Density	Relative Density	Natural	Optimum	Confining Pressure	Co-hesion	Angle of Repose	

Following additional information should also be provided:

- (i) Maximum expected yearly rise / fall of water table
- (ii) General topography of the location: whether cultivated or barren, hilly / plain location, river bank location etc.

Note: where ever undisturbed sampling is not possible, reasons must be clearly indicated and all the tests shall be conducted on re-moulded samples.

(Signature)
Prepared by
Soil
investigator

(Signature)
Checked & Reviewed
by
Line Contractor

(Signature)
Checked & Approved
by
Nodal officer PGCIL.

B) SUMMARY OF ULTIMATE BEARING CAPACITIES CONSIDERING MAXIMUM RISE OF WATER

TABLE

Location no.	Foundation Classification	Depth of footing considered for bearing capacity calculation	Size of footing considered for bearing capacity calculation	Bearing capacity*	
				Based on settlement criteria (for 40mm total settlement)	Based on shear failure criteria
		3.0m	3.0m x 3.0m		
		3.0m	5.0m x 5.0m		
		3.0m	7.0m x 7.0m		
		3.0m	9.0m x 9.0m		
		3.5m	3.0m x 3.0m		
		3.5m	5.0m x 5.0m		
		3.5m	7.0m x 7.0m		
		3.5m	9.0m x 9.0m		

* Detailed calculations of all the bearing capacities should be enclosed with soil investigation reports.

(Signature)	(Signature)	(Signature)
Prepared by	Checked & Reviewed by	Checked & Approved
by		
Soil investigator	Line Contractor	POWERGRID Nodal officer.

c) For Chemical Test

As per Specifications - Clause 4.8.4

4.8.3 Recommendations

4.8.3.1 Recommendations shall be provided for each tower location duly considering soil type and tower spotting data. The recommendations shall provide all design parameters and considerations required for proper selection, dimensioning and future performance of tower foundations and the following:-

- The subsurface material must provide safe bearing capacity and uplift resistance by incorporating appropriate safety factors thereby avoiding rupture under ultimate loads;

- b) Movement of the foundation, including short-term and long-term components under transient and permanent loading, shall be strictly controlled with regard to settlement, uplift, lateral translation and rotation:
- c) Co-efficient of permeability of various sub soil and rock strata based on in-situ permeability tests.

Core resistance, frictional resistance total resistance, relation between core resistance, Standard Penetration Test N value, and settlement analysis for different sizes of foundation as specified in para 4.1.8.3 (I) based on static cone penetration test.

- d) For shallow foundation the following shall be indicated with comprehensive supporting calculations: -
 - i) Net Safe allowable bearing pressure for isolated square footing of sizes 4.0, 5.0, 6.0 & 70. m at three different founding depths of 1,2 and 3 & 3.5m below ground level considering both shear failure and settlement criteria giving reasons for type of shear failure adopted in the calculation.
 - ii) Net safe allowable bearing pressure for raft foundations of widths greater than 5m at 2.0, 3.0 and 4.0m below ground level considering both shear failure and settlement criteria.
 - iii) Rate and magnitude of settlement expected of the structure.
 - iv) Net safe bearing capacity for foundation sizes mentioned in para(i) above, modulus of sub grade reaction, modules of elasticity from plate load test results along with time settlement curves and load settlement curve in both natural and log graph, variation of Modulus of sub grade reaction with size, shape and depth of foundation.
- e) The stable slopes for shallow and deep excavations, active and passive earth pressure at rest and angle of repose for sandy soils shall be furnished. The loading of the foundations shall not compromise the stability of the surrounding subsurface materials and the stability of the foundation shall be ensured against sliding or overturning.
- f) Depending on the subsurface material, water table level and tower type, either reinforced concrete isolated pad and chimney, cast-in-situ bored pile of special foundations shall be installed at a given location.
- g) Net Safe allowable bearing pressure and uplift resistance shall be provided for the various sizes of isolated square footings founded at various depths below ground level considering both shear failure and movement criteria; rate and magnitude of movement expected of the structure (settlement, uplift, rotation) shall also be given.

- h) In cases where normal open cast/ pile foundations appear to be impractical, special pile foundations shall be given due consideration along with the following:
 - i) Type of pile foundation and reasons for recommending the same duly considering the soil characteristics.
 - ii) Suitable founding strata for the pile.
 - iii) Estimated length of pile for 500, 750 and 1000 KN and 4500 KN capacities; end bearing and frictional resistance shall be indicated separately.
 - iv) Magnitude of negative skin friction or uplift forces due to soil swelling.
- i) Where the subsoil water and soil properties are found to be chemically aggressive. Contractor shall take suitable precautions during construction including any protective coating to be applied on the foundations; susceptibility of soil to termite action and remedial measures for the same shall be dealt with.
- j) Suitability of locally available soils at site for filling, backfilling and adequate compaction shall be investigated.
- k) If expansive soil such as black cotton soil is encountered recommendation of removal or retainment of the same shall be given in the latter case, detailed specifications of special requirements shall also be given.
- l) Susceptibility of subsoil strata to liquefaction in the event of earthquake and remedial measures, if required, shall be considered.
- m) Any other information of special significance such as dewatering schemes, etc. which may have a bearing on the design and construction shall be provided.
- n) Recommendations for additional soil investigations, beyond the scope of the present work, shall be given if Contractor considers such investigations necessary.

4.8.4 Hydrogeological Conditions

- 4.8.4.1 The maximum elevation of ground water table, amplitudes of its fluctuations and data on water aggressivity with regard to foundation structure materials shall be reported. While preparing ground water characteristics the following parameters should be specified for each aquifer:

- a) bicarbonate alkalinity mg-eq/(deg)
- b) pH value
- c) content of aggressive carbon dioxide, mg/l;
- d) content of magnesia salts. mg/l, recalculated in terms of ions Mg^{+2} ;
- e) content of ammonia salts, mg/l, recalculated in terms of ions NH_4^+
- f) content of caustic alkalis, mg/l, recalculated in terms of ions Na^+ and K^+
- g) contents of chlorides,mg/l recalculated in terms of ions Cl^-
- h) contents of sulphates, mg/l, recalculated in terms of ions SO_4^{2-}
- i) aggregate content of chlorides, sulphates, nitrates, carbonates and other salts, mg/l

4.9 Rates and Measurements

4.9.1 Rates

The unit rates are indicated in the bid, contractor to quote on percentage basis as defined in the bid document shall be inclusive of making observations, establishing the ground level and co-ordinates at the location of each borehole, test pit etc. No extra payments shall be made for conducting Standard Penetration Test, collecting, packing, transporting of all samples and cores, recording and submittal of results on approved formats.

4.10 Specific Requirements for Geotechnical Investigation at River Crossings

4.10.1 The entire soil investigation work at river crossing locations (if required) shall be carried out in accordance with the relevant parts of the specifications for geotechnical investigation modified to the extent given below.

4.10.2 Requirements

4.10.2.1 Boreholes shall be executed to specified depth of 40m (refer clause 4.5.1.1 (b). If refusal strata is reached (i.e. SPT-N value is greater than 100 continuously for 5m depth) with characteristics of rock the borehole may be terminated at shallower depth i.e. at 5m in refusal strata, with prior approval of the Employer.

4.10.2.2 Laboratory testing shall be conducted on all soil samples to determine grain size distribution, liquid limit and plastic limit of the different soil strata encountered.

4.10.2.3 Geotechnical Report must furnish the following:

- a) Geotechnical investigation scheme;
- b) Bore-logs indicating soil stratification, with IS classification, sampling details and
- c) SPI 'N' values;

- d) Soil cross-sections along various boreholes in two orthogonal directions indicating soil stratification based on field and laboratory tests;
- e) Grain size distribution curves;
- f) IS classification of soils;
- g) Shear tests (UU), to be done on saturated soil samples;
- h) Bearing capacity of soil at different levels;
- i) Highest flood level (HFL);
- j) Maximum discharge, velocity etc. (from authenticated source such as CWC or appropriate State authorities);
- k) Recommendations regarding type of foundation to be adopted at the location

4.10.3 A check list for reporting results of river crossing locational details, detailed soil investigation and river values for river crossing locations is enclosed at Annexure-C.

4.11 Special Terms and conditions for Geotechnical Investigation in the River bed

- 4.11.1 Contractor is required to mobilise a suitable arrangement (floating pontoon, plant, equipment etc.) to carry out geotechnical investigation work in creek/ river locations identified by the Employer.
- 4.11.2 In the event of storm or stoppage of work, etc., Contractor shall not be paid extra for mobilization/ remobilisation of floating pontoon, plant, equipment, etc.
- 4.11.3 Contractor shall fully satisfy himself about the conditions of creek/ river (depth of water, wave currents, wind conditions, etc.) prevailing in the area of proposed investigation and plan the necessary tools and plant to be deployed before quoting. Any claim resulting from lack of data collection in this respect shall not be entertained.
- 4.11.4 Contractor shall make his own arrangements for locating the coordinates and position of boreholes in creek/ river with respect to two grid-lines indicated by Employer.
- 4.11.5 Boring in creek or river shall be payable only below the bed level and no payment shall be made for lowering the casing in water.
- 4.11.6 Contractor shall arrange for necessary transportation on water (e.g. motor boat) to facilitate the supervision of work by officials of Employer at its own cost.
- 4.11.7 Full details of the construction plant, proposed working method for boring and sampling in water shall be submitted along with the Tender.

5 Statutory Regulations and Standards

- 5.1 Contractor is required to follow statutory regulations stipulated in Electricity Act 2003, Indian Electricity Rules and other local rules & regulations.
- 5.2 The codes and standards referred to in these specifications shall govern. In case of a conflict between such codes/ standards and these specifications, the provisions of the specifications shall prevail. Such codes, standards referred to shall mean latest revisions, amendments, changes adopted and published by relevant agencies.
- 5.3 Other Internationally acceptable standards which ensure equivalent or better performance than those specified shall also be acceptable.

SECTION-IVA

TOWER DESIGN

**(Applicable for Transmission Lines
wherein Tower Design is in
Contractor's scope)**

(Strikeout/Delete whichever is not applicable)

**TECHNICAL
SPECIFICATIONS
SECTION- IV A
TOWER DESIGN**

1.1 Transmission Tower

The general description of towers applicable for the package and technical particulars thereof are indicated in Section-I of this Specification.

1.2 Tower Extensions

- 1.2.1 The towers shall be designed so as to be suitable for adding -6.0m/ -4.5m/ -3.0m/ -1.5m/ +0m/ +1.5m/ +3.0m/ +4.5m/ +6.0m/ +7.5m/ +9.0m/ +18m/+25m/ +30/ +35m body truncations/ extensions/ leg extensions for maintaining adequate ground clearances without reducing the factor of safety (actual stress / allowable stress) available for the members of tested extensions to the extent possible.

Contractor shall be required to develop Structural drawing, BOM and shop sketches for all the above body extensions and leg extensions and submit the same for approval of Employer/ PGCIL, irrespective of the actual requirement at site. Charges for the same are deemed to be included in the quoted prices.

- 1.2.2 The provision for addition of +12m/ +15m/ +18m/ +25m/ +30m/ +35m body extension to tower types A/DA/QA, B/DB/QB, C/DC/QC and D/DD/QD is also to be kept. For Power Line Crossing or any other obstacle, tower types A/DA/QA, B/DB/QB, C/DC/QC and D/DD/QD can be used with +12m/ +15m/ +18m/ +25m/ +30/+35m extensions depending upon the merit of the prevailing site condition (as per relevant Clause of Sec-III). The maximum reduced spans for A/DA/QA, B/DB/QB, C/DC/QC and D/DD/QD type towers shall be mentioned in the tower spotting data prepared by contractor based on design. However, this shall, in no case be less than 250 meters.

Power Line crossing shall be done as described in ***Section-III***.

- 1.2.3 For 400kV and above voltage level lines, the B/DB, C/DC, and D/DD towers shall be designed for providing unequal leg extensions from -6.0m/ -4.5m/ -3.0m/ -1.5m/ +0m/ +1.5m/ +3.0m/ +4.5m/ +6.0m/ +7.5m/ +9.0m with maximum difference between the shortest and the longest leg of 3m. These unequal leg extensions to be provided in the design shall be used during tower spotting/ execution stage to optimize the benching / revetment requirement besides use of suitable chimney extensions.

For 132 kV & 220 kV voltage level lines as well as A/DA/QA type tower of 400 kV & above voltage level lines, the towers shall not be designed for unequal leg extension. However, during execution of the project, suitable chimney extension and/or unequal leg extension shall be used on case-to-case basis considering the actual site condition. The contractor shall submit the proposal for approval of the Employer. For unequal leg extension of these towers, either the same may be considered for use with reduced spans or suitable changes in the design shall be made by the contractor. The design charges for these unequal leg extension

towers shall be deemed to be included in the contract price. The charges for the towers shall be paid on pro-rata basis derived from the rates indicated in price schedule of Contract Agreement and final approved weight of the corresponding standard (± 0 m) tower.

- 1.2.4 In situations where difference in leg differential does not suit the standard unequal leg extension provisions on the towers mentioned above, suitable chimney extensions shall be provided to reduce benching/ revetment requirement.
- 1.2.5 The leg extensions, unequal leg extensions, chimney extensions and/ or a combination of these suitable for a tower location shall be selected on the basis of techno-economics evaluation.
- 1.2.6 All above body/ leg extension provisions to towers shall be treated as part of normal tower only.
- 1.2.7 The payment for leg extensions, as per payment terms indicated shall be on pro-rata basis derived from the rates indicated in price schedule of Contract Agreement and final approved weight of the corresponding standard (± 0 m) tower
- 1.2.8 During execution, if other types of towers/ structures viz Gantry, single circuit/ Multi circuit towers in Double circuit line, Double circuit/ Multi-circuit towers in a Single circuit line, Single circuit/ Double circuit towers in a Multi-circuit line, Narrow base towers, Towers of higher extensions (viz. +43m/ +55 m for 765 kV D/C lines wherever applicable), Towers of different configuration etc. are required, fabrication and installation of these items shall be carried out by the contractor as per Employer supplied design/drawings. If Employer designed towers are not covered in the BOQ, payment for these shall be made on the basis of per MT rate(s) derived from the rate(s) contained in the Contract for A+0/DA+0/QA+0 m tower as the case may be.
- 1.2.9 **Gantry structures/ Towers with higher extensions/ Special River Crossing Towers/ Multi Circuit Towers Specified in BPS**
- The unit rates are indicated in BOQ, the bidder to quote on percentage basis on entire tender cost for supply, transportation & installation of towers as well as installation of Stub & Foundations for Gantry structures/ Towers with higher extensions (viz. +43m/ +55 m for 765kV D/C lines wherever applicable)/ Special River Crossing Towers/ Multi Circuit Towers based on the Bill of Quantities (BOQ) furnished in the Bid Proposal. However, the payment will be made as per actual quantity executed as per Employers' supplied design & drawing and the quoted unit rates.
- 1.2.10 **Towers for Major Crossings**
- B/DB/QB, C/DC/QC & D/DD/QD towers shall also be used with suitable modifications for very long spans (spans more than that of given in clause which cannot be crossed by normal tower with extensions as given in clause.no.1.2.3 like Major river crossings etc. These Towers shall be developed by strengthening the above B/DB/QB, C/DC/QC and D/DD/QD type towers as per the site requirement. Additional weight of tower due to strengthening shall be paid on pro-rata basis

derived from the rates indicated in percentage BOQ schedule of Contract Agreement and final approved weight of the standard (± 0 m) tower.

1.3 Spans

1.3.1 Design Span or Normal Span

The design Span or normal ruling span of the line of different voltage level is given in Table 1.3.1 below:

Table: Design Span or Normal Ruling Span

Sl. No.	Voltage Level of Transmission Line	Design Span or Normal Ruling Span
A)	400 kV, 765 kV, ± 500 kV HVDC and ± 800 kV HVDC	400 meters
B)	220 kV	350 meters
C)	132 kV	320 meters

1.3.2 Wind Span

The wind span is the sum of the two half spans adjacent to the tower under consideration. For normal horizontal spans, this equals to normal ruling span.

1.3.3 Weight span

The weight span is the horizontal distance between the lowest points of the conductors on the two spans adjacent to the tower. For spotting of structures, the span limits are given in Table 1.3.2 below:

Table: 1.3.2: Weight Span

Sl. no.	Tower Type	Normal Condition		Broken wire condition	
		Maximum (m)	Minimum (m)	Maximum (m)	Minimum (m)
A)	400 kV, 765 kV, $\pm$500 kV HVDC and +800 kV HVDC line				
i)	A/DA/QA	600	200	360	100
li)	B/DB/QB, C/DC/QC	600	0	360	-200
iii)	D/DD/QD	600	0	360	-300
iv)	Dead End condition for D/ DD/QD	300	0	60	0
v)	Dead End with Slack Span condition for D/DD/QD	450	0	330	-300
B)	220 kV line				
i)	A/DA/QA	525	200	315	100
li)	B/DB/QB, C/DC/QC	525	0	315	(-) 200
iii)	D/DD/QD	525	0	315	(-) 300
iv)	Dead End condition for D/ DD/QD	263	0	53	0
v)	Dead End with Slack Span condition for D/DD/QD	413	0	300	(-) 300
C)	132 kV line				
i)	A/DA/QA	480	200	300	100
li)	B/DB/QB, C/DC/QC	480	0	310	(-) 200
iii)	D/DD/QD	480	0	310	(-) 300
iv)	Dead End condition for D/ DD/QD	240	0	48	0
v)	Dead End with Slack Span condition for D/DD/QD	390	0	270	(-) 300

1.3.4

In case at certain locations where actual spotting spans exceed the design spans and cross-arms & certain members of towers are required to be modified/ reinforced, in that case design, structural & shop drawings for the modified/ reinforced towers will be prepared by the Contractor as per the requirement on the basis of approved line diagram without any additional financial implications to the Employer (NHIDCL) for the design and drawings.

1.4 Electrical Clearances

1.4.1 Ground Clearance

The minimum ground clearance from the bottom conductor at maximum sag conditions i.e. at 85°C and still air shall be as indicated in ***Section-I*** of TS.

1.4.3 Live Metal Clearance

The minimum live metal clearance to be provided between the live parts and steel work of superstructure shall be as given in Tables below

For 765kV S/C (Vertical Delta)/ 765kV D/C transmission lines:

Wind pressure Condition	Minimum electrical clearance
A. For "I" Suspension Insulator Strings (for A/DA Tower):	
1. 0° Swing	6100 mm (For D/C) 5600 mm (for S/C)
2. 25° Swing	4400 mm
3. 55° Swing	1300 mm
B. For Jumpers in tension insulator strings (with or without Pilot)	
1. 0° Swing	6100 mm (For D/C) 5600 mm (for S/C)
2. 25° Swing	4400 mm
3. 55° Swing	1300 mm

For 765kV D/C, Pilot insulator strings are to be used for D/DD/QD towers only.

For 765kV S/C (Vertical Delta), Pilot Insulator Strings are to be used in the top cross-arm for all Vertical Delta tension towers (as per indicative sketch enclosed in the technical specification). Only for D type towers, Pilot insulator strings are also to be used in the bottom cross-arm.

For 765kV S/C (Horizontal Configuration) transmission lines:

Wind pressure Condition	Minimum electrical clearance
A. For "I" Suspension Insulator Strings (for A type Tower):	
1. 0° Swing	5600 mm
2. 25° Swing	4400 mm
3. 55° Swing	1300 mm
B. For "I" Suspension Insulator Strings (for B type Tower):	
1. 20° Swing	5600 mm

2. 41° Swing	4400 mm
3. 64° Swing	1300 mm
C. For Jumpers in tension insulator strings (with I pilot or without Pilot)- for C type towers	
1. 15° Swing	5600 mm
2. 25° Swing	4400 mm
3. 40° Swing	1300 mm
D. For Jumpers in tension insulator strings (with I pilot or without Pilot)- for D type towers	
1. 20° Swing	5600 mm
2. 30° Swing	4400 mm
3. 40° Swing	1300 mm
E. For V string used in Central phase of Tower type A & B and V-Pilot string used in Central phase of Tower type C & D	
To boom frame	5100 mm
To window frame	5600 mm

I Pilot string shall be used in outer phases of only Tower type C & D
V Pilot string shall be used in central phase of only Tower type C & D

For 400kV transmission lines:

Wind pressure Condition	Minimum electrical clearance
A. For Single Suspension Insulator Strings	
1. 0°-22° Swing	3050 mm
2. 22°-44° Swing	1860 mm
B. For Jumpers in tension insulator strings	
The pilot insulator strings are to be used for D/DD /OD towers only.	
1. 0°-25° Swing	3050 mm
2. 40° Swing	1860 mm

For 220 kV transmission lines:

The minimum live metal clearances for 220 kV D/C transmission lines shall be considered as follows:

- (i) Under stationary conditions From tower body: 2.13 m
- (ii) Under swing conditions

Wind pressure Condition	Minimum electrical clearance	
For “I” Suspension Insulator Strings		
1. 0° Swing	2130 mm	
2. 15° Swing	1980 mm	
3. 30° Swing	1830 mm	
4. 45° Swing	1675 mm	
For Jumpers in tension insulator strings		
Wind pressure Condition	(without Pilot)	(with Pilot)
1. Swing angle (0° - 10°)	2130 mm	2130 mm
2. Swing angle (0° - 15°)	NA	1980 mm
3. Swing angle (20°)	1675 mm	NA

The pilot insulator strings are to be used for D/DD /QD towers only.

For 132 kV transmission lines:

The minimum live metal clearances for 132 kV transmission lines shall be considered as follows:

- (i) Under stationary conditions From tower body: 1530 mm
- (ii) Under swing conditions

Wind pressure Condition	Minimum electrical clearance
For "I" Suspension Insulator Strings	
1. Swing angle (15°)	1530 mm
2. Swing angle (30°)	1370 mm
3. Swing angle (45°)	1220 mm
4. Swing angle (60°)	1070 mm
For Jumpers in tension insulator strings (without Pilot)	
1. Swing angle (0° - 10°)	1530 mm
2. Swing angle (20°)	1070 mm
3. Swing angle (30°)	1070 mm

Pilot (s) is not to be considered for Jumper Swing

The bidder is permitted to adopt separate cross arm for D/DD/QD type towers under dead end conditions provided adequate live metal clearance is available With at least 15° angle on both sides i.e. line side and slack span side, and also provided that all the specified conditions of the specification are fulfilled.

For 765kV S/C Vertical Delta Tension Towers, provisions shall be made so that the top cross arm can be attached to either side of the tower body.

- 1.4.4** Bidder shall adopt same cross arm design where jumper is projecting outside of cross-arm for D/DD/QD type tower, used as dead end and angle tower.
- 1.4.5** For computing the live metal clearances, the dimensions of strings shall be taken from the drawings enclosed. The design of the tower shall be such that it should satisfy all the above conditions when clearances are measured from any live point of the strings.
- 1.4.6** Cross arm projections for Dead end towers shall be fixed in such a way that it can accommodate a condition of 15degree deviation of conductors towards tower at both Left and Right-side cross arms on slack span side and 0-15 degrees deviation on line side.
- 1.4.6.1** For Dead End Tower design conditions, following wind span is to be considered:

Wind Span for Dead End

Tower Type	Normal Condition	Broken wire condition
For 765kV & 400kV		
Dead End	200	40
Dead End with Slack Span	300	220
For 220kV		
Dead End	175	35
Dead End with Slack Span	275	195
For 132kV		
Dead End	160	32
Dead End with Slack Span	260	180

1.4.7 Angle of Shielding

The angle of shielding is defined as the angle formed by the line joining the centre lines of the earth wire/OPGW and outer power conductor in still air at tower supports, to the vertical line through the center line of the earth wire. Bidders shall design the tower in such a way that the angle of shielding does not exceed the value given in the table below. The drop of the earth wire clamp equal to 150 mm should be considered while calculating the minimum angle of protection:

Sl. No.	Voltage Level of Transmission Line	Angle of Shielding
A)	765 kV D/C ± 500 kV HVDC and ± 800 kV HVDC line	10^0
B)	765 kV S/C and 400 kV line	20^0
C)	220 kV and 132 kV line	30^0

1.4.8 Mid Span Clearance

The minimum vertical mid span clearance between the earthwire and the nearest power conductor shall not be less than the value given below, which shall mean the vertical clearance between earthwire and the nearest conductor under all temperatures and still air condition in the normal ruling span. Further, the tensions of the earthwire/ OPGW and power conductor shall be so co-ordinated that the sag of earthwire/ OPGW shall be at least 10% less than that of power conductors under all temperature loading conditions.

Sl. No.	Voltage Level of Transmission Line	Mid Span Clearance
A)	± 800 kV HVDC	12000 mm
B)	400 kV, 765 kV and ± 500 kV HVDC	9000 mm
C)	220 kV	8500 mm
D)	132 kV	6100 mm

1.4.9 Tower Loading Conditions:

- The design of towers shall be carried out by the Contractor as per IS 802 (Part 1/section-1)2015* except for drag coefficients which shall be as per IS 802 (Part 1/section-1) 1995 and considering Wind Zone as per Section-I of the TS.
- Terrain category shall be considered as 2.
- Reliability level shall be considered as 1 for 132kV, 220kV & 400 kV (twin bundle conductor) and 2 for triple & quadruple circuit towers and towers with more than two sub-conductors per phase upto 400 kV & 765 kV towers.
- Contractor shall offer tower/ foundation design considering the type of conductor, being supplied by them under the package and the conductor, earthwire & OPGW properties as per those mentioned in the respective sections.

- e) Under broken wire condition, tower shall be designed considering transverse load based on maximum angle of deviation and longitudinal load based on minimum angle of deviation mentioned in **Section-I** of Technical specifications.

* Note:

- i) As per Clause 12.1.2.1 b) 2) of IS 802:2015, Under security condition for tension and dead end towers, the transverse loads due to line deviation shall be the component of 100 percent mechanical tension of conductor and ground wire/ OPGW corresponding to 100% of design wind pressure at everyday temperature or 36% design wind pressure at minimum temperature after accounting for drag coefficient and gust response factor.
- ii) As per Clause 15 of IS 802:2015, for 400kV and higher voltage lines, the final unloaded tension of conductor at everyday temperature shall not exceed 22 percent of the ultimate tensile strength of conductors and 20 percent of the ultimate tensile strength of ground wire/ OPGW irrespective of the design criteria specified for conductor.
- iii) For normal towers, the value of final unloaded tension of conductor at everyday temperature considered for Tower Design under Safety Condition and Anti-cascading condition, shall not be less than 25% of the ultimate tensile strength of conductors for below 400kV voltage level transmission lines and not less than 22% of the ultimate tensile strength of conductors for 400 kV and higher voltage lines.
- iv) At ruling span, the final unloaded tension of conductor at everyday temperature of upper phase shall not be less than that of conductor in lower phase so as to maintain the phase-to-phase spacing.
- v) The main load carrying members shall be designed in such a way that even under the worst combination of unequal /equal leg extensions and loading, utilization of members does not exceed the values indicated in the table below:

Sl. No	Members	Utilizations	
		Compression	Tension
1	Leg / peak	96 %	96 %
2	Bracings (Diagonals/ Horizontals)	90 %	95 %
3	Cross Arm/Boom members i. e. Top/ Bottom member	90 %	95 %

1.4.10 Design Temperatures

The following temperature range for the conductors and ground wires shall be adopted for transmission line design:

- i) Minimum Temperature : 0°C
- ii) Every day temperature of conductor : 32°C
- iii) Max. temperature of
 - a) Conductor (ACSR/ Al59/AAAC) : 85°C
 - b) Conductor (HTLS) : Refer TS for HTLS conductor
 - b) Earthwire exposed to sun : 53°C

1.4.11 Phase Configuration

For single circuit towers of Horizontal Configuration, three phases shall be in Horizontal formation. For single circuit towers of Vertical Delta configuration, three phases shall be in vertical delta formation (as per the drawing enclosed with Technical Specifications) and for double circuit towers, three phases shall be in vertical formation. The phase to phase spacing for conductors shall be not less than 15000 mm for 765 kV & 8000 mm for 400 kV vertically. For 220kV & 132kV, required vertical phase to phase spacing shall be governed by the tower design as well as minimum live metal clearances under different insulator swing angles.

1.5 BOLTS, NUTS, JOINTS AND PANEL HEIGHT

- 1.5.1 The minimum bolt spacing and rolled edge distance and sheared edge distance from the centers of bolt holes to be maintained are given in the Table below:

Diameter of Bolt (mm)	Hole diameter (mm)	Minimum Bolt spacing (mm)	Minimum Rolled distance (mm)	Minimum Sheared Edge distance (mm)
16	17.5	40	20	23
24	25.5	60	33	38

Bolts sizes mentioned above shall only be used. The minimum width of the flanges without bolt holes shall be 30 mm

- 1.5.2 For the purpose of calculating shearing stress and bearing stress for bolts, clause 5.6 Of IS 802 (Part-1/Sec 2):2016 shall be referred.
- 1.5.3 The bolt positions in assembled towers shall be as per IS 5613 (Part-II / Section 2): 1976.

- 1.5.4 Joints shall be designed so as to avoid eccentricity. The use of gusset plates for jointing tower member shall be avoided as far as possible. However, where connections are such that the elimination of the gusset plates would result in eccentric joints then gussets plates and spacer plates may be used in conformity with modern practices. The thickness of the gusset plate, required to transmit stress, shall not be less than that of the thinnest of connected member but not less than 5 mm in any case.
- 1.5.5 For butt joints, the cleat area shall not be less than 60% of the area of the smaller section and the total area of plate and cleat shall not be less than 1.2 times the area of the smaller section
- 1.5.6 Height of any panel shall not be more than 14 meters.
- 1.5.7 For designing of towers, rationalized steel sections conforming to IS 808 or BS EN 10025 shall be used.

SECTION-IVB

TOWER TESTING (Applicable for Transmission Lines wherein Tower Testing is in Contractor's scope)

**TECHNICAL
SPECIFICATIONS
SECTION- IV B
TOWER TESTING**

1.0 Tower Load Tests

1.1 Testing of Tower

A Galvanized tower of each type complete with 0m extension for 765 kV & with +9M extension for 400 kV, 220 kV & 132 kV shall be subjected to design and destruction tests by first applying test loads applied in a manner approved by the Employer. The tower shall withstand these tests without showing any sign of failure or permanent distortion in any part. Thereafter, the tower shall be subjected to destruction by increasing the loads further in an approved manner till it fails. The tower shall be tested for all the conditions considered for the design of tower. The Contractor shall submit to the Employer /PGCIL, for approval, the detailed programme and proposal for testing the towers showing the methods of carrying out the tests and manner of applying the loads. After the Employer/ PGCIL has approved the test procedures and programme, the Contractors will intimate the Employer/ PGCIL about carrying out the tests at least 30 days in advance of the scheduled date of tests. Employer /PGCIL will arrange to depute his representative to be present at the time of carrying out the tests. Two (2) copies of the test reports shall be submitted after completion of the tests. The Contractor shall submit one set of shop drawings alongwith the bill of materials at the time of prototype tower testing for checking the tower material. Further, at the time of submitting test report, the contractor has to submit the final structural drawings, shop drawings and Bill of materials for Employer's reference and record.

- 1.1.1 In case of premature failure, the tower shall be retested and steel already used in the earlier test shall not be used again. However, in case of minor failures, the contractor can replace the members with higher section and carry out the testing. The Contractor shall provide facilities to the Employer/ Nodal officer of PGCIL for inspection of materials during manufacturing stage and also during testing of the same.
- 1.1.2 In case of any premature failure even during waiting period, the tower is to be retested with rectified members. However, if the failures are major in nature and considerable portion of tower is to be re-erected, in such cases, all the tests which has been carried out earlier are required to be re-conducted again in compliance with Specification.
- 1.1.3 No part of any tower subject to test shall be allowed to be used on the line.

- 1.1.4 The Contractor shall ensure that the specification of materials and workmanship of all towers actually supplied conform strictly to the towers which have successfully undergone the tests. In case any deviation is detected, the Contractor shall replace such defective towers free of cost to the Employer. All expenditure incurred in erection, to and from transportation and any other expenditure or losses incurred by Employer on this account shall be fully borne by the Contractor. No extension in delivery time shall be allowed on this account.
- 1.1.5 Each type of tower to be tested shall be a full-scale prototype galvanized tower and shall be erected vertically on rigid foundation of the stub protruding above ground level as provided in the design/ drawing between ground level and concrete level. This portion of the stub shall be kept un-braced while testing. The tower erected on test bed shall not be out of plumb by more than 1 in 360.
- 1.1.6 All the measuring instruments shall be calibrated in systematic/ approved manner with the help of standard weight/ device. Calibration shall be done before commencing the test of each tower up to the maximum anticipated loads to be applied during testing.
- 1.1.7 The suspension tower is to be tested with an arrangement similar to 'I' string. The tension tower is to be tested with strain plate as per approved design/ drawings.
- 1.1.8 The sequence of testing shall be decided by the Employer/ Nodal officer of PGCIL at the time of approving the rigging chart/ test data sheet.
- 1.1.9 The Employer/ PGCIL may decide to carry out the tensile test, bend test etc. as per the relevant IS on few members of the test tower after completion of the test or in case of any premature failure. The Contractor shall make suitable arrangement for the same without any extra cost to the Employer.
- 1.1.10 Prefix 'T' shall be marked on all members of test tower in addition to the Mark No. already provided.
- 1.2 **Method of Load Application**
- 1.2.1 Loads shall be applied according to the approved rigging arrangement through normal wire attachments angles on bent plates.
- 1.2.2 The various types of loads, transverse, vertical and longitudinal shall be applied in such a way that there is no impact loading on the tower due to jerks from the winches.
- 1.2.3 All the loads shall be measured through a suitable arrangement of strain devices or by using weights. Positioning of the strain devices shall be such that the effect of pulley friction is eliminated. In case the pulley friction cannot be avoided, the same will be measured by means of standard weights and accounted for in the test loads.

1.3 Tower Testing Procedure

The procedure for conducting the tower test shall be as follows:

1.3.1 Bolt Slip Test

In a bolt slip test, the test loads shall be gradually applied up to the 50% of design loads under normal condition, kept constant for two (2) minutes at that loads and then released gradually.

For measurement of deflection, the initial and final readings on the scales (in transverse & longitudinal directions) i.e. before application and after the release of loads shall be taken with the help of theodolite. The difference between readings gives the values of the bolt slip.

1.3.2 Normal Broken Wire Load Tests

All the loads, for a particular load-combination test, shall be applied gradually upto the full design loads in the following steps and shall also be released in the similar manner:

25 percent,

50 percent,

75 per cent,

90 percent,

95 percent and

100 percent

1.3.3 Observation Periods

Under normal and broken wire load tests, the tower shall be kept under observation for sign of any failure for two minutes (excluding the time of adjustment of loads) for all intermediate steps of loading up to and including 95 percent of full design loads.

For normal, as well as broken wire tests, the tower shall be kept under observation for five (5) minutes (excluding the time for adjustment of loads) after it is loaded up to 100 percent of full design loads.

While the loading operations are in progress, the tower shall be constantly watched, and if it shows any tendency of failure anywhere, the loading shall be immediately stopped, released and then entire tower shall be inspected. The reloading shall be started only after the corrective measures are taken.

The test shall be considered to be satisfactorily passed if it is able to support the specified full design loads for five (5) minutes with no visible local deformation After unloading (such as bowing, buckling etc.) and no breakage of elements or constituent parts.

Ovalization of holes and permanent deformation of bolts shall not be considered as failure.

1.3.4 Recording

The deflections of the tower in transverse and longitudinal directions shall be recorded at each intermediate and final stage of normal load and broken wire load tests by means of a theodolite and graduated scale. The scale shall be of about one meter long with marking up to 5 mm accuracy.

1.3.5 Destruction Test

The destruction test shall be carried out under normal condition or broken wire condition. Load condition for destruction test shall be mentioned in approved

rigging chart/ test data sheet.

The procedure for application of load for normal/ broken wire test shall also be applicable for destruction test. However, the load shall be increased in steps of five (5) per cent after the full design loads have been reached.

- 1.3.5.1 Type tests specified above shall not be required to be carried out if a valid test certificate is available for a similar design meeting all technical specification requirements. The tests certificate shall be considered valid if

Tests certificate issued thereof by the Test Agency to the contractor approved by the representative(s) of any utility, preferably by Public owning Utility.

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

- 1.3.5.2 Type test charges for type test indicated above are deemed to be taken in to account by the bidder.

SECTION-IVC

TOWER: MATERIALS, FABRICATION, ERECTION & STRINGING

(Strikeout/Delete whichever is not applicable)

**TECHNICAL
SPECIFICATIONS
SECTION-IV C
TOWER: MATERIALS, FABRICATION, ERECTION & STRINGING**

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**TECHNICAL
SPECIFICATIONS**

SECTION- IV C

TOWER: MATERIALS, FABRICATION, ERECTION & STRINGING

1.1 Transmission Tower Materials

1.1.1 Tower Steel Sections

For Non-Snow Regions, IS Steel Sections of any tested quality A, B0 or BR in conformity with IS 2062:2011 corresponding to grade E250 (Designated Yield Strength. 250 MPa) and/ or grade E350 (Designated Yield Strength 350 MPa) may be used in towers, extensions, stubs and stub setting templates. For Snow Regions, IS Steel Sections of tested quality C in conformity with IS 2062:2011 corresponding to grade E250 and/or E350 shall be used. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards viz BSEN 10025. However, use of steel grade having designated yield strength more than that of EN 10025 grade S355 JR/JO (designated yield strength 355 MPa) is not permitted, unless otherwise indicated in this specification.

Steel plates below 6mm size exclusively used for packing plates/ packing washers produced as per IS 1079 (Grade-0) are also acceptable. However, if below 6mm size plate are used as load bearing plates viz gusset plates, joint splices etc. the same shall conform to IS 2062 or equivalent standard meeting mechanical strength/ metallurgical properties corresponding to grade E250 or above grade (designated yield strength not more than 355MPa), depending upon the type of grade incorporated into design. Flats of equivalent grade meeting mechanical strength/ metallurgical properties may also be used in place of plates for packing plates/ packing washers. The chequered plates shall conform to IS 3502. SAILMA 350HI grade plate can also be accepted in place of HT plates (EN 10025 grade S355 JR/ JO/ IS 2062:2011- grade E350, as applicable) provided SAILMA 350HI grade plate meet all the mechanical properties of plate as per EN 10025 grade S355 JR/JO (designated yield strength 355 MPa)/ IS 2062:2011-grade E350. While selecting equivalent grade, requirement of IS 2062 for particular grade has to be fully complied. Further, material shall be imported from the manufacturers having valid BIS license.

During execution of the project, if any particular section is not available, the same shall be substituted by higher section/ Grade. Any cost on account of the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Employer/ PGCIL before any substitution and records of such substitutions shall be maintained by the Contractor.

1.1.2 Fasteners: Bolts, Nuts and Washers

1.2.2.1 All tower members shall be joined together with Hexagonal Bolts and nuts. All hexagonal bolts and nuts shall conform to IS 12427. They shall have hexagonal head and nuts, the heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight.

All bolts and nuts shall be galvanized as per IS 1367 (Part-13)/IS 2629.

1.2.2.2 The bolt shall be of 16/ 24 mm diameter and of property class 5.6 as specified in IS 1367 (Part-III) and matching nut of property class 5.0 as specified in IS 1367 (Part-VI).

1.2.2.3 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 bolts 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-I) to ensure proper bearing.

1.2.2.4 Nuts for hexagonal bolts 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 0.4mm oversize on effective diameter for size up to M16.

1.2.2.5 Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.

1.2.2.6 All bolts shall be threaded to take the full depth of the nuts and threaded for enough to permit firm gripping of the members, but not further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3mm and not more than 8mm when fully tightened. All nuts shall fit tight to the point where the shank of the bolt connects to the head.

1.2.2.7 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be steel electro- galvanised, positive lock type and 3.5mm in thickness for 16mm dia bolt and 4.5mm for 24 mm bolt.

1.2.2.8 To avoid bending stress in bolts or to reduce it to minimum, no bolt shall connect aggregate thickness of members more than three (3) times its diameter.

1.2.2.9 The bolt positions in assembled towers shall be as per structural drawing.

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

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

1.5.1 **Design and Drawings**

1.5.2 **In case design of tower is covered in the scope of Contractor: -**

1.5.2.1 The following design calculation and drawings are required to be furnished to the Employer/ PGCIL

A) Alongwith the bid:

i) Detailed design calculations and drawings for A/DA/QA (as applicable) type tower of any one wind zone applicable for each of the package quoted by the Bidder

ii) Line diagram of all the tower types indicating live metal clearances, ground clearance, mid span clearance, shielding

angle etc. as applicable in the package.

- iii) Typical foundation sketches adopted for various types of soil. Bidder has to furnish along with the bid one sample calculation for one type of foundation for Towers at A i) above.

The above is for assessing the present design capability of the Bidder and should not be construed as review/ approval of correctness of drawings/ designs by the Employer. Subsequent to the award, successful Bidder shall have to comply with the technical specifications irrespective of the designs/drawings submitted at the bidding stage without any financial implication to the Employer.

B) After award of contract:

The Contractor shall submit detailed design of tower & extension alongwith stress diagram/ computer output together with sample calculations for few critical members etc., stub templates and loading/ rigging arrangement of tower testing to enable the Employer to make a preliminary check regarding structural stability of tower (before) tests.

In case, contractor proposes to use tested design of tower/ towers meeting all technical specification stipulations, the approved copy of design/ drawing of tower from utility along with proto type test report shall be submitted to purchaser for approval.

- C) After successful testing of the tower and subsequent approval of design, drawings and bill of materials, the Contractor shall submit the documents to the Employer for necessary distribution with in fifteen (15) days after approval of drawings:
 - a) Detailed design calculation and drawing for towers and foundations.
 - b) Detailed structural drawings indicating section size, length of members, sizes of plates along with hole to hole distance & joint details etc.
 - c) Bill of materials,
 - d) Shop drawings showing all details relevant to fabrication including cutting and bending details against each member.
 - e) All the drawings for the tower accessories.

1.5.3 **In case of Employer design tower: -**

1.5.3.1 The relevant drawings for all the towers and their extensions shall be furnished to the Contractor by the Employer/ Nodal officer of PGCIL which shall include structural drawings/ erection drawings and/ or shop fabrication drawings, Bill of Materials for all the towers and their extensions as well as construction drawings for foundations.

1.5.3.2 The tower members can be directly fabricated from the structural/ erection drawings wherever the required fabrication details are provided on the same or shop fabrication drawings. However, if the contractor is required to prepare shop fabrication drawings, of their own, in addition to the structural/

erection drawings with required fabrication details, they may prepare the same without any additional financial implication to Employer.

1.5.4

Proto Assembly:

- i) Contractors, who have not done the proto-assembly of the towers/ tower extensions or have not supplied the same towers/ tower extensions against any earlier POWERGRID's project, shall before taking up mass fabrication, the Contractor shall arrange for one number proto assembly for each type of towers and extensions. POWERGRID reserves the right to get the same witnessed by their representative. After proto-assembly, the contractors, shall incorporate revisions in the drawings/ documents if any on account of proto corrections, and make necessary endorsement with reference to the respective packages/ Letter of Awards. The revised drawing/ documents shall be submitted for final approval by the Employer.
- ii) The contractors who have already done the proto-assembly of the towers/ tower extensions or have supplied the same towers/ tower extensions against any earlier POWERGRID's project need not do the proto assembly. They shall submit documentary evidence viz. proto-inspection reports, supply records etc. in its support. However, they may do the proto- assembly for their verification and satisfaction. Further, they shall submit the structural drawings and BOM of tower/ tower extensions after endorsing the projects name for further distribution by Employer. No payment shall be made to the Contractor on the account of proto-assembly in either of the cases mentioned at (i) or (ii).

In any case, the onus of correct fabrication / fitment of tower parts shall lie with contractor. Any defect, if found during erection at site, the same has to be rectified by the contractor without any additional financial implication to POWERGRID.

1.5.5

All the drawings shall have a proper name plate clearly displaying the name of Employer on right hand bottom corner. The approval for exact format of the nameplate shall be provided to the successful bidder for incorporation of the same on all the drawings.

1.5.6

The Contractor is required to submit the drawings as mentioned in clause 1.5.1 for Employer's/ Nodal officer of PGCIL approval. While submitting the designs, structural drawings, bill of materials and any other drawing pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing POWERGRID/ S-V 1 NHIDCL Specification No., Name of the transmission line and project, letter reference No. and date on which the submission are made. The same practice is also to be followed while submitting distribution copies.

1.5.7

The tower accessories drawings like device, Earthing Arrangement, Bird Guard, flight diverter, etc. are enclosed in drawing section of this

specification. The contractor is required to submit distribution copies of the above drawings after endorsing the name of the projects.

- 1.5.8 The drawings submitted by the Contractor shall be approved/ commented by the Employer/ PGCIL as the case may be within fifteen (15) days of receipt of drawings in PGCIL office. If the designs/ drawings are commented by the PGCIL, the Contractor shall submit revised design/ drawings duly incorporating all comments within fifteen (15) days of date of issue of comments.

The mass fabrication shall be taken up from the shop drawings. The overall responsibility of fabricating tower members correctly lies with the Contractor only and the Contractor shall ensure that all the tower members can be assembled/ fitted while erecting without any undue strain on them.

- 1.5.9 The Contractor is required to furnish the progress of submissions and approvals of designs and drawings on twenty fifth day of every month till the completion of all the design activities.
The details shall include description of design/ drawing, schedule date of submission, actual date of submission, schedule date of approval, actual date of approval, schedule date of submission of distribution copies, actual date of submission of distribution copies, schedule date of tower test, actual date of tower test and 'Remarks' column. Provision of six additional columns shall also be made in the above progress report to indicate date of comments issued by the Employer/ PGCIL and details of submission of revised designs/ drawings.
- 1.5.10 Other than the items indicated above, some other drawings and documents such as BOM, Shop drawings, structural drawings for towers/ extensions which are required for the project, shall also be developed by the Contractor based on single line diagram provided by the Employer. However, no extra cost on this account shall be payable to the Contractor.

1.3 Tower Accessories

Arrangement shall be provided for fixing of all tower accessories to the tower at a height between 2.5 meters and 3.5 meters above the ground level.

1.3.1 Step Bolts & Ladders

Each tower shall be provided with step bolts as per drawing enclosed in the section of drawing. The step bolts conforming to IS 10238 of not less than 16mm diameter and 175 mm long, spaced not more than 450 mm apart and extending from 2.5 meters above the ground level to the top of the tower. However, the head diameter shall be 35mm as indicated in the enclosed drawing. The step bolt shall be fixed on two diagonally opposite legs up to top of the towers for single, double and multi circuit towers. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN. For special river crossing towers, ladders alongwith protection rings as per the Employer approved design shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. From 2.5m to 30m height of super structure step bolts shall be fixed on two diagonally opposite legs. Suitable platform using 6mm thick perforated chequered plates alongwith suitable railing for access from step bolts to the ladder and from the ladder to

each cross-arm tip and the ground wire support shall also to be provided. The platform shall be fixed on tower by using counter-sunk bolts.

1.3.2 Insulator Strings and Earth wire Clamps Attachments

- a) For the attachment of suspension Insulator string, if required a suitable dimensioned swinging hanger on the tower shall be provided so as to obtain specified clearances under respective swinging condition of the strings. The hanger, extensions links, D-shackles etc. as required shall be of same rating/ strength as that of corresponding rating/ Ultimate tensile Strength of Insulator string. The design and supply of hanger, D-shackles, strain plate, extension link etc. are also in the scope of Contractor.
- b) At tension towers, strain plates of suitable dimensions under each cross-arm tip, shall be provided for taking the hooks or D-shackles of the tension insulator strings. Full details of the attachments shall be provided to the contractor. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the same shall be supplied by the Contractor. These items shall be same rating/strength as that of as that of corresponding rating/ Ultimate tensile Strength of Insulator string.
- c) D shackles, if required for attachment of Insulator strings, shall be supplied by the contractor from the identified and approved sub-vendor/ supplier of Hardware fittings.

1.3.3 Earth wire Clamps Attachments

For Suspension and tension clamp for attachment of earthwire, wherever required, the Contractor shall supply U-Bolts, D-Shackles etc. for attachment of clamp to the tower. Full details of the attachments shall be provided to the contractor. These items shall be same rating/ strength as that of corresponding rating/ Ultimate tensile Strength of earthwire suspension/tension clamp.

1.3.4 Anti climbing Device

Barbed wire type anti climbing device, as per enclosed drawing shall be provided and installed by the Contractor for all towers. The barbed wire shall conform to IS 278 (size designation A1). The barbed wires shall be given chromating dip as per procedure laid down in IS 1340

1.3.5 Danger, Number, Circuit and Phase plate

Danger Plates, Circuit plates, Phase Plates and Number plates shall installed by the Contractor. . The contractor shall submit distribution copies of the same endorsing the package details (i.e. line name, LOA No. etc.) and installed by the Contractor.

- a) Each tower shall be fitted with a danger plate, number plate, circuit plate and a set of phase plates for single circuit tower and two sets of phase plates for double circuit tower. The transposition towers should have provision of fixing phase plates on both the transverse faces.
- b) The letters, figures and the conventional skull and bones of danger

plates shall conform to IS 2551 and shall be in a signal red on the front of the plate.

- c) The corners of the danger, number and circuit plates shall be rounded off to remove sharp edges.
- d) The letters of number and circuit plates shall be red enameled with white enameled background.

1.3.5.1 Bird Guard

To prevent birds perching immediately above the suspension insulator strings (I type/ V type) and fouling the same with dropping, suitable bird guards shall be provided on all suspension towers. In case of I string Bird Guard as per IS 5613 shall be provided at cross arm tips. In case of V string, saw type Bird Guard shall be provided on all the members/ redundant members provided on Top and Bottom plan of cross arm/ Girder/ BOOM/ Beam of Suspension. The typical drawing of Bird guard is attached at the drawing section of this specification. Suitable provision of cleat/ plate to be provided on all Suspension towers facilitating installation of bird guard after stringing.

1.3.6 Aviation Requirements

- 1.3.6.1 Aviation requirements viz span marker, night marker (obstruction light) and painting of towers conforming to IS 5613 shall be in the scope of Contractor, wherever indicated in BOQ.

1.3.6.2 Night Markers (Obstruction lights)

- 1.3.6.2.1 The scope of night markers covers the design, manufacture, testing at manufacturers works, if any, supply, delivery, erection, testing and commissioning of medium intensity, low intensity, lights along with storage battery & solar panel, control panel, cables, clamps other accessories etc. as per the provision of IS 5613 (Part-II/Section-I) regarding night & day visual aids for denoting transmission line structures as per the requirement of directorate of flight safety.

- 1.3.6.2.2 The detail of each component of medium intensity, low intensity lights & associated accessories to be provided on the towers shall be as per the technical specifications given in the preceding clauses and IS/ICAO, International Standards recommended practices.

- 1.3.6.2.3 One set of Aviation Lights shall consist of one medium intensity light & two/four (as applicable) low intensity lights along with all accessories such as solar panel, control panel, batteries, cables etc.

1.3.6.2.4 Medium Intensity Light

Medium Intensity light shall be provided on the top of each tower. The medium light should have night time intensity as per ICAO requirements in international Standards Recommended Practices. The light on top of the structure should flash at the rate of 20 sequences per minute. The effective intensity during night time for the medium flashing light shall be 1600 CD. The light shall conform to ICAO requirements/ BS 3224a and shall have weather protection conforming to IP 55.

The above lights conforming to ICAO specifications flashing red lights shall be DC operated through a suitably sized battery bank at the operating voltage 12V/24V DC. The burning life of the lamps shall be maximum possible in view of the maintenance hazard of H.T. live but in no case, it should be less than 15,000 burning hours. In case of failure of the lamp before 15,000 burning hours, the same shall have to be replaced by the Contractor free of cost even if the pendency of contract expires. The light shall be equipped with radio suppression facility conforming to BS800 in order to avoid any interference with signals of PLCC etc.

1.3.6.2.5 Low Intensity Lights

Two/ four (as applicable) nos. of low intensity lights are required to be put on each of the towers. Placement drawing for the same shall be submitted by the bidder Contractor.

The light shall be stationary lamp with minimum effective intensity of 32 CD. of red light. The lamps shall conform to the ICAO requirement/relevant BS and shall have weather protection of minimum IP 55 class.

Two/four nos. of L.I. lamp required for each tower shall be operated through a suitable size common battery bank solar panel as per the requirement of operating voltage and load current of the type of lamps being offered.

The burning life of the lamps shall be maximum possible in view of the maintenance hazard of H.T live line, but in no case, it should be less than 15,000 burning hours. In case of failure of the lamp before 15,000 hours, the same shall have to be replaced by the Contractor free of cost even if the pendency of contract expires.

The low intensity lamp shall not generate any R.F. which can interfere with the PLCC signals.

1.3.6.2.6 Storage Battery

Storage Battery required for the above purpose shall be sealed maintenance free, valve regulate lead acid and suitable for mounting on the top of the transmission line towers. Contractors shall offer the most optimum capacity of the Battery Bank at 120hour discharge rate (considering 80 % percentage usage) matching with the load requirement of the type of lamps being offered including any power loss in the associated cables. The battery sizing shall conform to JISC 8707/ relevant Indian Standard or any other internationally recognized standard. The battery shall be hermetically sealed explosion proof and self-resealing type and free from orientation constraints. The working temperature ranges shall be minimum 0⁰ C and maximum 50⁰ C. Performance certificate of the offered batteries shall be submitted by the Contractor.

1.3.6.2.7 Battery Box

The battery box suitable for mounting on power transmission tower shall be robust construction suitable to accommodate desired number of storage batteries with proper clearance between the batteries. The sides and the top of the battery box shall be made from MS sheets not less than 14 SWG thickness duly mounted on MS angle frame. The bottom of the battery box shall have suitably designed MS structure to freely hold the total weight of the batteries. The batteries should be placed on insulated base with proper drainage holes. Lifting lugs shall be provided. Dust and vermin proof lockable doors shall be provided for safety and easy access to the batteries for the maintenance. The battery box should incorporate the design for proper ventilation system in order to prevent a gas concentration inside the box. The ventilation opening shall be

protected against rain/ splash water and dust. The inside of the battery box shall be lined with insulating polyurethane plating and the exterior painted with weather proof polyurethane paint. The cable entry into the battery box shall be through suitable cable glands.

1.3.6.2.8 Solar Modules

Solar module required for the system shall be suitable for mounting on the transmission line towers and shall be designed for high performance, maximum reliability and minimum maintenance and shall be installed below bottom cross arms levels. The solar modules shall be IP 55 grade protection class. These should be highly resistant to water, abrasion, nail, impact and other environmental factors.

These should be placed on the tower at a most optimum angle so as to harness the maximum solar energy and facilitate self-cleaning and shall conform to relevant Indian/ International Standards.

Module mounting frames shall be weather proof suitable for mounting on tall towers. Details of mounting frames shall be furnished by the Contractor.

Junction box shall be provided with weather proof hinged lid with provision for cable glands entry and protections grade of class IP-55.

The Contractor shall submit the basis of selecting the numbers of solar modules.

The provision for design, supply & erection of mounting arrangements for photovoltaic modules on the transmission towers in a suitable manner to harness maximum solar energy shall be in the scope of the Contractor.

Provision for design, supply & erection of resting platform for the erection of battery bank in a closed enclosure with safety arrangement on the transmission towers shall also be in the scope of the Contractor. The design and load consideration for safety of towers due to additional plate form shall be kept in view while designing, selecting the above.

1.3.6.2.9 Control Panels

Control panels shall consist of solar charge controller, flasher unit, sensor, isolator, MCB, Voltmeter, Ammeter and other control gears. Panel enclosure shall be fabricated out of 14 SWG CRCA sheet and thoroughly treated and painted. Suitable neoprene rubber gasket and pad locking device shall be provided and the protection class shall be of IP 55 class.

The Solar charge controller shall be most efficient and preferably fully solid state. It shall be provided with protection to load against increase in temperature, Surge, automatic low voltage and automatic disconnection and reconnection during high inrush current and normalcy respectively.

The flash regulator shall be provided for regulating light flashing. The same shall be completely solid state and provided with flash rate set points. The protection against overload current shall also be provided.

Necessary sensor/ timer shall be provided in the system to "switch on" the light automatically in the evening and poor visibility period and switch off the same during day time and normal visibility period.

1.3.6.2.10 Cables, Cable Glands, Conduits and Accessories

The cable to be supplied and erected shall be of multi strands copper conductor, weather proof, PVC insulated PVC sheathed, armoured 1.1 KV grade. The same shall conform to IS 1554.

All the cable accessories such as thimble, glands etc. shall be in the scope of supply and erection of the Contractor.

Supply and erection of all the PVC conduits and accessories shall be in the scope of the contract. All the conduit and accessories shall be as per the relevant ISS or ISI brand.

The inter-connection cable/ conduit will be clamped in a secured manner with the tower members and any interconnection should be made only inside the environmentally protected junction box.

1.3.6.2.11 Earthing

All the installations on the tower shall be securely and properly earthed with the tower body by using flexible copper braided wire. Cost of earthing material shall deem to be included in the total cost.

1.3.6.2.12 Bird flight Diverter

Bird diverters shall be placed in identified stretches as per the conditions stipulated by forest authority to avoid the chances of collision of birds with transmissions lines. These bird Diverters shall be placed on earth wire/ OPGW in staggered manner (in case of power line having earthwire and OPGW or both Earthwire/OPGW) at a distance of 10 m unless otherwise specified by forest/ wildlife authority in the middle portion of the identified spans leaving 50 m either side from tower and at least one bird diverter for spans up to 100 m in both earth wire/OPGW. An indicative sketch of the placement of the bird diverter is attached in the drawing section of this specification.

The BIRD-FLIGHT Diverter shall be lightweight (weight not more than 500 gm each), shall offers little wind resistance and should be easily installed by hand or by hot stick or by any other suitable method. The bird diverters should retain good physical characteristics within a range of extreme temperatures i.e. from - 30° C to 100° C. Contractor/ Subcontractor shall submit valid test report/ test certificate for mechanical test, ageing test i.e. solar radiation test & sand and dust test as per MIL- STD 810 F etc. from accredited third-party laboratory for the design which they intend to supply. The grip on the earthwire/ OPGW should ensure that the Bird-Flight Diverter remains in the applied position and does not move along the span under Aeolian vibration or other conditions.

Generally Suspended devices i.e. Dynamic Bird Flight Diverters shall be used in the transmission line as bird diverters.

1.3.6.2.12.1 Suspended devices: Dynamic Bird Flight Diverters

Bird flight Diverters shall have one warning disc which shall be attached to the wire through spring loaded clamp. Warning disc shall be made through injection moulding of UV stabilized plastic while the attachment clamp shall be made of UV stabilized engineered composite plastic. All fasteners and spring shall be of stainless steel.

1.3.6.2.12.1.1 Warning Disc

Warning disk of Bird Flight Diverter must swing, sway and rotate and should have different coloured sun and moon light reflectors on both faces. Warning disk must glow in dark.

Diameter of circular warning disk shall not be less than 150 mm. If warning disk is quadrilateral or trapezoid, then shortest arm length should not be less than 90 mm. Thickness of the warning disk shall not be less than 3 mm. Minimum reflective area on each face of warning disk shall not be less than 50 % of the entire area subject to minimum 4000 sq. mm. All suspension hardware which are directly exposed (moving or static) must be corrosion free. Bearing swivel shall be made of stainless steel and should allow free spinning in minimum wind speed of

2 km/hour.

1.3.6.2.12.1.2 Clamp

The clamp of the Bird flight diverter shall be made of UV stabilized engineered composite plastic. Spring type clamp, suitable for holding earth wire/ OPGW shall be used.

It shall be capable of supporting the Bird flight diverter during installation and prevent damage or chaffing of the earth wire/ OPGW during erection or continued operation. The clamp shall have smooth and permanent grip to keep the Bird flight diverter in position on the earth wire/ OPGW without damaging the strands or causing premature fatigue failure of the earth wire/OPGW under the clamp. The clamp groove shall be in uniform contact with the earth wire/ OPGW over the entire clamping surface. 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/ OPGW when the clamp is installed.

The Clamp shall have strong grip on earth wire/ OPGW. The clamp should not slip when pulled by a force of 0.25 KN in the direction parallel to earthwire/ OPGW the details/ properties of Earthwire / OPGW are mentioned in relevant section of Earth wire/ OPGW of Technical specification. All exposed metal parts of clamp shall be corrosion free. The Clamp must be able to bear pulling load of minimum 100kg.

- 1.3.6.2.12.2** The supplier shall guarantee that there shall not be any failure/ breaking of bird flight diverters under normal operating condition. In the event of any failure/ breaking of bird flight diverters during the first five (05) years of service, supplier shall supply to the purchaser free of cost spare bird flight diverters equal to the failed bird flight diverters quantity.

1.4 Tower Fabrication

The fabrication of towers shall be in conformity with the following:

- 1.4.1 Except where hereinafter modified, details of fabrication shall conform to IS 802 (Part-II) or the relevant international standards.
- 1.4.2 The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.
- 1.4.3 No angle member shall have the two leg flanges brought together by closing the angle.
- 1.4.4 The diameter of the hole shall be equal to the diameter of bolt plus 1.5 mm.
- 1.4.5 The structure shall be such that all parts are accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water.
- 1.4.6 All steel sections before any work is done on them, shall be carefully leveled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure.
- 1.4.7 Drilling and Punching**

- 1.4.7.1 Before any cutting work is started, all steel sections shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.
- 1.4.7.2 Holes for bolts shall be drilled or punched with a jig but drilled holes shall be preferred. The punching may be adopted for thickness up to 12 mm. Tolerances regarding punch holes are as follows: -
- a) Holes must be perfectly circular and no tolerances in this respect are permissible.
 - b) The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8mm. i.e. the allowable taper in a punched holes should not exceed 0.8mm on diameter.
 - c) Holes must be square with the plates or angles and have their walls parallel.
- 1.4.7.3 All burns left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly concentric/ matching to each other. Drilling or reaming to enlarge holes shall not be permitted.

1.4.8 Erection mark

- 1.4.8.1 Each individual member shall have erection mark conforming to the component number given to it in the fabrication drawings. The mark numbers shall be marked with marking dies of 16mm size before galvanising and shall be legible after galvanizing.

- 1.4.8.2 Erection Mark shall be A-BB-CC-DDD

A	=	Employer's code assigned to the Contractors- Alphabet
BB	=	Contractor's Mark-Numerical
CC	=	Tower Type Alphabet.
DDD =		Number mark to be assigned by Contractor - Numerical.

Erection mark for high tensile steel members shall be prefixed by the letter "H"

1.5 Quantities and weights

- 1.5.1 The quantities of the following items have been envisaged in Metric Tonne (MT) in the relevant price Schedules for various types of towers: -
- i) Basic Body.
 - ii) Body Extensions.
 - iii) Leg Extension.
 - iv) Stubs & Cleats
 - v) Bolts & Nuts including spring washers and step bolts etc.

During detailed engineering, proto corrected shop drawings shall be released by POWERGRID for fabrication and manufacturing as per the Technical Specification to the Contractor. The contractor shall carry out proto-assembly after fabrication from

the Employer's shop drawing for his verification/ satisfaction prior to mass production of the tower.

The manufacturing of the above items shall be taken up in such a manner that the Equipment/ Material offered for inspection to POWERGRID are on completed tower basis for each type of tower, completed Stubs & Cleats set basis so as to facilitate availability of erectable tower of each type and erectable stubs & cleats set for casting of foundation. After inspection of the offered Equipment/ Material by POWERGRID representative(s), CIP shall be issued by POWERGRID for the material meeting the Technical Specification. However, MICC shall be issued only on Completed Tower Basis for each type of tower (comprising the required Basic Body, body extensions wherever required, four (4) equal or defined unequal Leg Extension, Bolts & Nuts along with D-shackles, Hangers, Packing and Spring Washers) and on completed Stubs & Cleats set basis for each type of tower foundations (comprising a set of stubs & Cleats, required Bolts and Nuts along with Spring Washers).

Towers to be supplied by the Contractors/ Tower Manufacturers shall be dispatched Panel wise as per mutually agreed procedure with Employer Quality Assurance & Inspection Department.

Accordingly, the payment shall be released on completed Tower Basis for each type of tower (comprising the Basic Body, body extensions, wherever applicable, bolts & nuts along with spring washer and step bolts, unequal leg extensions wherever applicable for a completed tower) and on completed Stubs and Cleats set basis for each type of foundation (comprising a set of stubs & cleats, required Bolts and nuts along with Spring Washers) based on the weight of the tower parts as calculated as per Clause 1.5.3 and fasteners based on the unit rates incorporated in the contract.

- 1.5.2 The provisional quantities required (including provisional spare tower quantity) are mentioned in the respective Schedules of BPS. Final quantities shall be determined after completion and approval of the detailed route survey. The final quantities of tower including spare towers shall be confirmed by the Employer/ Site -in-charge of PGCIL based on the requirement of quantities of various towers furnished by the Contractor after completion of detailed survey. Hence it will be responsibility of the Contractor to intimate the exact requirement of all towers and various line materials required for line immediately after the survey.

The Employer reserves the right to order the final quantities including required quantities of spares for which the rates quoted in the Bid shall be valid. Regarding quantity variation the provisions of relevant clauses of SCC shall apply.

- 1.5.3 The estimated total weight of tower/ tower parts as well as bolts & nuts along with spring washers and step bolts to be supplied by the Contractor under various packages have been envisaged in the relevant percentage BOQ Schedule. Though fully galvanized tower parts are to be supplied, the weight of tower shall mean the weight of tower calculated by using the black sectional (i.e. ungalvanised) weight of steel members of the size indicated in the approved fabrication drawings and bill of materials, without taking into consideration the reduction in weights due to holes, notches and bevel cuts etc. but taking into consideration the weight of the D shackles, hangers, strain plates, pack plates, gusset plates, extension link/plates and pack washers etc. The weight of stub and cleats also shall be calculated in similar manner. The weight of strain plates, pack plates, extension link and gusset plates shall mean the weight of its circumscribing rectangle, without taking into considerations the reductions

in weight due to holes, notches etc. The weight of D-shackles, hangers and pack washers shall be net actual weight taking into consideration reduction due to holes. For bolts and nuts along with spring washers and step bolts, the weight per tower shall be calculated from the bolt schedule applicable to each type of towers and body extensions as approved by the Employer. The unit rate indicated in percentage BOQ for tower/tower parts supply is inclusive of galvanising charges including the cost of zinc. The bidder to quote on percentage basis on entire cost.

- 1.5.4 The contractor is permitted to get inspected and supply upto 2.5% extra fasteners to take care of losses during erection. No payment shall be admissible for these extra supplies.

1.6 Galvanising

1.6.1 Fabricated Tower Parts & Stubs

The tower parts, stubs and pack washers shall be hot dip galvanized. The galvanization shall be done as per requirements of IS 4759 after all fabrication work is completed. The contractor shall also take guidelines from the recommended practices for hot dip galvanizing laid down in IS 2629 while deciding and implementing galvanizing procedure. The mandatory requirements however, are specified herein.

The fabricated tower parts and stubs shall have a minimum overall Zinc coating of 610 gm per sq. m of surface area except for plates & sections below 5mm which shall have Zinc coating of 460 gm per sq. m of surface area. The average zinc coating for all sections and plates 5mm & above shall be maintained as 87 microns and that for plates & sections below 5mm shall be maintained as 65 microns.

However, under marine environment, the fabricated tower parts and stubs shall have a minimum overall zinc coating of 900 gm/ sqm of surface area except for plates and sections below 5mm which shall have a minimum overall zinc coating of 610 gm/sqm of surface area. The average zinc coating for all sections and plates 5mm and above shall be maintained as 127 microns and that for plates and sections below 5mm shall be maintained as 87 microns.

The zinc coating shall be adherent, reasonably uniform, smooth, continuous and free from imperfections such as black/ bare spots, ash rust strains, bulky white deposits/ wet storage strains and blisters.

The surface preparation for fabricated tower parts and stubs for hot dip galvanizing shall be carried out as indicated herein below:

- (i) **Degreasing & Cleaning of Surface:** Degreasing and cleaning of surface, wherever required, shall be carried out in accordance with clause 4.1 of IS 2629. After degreasing the article shall be thoroughly rinsed. However, if acidic degreasers are used rinsing is not required.
- (ii) **Pickling:** Pickling shall be done using either hydrochloric or

sulphuric acid as recommended at clause 4.3 of IS 2629. The actual concentration of the acids and the time duration of immersion shall be determined by the Contractor depending on the nature of material to be pickled. Suitable inhibitors also shall be used with the acids to avoid over pickling. The acid concentration, inhibitors used, and maximum allowable iron content shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program.

- (iii) Rinsing: After pickling, the material shall be rinsed, preferably in running water to remove acid traces, iron particles or any other impurities from the surface. Two rinse tanks are preferable, with water cascading from the second tank to the first to ensure thorough cleaning. Wherever single tank is employed, the water shall be periodically changed to avoid acid contamination, and removal of other residue from the tank.
- (iv) Fluxing: The rinsed article shall be dipped in a solution of Zinc ammonium chloride. The concentration and temperature of the flux solution shall be standardized by the contractor depending on the article to be galvanized and individual circumstances. These shall form part of plant standard to be formulated and submitted to Employer along with Quality Assurance Program. The specific gravity of the flux solution shall be periodically monitored and controlled by adding required quantity of flux crystals to compensate for drag-out losses. Free acid content of the flux solution also shall be periodically checked and when it is more than two (2) grams of free acid per litre of the solution, it shall be neutralized. Alternatively, Ph value should be monitored periodically and maintained between 5.0 to 5.5.
- (v) Drying: When dry galvanizing is adopted the article shall be thoroughly dried after fluxing. For the purpose of drying, the contractor may use hot plate, air oven or any other proven method ensuring complete drying of the article after fluxing and prior to dipping in the molten zinc bath. The drying process shall be such that the article shall not attain a temperature at which the flux shall get decomposed. The article thus dried shall be galvanized before the flux coating picks up moisture from the atmosphere or the flux layer gets damaged or removed from the surface. The drying procedure, time duration, temperature limits, time lag between fluxing, drying, galvanizing etc. shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program.
- (vi) Quality of Zinc: Any one or combination of the grades of zinc specified in IS 209 or IS 13229/ Prime Western (PW grade) (Zn 98.65%) or other comparable international standard shall be used for galvanizing. The contractor shall declare the grade(s) of zinc proposed to be used by them for galvanizing. The molten metal in the zinc bath shall contain minimum 98.5 % zinc by mass. It shall be periodically measured and recorded. Zinc

aluminum alloy shall be added as per IS 2629.

- (vii) Dipping Process: The temperature of the galvanizing bath shall be continuously monitored and controlled. The working temperature of the galvanizing bath shall be maintained at $450 \pm 10^{\circ}$ C. The article should be immersed in the bath as rapidly as possible without compromising on safety aspects. The galvanizing bath temperature, immersion angle & time, time duration of immersion, rate of withdrawal etc. shall be monitored and controlled depending upon the size, shape, thickness and chemical composition of the article such that the mass of zinc coating and its uniformity meets the specified requirements and the galvanized surface is free from imperfections and galvanizing defects.
- (viii) Post Treatment: The article shall be quenched in water. The quench water is to be changed/ drained periodically to prevent corrosive salts from accumulating in it. If water quenching is not done then necessary cooling arrangements should be made. The galvanized articles shall be dipped in chromating solution containing sodium dichromate and sulphuric acid or chromic acid base additive at a predetermined concentration and kept at room temperature to retard white rust attack. The temperature of the chromate solution shall not exceed 65° C. The articles shall not be stacked immediately after quenching and dichromating. It shall be ensured that the articles are dry before any further handling operation.
- (ix) Storing, Packing and Handling: In order to prevent white rust formation sufficient care should be exercised while storing handling and transporting galvanized products. The articles shall be stored in an adequately ventilated area. The articles shall be stored with spacers in between them and kept at an inclination to facilitate easy drainage of any water collected on the articles. Similar care is to be taken while transporting and storing the articles at site.

The Contractor shall prepare a detailed galvanizing procedure including Flow Chart with control parameters and all plant standards as required above and submit to POWERGRID Nodal officer for approval as part of Quality Assurance Plan.

1.6.2 Fasteners

For fasteners, the galvanizing shall conform to IS 1367 (Part-13). The galvanizing shall be done with centrifuging arrangement after all mechanical operations are completed. The nuts, may however be tapped (threaded) or rerun after galvanizing and the threads oiled. The threads of bolts & nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of the threads of bolts and they shall be capable of developing full strength of bolts. Spring washers shall be electro galvanized as per Grade-IV of IS 1573.

1.7 Earthing

Each tower shall be earthed. The tower footing resistance shall not exceed 10

ohms. The Contractor shall measure the tower footing resistance (TFR) of each tower during dry weather after it has been erected and before the stringing of the earth wire.

Pipe type earthing and counter poise type earthing shall be done as required in accordance with the following standards:

IS 3043 Code of practice for Earthing

IS 5613 Code of practice for Design, Installation and maintenance (Part-II/Section-2) of overhead power lines

- 1.7.1 The drawings for pipe & counterpoise type earthing are enclosed with these specifications.
- 1.7.2 For pipe type earthing, length of flat indicated in the drawing is indicative only and actual length shall vary depending on site requirement (to avoid fouling of pipe type earthing with foundation base slab). The payment for the pipe type earthing shall be as per the unit rates in the BOQ irrespective of the length of flat
- 1.7.3 For counterpoise type earthing, the earthing will vary depending on soil resistivity. For soil resistivity less than 1500 ohms-meter, earthing shall be established by providing 4 lengths of 30m counterpoise wire. Otherwise, for soil resistivity greater than 1500 ohms meter earthing shall be established by providing 4 length of 70m counterpoise wire. The contractor shall also measure tower footing impedance using high frequency Tower footing impedance measurement kit, in addition to Tower footing resistance (TFR). The value of Tower footing resistance as well as tower footing impedance shall not exceed 10 Ohms.
- 1.7.4 The provisional quantities for pipe type earthing and counterpoise earthing are indicated in the BOQ. The unit rates of the items are indicated in BOQ. The bidder to quote with respect to bid conditions. The unit rates indicated in BOQ includes fabrication, supply and installation of earthing material including supply of coke, salt etc. In case of counterpoise type earthing, the unit rates are indicated and shall correspond to typical design attached with the Bid.
- 1.7.5 Chemical pipe/ counter poise type earthing shall be provided in some locations as decided by Site In charge, where due to high resistivity tower footing resistance/ impedance below 10 ohms is not achieved with normal pipe/ counter poise type earthing. The provisional quantities for chemical pipe type earthing and counterpoise earthing are indicated in the BOQ. For chemical pipe/ counter poise type earthing, ground enhancement material/ back fill/ grounding compound shall be used. The material should generally conform to IEC 62561 (Part-7). The material should be permanent and maintenance free. It should not dissolve or decompose or otherwise pollute the soil or local water table & environment and should not depend on the continuous presence of water or moisture in the surrounding to maintain its conductivity. The material of the earthing enhancing compound in its set form should have a resistivity of less than 0.12 ohm-m (as per IEEE 80-2000, Clause No. 14.5(d)). It should have hygroscopic properties and should not cause burns, irritation to eyes, skin etc. Test report for the following test on earthing enhancement compound (conducted at accredited laboratory as per IEC 62561 (Part-7) shall be submitted by the

contractor to the site in charge.

- Resistivity test using soil box
- Leaching test
- Sulfur determination
- Corrosion test

1.7.6 Earthing for River Crossing Towers /Pile foundation

Galvanised earthing strip of flat 50x6 mm is to be provided in two legs of tower for each location with proper arrangement of connecting these strips by 16 mm bolts shall be provided in the stubs. The Earthing strip from the tower leg may be connected to the MS liner through the pile cap (an indicative drawing is enclosed at drawing section). In case the length of the liner embedded in the ground/ river bed is less than 3m or pile without liner the earthing strip shall be extended along the pile & embedded in the soil upto min. 3m depth from the present minimum RL. After execution of the earthing tower footing resistance/impedance is to be measured and should be maintained below 10 Ohms by suitable measures. In case due to specific soil conditions required tower footing resistance/ impedance below 10 Ohms is not achieved, then additional separate earthing (pipe/ counterpoise type) may be provided. Only bolted connections are allowed for connecting this strip to achieve desired length. Contractor shall submit the detailed drawing for approval of Employer before installations.

1.7.7 In case of location where foundation is classified as hard rock and laying of counter poise earthing at required depth of 1 m below the ground level is not feasible, the earthing shall be provided at reduced depth as per enclosed drawing of "counter poise earthing in hard rock strata. For the payment of hard rock earthing, the unit rate under the contract for chemical counter poise earthing shall be applicable and shall be as per bid conditions.

1.7.8 Additional earthing shall be provided on every 7 to 8 km distance at tension tower (exact quantity & location to be decided by Site In-charge) for direct earthing of both shield wires (earthwire/ OPGW). Indicative drawing of shield wire earthing arrangement is enclosed at relevant section (Drawing) of technical specification. The scope of work shall inter-alia include supply & installation of PG clamp & down lead clamps and supply & installation of additional earthing (pipe type or counter poise type) depending upon soil resistivity. Additional earthwire bits required for down leads connecting shield wires with the earthing ~~shall be either supplied by Owner separately (as Owner supplied material) or shall be supplied by contractor (payable as per unit rate indicated in of GS Earthwire under the contract), as may be decided by the Nodal officer of PGCIL.~~

1.7.9 Additional Rod type earthing shall be provided in one of the foundation pit (diagonally opposite to pipe type earthing) of all the transmission line towers in normal soil (i.e. Dry, Wet cultivated, Wet, PS, FS & Black Cotton soil) in addition to pipe type earthing. This additional earthing MS Rod of 40 mm dia & 3.0 M length shall be driven after excavation of foundation pit and connected to stub cleat. The indicative drawing of Rod type earthing is enclosed in the section of drawing.

1.8 Standards

1.8.1 The design, manufacturing, fabrication, galvanising, testing, erection procedure and materials used for manufacture and erection of towers, design and construction of foundations shall conform to the following Indian Standards (IS)/ International Standards which shall mean latest revisions, with amendments/ changes adopted and published, unless specifically stated otherwise in the Specification. In the event of supply of material 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 Bidder and those specified in this document will be provided by the Contractor to establish their equivalence.

1.8.2 The material and services covered under these specifications shall be performed as per requirements of the relevant latest standard code referred hereinafter against each set of equipment and services

Sl. No.	Indian Standard	Title
1	IS 209	Zinc INGOT - Specification
2	IS 278	Galvanized steel barbed wire for fencing- Specification
3	IS 800	General construction in steel - Code of practice
4(a)	IS 802(Part 1) Sec 1-2015 Sec 2-2016	Use of structural steel in overhead transmission line towers - code of practice part 1 materials, loads and design strengths Section-1: Materials and loads Section-2: Design Strengths.
4(b)	IS 802(Part 2)	Code of Practice for use of structural steel in Overhead Transmission Line Towers: Part-2 Fabrication, Galvanising, inspection & Packing
4(c)	IS:802(Part 3)	Code of Practice for use of structural steel in Overload Transmission Line: Part-3 Tower testing
5	IS 808	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.

Sl. No.	Indian Standard	Title
6(a)	IS 875, Part-1, 2, 4, 5	Code of Practice for Design Loads (other than Earthquakes) for Buildings and Structures.
6(b)	IS 875-Part-3	Design Loads (other than Earthquakes) for Buildings and Structures- Code of Practice
7	IS 1363- Part-1, 2, 3	Hexagon head bolts, Screws and Nuts of product Grade `C`
8	IS 1367, Part 1 to 20	Technical Supply Conditions for Threaded Steel Fasteners
9	IS 1477	Code of practice for Painting of Ferrous Metals in Buildings: Part-I: Pre-treatment Part-II: Painting.
10	IS 1573	Electro-Plated Coatings of Zinc on iron and Steel
11	IS 1852	Rolling and Cutting Tolerances of Hot Rolled Steel Products
12	IS1893 Part 1 Part 2 Part 3 Part 4	Criteria for Earthquake Resistant Design of Structures
13	IS 2016	Specification for Plain Washers
14	IS 2062	Hot Rolled medium and High tensile Structural Steel
15	IS 2074 & IS 2074 (Part-1)	Ready Mixed Paint. Air Drying, Red Oxide Zinc Chrome, Priming Specification.
16	IS 2551	Danger Notice Plates
17	IS 2629	Recommended Practice for Hot Dip Galvanizing of iron and steel.
18	IS 2633	Method of Testing Uniformity of Coating of Zinc Coated Articles
19	IS 3043	Code of Practice for Earthing
20	IS:3063	Fastners-Single coil Rectangular Section Spring Lock Washers
21	IS 3757	Specification for High Strength Structural Bolts
22	IS 4759	Specification for Hot-dip zinc coatings on structural steel and other Allied products

23	IS 5369	General Requirements for Plain Washers and Lock Washers

Sl. No.	Indian Standard	Title
24 a)	IS 5613 (Part 1)	Code of Practice for Design installation and Maintenance of Overhead Power Lines: Lines up to and including 11 KV Section-1: Design, Section-2: Installation and Maintenance
24 b)	IS 5613 (Part 2)	Code of Practice for Design installation and Maintenance of Overhead Power Lines: Lines above 11 KV and upto and including 220 KV Section-1: Design, Section-2: Installation and Maintenance
24 c)	IS 5613 (Part 2)	Code of Practice for Design installation and Maintenance of Overhead Power Lines: 400kV Lines Section-1: Design, Section-2: Installation and Maintenance
25	IS 6610	Specification for Heavy Washers for Steel Structures
26	IS 6623	High Strength Structural Nuts
27	IS 6639	Hexagon Bolts for Steel Structure.
28	IS 6745	Method for Determination of Mass of Zinc coating on zinc coated iron and Steel Articles.
29	IS 10238	Fasteners - Threaded Steel Fasteners - Step Bolts for Steel Structures
30	IS 12427	Fasteners - Threaded Steel Fasteners - Hexagon Head Transmission Tower Bolts
31	Publication No. 19(N)/700	Regulation for Electrical Crossing of Railway Tracks

The standards mentioned above are available from

Reference Abbreviation	Name and Address
BIS/IS	Bureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001 INDIA

ISO	International Organisation for Standardization. ISO Central Secretariat
	BIBC II Chemin de Blandonnet 8 CP 401 1214 Vernier, Geneva Switzerland

2.0 Inspection and Tests

2.1 General

All standard tests, including quality control tests, in accordance with appropriate Indian/ International Standard, shall be carried out unless otherwise specified herein.

2.1.1 Inspection

In addition to the provision of GCC and Cl. 1.7.3 of Section II of this Specification, the following shall also apply:

- a) The Contractor shall keep the Employer informed in advance about the time of starting and of the progress of manufacture and fabrication of various tower parts at various stages, so that arrangements could be made for inspection.
- b) The acceptance of any part of items shall in no way relieve the Contractor of any part of his responsibility for meeting all the requirements of the Specification.

2.1.2 The Employer or his representative shall have free access at all reasonable times to those parts of the Contractor's works which are concerned with the fabrication of the Employer's material for satisfying himself that the fabrication is being done in accordance with the provisions of the Specification.

2.1.3 Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be concluded so as not to interfere unnecessarily with the operation of the work.

2.1.4 Should any member of the structure be found not to comply with the supplied design, it shall be liable to rejection. No member once rejected shall be resubmitted for inspection, except in cases where the Purchaser or his authorized representative of PGCIL considers that the defects can be rectified.

2.1.5 Defect which may appear during fabrication shall be made good with the consent of the Employer according to the procedure proposed by the Contractor and its approval.

- 2.1.6 All gauges and templates necessary to satisfy the Employer shall be supplied by the Contractor.
- 2.1.7 The specified grade and quality of steel shall be used by the Contractor. To ascertain the quality of steel used, the inspector may at his discretion get the material tested at an approved laboratory.

3.0 Tower Erection, Stringing and Installation of Line Materials

3.1 General

- 3.1.1 The scope of erection work shall include the cost of all labour, tools and plant such as sagging bridges/ working platform, power operated winch machines, cranes of suitable capacity and height (wherever feasible), tension stringing equipment, mechanized rope way wherever required for hilly areas for transportation of materials and all other incidental expenses in connection with erection and stringing work. The stringing equipment shall be of sufficient capacity to string the bundle conductors of specified size. Use of Tractor for tower erection & final sagging shall not be permitted.

Use of helicopter for faster erection of transmission line, particularly in difficult and inaccessible terrain, may be considered subject to the required clearance from Director General of Civil Aviation (DGCA) / any other competent authority.

- 3.1.2 The Contractor shall be responsible for transportation to site of all the materials to be supplied by the Contractor as well as proper storage and preservation of the same at his own cost, till such time the erected line is taken over by the PGCIL.
- 3.1.3 Contractor shall set up required number of stores along the line and the exact location of such stores shall be discussed and agreed upon with the Employer. Employer during the kick off meeting at site supplied items shall be dispatched to the stores set up by the Contractor.
- 3.1.4 Payment for stringing shall be done on the basis of payment terms, as specified in the Bid.
- ~~3.1.5 While handing over the Employer supplied OPGW drums, the testing (fibre loss and length measurement using OTDR) of OPGW in each drum shall be carried out by Contractor in presence of OPGW supplier and/or Employer representatives. OPGW is in scope of Contractor.~~
- 3.1.6 After installation of OPGW, the testing of each section shall be carried out by Contractor in presence of Employer /PGCILrepresentatives. In case of any damage

/ high loss in the fiber, the total length of that particular section/ portion of OPGW shall be replaced by the contractor and in such case, the de-stringing & re-stringing shall be carried out by the contractor without any extra cost to Employer and cost of additional OPGW cable, hardware fittings and joint box, if any, for replacement of damaged OPGW etc. shall be recovered from the contractor. However, introduction of additional joints in the links due to replacement of OPGW in damaged portion shall be allowed subject to meeting the optical link budget.

- 3.1.7 In case FO Cabling (OPGW, Approach cable etc.) installation is covered under the scope of package, Site Acceptance Testing (SAT) for FO Cabling shall be carried out by contractor as per *Annexure-I*.

3.2 Treatment of Minor Galvanization Damage

Minor defects in hot-dip galvanized members shall be repaired by applying zinc rich paint to the satisfaction of the Employer before erection.

3.3 Assembly

The Contractor shall give complete details of the erection procedures he proposes to follow. For erection of towers using crane (wherever feasible) Cranes of suitable capacity along with other necessary T&P, power operated hydraulic/ motorized winches, Gin pole/ Derrick etc. shall be deployed by the Contractor accordingly.

In case erection of tower is carried out by conventional method, Gin Pole/ center mast shall be used for erection of 400 kV towers with +18 m & higher extensions and 765 kV towers with +9 m & higher extensions. For these extension towers, in cases of difficult site conditions/constraints, derricks for tower erection, if proposed by the contractor, to be permitted only with approval of GM NHIDCL PMU Silchar/ CGM of PGCIL.).

- 3.3.1 The method for the erection of towers shall ensure the following:

- a) Straining of the members shall not be permitted for positioning. It may, however, be necessary to match hole positions at joints using tommy bars not more than 450 mm in length;
- b) Prior to erection of an upper section, the lower sections shall be completely braced, and all bolts provided tightened adequately in accordance with approved drawings to prevent any mishap during tower erection;

- c) All plan diagonals, oblique bracings etc. for relevant section of tower shall be in place prior to assembly of an upper Section; The bolt positions in assembled towers shall be as per IS 5613 (Part II/Section 2);
- d) Tower shall be fitted with number, danger, Bird guard, circuit plate, pole plate and phase plates as well as anti-climbing device, as described;
- e) After complete erection of the tower, all blank holes, except for additional holes, if any in universal plates and/or in redundant members at different levels for fixing tower accessories (viz. Tower Number plate, Danger plate, Phase plate etc.) are to be filled by bolts and nuts of correct size.
- f) The towers shall not be out of vertical by more than 1 in 360 before stringing is carried out.

3.3.2 Tools & plants and PPEs

In addition to the provisions stipulated in the sections of bidding document under conditions of contract, Safety Plan etc., the following shall also apply:

Broad list & basic parameters of major T&P to be used for tower erection & stringing is enclosed at **Appendix III** to this specification.

The above-mentioned list is not exhaustive and all T&Ps/ PPEs required for execution of works covered under the contractor scope of work within the schedule in a safe manner, to be deployed by the Contractor.

The contractor shall provide details of all Tools & Plants including lifting machines, lifting tools/ lifting tackles/ lifting gears and all types of ropes and slings and PPEs to be deployed at site for approval of site-in-charge/ project manager as part of safety plan.

All the tools and plants required for safe and efficient tower erection should be available at site. Detailed list of T&P being deployed by the contractor and used by different erection gangs shall be maintained.

Tools and plants should be tested as per applicable standards and safety norms. Relevant test certificates should be available at respective sites.

Derricks/ Gin pole and other load bearing tools i.e. Wire rope, PP rope, D- Shackles, pulleys etc. must be inspected for their healthiness before putting them in use. Only tested tools with valid test certificates should be used. Periodic testing should be carried out to check safe working capacity as per safety plan.

Homemade tools shall not be allowed to use at site.

All necessary PPEs like hand gloves, Safety Belts (Full body harness), safety helmet, safety shoes, etc. as per relevant IS should be used and their healthiness should be ensured.

All the persons working on tower should wear safety helmet,

gloves, safety harnesses, fall arrester, high visible vest and safety shoes as the per job requirements. Similarly, all the persons working on ground should wear safety helmet, high visible vest and safety shoes. Detailed list of safety equipment & PPEs being used by the gangs shall be maintained at site.

Condition of safety equipment should be visually checked before every use. These should be tested as per applicable standards; safety norms and necessary test certificate should be available. Also, periodic check should be carried out to ensure their requisite strength.

3.3.3 Use of safety nets

Suitable safety nets shall be used during tower erection activity to provide protection to workers in case of fall from heights.

3.4 Tightening of Bolts and Nuts

3.4.1 All nuts shall be tightened properly using torque wrench, applying the torque recommended by manufacturer of bolts & nuts and proper tightening of bolts & nuts shall be checked by Site-Engineer of PGCIL randomly. Before tightening, it will be verified that filler washers and plates are placed in relevant gap between members, bolts of proper size and length are inserted, and one spring washer is inserted under each nut. In case of step bolts, spring washers shall be placed under the outer nuts. The tightening shall progressively be carried out from the top downwards, care being taken that all bolts at every level are tightened simultaneously. The threads of bolts projecting outside the nuts shall be punched at their position on the diameter to ensure that the nuts are not loosened in course of time. If, during tightening, a nut is found to be slipping or running over the bolt threads, the bolt together with the nut shall be replaced.

3.4.2 The threads of all the bolts projected outside the nuts shall be welded at two diametrically opposite places; the circular length of each welding shall be at least 10mm. The welding shall be provided from ground level up to waist level for single circuit towers and up to bottom cross arm level for double circuit towers and single circuit vertical configuration towers subject to maximum 30 m height from ground level. After welding the surface of welding shall be cleaned, dried and made free of oil, grease and corrosion product and on this surface Zinc-Rich Paint shall be applied by means of a brush according to the paint manufacturer's recommendations. Zinc Rich Paint, Pre-mixed type paint, based on organic/inorganic binders specially formulated for steel surfaces

may be used. The dried film of Zinc Rich Paint should contain a minimum of 90 percent Zinc Dust by mass. The cost of welding and paint including application of paint shall be deemed to be included in the erection price.

3.5 Insulator Hoisting

Suspension insulator strings shall be used on Suspension towers and tension insulator strings on angle and dead-end towers. These shall be fixed on all the towers just prior to the stringing. Damaged insulators and strings, if any, shall not be employed in the assemblies. Prior to hoisting, all insulators shall be cleaned in a manner that will not spoil, injure or scratch the surface of the insulator, but in no case shall any oil be used for that purpose. Also, for checking the soundness of Porcelain Disc insulators, IR measurement using 10 kV (DC) Megger shall be carried out on 100% insulators (*Not applicable for porcelain longrod insulators/ Composite longrod insulators/Glass disc insulators*). Corona control rings/ arcing horn shall be fitted in an approved manner. Torque wrench shall be used for fixing various line materials and components, such as suspension clamp for conductor and earth wire, etc., whenever recommended by the manufacturer of the same.

3.6 Handling of Conductor and Earth wire

3.6.1 Running Out of the Conductors

- 3.6.1.1 The conductors shall be run out of the drums from the top in order to avoid damage. The Contractor shall be entirely responsible for any damage to tower or conductors during stringing.
- 3.6.1.2 A suitable braking device shall be provided to avoid damaging, loose running out and kinking of the conductors. Care shall be taken that the conductors do not touch and rub against the ground or objects which could scratch or damage the strands.
- 3.6.1.3 The sequence of running out shall be from the top down i.e. the earth wire shall be run out first followed in succession by the conductors. Unbalanced loads on towers shall be avoided as far as possible. Inner phase of line conductors shall be strung before the stringing of the outer phases is taken up.
- 3.6.1.4 The Contractor shall take adequate steps to prevent clashing of sub conductors until installation of the spacers/ spacer dampers. Care shall be taken that sub conductors of a bundle are from the same Contractor and preferably from the same batch so that creep behavior of sub conductors remains identical. During sagging, care shall be taken to eliminate differential sag in sub-conductors as far as possible. However, in no case shall sag mismatch be more than 25mm.

- 3.6.1.5 Towers not designed for one sided stringing shall be well guyed and steps taken by the Contractor to avoid damage. Guying proposal along with necessary calculations shall be submitted by the Contractor to Employer for approval. All expenditure related to this work is deemed to be included in the bid price and no extra payment shall be made for the same.
- 3.6.1.6 When the transmission line runs parallel to existing energised power lines, the Contractor shall take adequate safety precautions to protect personnel; from the potentially dangerous voltage built up due to electromagnetic and electrostatic coupling in the pulling wire, conductors and earth wires during stringing operations.
- 3.6.1.7 The Contractor shall also take adequate safety precautions to protect personnel from potentially dangerous voltage build up due to distant electrical storms.

3.6.2 Running Blocks

- 3.6.2.1 The groove of the running blocks shall be of such a design that the seat is semicircular and larger than the diameter of the conductor/ earth wire and it does not slip over or rub against the slides. The grooves shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on properly lubricated bearings.
- 3.6.2.2 The running blocks shall be suspended in a manner to suit the design of the cross- arm. All running blocks, especially at the tensioning end will be fitted on the cross-arms with jute cloth wrapped over the steel work and under the slings to avoid damage to the slings as well as to the protective surface finish of the steel work.

3.6.3 Repairs to Conductors

- 3.6.3.1 The conductor shall be continuously observed for loose or broken strands or any other damage during the running out operations.
- 3.6.3.2 Repairs to conductor if accidentally damaged, shall be carried out with repair sleeve.
- 3.6.3.3 Repairing of the conductor surface shall be carried out only in case of minor damage, scuff marks, etc. The final conductor surface shall be clean, smooth and free from projections, sharp points, cuts, abrasions, etc.
- 3.6.3.4 The Contractor shall be entirely responsible for any

damage to the towers during stringing.

3.6.4 Crossings

Derricks or other equivalent methods ensuring that normal services need not be interrupted nor damage caused to property shall be used during stringing operations where roads, channels, telecommunication lines, power lines and railway lines have to be crossed. However, shut down shall be obtained when working at crossings of overhead power lines. The Contractor shall be entirely responsible for the proper handling of the conductor, earth wire and accessories in the field.

Joint measurement of electrical clearances shall be done by the Engineers of Employer and contractor after completion of final sagging in major crossing spans

i.e. Railway crossing, River crossing, National/ State Highway crossing, expressway crossing, transmission line crossing (132kV and above voltage level) by using hand held clearance measurement device/ total station. Deviation, if any, is to be attended immediately. Value of measured electrical clearances is to be recorded for future reference.

3.7 Stringing of Conductor and Earth wire

3.7.1 The stringing of the conductor shall be done by the control tension method. The equipment shall be capable of maintaining a continuous tension per bundle such that the sag for each conductor is about twenty percent greater than the sags specified in the stringing sag table.

3.7.2 The contractor shall give complete details of the stringing methods he proposes to follow. Prior to stringing the Contractor shall submit the stringing charts for the conductor and earth wire showing the initial and final sags and tension for various temperatures and spans alongwith equivalent spans in the lines for the approval of the Employer.

3.7.3 A controlled stringing method suitable for simultaneous stringing of the sub conductors shall be used. The conductors making up one phase bundle shall be pulled in and paid out simultaneously. The synchronous stringing of one phase with six bundle conductors may be carried out by using one TSE of adequate capacity. However, two pullers of adequate capacity, towing (4+2) or (3+3) conductors combined with two sets of tensioners may also be used. These conductors shall be of matched length. Conductors or earth wires shall not be allowed to hang in the stringing blocks for more than 96 hours before being pulled to the specified sag.

Conductor creep are to be compensated by over tensioning the conductor at a temperature of 30°C for ACSR BERSIMIS, SNOWBIRD & LAPWING /26°C for MOOSE/

ZEBRA/PANTHER lower than the ambient temperature or by using the initial sag and tensions indicated in the sag and tension chart.

3.8 Jointing

3.8.1 When approaching the end of a drum length at least three coils shall be left in place when the stringing operations are stopped. These coils are to be removed carefully, and if another length is required to be run out, a joint shall be made as per the specifications.

3.8.2 Conductor splices shall not crack or otherwise be susceptible to damage in the stringing operation. The Contractor shall use only such equipment/ methods during conductor stringing which ensures complete compliance in this regard.

3.8.3 All the joints on the conductor and earth wire shall be of the compression type, in accordance with the recommendations of the manufacturer, for which all necessary tools and equipment like compressors, dies etc., shall be obtained by the Contractor. Each part of the joint shall be cleaned by wire brush till it is free of dust or dirt etc., and be properly greased with anti-corrosive compound. If required and as recommended by the manufacturer, before the final compression is carried out with the compressors.

Dimensions of compression type joints (Dead end clamps, MS compression joints, jumper cones, repair sleeves etc.) shall be measured before and after compression to check compliance as per approved drawings. Record of dimension measurement shall be maintained by the Contractor. POWERGRID Nodal officer shall check the records and verify the dimensions on sample basis.

3.8.4 All the joints of splices shall be made at least 30 meters away from the tower structures. No joints or splices shall be made in spans crossing over state/ National highway, railways, power lines and major river crossing. Not more than one joint per sub conductor per span shall be allowed. The compression type fittings shall be of the self-centering type or care shall be taken to mark the conductors to indicate when the fitting is centered properly. During compression or splicing operation; the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After compressing the joint the aluminium sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.

3.8.5 During stringing of conductor to avoid any damage to the

joint, the Contractor shall use a suitable protector for mid span compression joints in case they are to be passed over pulley blocks/ aerial rollers. The pulley groove size shall be such that the joint alongwith protection can be passed over it smoothly.

3.9 Tensioning and Sagging Operations

- 3.9.1 The tensioning and sagging shall be done in accordance with the approved stringing charts or sag tables. The “initial” stringing chart shall be used for the conductor and final stringing chart for the earth wire. The conductors shall be pulled up to the desired sag and left in running blocks for at least one hour after which the sag shall be rechecked and adjusted, if necessary, before transferring the conductors from the running blocks to the suspension clamps. The conductor shall be clamped within 96 hours of sagging in.
- 3.9.2 The sag will be checked in the first and the last section span for sections up to eight spans, and in one additional intermediate span for sections with more than eight spans. The sag shall also be checked when the conductors have been drawn up and transferred from running blocks to the insulator clamps.
- 3.9.3 The running blocks, when suspended from the transmission structure for sagging, shall be so adjusted that the conductors on running blocks will be at the same height as the suspension clamp to which it is to be secured.
- 3.9.4 At sharp vertical angles, conductor and earth wire sags and tensions shall be checked for equality on both sides of the angle and running block. The suspension insulator assemblies will normally assume verticality when the conductor is clamped.
- 3.9.5 Tensioning and sagging operations shall be carried out in calm whether when rapid changes in temperature are not likely to occur.

3.10 Clipping In

- 3.10.1 Clipping of the conductors into position shall be done in accordance with the manufacturer’s recommendations.
- 3.10.2 Jumpers at section and angle towers shall be formed to parabolic shape to ensure maximum clearance requirements. Pilot suspension insulator strings shall be used, as per design requirement, to restrict jumper swing to design values. Balancing weights shall be provided with pilot insulator strings in case of triple/ quad/ hexa

bundle line and for all lines with composite insulators.

- 3.10.3 The Jumper drop shall be maintained as per design requirement. Jumper length calculations for different line deviation angles shall be submitted by the Contractor to Employer / Nodal officer of PGCIL. The jumpers shall be prepared to the required length & compressed with jumper pads at site stores. These shall be assembled with due care taking into consideration conductor bundle configuration and installed correctly.
- 3.10.4 Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.
- 3.11 Fixing of Conductors and Earth wire/OPGW Accessories and Bird Guard**
- Conductor and earth wire/ OPGW accessories including spacers, spacer dampers (for bundle conductor) and vibration dampers shall be installed by the Contractor as per the design requirements and manufacturer's instruction within 24 hours of the conductor/earth wire clamping. While installing the conductor and earth wire accessories, proper care shall be taken to ensure that the surfaces are clean and smooth and that no damage occurs to any part of the accessories or of the conductors. Torque wrench shall be used for fixing the Dampers/ Spacer Dampers, Suspension Clamps etc. and torque recommended by the manufacturer of the same shall be applied. Bird guard shall be installed on all suspension towers. Stringing shall not be considered completed without installation of Bird guard and all Conductors and Earth wire/ OPGW Accessories.

3.11.1 Insulated Conductor sleeve

Insulating sleeve shall be used on bare conductor of Jumper of transposition tower as per site requirement with approval of Employer site in-charge. However, Insulation sleeves shall not be used for HTLS conductors. Insulating sleeve shall provide minimum 66kV class insulation. The protective conductor cover shall be made of silicone rubber. The conductor cover shall be secured with the application of self-adhesive silicone rubber tape. Insulating tape and insulating sleeve shall be suitable for conductor operating temperature of 0 to 180 degree centigrade. The insulating sleeve and insulation tape shall be Flame, Arc, UV & Ozone Resistant.

Supply & installation charges for insulated conductor sleeve shall be payable pro- rata basis as per payment terms of Bid document.

Type tests on Insulated Conductor sleeve

The required type tests on insulation sleeve are stipulated hereunder. The specified type tests under the following clause

shall not be required to be carried out if a valid test certificate is available for a similar design. The tests certificate shall be considered valid if:

- i) Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of POWERGRID or utility and
- ii) Tests have been conducted not prior to 5 (five) years from the date of LOA.
- iii) In case the test have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test not applicable due to any design/manufacturing change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the Supplier at no extra cost to the Purchaser.

Sl. No.	Type test Description	Applicable Test Standard/ Procedure
1	Ozone Resistance Test on Insulation Sleeve and Tape	ASTM D1149*
2	Power Frequency Voltage Withstand Test on Insulation Sleeve and Tape	The test sample consisting of Insulation sleeve along with Insulating tape (as per the installation condition) shall withstand 66 kV for 1 minute
3	Arc Resistance on Insulation Sleeve and Tape	ASTM D495*
4	UV Resistance on Insulation Sleeve and Tape	1000 hrs as per IEC 62217*
5	Hardness test on Insulation Sleeve	ASTM D2240*
6	Tensile Strength test on Insulation Sleeve & tape	ASTM D 412*
7	Elongation test on Insulation sleeve and Tape	ASTM D 412*
8	Dielectric Strength test on Insulation sleeve and Tape	ASTM D 149*

9	Silicone Content test on Insulation sleeve and Tape	Minimum content of silicone as guaranteed by supplier shall be verified through FT-IR spectroscopy & TGA analysis or any other suitable method mutually agreed between Purchaser & Supplier in Quality Assurance Programme
10	Tracking and Erosion Resistance on Insulation sleeve and Tape	ASTM D2303*
11	Flammability test on Insulation sleeve and Tape	IEC 62217*
12	Temperature test for 180 ⁰ for Insulation sleeve and Tape	Sample shall not develop any cracks/ fissures after subjecting to 180 ⁰ for 4 hours.

* Equivalent Indian Standards shall also be acceptable.

Acceptance Tests on Insulated Conductor sleeve:

1. Verification of dimensions of Insulation sleeve and Insulating Tape
2. Tensile Strength test of Insulation sleeve and Insulating Tape
3. Elongation test of Insulation sleeve and Insulating Tape
4. Hardness test of Insulation sleeve
5. Silicone Content Test on Insulation sleeve and Insulating Tape

3.12 Replacement

If any replacement is to be affected after stringing and tensioning or during maintenance, leg member and bracing shall not be removed without first reducing the tension on the tower by proper guying techniques or releasing of the conductor. For replacement of cross arms, the conductor shall be suitably tied to the tower at tension points or transferred to suitable roller pulleys at suspension points.

3.13 Permitted Extra Consumption of Line materials

- 3.13.1 The quantity of conductor and earth wire to be incorporated in the line shall be worked as per the following norms.

Quantify of Conductor = Line length* as per detailed survey x 3
phases x Nos.
of conductor per phase (for Single Circuit)

Line)
 = Line Length* as per detailed survey x 3 phases x Nos. of conductor per phase x 2 (for Double Circuit Line)

Quantity of Earthwire = Line length* as per detailed survey x nos. of earthwire
 Quantity of OPGW = Line length* as per detailed survey x no. of OPGW

* For calculation of conductor & Earth wire requirement in hilly stretches, inclined distance between the towers shall be considered instead of horizontal distance (considered for line length).

- 3.13.2 The Contractor shall make every effort to minimise breakage, losses and wastage of the line materials during erection. However, the Contractor shall be permitted and extra consumption of line materials up to the limits specified in the table below and shall be permitted to dispose of the scrap, if any at the end.

Table: Permitted extra consumption of line materials

Item	% of permitted extra consumption
Conductor & earth wire	1
Insulators	1*
OPGW (in Plain area)	5
OPGW (in Hilly area)	7

~~* will be applicable whenever insulators are supplied by owner. In case of Composite Long Rod Insulators, permitted extra consumption will be subject to physical evidence of damaged insulators otherwise excess insulators are required to be returned to POWERGRID.~~

- 3.13.3 In case of conductor and earth wire, the maximum permitted extra consumption limit of one percent is inclusive of sag, jumpering, damage, loss and wastage etc.
- 3.13.4 The Conductor can be supplied in Wooden drums/ steel drums and hybrid drums and the following methodology/ procedure to be followed: -
 In case of wooden drums for conductor and earthwire, the Contractor shall not be required to return empty wooden drums to the Employer. The empty drums shall dispose-off by the contractor at his cost. The contractor
 In case of steel drums and hybrid drums for conductor, the Ownership of the empty conductor drums shall lie with the conductor supplier who shall ultimately take back the empty conductor drum from the Project site(s). Accordingly, erection Contractor is required to return the drums

to the Conductor Supplier at erection contractor's designated stores after the running out of conductor from the drum.

The erection contractor shall intimate the Conductor supplier and Employer regarding empty steel drums at their designated stores. Necessary coordination for taking back the empty steel/ hybrid drums in this regard shall be carried out by the Conductor Supplier with the erection Contractor. The erection Contractor shall handle the Steel/ Hybrid Drums in a manner so that these drums can be reused. All efforts shall be made by the erection Contractor to use the Conductor at the earliest. Erection Contractor is required to return all the empty steel/ hybrid drums. However, 2% wastage due to transportation & handling etc. of steel/ hybrid drums is allowed. The wastage beyond 2% has to be reimbursed by Erection Contractor.

- 3.13.5 Any conductor and earth wire drum which has been opened by the Contractor shall not be taken back by Employer and the unused conductor or earth wire in such drums may be treated as waste permissible within the overall limits specified in the Table above under *clause 3.1.3.2*.
- ~~3.13.6 The Contractor shall return to the Employer all Employer supplied material not incorporated in the works, except those permitted by Employer as scrap in terms of Table above under *clause 3.1.3.2*. Otherwise, the Contractor shall either replenish the excess material from approved source or pay in respect of such excess materials which he is unable to return at rates corresponding to the actual cost of procurement plus (i) 15% for OSM procured under domestically funded packages; and (ii) 26.5% for OSM procured against packages funded by multilateral funding agencies. The "cost of procurement" for the above purpose shall be F O R destination site cost of OSM as per LOA of the respective packages plus taxes & duties plus price variation (if positive) applicable as on the date of issuance of TOC for Tower Package. In case of contract in Foreign currency, Bills clearing (BC) Selling, Market Rate of Exchange (MRE) established by State Bank of India (SBI) as prevalent on date of TOC shall be applicable for converting into Indian Rupees.~~
- 3.13.7 The quantities of line materials to be supplied by the contractor (i.e. earth wire and/or OPGW, Hardware fittings & accessories) as indicated in the bill of quantities are provisional and the actual quantity shall depend upon detailed survey. Contractor shall be responsible for regulating the supplies of contractor supplied materials on the basis of actual requirements. The Employer shall have right, not to take any surplus contractor supplied line materials.

- 3.13.8 OPGW shall be supplied as per standard length of 5 km in plain area and 3 km in hilly area.

3.14 Final checking, Testing and Commissioning

After completion of the works, final checking of the line shall be carried out by the Contractor to ensure that all foundation works, tower erection and stringing have been done strictly according to the specifications and as approved by the Employer. All the works shall be thoroughly inspected in order to ensure that:

- a) Sufficient backfilled earth covers each foundation pit and is adequately compacted;
- b) Concrete chimneys and their copings are in good condition and finely shaped.
- c) All tower members are used strictly according to final approved drawing and are free of any defect or damage whatsoever.
- d) All bolts are properly tightened, punched, tack welded and painted with zinc rich paint;
- e) The stringing of the conductors and earth wire has been done as per the approved sag and tension charts and desired clearances are clearly available;
- f) All conductor and earth wire accessories are properly installed;
- g) All other requirements for completion of works such as fixing of danger plate, phase plate, number plate, anti-climbing device and aviation signal have been fulfilled.
- h) Wherever required, that proper revetment (erosion protection) is provided;
- i) The original tracings of profile and route alignment as well as tower design, structural drawings, bill of material and shop drawings of all towers are submitted to the Employer for reference and record.
- j) The insulation of the line as a whole is tested by the Supplier through provision of his own equipment, labour etc., to the satisfaction of the *PGCIL*.
- k) All towers are properly grounded.
- l) The line is tested satisfactorily for commissioning purpose.

- 3.14.1 The contractor shall submit minimum 4 nos. of high resolution (min. 20MP) geo tagged photographs of each tower after completion of stringing. Stringing shall not be

considered completed without submission of soft copy of following photographs of each tower.

- i) Complete tower
- ii) Close up on Cross arms covering insulators, Hardware etc.
- iii) Forward span focusing on Conductor & corridor
- iv) Foundation

3.14.2 The contractor should also fulfill the requirements of pre-commissioning procedure as given in ***Appendix-I*** to this Specification

3.14.3 After commissioning of the line, thermos-vision scanning of jumper connections, dead end joints and mid span compression joints of the complete line shall be completed by the Contractor by deploying third party agency within three months of commissioning of the line using minimum 640x480 pixel resolution day time thermos-vision Camera alongwith suitable lenses. Details of the proposed third- party agency (including past experience) shall be submitted by the Contractor to POWERGRID site-in-charge. The thermos-vision scanning shall be carried out under supervision of Contractor & POWERGRID site engineers. Location and span wise report of thermos-vision scanning shall be submitted by the Contractor to POWERGRID Nodal officer Identified defects, if any, shall be rectified by the Contractor within contractual defect liability period.

4.0 Field Quality Plan

The Contractor shall execute the work in accordance with the Field Quality Plan which is attached along with BID.

Tower manufacturing shall be carried out in accordance with Standardized Manufacturing Quality plan as given in ***Appendix-II***.

SECTION-IVD

CONTRACTOR DESIGN FOUNDATIONS

**(Applicable for Transmission Lines
wherein Foundation Design is in
Contractor's scope)**

(Strikeout/Delete whichever is not applicable)

**TECHNICAL
SPECIFICATIONS
SECTION-IV D
CONTRACTOR DESIGN FOUNDATIONS**

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1.9	Construction of Tower Foundation

**TECHNICAL
SPECIFICATIONS
SECTION- IV D
CONTRACTOR DESIGN FOUNDATIONS**

1.1 Foundations

Foundation includes supply of all labour, tools & machineries, materials such as cement, sand, coarse aggregates and reinforcement steel and all associated activities, such as, excavation, concreting and back filling etc.

1.2 Type of Foundations

The foundation shall generally be of open cast type. Plain Cement Concrete/ Reinforced Cement Concrete footing shall be used for all type of normal towers. All the four footings of the tower and their extensions shall be similar for a particular location, irrespective of down thrust and uplift except where soil condition and or water table are different at different legs. The Bidder shall offer open type of foundation (i.e., slab and chimney) with maximum depth of foundation up to 3.5 meters for above classification of foundations depending on economy and feasibility of construction at site. For Hard Rock type and also where specific site conditions/ properties demand foundation of different depths (lower or higher), the same shall be adopted

Bidder has to furnish along with the bid one sample calculation for assessment of present design capability of the Bidder.

1.3 Classifications of Foundations:

The foundation designs shall depend upon the type of soil, sub soil water level and the presence of surface water which have been classified as follows (except pile foundations which is described in relevant section of this specification).

1.3.1 Normal Dry

To be used for locations where normal dry cohesive or non-cohesive soils are met. Foundations in areas where surface water encountered from rain runoff shall also be classified as normal dry.

1.3.2 Sandy Dry Soil

To be used for locations where cohesion less pure sand or sand with clay content less than 10% met in dry condition. If the clay content is more than 10 % met in dry condition, the foundation shall be classified as Normal Dry.

1.3.3 Wet

To be used for locations where sub-soil water table is met between 1.5 meters from ground level and the depth of foundation below the ground level.

1.3.4 Wet Cultivated

To be used for locations where there is no sub-soil water within the foundation depth but which are in surface water for long period with water penetration not exceeding one meter below the ground level e.g. paddy fields/ cultivated field. However, if water penetration due to surface water is more than one meter below ground level, the adoption of suitable foundation shall be decided by site In- charge in consultation with Corporate engineering Department.

1.3.5 **Partially Submerged**

To be used at locations where sub-soil water table is met between 0.75 meter and 1.5 meter below the ground level.

1.3.6 **Fully Submerged**

To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.

1.3.7 **Black Cotton Soil**

To be used at locations where soil is clayey type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing foundations, for such locations, the soil is considered submerged in nature.

1.3.8 **Fissured Rock**

To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations.

In case of fissured rock locations, where water table is met at 1.5M or more below ground level, wet fissured rock foundations shall be adopted. Where fissured rock is encountered with subsoil water table less than 1.5 meter below ground level, submerged fissured rock foundations shall be adopted. In case of dry locations dry fissured rock foundations shall be adopted.

1.3.9 **Hard Rock**

The locations where chiseling, drilling and blasting is required for excavation for monolithic rock for a particular leg/tower, Hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces. For quoting prices of Hard Rock foundations, Rock level shall be assumed at 1.5 meters below the ground level. Due to change in Rock level, no extra payment shall be payable on account of increase in concrete volume, excavation volume and weight of reinforcement. Also, no recovery shall be made if the actual volume of concrete, excavation and weight of reinforcement are less than that quoted in Schedule of prices. However, for design purpose, Rock level shall be considered at ground level and no over burden soil weight shall be considered for resisting the uplift.

1.3.10 The sub-soil water table is not constant and its level changes during different seasons due to various factors. In case during soil investigation/ trial pit or during excavation, if wet soil/ fissures rock is encountered within the foundation depth, it is to be considered that water table has been encountered (considering that water table had reached that level sometime in past) and accordingly type of foundation shall be classified.

1.3.11 Where soil is of composite in nature, classification of foundation shall be according to the type of soil predominant in the foundation pit.

1.3.12 The foundation classification at any particular location shall be based on the type of soil (clay/ sandy/ silt/ fissured rock etc.) and water table, presence of surface water, etc. at the location. However, in case of locations which are in vicinity of rivers, depending upon case to case, type

of foundation is to be decided considering other aspects also e.g. in case RL (reduced level) of a location in comparison to the HFL is lower and there is possibility of submergence at the time of floods due to absence of river bunds/ protection etc., FS type foundation with suitable raised chimney is to be adopted. Further in case there is a possibility of change in river course, considering the nature and turbulence of probable water flow and subsequent scouring of soil, pile type or special foundation may be considered for these locations.

- 1.3.13 In addition to above, if required, depending on the site conditions, special type foundations shall also be provided by the Contractor suitable for intermediate conditions under the above classifications to affect more economy for following reasons:
- (a) Shallow Depth or Raised Chimney foundations are necessarily required to suit the site condition or
 - (b) Soil properties as per the soil report at particular location are found inferior/ superior to the properties specified in the bid documents and considered for normal foundation design.
- 1.3.14 The proposal for special foundations shall be submitted by the Contractor based on the detailed soil investigation report/ to suit site conditions and approval for the same shall be obtained from the Employer. Decision of the Employer shall be final and binding with respect to requirement of special foundation. In case of Special foundations, payment for installation of stub shall be made on pro-rata basis of installation rate of approved stub weight of normal tower up to +9m extension.
- 1.3.15 During execution of the Line, if foundation for other types of towers/ structures viz Gantry, single circuit/ Multi circuit towers in Double circuit line, Double circuit/ Multi-circuit towers in a Single circuit line, Single circuit/ Double circuit towers in a Multi circuit line, Narrow base towers, Towers of higher extensions (viz. +43m/+55 m for 765kV D/C lines wherever applicable), Towers of different configuration, etc. are required, supply & all works associated for installation of these shall be carried out by the contractor as per Employer supplied design/ drawings.
If Employer designed towers are not covered in the BPS, Payment for these, shall be made on mutually agreed rates to be derived on the basis of rates available in the Contract during execution stage.
- 1.3.16 Design and Casting of Foundations for Contractor design towers, which are not specified in the Final BPS of the Contract Agreement, but required during execution of the project and authorized by the Employer, shall have to be carried out by the Contractor. No additional payment on account of Design charges shall be payable. Payment for execution of such foundations shall be made on mutually agreed rates to be derived on the basis of rates available in the Contract during execution stage.

1.4 Soil Investigation

The contractor may be required to undertake soil investigation as per clause 4.0 of Section-3

at tower locations as required by the Employer. The provisional number of soil testing locations is furnished in Schedule of Prices. However, contractor shall take reference to the soil investigations wherever already carried out by the Employer.

1.5 Design of Foundations

Design of foundations as classified under Clause 1.3 for all towers and towers with extensions shall be developed by the Contractor based on the standard soil properties of the concerned state and shall be submitted for approval of Employer, irrespective of the actual site requirement. Charges for the same are deemed to be included in the quoted prices.

The indicative shape of foundation is enclosed in this specification. In case of normal foundation, minimum clearance between chimney concrete level and ground level shall be 225 mm. Based on specific site condition to avoid rusting of stubs, foundation with 500 mm clearance between concrete level and ground level may be used on case to case basis as may decide by Site In-charge.

1.5.1 Loads on Foundations

1.5.1.1 The foundations shall be designed to withstand the specific loads of the superstructure and for the full footing reactions obtained from the structural stress analysis in conformity with the relevant factors of safety.

1.5.1.2 The reactions on the footings shall be composed of the following type of loads for which these shall be required to be checked:

- a) Maximum Tension or uplift along the leg slope.
- b) Maximum Compression or down-thrust along the leg slope.
- c) Maximum Horizontal shear or side thrust.

1.5.2 Stability Analysis

1.5.2.1 In addition to the strength design, stability analysis of the foundation shall be done to check the possibility of failure by over-turning, uprooting, sliding and tilting of the foundation.

1.5.2.2 The following primary types of soil resistance shall be assumed to act in resisting the loads imposed on the footing in earth:

A) Resistance against Uplift

The uplift loads will be assumed to be resisted by the weight of earth in an inverted frustum of a conical pyramid of earth of this Section on the footing pad whose sides make an angle equal to the angle of repose of the earth with the vertical, in average soil. The weight of concrete embedded in earth and that above the ground will also be considered for resisting the uplift. In case where the frustum of earth pyramids of two adjoining legs super-impose each other, the earth frustum will be assumed truncated by a vertical plane passing through the centre line of the tower base. In case of foundation with undercut, resistance provided by weight of earth in an inverted frustum of a conical pyramid shall be increased by 25 %. This shall

also be applicable for stability analysis check for over turning in case of foundation with undercut.

B) Resistance Against Down Thrust

The down-thrust loads combined with the additional weight of concrete above earth will be resisted by bearing strength of the soil assumed to be acting on the total area of the bottom of the footings.

C) Resistance Against Side-Thrust

The lateral load capacity of a chimney foundation shall be based on chimney acting as a cantilever aided by passive earth resistance developed 500 mm below the ground level.

The chimney shaft shall be reinforced for the combined action of axial force, tension and compression and the associated maximum bending moment. In these calculations, the tensile strength of concrete shall be ignored. The contribution of stub for chimney design shall be considered as per latest CBIP Manual.

The increase in vertical toe pressure due to maximum bending moment at the bottom of the slab shall be taken into account and the base itself shall be designed for structural adequacy. In this case, the allowable vertical toe pressure may be increased by 25%. The unit weight of reinforced concrete is stipulated in *Table 2-2*.

1.6 Design Criteria

1.6.1 As per IS 456: 2002 Partial safety factor shall be considered 1.5 for concrete and 1.15 For steel.

1.6.2 The overload factors for open type foundations shall be as 1.1 i.e. all the reactions (compression, tension and side thrust) on foundations shall be increased by 10 percent for development of foundation design.

1.6.3 The physical properties of soil under various conditions are furnished in *Table 2.1* to be considered for the design of foundations. These types of foundations correspond to list of foundations furnished in Schedule of prices.

1.6.4 The composite rate shall be paid to the contractor for above foundations irrespective of approved design volumes except for Gantry, Single circuit & Multi circuit towers, not specified in BPS, for which payment shall be made on mutually agreed rates to be derived on the basis of rates available in the Contract during execution stage. Further, once the foundations are classified based on the preponderant soil, extra claim is not admissible for excavation in different kinds of soil encountered inside the pit.

It may be noted that the soil properties furnished in *Table 2.1* are standard for respective states. However, after soil investigations, if it is found that the foundations listed in Schedule of Prices Vol. III cannot be used at that location; new foundation design shall be developed by the Contractor based on properties

furnished in soil report. No additional payment on account of Design charges shall be payable. Any such foundations required during execution of the project and authorised by the Employer, shall have to be carried out by the Contractor for which payment shall be made on mutually agreed rates to be derived on the basis of rates available in the Contract during execution stage.

- 1.6.5 The foundation shall be designed such as to satisfy the following conditions:
 - 1.6.5.1 The thickness of concrete in the chimney portion of the tower footing shall be provided with minimum cover of not less than 100 mm from any part of the stub angle to the nearest outer surface of the concrete in respect of all dry locations limiting the minimum section of chimney to 300 mm square. In respect of all wet locations, the chimney should have all around clearance of 150 mm from any part of stub angle limiting the minimum section of chimney to 450 mm square.
 - 1.6.5.2 The chimney top or muffing must be at least 225 mm above ground level and also the coping shall be extended up to lower most joint level between the bottom lattices and the main corner legs of the tower.
 - 1.6.5.3 The centroidal axis of slab shall coincide with the axis of the chimney and pass through the center of foundation base. The design of the foundation (base slab and its reinforcement) shall take into account the additional stresses in the foundation resulting from the eccentricity introduced due to non-compliances of this requirement.
 - 1.6.5.4 In case of RCC type foundations, the frustum can be single or multi stepped. The thickness of bottom slab (including slopped slab portion) should not be less than 300 mm. The bottom portion of minimum 100 mm thickness of the slab shall have vertical sides and balance portion shall have 45° slope as indicated in drawing enclosed in the bidding documents.
 - 1.6.5.5 The minimum distance between the lowest edge of the stub angle and the bottom surface of concrete footing shall not be less than 100 mm or more than 150 mm in case of dry locations and not less than 150 mm or more than 200 mm in case of wet locations.
 - 1.6.5.6 The total depth of open type foundations below the ground level (including lean concrete pad) shall not be less than 1.5 meters and more than 3.5 meters.
 - 1.6.5.7 The portion of the stub in the slab shall be designed to take full down-thrust or uplift loads by the cleats combined with the bond between stub angles and slab concrete. The Contractor shall furnish the calculation for uprooting of stub along with the foundation design. Bolted cleat angles evenly spaced in sets of 4 along all sides of embedded portion of the stub shall be provided to act as shear connector with sufficient number of bolts.

- 1.6.5.8 In case of R.C.C. foundations having steel reinforcement in base slab, at least 50mm. thick pad of lean concrete corresponding to 1:3:6 nominal mix shall be provided below the bottom slab.
- 1.6.5.9 The base slab of the foundation shall be designed for additional moments due to eccentricity of the loads.
- 1.6.5.10 The additional weight of concrete in the footing below ground level over the earth weight & full weight of concrete above the ground level in the footing and embedded steel parts will also be taken into account adding to the down thrust.

TABLE 2.1: Soil Properties

Sl. No	Properties of Soil	Ultimate Bearing Capacity in KN/M ² (Kg/M ²)	Angle of Repose (Degree)
1	For Normal Soil (UP, Uttarakhand, Haryana, Delhi, Bihar, Jharkhand, WB, MP, Chhattisgarh, Kerala, J&K, Ladakh, Assam, Andhra Pradesh, Telangana, Tamil Nadu)		
	Normal Dry Soil	268 (27350)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	134 (13675)/ 268(27350)	15
	Black cotton Soil Due to Presence of Subsoil/Surface water and dry condition	134 (13675)	0
	Sandy Soil	268 (27350)	20
2	For Normal Soil (Rajasthan)		
	Normal Dry Soil	268 (27350)	25
	Wet Soil Due to Presence of Subsoil/ Surface Water	134 (13675)/ 268(27350)	10
	Black cotton Soil Due to Presence of Subsoil/Surface water and dry condition	134 (13675)	0
	Sandy Soil	268 (27350)	20
3	For Normal Soil (Maharashtra)		
	Normal Dry Soil	490(50000)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	122.5 (12500)/ 490(50000)	10
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	122.5 (12500)	0
4	For Normal Soil (Himachal Pradesh)		
	Normal Dry Soil	196 (20000)	30

	Wet Soil Due to Presence of Subsoil/ Surface Water	98 (10000)/ 196 (20000)	15
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	98 (10000)	0
	Sandy Soil	196 (20000)	20
5	For Normal Soil (Karnataka)		
	Normal Dry Soil	214.5 (21870)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	107.2 (10935)/ 214.5 (21870)	15
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	107.2 (10935)	0
	Sandy Soil	214.5 (21870)	20
6	For Normal Soil (Odisha)		
	Normal Dry Soil	256.5 (26175)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	183.8 (18750)/ 256.5 (26175)	15
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	183.8 (18750)	0
	Sandy Soil	256.5 (26175)	20
7	For Normal Soil (Punjab)		
	Normal Dry Soil	264.6 (27000)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	132.3 (13500)/ 264.6 (27000)	15
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	132.3 (13500)	0
	Sandy Soil	264.6 (27000)	20
8	For Normal Soil (Gujarat)		
	Normal Dry Soil	268 (27350)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	134 (13675)/ 268(27350)	15
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	107.8 (11000)	0
	Sandy Soil	268 (27350)	20
9	Fissured Rock		
	a) Fissured rock in dry portion	613 (62500)	20
	b) Fissured rock in presence of water	613 (62500)	10
10	Hard Rock	1225.83 (125000)	

11	Weight of earth for normal soil and black cotton soil	UNIT	VALUE
	a) Dry	KN/M3 (Kg/M3)	14.12 (1440)
	b) In presence of Surface Water	KN/M3 (Kg/M3)	14.12 (1440)
	c) In presence of Subsoil Water	KN/M3 (Kg/M3)	9.22 (940)
12	Weight of Fissured Rock		
	a) Dry	KN/M3 (Kg/M3)	14.12 (1440)
	b) In presence of Subsoil Water	KN/M3 (Kg/M3)	9.22 (940)
13	Ultimate bond between Steel & Rock for Hard Rock foundations	KN/M2 (Kg/M2)	0.147 (15)

The above soil properties (except Ultimate Bond between Steel & Rock) of the earth will be measured by the Contractor at the various locations in conformity with the standard method of testing and the foundation design will be revised suiting the site conditions from such tests.

1.7 Properties of Concrete

The cement concrete used for the foundations shall generally be of grade M20 having 1:1.5:3 nominal volumetric mix ratio with 20 mm coarse aggregate graded downward for chimney portion and pyramid or slab portion. All the properties of concrete regarding its strength under compression, tension, shear, punching and bending etc. as well as workmanship will conform to IS 456.

- 1.7.1 The weight of concrete to be considered for design of foundations is given in **Table 2.2**.

Table 2.2: Weight of Concrete

Type of concrete	Weight of dry region KN/m ³ (Kg/m ³)	Weight in presence of sub-soil water KN/m ³ (Kg/m ³)
Plain Concrete	21.96 (2240)	12.16 (1240)
Reinforced Concrete	23.54 (2400)	13.73 (1400)

- 1.7.2 The Quantity of minimum cement to be used per unit quantity of consumption for different mix (nominal mix) of concrete should be as follows:

Sl. No.	Description	Unit	Quantity of Minimum cement to be used per Unit quantity of work (in kg)
1.	1:1.5:3 nominal mix concrete	cum	400
2.	1:2:4 nominal mix concrete	cum	320

3.	1:3:6 nominal mix concrete	cum	220
4.	Random Rubble Masonry with 1:6 cement mortar	cum	83

In this regard utilisation record is to be maintained at site.

- 1..7.3 Alternatively, ready-mix concrete from batching plant as per IS 4925 can also be used with no extra payment and without any recovery. However, cement content shall be as per IS 456. The ready-mix concrete shall conform to IS 4926. The selection and use of Materials for the ready-mix concrete shall be in accordance with IS 456. The concrete shall be of M25 grade design mix as per IS 456. The transport of concrete and transportation time shall be as per IS 4926.
- 1.7.4 Ready-mix concrete of M25 grade design mix as per IS 456, shall be used for foundations of railway crossing locations.
- 1.7.5 Use of small batching machines/ self-loading mixers may be allowed after verification of cement consumption and mix by Employer site in-charge. The equipment shall have facility of checking the proportion of ingredients of concrete being made. The records of mix shall be maintained at site. The calibration of equipment shall be done at regular intervals.
- 1.7.6 Ready mix concrete of M25 grade shall be designed as per IS 456. However, minimum cement content shall not be less than 330 kg/m³.
- 1.7.7 Cement used shall be ordinary Portland Cement, unless mentioned otherwise, conforming to the latest Indian Standard Code IS 269 or IS 8112 or IS 12269.

Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS 1489 (latest edition) or Portland Slag Cement conforming to IS 455 (Latest edition) can also be used. The Contractor shall submit the manufacturer's certificate, for each consignment of cement procured, to the Employer. However, Employer reserves the right to direct the Contractor to conduct tests for each batch/ lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Employer. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the Employer. Sulphate Resistant Cement shall be used if Sulphate content is more than the limits specified in IS 456, as per Geotechnical investigation report.

Ordinary Portland Cement (OPC) and Portland Pozzolana Cement (PPC) or Portland Slag Cement are Technically Equivalent and there would not be any financial implication/ or recovery to be borne by Employer/ Contractor. However, the minimum cement content shall be as per above table for nominal mix concrete.

- 1.7.8 Coarse and fine aggregates shall conform to IS 383.
- 1.7.9 The water used for mixing concrete shall be fresh, clean and free from oil,

acids & alkalis, organic materials or other deleterious substances.

- 1.7.10 Reinforcement shall conform to IS 1786 for high strength steel bars (Fe 500/ Fe500D). If mentioned in BPS, epoxy coated reinforcement conforming to IS 13620 shall be used. Thermo Mechanically Treated (TMT) bars (equivalent grade) in place of cold twisted bars are also accepted. Hard drawn steel wire shall conform to IS 432. All reinforcement shall be clean and free from loose mill scales, dust, loose rust and coats of paint, oil or other coatings, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of approved foundation drawings and Specifications. The Contractor may also use pre- fabricated/ assembled reinforcement cage conforming to shape, dimension, size as per approved foundation drawing. Spacers, chairs, stays, hangers, overlaps and annealed steel wire for binding etc. as may be necessary, should be used for proper completion of the foundation job as per requirement. Spacers or chairs should be placed at a maximum spacing of 1m and closer spacing shall be provided wherever necessary.
- 1.7.11 Use of crushed stone in place of natural sand, in case of non-availability or restriction by local authority, may be allowed by Employer site in-charge subject to sieve analysis meeting acceptance criteria as per relevant IS and complying of other requirement as per standard field quality plan.
- 1.7.12 For foundation in creek or aggressive soil areas, if mentioned in BPS, Concrete of M30 Grade design Mix conforming to IS 456 and epoxy coated reinforcement as per IS 13620 shall be used. In addition, 02 (two) numbers of coats of bituminous painting of minimum 1.6 kg/m² per coat shall be applied on all the exposed faces of the foundation (i.e. pedestal & base slab). Cost of bituminous painting shall be deemed to be included in the unit rate of M30 concrete.

1.8 Measurement, Unit Rates and Payment for Foundation

1.8.1 Measurement

- 1.8.1.1 The indicative shape of foundations is enclosed in this Specification. The unit prices for foundation work are indicated in BOQ bidder is required to quote accordingly on single percentagebasis as defined as per Bid document.
- 1.8.1.2 The concrete volume and dimensions of the foundation shall be determined from the drawing approved. Measurement of concrete volume shall be in cubic meters and shall be worked out to the second place of decimal.
- 1.8.1.3 The excavation volumes for each tower footing shall be estimated assuming the faces of surrounding earth as vertical keeping a distance of 150 mm clearances from the extreme edge of the base slab of footing. For footings with undercut, excavation volumes shall be calculated as per drawings without any side clearance.

- 1.8.1.4 The steel required for reinforcement of foundation shall be provided by the Contractor. Measurement of reinforcement steel will be based on the calculated weights of actually used steel in tons corrected to third place of decimal, no allowance being made for wastage. No payments will be made for wire required for binding the reinforcement, chairs, bolsters and spacers, as the cost of these is deemed to be included in the unit rate quoted.

1.8.2 Payment for Foundation

1.8.2.1 Normal Foundations

1.8.2.1.1 The unit

1.8.2.1.2 Rates of foundation work are indicated in BOQ.

- 1.8.2.1.3 The rate of foundation item wise indicated in BOQ, which are excavation, benching, concreting (including all associated works related to foundation not covered in Excavation and reinforcement) like concreting and Lean concrete.

- 1.8.2.1.4 The unit rate as incorporated in percentage BOQ of Foundation include supply and placement of reinforcement steel, stirrups, wire for binding the reinforcement, chairs, bolsters and spacers etc. as required to complete the foundation work. In case of actual unit weight of the reinforced steel is found less than standard unit weight, but within acceptable tolerance variation as per applicable standard, the same shall be accepted without any compensation/ deduction. However, if unit weight is found to be beyond the negative (-ve) tolerance limits specified in IS, the material shall be rejected. Wastage overlaps, spacer bars, chairs, stays, hangers and annealed steel wire etc. shall not be measured for the payment and cost of these items shall be deemed to be included in the quoted rate of bidder.

1.9 Construction of Tower Foundation

1.9.1 Testing of soil

- 1.9.1.1 The Contractor shall be required to undertake testing of soil for the tower locations in the manner specified under ***Clause 4.0 of Section-3*** of this Specification and shall submit his report about the subsoil water table, type of soil encountered, bearing capacity of soil, possibility of submergence and other soil properties required for the design of foundations. The Contractor shall also furnish soil resistivity values to the Employer along the line alignment.

1.9.2 Excavation

1.9.2.1 The excavation work for foundations shall be taken up by the contractor progressively stretch wise/ section wise after obtaining approval from Employer for the proposed stretch wise/ section wise tower schedule, profile etc. as per detailed survey along the approved route alignment.

1.9.2.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be vertical and the pit dimensions shall be based on an assumed clearance of 150 mm on all sides of the foundation pad. For footings with undercut, care shall be taken to carry out excavation as per drawing without any side clearance. For Fissured rock foundations, undercut as shown in the drawing is required and shall be provided accordingly. In cases where undercutting portion is excavated beyond stipulated dimension, the extended undercut portion shall be filled with additional concrete and reinforcement shall be extended into the undercut portion considering margin for concrete cover. However, payment of concrete & reinforcement shall be limited to design volumes of excavation, concrete, reinforcement etc. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, wherever the soil is loose or collapsible or in case of water in excavated pit, using timbering, shoring, shuttering, dewatering arrangements etc. as approved by the Employer/ Site-In-Charge. Contractor shall especially avoid disturbing the bearing surface of the pad. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit or borehole shall be removed by Contractor before placing concrete.

Keeping in view of safety aspect, in case any sloped/ stepped/ ramp excavation for easy movement of man and material in excavation pit is required the same shall be done by the contractor. No Extra payment shall be admissible to the Contractor for the same.

1.9.2.4 The soil to be excavated for tower foundations shall be classified as follows depending upon the physical state of the soil at the time of excavation irrespective of the type of foundation installed.

a) **Dry Soil**

Soil removable either manually, by means of a spade and shovel or mechanically by poclains, excavators etc.

Excavation done in dry soil for wet, partially submerged, fully submerged and wet black cotton type of foundations shall also be covered under this.

b) **Wet Soil**

During excavation, if wet soil is encountered within the

foundation depth, the type of soil shall be considered as Wet irrespective of whether pumping/ bailing out of water is required or not. The excavation done in wet soil in case of wet, wet cultivated, partially submerged, fully submerged and wet black cotton type of foundation shall also be covered under this.

c) **Dry Fissured Rock**

Limestone, laterite, hard conglomerate or other soft or fissured rock in dry condition which can be quarried or split with crowbars, wedges, pickaxes etc. However, if required, light blasting may be resorted to for loosening the material but this will not in any way entitle the material to be classified as hard rock.

d) **Wet Fissured Rock**

Above fissured rock, when encountered with subsoil water within the range of foundation depth or land where pumping or bailing out of water is required, shall be treated as wet fissured rock.

e) **Hard Rock**

Any rock excavation, other than specified under fissured rock above, for which blasting, drilling, chiseling is required. The unit rate quoted for hard rock excavation shall be inclusive of all costs for such drilling (including drilling required for anchoring), chiseling and blasting, etc.

1.9.2.5 No extra payment shall be admitted for the removal of fallen earth into a pit or borehole once excavated.

1.9.2.6 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, if permitted by the Employer, shall be done with utmost care to minimise fracturing rock and using extra concrete for filling the blasted area. All necessary precautions for handling and use of blasting materials shall be taken. In case where drilling is done, the stubs may be shortened suitably with the approval of the Employer.

In cases where unnecessarily large quantities are excavated/ blasted for fissured rock/ hard rock, resulting in placement of large volumes of concrete, payment of concrete shall be limited to design volumes of excavation, concreting, reinforcement etc.

In cases where unnecessarily excavation is done beyond foundation depth for normal foundation other than Hard rock, the same shall be filled with additional Plain cement concrete (PCC) corresponding to a 1:3:6 nominal mix without any additional financial implication to Employer. However, minimum thickness of PCC above founding level as shown in the construction drawing of foundation shall be provided.

1.9.2.7 The Contractor shall arrange and supply requisite blasting material, and be responsible for its storage and use, without any extra cost to the Employer.

1.9.2.8 Indian Standard IS 3764 shall be followed regarding safety of

excavation work.

1.9.3 Setting of Stubs

- 1.9.3.1 The stubs shall be set correctly and precisely in accordance with approved method at the exact location, alignment and levels with the help of stub setting templates and leveling instruments. Minimum clearance between chimney concrete level and ground level shall be ensured as per foundation drawing. Stubs setting shall be done in the presence of Employer's representative/ Nodal officer of PGCIL available at site where required and for which adequate advance intimation shall be given to Employer/ Nodal officer of pgcil by Contractor. Tolerances as per provisions of IS 5613 shall be allowed for stub setting.
- 1.9.3.2 Setting of stub at each location shall be approved by Employer/ Nodal officer of
- 1.9.3.3 Individual Leg stub setting template may also be used by the contractor with prior approval from Employer Site-In-Charge. An indicative drawing for individual leg stub setting template is attached with the specification. Proper care shall be taken by the contractor for accurate setting & alignment of stub levels
- 1.9.3.4 However, towers with unequal leg extensions, for Multi Circuit tower, for towers with +18/ +25/ +30 m Extensions, for raised chimney foundations, for river crossing towers, Anchor tower and for foundations in highly collapsible soils, props may be used with complete accuracy and high skilled supervision, subject to prior approval from Employer/ Site-In-Charge. No recovery shall be made on account of using Props for stub setting.

1.9.4 Stub Setting Templates/ Props

- 1.9.4.1 Stub setting templates shall be arranged by the Contractor at his own cost for all heights of towers. Stub templates shall be of adjustable type. The Contractor shall also arrange for props for setting of stubs at specific locations where use of prop is approved by the Employer. Stub templates/ props should be painted.
- 1.9.4.2 The Contractor shall deploy sufficient number of templates/ props for timely completion of the line without any extra cost to Employer.
- 1.9.4.3 However, the number of templates to be deployed shall depend upon type of terrain condition, number of types of towers etc. Hence, the quantity of template to be deployed for timely completion of the line shall be finalized in consultation with Site-In-Charge without any extra cost to the Employer.

The number of sets of props (if permitted) to be arranged, will depend as per actual site condition and completion schedule of line.

- 1.9.4.4 One set of each type of stub setting template/ props (if used) shall be supplied to the Employer, on completion of the project, at no extra cost to Employer.

1.9.5 Mixing, Placing and Compacting of Concrete

- 1.9.5.1 The concrete shall be mixed in the mechanical mixer. However, in case of difficult terrain, hand mixing may be permitted at the discretion of the Employer. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalis. Saltish or blackish water shall not be used.

Alternatively, Ready Mix concrete from batching plant as per IS 4925 can also be used with no extra payment and without any recovery. However, Cement content shall be as per IS 456. The ready-mix concrete shall conform to IS 4926. The selection and use of Materials for the ready-mix concrete shall be in accordance with IS 456. The concrete shall be of M25 grade design mix as per IS 456. The transport of concrete and transportation time shall be as per IS 4926. Record of delivery ticket information as per Annexure-G of IS 4926 has to be maintained.

- 1.9.5.2 Mixing shall be continued until there is uniform distribution of material and mix is uniform in colour and consistency, but in no case the mixing be carried out for less than two minutes. Normal mixing shall be done close to the foundation but exceptionally, in difficult terrain, the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

- 1.9.5.3 To avoid the possibility of reinforcement rods being exposed due to unevenness of the bottom of the excavated pit, a pad of lean concrete 50 mm thick and corresponding to a 1:3:6 nominal mix shall be provided at the bottom of the pad. The coarse aggregate shall be of 20mm size and shall conform to IS 383.

- 1.9.5.4 Form boxes shall be used for casting all types of foundations except at an undercut interface for which the adjoining subsurface material shall provide adequate support. Form boxes shall conform to the shape, lines & dimensions of the foundation drawing and shall be constructed so as to be rigid during the placing and compacting of concrete. Contractor shall ensure that Form boxes are in good condition. Repeated use & maintenance of form box shall be as per IS 456 & IS 14687.

- 1.9.5.5 The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works, up to the

top and no honey-combing occurs in the concrete. A mechanical vibrator shall be employed for compacting the concrete. Monolithic casting of foundation must be carried out. However, in case of unavoidable circumstances, a key construction joint can be provided at the chimney-pad interface subject to approval of the Employer or as directed by the Engineer-in-charge. Number of such joints shall be kept minimum. Joints shall be kept as straight as possible & such construction joints should comply with IS 456. There shall not be any construction joint near stub & cleat portion of frustum. However, nothing extra shall be paid to the Contractor for providing such construction joints. For raised chimney, joint in concrete shall be of 3 m in chimney portion if casting of full chimney is not possible in one stretch.

- 1.9.5.6 After concreting the chimney portion to the required height, in the top 50 mm portion between CL & GL coping shall be done after erection of tower and the top surface should be finished smooth with a slight slope towards the outer edge for draining rain water.

Further, in case of Wet, Wet cultivated, PS, FS & WBC foundation before coping of chimney top portion, three coats of anti-corrosive paint (As recommended by paint manufacture for structural steel application) of minimum 30-35 microns dry film thickness each shall be applied on the stub in the 50 mm coping portion as well as upto 350 mm above CL portion. Cost of supply and application of anti-corrosive paint shall be deemed to be included in the unit rate of concreting.

- 1.9.5.7 Wet locations shall be kept completely dewatered, both during and 24 hours after placing the concrete, without disturbance of the concrete.

- 1.9.5.8 If minor defects in concrete surface is found after the form work has been removed, the damage shall be repaired with a rich cement sand mortar to the satisfaction of the Employer before the foundation is back filled.

1.9.6 Curing

The concrete shall be cured by maintaining the concrete wet for a period of at least 10 days after placing. Once the concrete has set for 24 hours the pit may be backfilled with selected moistened soil and well consolidated in layers thereafter both the backfill earth and exposed chimney shall be kept wet for the remainder of the prescribed 10 days. The exposed concrete chimney shall also be kept wet by wrapping gunny bags around it and wetting the bags continuously during the initial 10 days period.

1.9.7 Backfilling and Removal of Stub Templates

- 1.9.7.1 After opening of formwork and removal of shoring, shuttering etc., backfilling shall be done with the excavated soil, unless it consists of large boulders/ stones, in which case the boulders/

stones shall be broken to a maximum size of 80 mm or disposed-off. At locations, where borrowed earth is required for backfilling, Contractor shall bear the cost of the borrowed earth irrespective of leads & lift.

1.9.7.2 The backfilling materials shall be clean and free from organic or other foreign materials. The earth shall be deposited in various layers, levelled, wetted if necessary and shall be fully compacted. All excavated earth shall be placed over the filled in pit to allow further settlement, if any, by gravity.

1.9.7.3 The backfilling and grading shall be carried to an elevation of about 75 mm above the finished ground level to drain out water. After backfilling 50 mm high, earthen embankment (band) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours. After the pits have been backfilled to full depth the stub template can be removed.

1.9.8 **Benching**

When the line passes through hilly/ undulated terrain, levelling the ground may be required for casting of tower footings. All such activities shall be termed benching and shall include cutting of excess earth and removing the same to a suitable point of disposal as required by Employer. Benching shall be resorted to only after approval from Employer. Volume of the earth to be cut shall be measured before cutting and approved by Employer for payment purposes. Further, to minimise benching, unequal leg extensions/ raised chimney shall be considered and provided if found economical. The proposal shall be submitted by the Contractor with detailed justification to the Employer.

1.9.9 **Protection of Tower and Tower Footing**

1.9.9.1 Tower shall be spotted such that the quantities of revetment are optimum. For tower locations in undulated terrain such as hill/ mountain slopes, options like use of unequal leg extensions for towers, unequal chimney extensions etc. shall be explored by the contractor for optimizing the need for revetment & benching.

1.9.9.2 The work shall include all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in nalas, river bank/ bed, undulated terrain, protection of uphill/ downhill slopes required for protection of tower etc., including suitable revetment or galvanised wire netting and meshing packed with boulders. The top cover of stone revetment shall be sealed with 1:2:4 nominal mix concrete. Contractor shall recommend protection at such locations wherever required. Details of protection of tower/ tower footing are given in drawing enclosed with these specifications for reference purpose only.

1.9.9.3 Tower footings shall generally be backfilled using soil excavated at site unless unsuitable for backfilling. In the latter

case, backfilling shall be done with borrowed earth of suitable quality irrespective of leads and lift. The unit rate for backfilling quoted in BPS shall include the required lead and consolidation and leveling of earth after backfilling.

1.9.9.4 For protection work if required any the unit rates derived shall be applicable for any quantity variations during execution. The same unit rates shall hold good for protection work carried out on down hills or up hills slopes applicable for the tower locations.

1.9.9.5 The unit rates for random rubble masonry revetment quoted in price schedule shall also include excavation & (1:5) random masonry and unit rate for top sealing with M15 concrete. For payment purposes the volume of random rubble masonry revetment shall be measured from bottom to top sealing coat and paid at the unit rates indicated in the Contract.

No extra payment shall be made for allied works such as excavation for revetment, packed stone at head of weep holes etc. However, no deduction shall be made for the volume enclosed by weep holes.

1.9.9.6 For some of the locations in nalas, river bed or undulated terrain etc., boulders of minimum. 150mm size bounded and packed in galvanised wire net/ mesh of 8 SWG wire and 152 square mm (maximum) mesh are to be provided. These stones shall be provided in crates size of 2.0 m x 2.0 m or as deemed suitable for a particular location. Measurement shall be taken in cubic meters and 15% deduction will be made for void from cage/ stack measurements.

1.9.10 After completion of foundation, stub levels, back to back dimensions, diagonal dimensions etc. shall be measured jointly by the Engineer of Contractor and Employer before taking up erection of tower and same shall be recorded for future reference. In case of any deviations beyond permissible limits as per IS 5613, the foundation shall be rectified or re-casted by the contractor at his own cost.

SECTION-IVE

EMPLOYER DESIGN FOUNDATIONS

**(Applicable for Transmission Lines
wherein Foundation Design is in
Employer's scope)**

**TECHNICAL
SPECIFICATIONS
SECTION-IV E
EMPLOYER DESIGN FOUNDATIONS**

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**TECHNICAL
SPECIFICATIONS
SECTION- IV E
EMPLOYER DESIGN FOUNDATIONS**

1.1 Foundations

Foundation includes supply of all labour, tools & machineries, materials such as cement, sand, coarse aggregates and reinforcement steel and all associated activities, such as, excavation, concreting and back filling etc.

1.2 Type of Foundations

The foundation shall generally be of open cast type. Plain Cement Concrete/ Reinforced Cement Concrete footing shall be used for all type of normal towers. All the four footings of the tower and their extensions shall be similar for a particular location, except where soil condition and or water table are different at different legs. The total depth of foundation, below ground level shall be upto 3.5 meters. For Hard Rock type and also where specific site conditions/ properties demand foundation of different depths (lower or higher), the same shall be adopted.

Further, for multi-circuit tower foundations, the foundation depth shall be 3.5 meters and for river crossing open cast foundations, the foundation depth shall be more than 3.5 meters.

1.3 Classifications of Foundations:

The foundation designs shall depend upon the type of soil, sub soil water level and the presence of surface water which have been classified as follows (except pile foundations which is described in relevant section of this specification).

1.3.1 Normal Dry

To be used for locations where normal dry cohesive or non-cohesive soils are met. Foundations in areas where surface water encountered from rain runoff shall also be classified as normal dry.

1.3.2 Sandy Dry Soil

To be used for locations where cohesion less pure sand or sand with clay content less than 10% met in dry condition. If the clay content is more than 10% met in dry condition, the foundation shall be classified as Normal Dry.

1.3.3 Wet

To be used for locations where sub-soil water table is met between 1.5 meters from ground level and the depth of foundation below the ground level.

1.3.4 Wet Cultivated

To be used for locations where there is no sub-soil water within the foundation depth but which are in surface water for long period with water penetration not exceeding one meter below the ground level e.g. paddy fields/ cultivated field. However, if water penetration due to surface water is more than one meter below ground level, the adoption of suitable foundation shall be decided by site-in- charge in consultation with Corporate engineering Department

1.3.5 Partially Submerged

To be used at locations where sub-soil water table is met between 0.75 meter and 1.5 meter below the ground level.

1.3.6 Fully Submerged

To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.

1.3.7 Black Cotton Soil

To be used at locations where soil is clay type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing foundations, for such locations, the soil is considered submerged in nature.

1.3.8 Fissured Rock

To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations.

In case of fissured rock locations, where water table is met at 1.5M or more below ground level, wet fissured rock foundations shall be adopted. Where fissured rock is encountered with subsoil water table less than 1.5 meter below ground level, submerged fissured rock foundations shall be adopted. In case of dry locations dry fissured rock foundations shall be adopted.

1.3.9 Hard Rock

The locations where chiseling, drilling and blasting is required for excavation for monolithic rock for a particular leg/ tower, Hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces.

1.3.10 The sub-soil water table is not constant and its level changes during different seasons due to various factors. In case during soil investigation/ trial pit or during excavation, if wet soil/ fissures rock is encountered within the foundation depth, it is to be considered that water table has been encountered (considering that water table had reached that level sometime in past) and accordingly type of foundation shall be classified.

1.3.11 Where soil is of composite in nature, classification of foundation shall be according to the type of soil predominant in the foundation pit.

1.3.12 The foundation classification at any particular location shall be based on the type of soil (clay/ sandy/ silt/ fissured rock etc.) and water table, presence of surface water, etc. at the location. However, in case of locations which are in vicinity of rivers, depending upon case to case, type of foundation is to be decided considering other aspects also e.g. in case RL (reduced level) of a location in comparison to the HFL is lower and there is possibility of submergence at the time of floods due to absence of river bunds/ protection etc., FS type foundation with suitable raised chimney is to be adopted. Further in case there is a possibility of change in river course, considering the nature and turbulence of probable water flow and subsequent scouring of soil, pile type or special foundation may be considered for these locations.

1.4 Design of Foundations

1.4.1 Design of foundations as classified under Clause 1.3 for all towers and towers with extensions shall be developed by the Employer based on the standard soil properties. The indicative shape of foundation is also

enclosed in this specification.

- 1.4.2 In case of normal foundation, minimum clearance between chimney concrete level and ground level shall be 225 mm. Based on specific site condition to avoid rusting of stubs, foundation with 500 mm clearance between concrete level and ground level may be used on case to case basis as may decide by Site-In-charge.
- 1.4.3 Depending on the site conditions other types of foundations shall also be designed and provided by the Employer suitable for Intermediate conditions under the above classifications to affect more economy or to suit specific site conditions encountered.

The proposal for these types of foundations shall be submitted by the Contractor based on the detailed soil investigation and duly recommended by Engineer-in- charge.

- 1.4.4 The construction drawings/ working drawings of all type of foundations classified as in **Clause 1.3** shall be provided to the contractor progressively during execution stage. The drawings for other foundations designed for specific site conditions shall be provided based on actual site requirements only.
- 1.4.5 The special foundations like pile foundations and combined raft foundation if required shall also be designed by the Employer based on detailed soil investigation report. The working drawing of these foundations shall be provided by the Employer to the Contractor during execution stage based on requirements. For detailed specification for pile foundations relevant section of this specification shall apply.
- 1.4.6 The provisional quantities of excavation, concreting and reinforcement steel required for the project are furnished in the BPS.

1.5 Soil Investigation

The Contractor may be required to undertake soil investigation as **per clause 4.0 of Section-III** at some tower locations as required by the Employer. The provisional numbers of soil testing locations are furnished in BPS. However, contractor shall take reference to the soil investigations wherever already carried out by the Employer.

1.6 Properties of Concrete

1.6.1 For open cast type foundation

The cement concrete used for the foundations shall generally be of grade M20 having 1:1.5:3 nominal volumetric mix ratio with 20 mm coarse aggregate graded downward for chimney portion and pyramid or slab portion. All the properties of concrete regarding its strength under compression, tension, shear, punching and bending etc. as well as workmanship will conform to IS 456.

- 1.6.2.1 The Quantity of minimum cement to be used per unit quantity of consumption for different mix (nominal mix) of concrete should be as follows:

Sl. No.	Description	Unit	Quantity of Minimum cement to be used per Unit quantity of work (in kg)
1.	1:1.5:3 nominal mix concrete	cum	400

2.	1:2:4 nominal mix concrete	cum	320
3.	1:3:6 nominal mix concrete	cum	220
4.	Random Rubble Masonry with 1:6 cement mortar	cum	83

In this regard utilisation record is to be maintained at site.

- 1.6.2.2 Alternatively, ready-mix concrete from batching plant as per IS 4925 can also be used with no extra payment and without any recovery. However, cement content shall be as per IS 456. The ready-mix concrete shall conform to IS 4926. The selection and use of Materials for the ready-mix concrete shall be in accordance with IS 456. The concrete shall be of M25 grade design mix as per IS 456. The transport of concrete and transportation time shall be as per IS 4926.
- 1.6.2.3 Ready-mix concrete of M25 grade design mix as per IS 456, shall be used for foundations of railway crossing locations.
- 1.6.2.4 Use of small batching machines/ self-loading mixers may be allowed after verification of cement consumption and mix by Employer site-in-charge. The equipment shall have facility of checking the proportion of ingredients of concrete being made. The records of mix shall be maintained at site. The calibration of equipment shall be done at regular intervals.
- 1.6.2.5 Ready mix concrete of M25 grade shall be designed as per IS 456. However, minimum cement content shall not be less than 330 kg/m³.
- 1.6.3 Cement used shall be ordinary Portland Cement, unless mentioned otherwise, conforming to the latest Indian Standard Code IS 269 or IS 8112 or IS 12269.

Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS 1489 (latest edition) or Portland Slag Cement conforming to IS 455 (Latest edition) can also be used. The Contractor shall submit the manufacturer's certificate, for each consignment of cement procured, to the Employer. However, Employer reserves the right to direct the Contractor to conduct tests for each batch/ lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Employer. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the Employer. Sulphate Resistant Cement shall be used if Sulphate content is more than the limits specified in IS 456, as per Geotechnical investigation report.

Ordinary Portland Cement (OPC) and Portland Pozzolana Cement (PPC) or Portland Slag Cement are Technically Equivalent and there would not be any financial implication/ or recovery to be borne by Employer/ Contractor. However, the minimum cement content shall be as per above table for nominal mix concrete.

- 1.6.4 Coarse and fine aggregates shall conform to IS 383.
- 1.6.5 The water used for mixing concrete shall be fresh, clean and free from oil, acids & alkalis, organic materials or other deleterious substances.

- 1.6.6 Reinforcement shall conform to IS 1786 for high strength steel bars (Fe 500/ Fe500D). If mentioned in BPS, epoxy coated reinforcement conforming to IS 13620 shall be used. Thermo Mechanically Treated (TMT) bars (equivalent grade) in place of cold twisted bars are also accepted. Hard drawn steel wire shall conform to IS 432. All reinforcement shall be clean and free from loose mill scales, dust, loose rust and coats of paint, oil or other coatings, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of approved foundation drawings and Specifications. The contractor may also use pre- fabricated/ assembled reinforcement cage conforming to shape, dimension, size as per approved foundation drawing. Spacers, chairs, stays, hangers, overlaps and annealed steel wire for binding etc. as may be necessary, should be used for proper completion of the foundation job as per requirement. Spacers or chairs should be placed at a maximum spacing of 1m and closer spacing shall be provided wherever necessary.
- 1.6.7 Use of crushed stone in place of natural sand, in case of non-availability or restriction by local authority, may be allowed by Employer site-in-charge subject to sieve analysis meeting acceptance criteria as per relevant IS and complying of other requirement as per standard field quality plan.
- 1.6.8 For foundation in creek or aggressive soil areas, if mentioned in BPS, Concrete of M30 Grade design Mix conforming to IS 456 and epoxy coated reinforcement as per IS 13620 shall be used. In addition, two numbers of coats of bituminous painting of minimum 1.6 kg/m² per coat shall be applied on all the exposed faces of the foundation (i.e. pedestal & base slab). Cost of bituminous painting shall be deemed to be included in the unit rate of M30 concrete.

1.7 Construction of Tower Foundation, Stub Setting and Earthing

1.7.1 Excavation

- 1.7.1.1 The excavation work for foundations shall be taken up by the contractor progressively stretch wise/ section wise after obtaining approval from Employer/PGCIL for the proposed stretch wise/ section wise tower schedule, profile etc. as per detailed survey along the approved route alignment.
- 1.7.1.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be vertical and the pit dimensions shall be based on an assumed clearance of 150 mm on all sides of the foundation pad. For footings with undercut, care shall be taken to carry out excavation as per drawing without any side clearance. For Fissured rock foundations, undercut as shown in the drawing is required and shall be provided accordingly. In cases where undercutting portion is excavated beyond stipulated dimension, the extended undercut portion shall be filled with additional concrete and reinforcement shall be extended into the undercut portion considering margin for concrete cover. However, payment of concrete & reinforcement shall be limited to design volumes of excavation, concrete, reinforcement etc. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, wherever the soil is loose or collapsible or in case of water in excavated pit, using timbering, shoring, shuttering, dewatering arrangements etc. as approved by the Employer/ Site-In-Charge. Contractor shall especially avoid disturbing the bearing

surface of the pad. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit or borehole shall be removed by Contractor before placing concrete.

1.7.1.3 Keeping in view of safety aspect, in case any sloped/ stepped/ ramp excavation for easy movement of man and material in excavation pit is required the same shall be done by the contractor. No Extra payment shall be admissible to the Contractor for the same.

1.7.1.4 The soil to be excavated for tower foundations shall be classified as follows depending upon the physical state of the soil at the time of excavation irrespective of the type of foundation installed.

a) **Dry Soil**

Soil removable either manually, by means of a spade and shovel or mechanically by poclains, excavators etc.

Excavation done in dry soil for wet, partially submerged, fully submerged and wet black cotton type of foundations shall also be covered under this.

b) **Wet Soil**

During excavation, if wet soil is encountered within the foundation depth, the type of soil shall be considered as Wet irrespective of whether pumping/ bailing out of water is required or not. The excavation done in wet soil in case of wet, wet cultivated, partially submerged, fully submerged and wet black cotton type of foundation shall also be covered under this.

c) **Dry Fissured Rock**

Limestone, laterite, hard conglomerate or other soft or fissured rock in dry condition which can be quarried or split with crowbars, wedges, pickaxes etc. However, if required, light blasting may be resorted to for loosening the material but this will not in any way entitle the material to be classified as hard rock.

d) **Wet Fissured Rock**

Above fissured rock, when encountered with subsoil water within the range of foundation depth or land where pumping or bailing out of water is required, shall be treated as wet fissured rock.

e) **Hard Rock**

Any rock excavation, other than specified under fissured rock above, for which blasting, drilling, chiseling is required. The unit rate quoted for hard rock excavation shall be inclusive of all costs for such drilling (including drilling required for anchoring), chiseling and blasting, etc.

1.7.1.5 No extra payment shall be admitted for the removal of fallen earth into a pit or borehole once excavated.

1.7.1.6 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, shall be done with utmost care to minimise fracturing rock and using extra concrete for filling the blasted area. All necessary precautions for handling and use of blasting materials shall be taken. In case where drilling is done, the stubs may be shortened suitably with the approval of the Employer.

In cases where unnecessarily large quantities are excavated/ blasted for fissured rock/ hard rock, resulting in placement of large volumes of concrete, payment of concrete shall be limited to design volumes of excavation, concreting, reinforcement etc.

In cases where unnecessarily excavation is done beyond foundation depth for normal foundation other than Hard rock, the same shall be filled with additional Plain cement

concrete (PCC) corresponding to a 1:3:6 nominal mix without any additional financial implication to Employer. However minimum thickness of PCC above founding level as shown in the construction drawing of foundation shall be provided.

- 1.7.1.7 The Contractor shall arrange and supply requisite blasting material, and be responsible for its storage and use, without any extra cost to the Employer.
- 1.7.1.8 Indian Standard IS 3764 shall be followed regarding safety of excavation work.

1.8 Unit Rates and Measurement for Foundation

- 1.8.1 The indicative shape of foundations is enclosed in this Specification. The unit rates are indicated in the bid. The bidder has to go through the unit rate and accordingly quote on percentage basis on entire tender cost.
- 1.8.2 The unit rates are described in the percentage BOQ (Contractor has to quote on percentage basis on the entire tender cost) of excavation for each type of soil shall include excavation along with all associated activities like shoring, shuttering, dewatering till completion of foundation work stock piling, dressing, back filling of foundations after concreting with excavated/ borrowed earth (irrespective of lead) and consolidation of earth, carriage of surplus earth to the suitable point of disposal as required by the Employer or any other activity required for to completion of foundation work in all respect. The measurement for excavation shall be made on the basis of design excavation volume arrived at considering dimension of pit leaving 150 mm gap around (except for undercut foundations) the base pad or actually excavated whichever is less and the unit rate of this item as indicated in in the Contract. The payment for excavation shall be made as per actual type of soil encountered at the time of excavation, but the total payment for excavation portion shall not exceed the amount as payable for excavation considering the soil type same as that of foundation classification. The decision of the Employer/PGCIL shall be final and binding with respect to classification of soil and foundations.
- 1.8.3 Form boxes shall be used for casting of foundations (except under cut portion of foundation). The unit rate of concreting shall include the cost of supply, fabrication and placement of form boxes, cement, water, coarse and fine aggregates mixing and placing of concrete, curing of concrete and any other activities related/ required for completion of concreting works of foundation. The payment for this item shall be made as per the actual volumes of concreting completed but limited to design volume based on unit rates indicated in the Contract.
- 1.8.4 The unit rate are indicated in the bid for the reinforcement of steel(Supply and P{lacement). The bidder to quote accordingly on percentage basis on entire tender cost. 'Reinforcement Steel' shall include supply and placement of reinforcement steel, stirrups, wire for binding the reinforcement, chairs, bolsters and spacers etc. as required to complete the foundation work. The payment of reinforcement steel shall be made based on the working drawing. In case of actual unit weight of the reinforced steel is found less than standard unit weight, but within acceptable tolerance variation as per applicable standard, the same shall be accepted without any compensation/ deduction. However, if unit weight is found to be beyond the negative (-ve) tolerance limits specified in IS, the material shall be rejected. Wastage overlaps, spacer bars, chairs, stays,

hangers and annealed steel wire etc. shall not be measured for the payment and cost of these items shall be deemed to be included in the rates for reinforcement.

No payment shall be made on account of overlaps for joining the reinforcement in any type of foundations except for Pile & Combined Raft Foundation.

1.9 Setting of Stubs

1.9.1 The stubs shall be set correctly and precisely in accordance with approved method at the exact location, alignment and levels with the help of stub setting templates and leveling instruments. Minimum clearance between chimney concrete level and ground level shall be ensured as per foundation drawing. Stubs setting shall be done in the presence of Employer's representative available at site where required and for which adequate advance intimation shall be given to Employer by Contractor. Tolerances as per provisions of IS 5613 shall be allowed for stub setting.

1.9.2 Setting of stub at each location shall be approved by Employer/ PGCIL.

1.9.3 Individual Leg stub setting template may also be used by the contractor with prior approval from Employer Site-In-Charge. An indicative drawing for individual leg stub setting template is attached with the specification. Proper care shall be taken by the contractor for accurate setting & alignment of stub levels

1.9.4 However, towers with unequal leg extensions, for Multi Circuit tower, for towers with +18/ +25/ +30 m Extensions, for raised chimney foundations, for river crossing towers, Anchor tower and for foundations in highly collapsible soils, props may be used with complete accuracy and high skilled supervision, subject to prior approval from Employer/ Site-In-Charge of PGCIL. No recovery shall be made on account of using Props for stub setting.

1.9.5 Stub Setting Templates/ Props

1.9.5.1 Stub setting templates shall be arranged by the Contractor at his own cost for all heights of towers. Stub templates shall be of adjustable type. The Contractor shall also arrange for props for setting of stubs at specific locations where use of prop is approved by the Employer. Stub templates/ props should be painted.

1.9.5.2 The Contractor shall deploy sufficient number of templates/ props for timely completion of the line without any extra cost to Employer.

1.9.5.3 However, the number of templates to be deployed shall depend upon type of terrain condition, number of types of towers etc. Hence, the quantity of template to be deployed for timely completion of the line shall be finalized in consultation with Site-In-Charge of PGCIL without any extra cost to the Employer.

The number of sets of props (if permitted) to be arranged, will depend as per actual site condition and completion schedule of line.

1.9.5.4 One set of each type of stub setting template/ props (if used) shall be supplied to the PGCIL, on completion of the project, at no extra cost to Employer.

1.10 Mixing, Placing and Compacting of Concrete

- 1.10.1 The concrete shall be mixed in the mechanical mixer. However, in case of difficult terrain, hand mixing may be permitted at the discretion of the PGCIL.. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalis. Saltish or blackish water shall not be used. Alternatively, Ready Mix concrete from batching plant as per IS 4925 can also be used with no extra payment and without any recovery. However, Cement content shall be as per IS 456. The ready-mix concrete shall conform to IS 4926. The selection and use of Materials for the ready-mix concrete shall be in accordance with IS 456. The concrete shall be of M25 grade design mix as per IS 456. The transport of concrete and transportation time shall be as per IS 4926. Record of delivery ticket information as per Annexure-G of IS 4926 has to be maintained.
- 1.10.2 Mixing shall be continued until there is uniform distribution of material and mix is uniform in colour and consistency, but in no case the mixing be carried out for less than two minutes. Normal mixing shall be done close to the foundation but exceptionally, in difficult terrain, the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.
- 1.10.3 To avoid the possibility of reinforcement rods being exposed due to unevenness of the bottom of the excavated pit, a pad of lean concrete 50 mm thick and corresponding to a 1:3:6 nominal mix shall be provided at the bottom of the pad. The coarse aggregate shall be of 20mm size and shall conform to IS 383.
- 1.10.4 Form boxes shall be used for casting all types of foundations except at an undercut interface for which the adjoining subsurface material shall provide adequate support. Form boxes shall conform to the shape, lines & dimensions of the foundation drawing and shall be constructed so as to be rigid during the placing and compacting of concrete. Contractor shall ensure that Form boxes are in good condition. Repeated use & maintenance of form box shall be as per IS 456 & IS 14687.
- 1.10.5 The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works, up to the top and no honey-combing occurs in the concrete. A mechanical vibrator shall be employed for compacting the concrete. However Monolithic casting of foundation must be carried out. However, in case of unavoidable circumstances, a key construction joint can be provided at the chimney-pad interface subject to approval of the Employer or as directed by the Engineer-in-charge. Number of such joints shall be kept minimum. Joints shall be kept as straight as possible & such construction joints should comply with IS 456. There shall not be any construction joint near stub & cleat portion of frustum. However, nothing extra shall be paid to the Contractor for providing such construction joints. For raised chimney, joint in concrete shall be of 3 m in chimney portion if casting of full chimney is not possible in one stretch.
- 1.10.6 After concreting the chimney portion to the required height, in the top 50 mm portion between CL & GL coping shall be done after erection of tower and the top surface should be finished smooth with a slight slope towards the outer edge for draining rain water.

Further, in case of Wet, Wet cultivated, PS, FS & WBC foundation before coping of chimney top portion, three coats of anti-corrosive paint (As recommended by paint manufacture for structural steel application) of minimum 30-35 microns dry film thickness each shall be applied on the stub in the 50 mm coping portion as well as upto 350 mm above CL portion. Cost of supply and application of anti-corrosive paint shall be deemed to be included in the unit rate of concreting.

1.10.7 Wet locations shall be kept completely dewatered, both during and 24 hours after placing the concrete, without disturbance of the concrete.

1.10.8 If minor defects in concrete surface is found after the form work has been removed, the damage shall be repaired with a rich cement sand mortar to the satisfaction of the Employer before the foundation is back filled.

1.11 Curing

The concrete shall be cured by maintaining the concrete wet for a period of at least 10 days after placing. Once the concrete has set for 24 hours the pit may be backfilled with selected moistened soil and well consolidated in layers thereafter both the backfill earth and exposed chimney shall be kept wet for the remainder of the prescribed 10 days. The exposed concrete chimney shall also be kept wet by wrapping gunny bags around it and wetting the bags continuously during the initial 10 days period.

1.12 Backfilling and Removal of Stub Templates

1.12.1 After opening of formwork and removal of shoring, shuttering etc., backfilling shall be done with the excavated soil, unless it consists of large boulders/ stones, in which case the boulders/ stones shall be broken to a maximum size of 80 mm or disposed-off. At locations, where borrowed earth is required for backfilling, Contractor shall bear the cost of the borrowed earth irrespective of leads & lift.

1.12.2 The backfilling materials shall be clean and free from organic or other foreign materials. The earth shall be deposited in various layers, levelled, wetted if necessary and shall be fully compacted. All excavated earth shall be placed over the filled in pit to allow further settlement, if any, by gravity.

1.12.3 The backfilling and grading shall be carried to an elevation of about 75 mm above the finished ground level to drain out water. After backfilling 50 mm high, earthen embankment (band) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours. After the pits have been backfilled to full depth the stub template can be removed.

1.13 Benching

When the line passes through hilly/ undulated terrain, levelling the ground may be required for casting of tower footings. All such activities shall be termed benching and shall include cutting of excess earth and removing the same to a suitable point of disposal as required by Employer. Benching shall be resorted to only after approval from Employer. Volume of the earth to be cut shall be measured before cutting and approved by Employer for payment purposes. Further, to minimise benching, unequal leg extensions/ raised chimney shall be considered and provided if found economical. The proposal shall be submitted by the Contractor with detailed justification to the Employer.

1.14 Protection of Tower and Tower Footing

1.14.1 Tower shall be spotted such that the quantities of revetment are optimum. For tower locations in undulated terrain such as hill/ mountain slopes,

options like use of unequal leg extensions for towers, unequal chimney extensions etc. shall be explored by the contractor for optimizing the need for revetment & benching.

1.14.2 The work shall include all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in nalas, river bank / bed, undulated terrain, protection of uphill/ downhill slopes required for protection of tower etc., including suitable revetment or galvanised wire netting and meshing packed with boulders. The top cover of stone revetment shall be sealed with 1:2:4 nominal mix concrete. Contractor shall recommend protection at such locations wherever required. Details of protection of tower/ tower footing are given in drawing enclosed with these specifications for reference purpose only.

1.14.3 Tower footings shall generally be backfilled using soil excavated at site unless unsuitable for backfilling. In the latter case, backfilling shall be done with borrowed earth of suitable quality irrespective of leads and lift. The unit rate for backfilling quoted in BPS shall include the required lead and consolidation and leveling of earth after backfilling.

For protection work of Towers. The unit rates derived shall also be applicable for any quantity variations during execution. The same unit rates shall hold good for protection work carried out on down hills or up hills slopes applicable for the tower locations.

1.14.4 The unit rates for random rubble masonry revetment quoted in price schedule shall also include excavation & (1:5) random masonry and unit rate for top sealing with M15 concrete. For payment purposes the volume of random rubble masonry revetment shall be measured from bottom to top sealing coat and paid at the unit rates indicated in the Contract. No extra payment shall be made for allied works such as excavation for revetment, packed stone at head of weep holes etc. However, no deduction shall be made for the volume enclosed by weep holes.

1.14.5 For some of the locations in nalas, river bed or undulated terrain etc., boulders of minimum 150mm size bounded and packed in galvanised wire net/ mesh of 8 SWG wire and 152 square mm (maximum) mesh are to be provided. These stones shall be provided in crates size of 2.0 m x 2.0 m or as deemed suitable for a particular location. Measurement shall be taken in cubic meters and 15% deduction will be made for void from cage/ stack measurements.

1.14.6 After completion of foundation, stub levels, back to back dimensions, diagonal dimensions etc. shall be measured jointly by the Engineer of Contractor and Employer before taking up erection of tower and same shall be recorded for future reference. In case of any deviations beyond permissible limits as per IS 5613, the foundation shall be rectified or re-casted by the contractor at his own cost.

SECTION-V

GALVANISED STEEL EARTHWIRE

SECTION-V
GALVANISED STEEL EARTHWIRE

CONTENTS

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**TECHNICAL
SPECIFICATIONS**

SECTION- V

GALVANISED STEEL EARTH WIRE

1.0 Technical Description

1.1 Details of Earth wire

1.1.1 The galvanised steel earth wire shall generally conform to IS12776 except where otherwise specified herein.

1.1.2 Standard Technical Particulars

The standard Technical Particulars (STP) of Earth wire is enclosed at Annexure-B of this section. The values indicated in the STP are the minimum and/or maximum values required to be met by the supplier.

1.2 Workmanship

1.2.1 All steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions and kinks after drawing and also after stranding.

1.2.2 The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.

1.2.3 The steel strands shall be hot dip galvanized and shall have minimum Zinc coating after stranding, as stipulated in Standard Technical Particulars attached with. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in STP.

1.2.4 The steel strands shall be pre-formed and post-formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanization during performing and post forming operation.

1.2.5 To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

1.3 Joints in Wires

There shall be no joint of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splices in any length of the completed stranded earth wire.

1.4 Tolerances

The manufacturing tolerance to the extent of the limits as stipulated in Standard Technical Particulars attached with this specification shall only be permitted in the diameter of the individual steel strands and lay length of the earth wire.

1.5 Materials

1.5.1 Steel

The steel wire strands shall be drawn from high carbon steel rods and the chemical composition shall conform to the requirements as stipulated in Standard Technical Particulars attached with.

1.5.2 Zinc

The zinc used for galvanizing shall be electrolytic High Grade Zinc and shall conform to the requirements of IS 209.

1.6 Standard Length

1.6.1 The standard length of the earth wire shall be as stipulated in Standard Technical Particulars attached with, with the specified tolerance on standard length.

1.6.2 Random length will be accepted provided no length is less than 70% of standard length and the total quantity of random lengths is not more than ten (10) percent of the total quantity in each shipment.

2.0 Tests and Standards

2.1 Type Tests

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

a)	DC resistance test	Annexure-A
b)	UTS test on stranded earth wire	

2.1.1 Type tests specified under Clause 2.1 shall not be required to be carried out if supplier has conducted these tests earlier on the same type of earth wire and valid type test certificates are available. The test certificate shall be considered valid if,

- i) Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/ 17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of POWERGRID or utility and
- ii) Type test reports contain valid Calibration reports of the relevant testing equipment and information pertaining to ratings, the relevant drawings, model number, test circuit, calculations (if any), photos, acceptance

Criteria/values specified in Technical Specification/relevant standards (IS/IEC) and compliance to the same and

- iii) Tests conducted on the samples of earth wire manufactured from same manufacturing works within 10 (ten) years as on the date of LOA for the package.

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

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

2.2 Acceptance Tests

a)	Visual and dimensional check on drum	Annexure-A
b)	Visual check for joints, scratches etc. and lengths measurement of earth wire by rewinding	
c)	Measurement of diameter of individual steel strands	
d)	Check for lay-length	
e)	Galvanizing test	
f)	Torsion and elongation test	
g)	Breaking load test	
h)	Wrap test	
i)	DC resistance test	
j)	Barrel strength test on wooden drum	
k)	Chemical Analysis of steel	

2.3. Routine Tests

a)	Check for correctness of stranding
b)	Check that there are no cuts, fins etc. on the strands
c)	Check that drums are as per Specification

2.4. Tests During Manufacture Earthwire

a)	Chemical analysis of zinc used for galvanising	Annexure-B
b)	Chemical analysis of steel	Annexure-B

2.5 Testing Expenses

2.5.1 In the event of type testing, bidders shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that the tests can be completed in these laboratories within the time schedule.

2.5.2 In case of failure in any type test the Contractor is either required to manufacture fresh sample lot and repeat the entire test successfully once or repeat that particular type test three times successfully on the sample selected from the already manufactured lot at his own expenses. In case fresh lot is manufactured for testing then the lot already manufactured shall be rejected. The decision of the Employer in this regard shall be final and binding on Contractor.

2.5.3 The entire cost of testing for the type, acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted unit price except for the expenses of the inspector/ Employer's representative.

2.5.4 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 representative shall be to the supplier's account. Also, if on receipt of the Contract's notice of testing the Employer's representative/ Inspector does not find the test samples or testing facilities/ equipment ready for testing, the expenses incurred by the Employer for re-deputation shall be to the supplier's account.

2.6 Additional Tests

2.6.1 The Employer reserves the right of having at his own expenses 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 materials comply with the Specifications.

- 2.6.2 The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Contractor's premises or at any other test 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 item all without any extra cost to the Employer.

2.7 Sample Batch for Type Testing

- 2.7.1 In case the type tests are required to be carried out, the samples for type testing shall be manufactured in accordance with the Standard Manufacturing Quality Plan.
- 2.7.2 The Contractor shall offer at least three drums for selection of sample required for conducting all the type test.
- 2.7.3 The Contractor is required to carry out all the Acceptance tests successfully in presence of Employer's representative before sample selection.

2.8 Test Reports

- 2.8.1 In case type tests have been carried out earlier by the supplier and valid type test reports are available as specified in clause 2.1.1 above, the supplier shall submit one copy of the test report along with approval letter issued by Employer or utility.
- 2.8.2 In case fresh type tests have been carried out under the package, type test reports shall be furnished in original alongwith two copies. One copy will be returned duly certified by the Employer.
- 2.8.3 The commercial production of the earthwire can be taken up by the supplier after clearance from the purchaser.
- 2.8.4 Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Employer's representative.
- 2.8.5 Test Certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Employer.

2.9 Inspection

- 2.9.1 The Employer 's representative shall at all times be entitled to have access to the works and all places of manufacture, where earth wire shall be manufactured and representative shall have full facilities for unrestricted inspection of the Contractor's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.
- 2.9.2 The Contractor shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of earth wire in its various stages so that arrangements can be made for inspection.

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

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

2.10 Test Facilities

2.10.1 The following test facilities shall be available at the Contractor's works:

- a) Various testing and measuring equipment for carrying out specified acceptance tests, routine tests and tests during manufacture inter alia including tensile testing machine, resistance measurement facilities, torsion & wrap testing machine, dimension checking instruments viz. digital vernier and micrometer etc., galvanizing test instruments viz. digital elcometer and standard preece test etc., burette, digital thermometer, barometer etc.
- b) Digital milli/micro ohm meter along with standard resistance for calibration of resistance bridges.
- c) Finished Earth wire shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc., with traverse laying facilities.

2.11 Packing for Earth wire

2.11.1 The Earth wire shall be supplied in non-returnable, strong, wooden drums and provided with lagging of adequate strength, constructed to protect the Earth wire against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Contractor shall be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS: 1778-1980, except as otherwise specified hereinafter.

2.11.2 The drums shall be suitable for wheel mounting and for letting off the earth wire under a minimum controlled tension of the order of 5 kN

2.11.3 The standard drawing of the drum for earthwire is enclosed with the specification. The Bidder shall supply the earthwire in the drum conforming to the standard drawing only.

2.11.4 For Earth wire, two standard lengths shall be wound on each drum.

- 2.11.5 For Earth wire, each strand shall be individually welded to prevent parting of two lengths at a tension less than 15 kN. The two ends where the first length finishes and the second length starts, shall be clearly marked with adhesive tape and no weld should be present outside these marks. The length between the two marks shall be treated as scrap and will not be taken into account for measurement purposes.
- 2.11.6 All wooden components shall be free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the earth wire.
- 2.11.7 As an alternative to non-returnable wooden drums, bidder may supply the earthwire in returnable steel drum. However, for bid evaluation purpose, both types of drums shall be treated at par and bidder may quote accordingly.
- 2.11.8 The empty steel drums shall be taken back by the contractor/ supplier as & when these are available after usage of earthwire. However, 2% of the total drums shall not be returned to the contractor/ supplier as these may be used for storage of spare earthwire by the purchaser.
- 2.11.9 The steel drums may get damaged and/or wear & tear during transportation, normal handling & operation at site, which shall be rectified by the supplier before re-use.
- 2.11.10 Solid Polypropylene sheet of minimum 5mm thickness shall be used for outer covering of earthwire in steel drum. Outside the covering, there shall be minimum two binders consisting of hoop iron/ galvanised steel wire. Two numbers of additional binders per drum shall also be supplied for re-wrapping the polypropylene sheet with each lot of earthwire and 5 nos. crimping machines with the first lot of earthwire for crimping the binders at site. As an alternative, supplier may use wooden lagging of minimum 50 mm thickness for outer covering of earthwire without any extra financial implication to the purchaser.
- 2.11.11 Before reeling, cardboard or double corrugated or thick bituminous waterproof bamboo paper shall be secured to the drum barrel and inside of flanges of the drum by means of a suitable commercial adhesive material over which HDPE sheet to be provided. After reeling the earth wire, the exposed surface of the outer layer of earth wire shall be wrapped with self-adhesive plastic sheet to preserve the earth wire from ingress of water dirt, grit and damage during storage transport and handling.
- 2.11.12 The earth wire ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the earth wire layers during transit and handling.

2.12 Marking

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

- a) Contract/Award letter number.
- b) Name and address of consignee.
- c) Manufacturer's name and address.
- d) Drum number
- e) Size of earth wire
- f) Length of earth wire in meters
- g) Gross weight of drum with earth wire & lagging
- h) Weight of empty drum with lagging
- i) Arrow marking for unwinding
- j) Position of the earth wire ends
- k) Number of turns in the outer most layer
- l) Barrel diameter at three locations and an arrow marking at the location of measurement
- m) CIP/MICC No.

2.13 Verification of Earth wire Length

The Employer reserves the right to verify the length of earth wire after unreeling. The quantity for verification shall be between a minimum of five percent (5%) to a maximum of ten percent (10%) in a lot offered for inspection. The actual quantity will be discussed and mutually agreed to by the supplier & purchaser.

2.14 Standards

The earth wire shall conform to the following Indian Standards, which shall mean latest revisions, amendments/changes adopted and published, unless otherwise in the Specification.

In the event of the supply of earth wire conforming to standards other than specified, the Contractor 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 these documents will be provided by the Contractor to establish their equivalence.

Sl. No.	Indian Standard	Title
1	IS 209	Specification for zinc
2	IS 12776	Galvanized Strand for Earthing-Specification
3	IS 1778	Reels and Drums for Bare Conductors
4	IS 2629	Recommended Practice for Hot Dip Galvanizing of Iron and Steel
5	IS 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles
6	IS 4826	Galvanized Coating on Round Steel Wires
7	IS 6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BIS/IS	Beureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi 110001 India

3.0 Manufacturing Quality Plan

Earthwire manufacturing shall be carried out in accordance with Standardized Manufacturing Quality plan as given in the Appendix -I of this section

1.0 Tests on Earth wire

1.1 DC Resistance Test

An earth wire sample of minimum 5m length two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially at zero meter and subsequently one meter apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20°C. The test results shall conform to the requirement specified in the STP.

1.2 UTS Test on stranded earthwire

Circles perpendicular to the axis of the earth wire shall be marked at two places on a sample of earth wire of minimum 5 m length suitably compressed with dead end clamps at either end. The load shall be increased at a steady rate up to 50% of UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall be increased at steady rate to 100% of UTS and held for one minute. The earth wire sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.3 Visual and Dimensional Check on Drums

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this Specification.

1.4 Visual Check for Joints, Scratches etc. and Length measurement of Earth wire by rewinding

Ten percent drums from each lot shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and see that the earth wire generally conforms to the requirements of this Specification. The length of earth wire wound on the drum shall be measured with the help of counter meter during rewinding.

1.5 Measurement of diameter of individual steel strands

The diameter of the individual strands shall be checked to ensure that they conform to the requirement specified in the STP.

1.6 Check for Lay Length

The lay length shall be checked to ensure that they conform to the requirements specified in the STP.

1.7 Galvanising Test

The test procedure shall be as specified in IS 4826. The material shall conform to the requirements of this Specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

1.8 Torsion and Elongation Test

The minimum number of twists which a single steel strand shall withstand during torsion test shall be eighteen for a length equal to 100 times the standard diameter of the strand. In case test sample length is less or more than 100 times the stranded diameter of the strand the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number. In elongation test, the elongation of the strand after breakage, for a gauge length of 200 mm after

stranding, shall not be less than the value specified in STP.

1.9 Wrap Test

The test procedure shall be as specified in IS 12776 except the test shall be carried after stranding.

1.10 Breaking load test

The breaking load of individual strands of earthwire (after stranding) shall be determined by means of a suitable tensile testing machine. The load shall be applied gradually and the rate of separation of the jaws of the testing machine shall be not less than 25 mm/min and not greater than 100 mm/min. The ultimate breaking load of the specimens shall be not less than the value specified in the STP.

1.11 Barrel strength test on Wooden Drum

The barrel strength test shall be conducted as per IS 1778 on one drum of each lot offered for inspection. Barrel batten strength shall not be less than 300 kg.

1.12 Chemical Analysis of Steel

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

1.13 Chemical Analysis of Zinc

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

Annexure-B

Standard Technical Particulars for Galvanised Steel Earth wire

Sl. no.	Description	Unit	Standard Technical Particular of GS Earthwire			
			7/3.15 mm GS Earthwire	7/3.66 mm GS Earthwire	7/4.5 mm GS Earthwire	19/ 3.00 mm GS Earthwire
1.0	Raw Materials					
1.1	Steel wires / rods					
a)	Carbon	%	0.55 (Max)			
b)	Manganese	%	0.40 to 0.90			
c)	Phosphorous	%	0.04 (Max)			
d)	Sulphur	%	0.04 (Max)			
e)	Silicon	%	0.15 to 0.35			
1.2	Zinc					
a)	Minimum purity of Zinc	%	99.95			
2.0	Steel strands					
2.1	Diameter					
a)	Nominal	mm	3.15	3.66	4.5	3.00
b)	Maximum	mm	3.20	3.74	4.58	3.05
c)	Minimum	mm	3.10	3.58	4.42	2.95
2.2.	Minimum breaking load of strand after stranding	KN	8.55	10.58	16.49	7.84
2.3	Galvanising					
a)	Minimum weight of zinc coating per sq.m. after stranding	gm	275	275	290	230

b)	Minimum number of dips that the galvanized strand can withstand in the standard preece test	Nos.	3 dips of 1 minute and one dip of ½ minute	2 dips of 1 minute and one dip of ½ minute		
c)	Minimum number of twists in a gauge length equal to 100 times diameter of wire which the strand can withstand in the torsion test, after stranding	Nos.	18			
d)	Min. elongation of the strand (after stranding) for a gauge length of 200 mm (after break)	%	3.5			
3.0	Stranded Earth wire					
3.1	Minimum UTS of Earth wire	KN	56	68	106.2	139.3
3.2	Lay length of outer steel layer					
a)	Standard	mm	160	181	230	270
b)	Maximum	mm	175	198	243	330
c)	Minimum	mm	145	165	216	210
3.3	Maximum DC resistance of earth wire at 20 ⁰ C	Ohm/km	3.375	2.5	1.66	1.50
3.4	Standard length of earth wire	m	2300	2000	2000	2000
3.5	Tolerance on standard length	%	±5			
3.6	Direction of lay for outside layer		Right hand			
3.7	Linear mass					
a)	Standard	kg/km	428	882		1062
b)	Maximum	kg/km	441	913		1100
c)	Minimum	kg/km	414	851		1020

SECTION-VI A

HARDWARE FITTINGS & ACCESSORIES FOR CONDUCTOR & EARTHWIRE

(Applicable for all hardware fittings and accessories for conductor and earth wire of transmission line with all type of conductors except Suspension clamp, dead end clamp and accessories for HTLS conductor)

(Strikeout/delete whichever is not applicable)

TECHNICAL

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SECTION-VI A

HARDWARE FITTINGS & ACCESSORIES FOR CONDUCTOR &

EARTHWIRE CONTENTS

Clause	Description
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2.0	Technical Description of Accessories for Conductor
3.0	Technical Description of Accessories for GS Earthwire
4.0	Type Tests & Standards
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Annexure-B	Standard Technical Particulars of Hardware Fittings and Accessories for Conductor & Earthwire
Annexure-C	Typical Placement Chart for spacer Damper

**TECHNICAL
SPECIFICATIONS
SECTION- VI A
HARDWARE FITTINGS &
ACCESSORIES FOR CONDUCTOR &
EARTHWIRE**

1.0 Technical Description of Hardware Fittings

1.1 Details of Hardware Fittings

1.1.1 The hardware fittings shall be suitable for use with disc insulators, porcelain longrod insulators and composite long rod insulators having ball and socket fittings. The hardware fittings shall be as per the specification drawings enclosed with the section of drawings of the specification.

Standard lengths of insulators have been considered in the above specification drawings for indicative purpose only. The actual length of insulator string shall be based on the insulators being supplied for the package.

For hardware fittings for transmission line upto 765kV voltage level (except 765kV S/C, ± 500 kV HVDC, ± 800 kV HVDC), the suppliers shall be required to develop hardware components in line with the standard drawings enclosed with the section of drawings of the specification (which are based on component level interchangeability amongst various suppliers) and submit their drawing for approval of POWERGRID prior to testing and manufacturing. Employer may accept hardware components having better performance such as higher mechanical strength at no extra cost to POWERGRID, provided component level interchangeability is retained.

1.1.2 Each hardware fitting shall be supplied complete in all respects and shall include the following hardware parts:

1.1.2.1 Suitable arcing horn as specified in clause 1.8 hereinafter.

1.1.2.2 Suitable yoke plates complying with the specifications given hereinafter.

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

1.1.2.4 Sag adjustment plate for double/ triple/ quad tension hardware fittings and turn buckle for single tension hardware fittings.

1.1.2.5 Suspension and dead-end assembly to suit conductor type and size as covered in the scope.

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

- 1.1.2.7 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.
- 1.1.3 For owner supplied fittings 2.5% extra fasteners (excluding factory fitted fasteners) & retaining rods shall be provided to the Contractor to take care of losses during erection. No payment shall be admissible for these extra supplies. For fittings included in the scope of the Contractor, the contractor is permitted to get inspected and supply upto 2.5% extra fasteners & retaining rods to take care of losses during erection. No payment shall be admissible for these extra supplies.
- 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 at section of drawings of this specification.
- 1.2.1 For every set of tension hardware fitting for quad/ hexa bundle conductor configuration one no. 250 mm rigid spacer suitable for twin conductor shall also be provided to ensure that there is no fouling of conductors or any component of the fittings while bringing down top two conductors through bottom two conductors of quad/ hexa bundle, at the jumper location.
- 1.3 **Interchangeability**
- 1.3.1 The hardware for insulator strings with disc insulators/ porcelain long rod/ composite long rod insulators together with ball and socket fittings shall be of standard design, so that this hardware is inter-changeable with each other and suitable for use with insulators of any make conforming to relevant 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 the Standard Technical Particulars enclosed with this section of the specification. The designation should be in accordance with the standard dimensions stated in IS 2486 (Part-II). 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). 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, based on the drawings enclosed with the specifications.

- 1.8.2 The arcing horn shall be provided as shown in the drawing of the hardware fittings, enclosed 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 maintenance holes and suitable holes for fixing corona control rings/ grading ring/ arcing horn. All the corners and edges

should be rounded off with a radius of at least 3 mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the contractor. The holes provided for bolts in the yoke plate should satisfy shear edge condition as per Clause No. 10.2.4.2 of IS 800.

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/ equivalent length in insulator strings. 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 smooth finish. No blemish should be seen or felt when rubbing a hand over the metal.

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

1.10.5 The grading ring shall be of open type design with a gap of 125 mm for voltage up to 765 kV AC lines and 150 mm for ± 500 kV & ± 800 kV HVDC lines. The open ends shall be suitably terminated. The outside diameter of the tube of corona control rings/ grading ring shall be minimum 75 mm for voltage above 400 kV and minimum 60 mm for 400 kV and below voltage lines. The ends of grading ring tube shall be sealed with welded aluminium cap duly buffed.

1.11 Sag Adjustment Plate

1.11.1 The sag-adjustment plate to be provided with the double/ triple/ quadruple/ 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 330 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 Contractor. The hole provided for bolts should

satisfy shear edge condition as per Clause No. 10.2.4.2 of IS 800.

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 type and size as covered in the scope.

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

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

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

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

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

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

1.13.8 Free Center Type Suspension Clamp

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

1.13.9 Standard Preformed Armour Rod Set

- 1.13.9.1 The Preformed Armour Rods Set, suitable for specific Conductor, shall be used to minimise the stress developed in the sub-conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs, chafing and abrasion from suspension clamp and localised heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.
- 1.13.9.2 The preformed armour rods set shall have right hand lay and the inside diameter of the helics shall be less than the outside diameter of the conductor to have gentle but permanent grip on the conductor. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions etc.
- 1.13.9.3 The pitch length of the rods shall be determined by the Contractor but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.
- 1.13.9.4 The length of each rod along with permissible tolerances shall be as stipulated in the Standard Technical Particulars. The ends of armour rods should be ball ended for voltage upto 220kV and parrot billed for voltage above 220kV.
- 1.13.9.5 The number of armour rods in each set shall as stipulated in the Standard Technical Particulars. Each rod shall be marked in the middle with paint for easy application on the line.
- 1.13.9.6 The armour rod shall not loose their resilience even after five applications.
- 1.13.9.7 The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS) & Minimum tensile strength shall not be less than 35kg/mm².

1.13.10 Armour Grip Suspension Clamp

- 1.13.10.1 The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminium reinforcements and AGS preformed rod set.
- 1.13.10.2 Elastomer insert shall be resistant to the effects of temperature up to 95°C, Ozone, ultraviolet radiations and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS performed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene insert.
- 1.13.10.3 The AGS preformed rod set shall be as detailed in the relevant clause of the specifications. The length of the AGS preformed rods shall be

such that it shall ensure sufficient slipping strength as specified in the Standard Technical Particulars 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 'COMPRESSION ZONE' AND 'NON-COMPRESSION ZONE' distinctly with arrow marks showing the direction of compressions and knurling marks showing the end of the zones. The letters, number and other markings on the finished clamp shall be distinct and legible.

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

- 1.15.4 The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part 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 at transposition towers or when used with Composite Insulators, from excessive deflection, suitable balancing weights, weighing 200 kg (25x8) for 400kV and above voltage lines and 100 kg (25kg x 4) for 220kV shall be provided.

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 for parts/ components requiring shear/ tensile strength. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts. Bolts & Nuts for these parts/ components shall be of minimum 5.6 grade conforming to IS 1367 or equivalent International standards.
 - 1.17.4.1 For parts/ components requiring grip strength viz. arcing horn, corona rings & dead-end jumper assembly, fully threaded bolts can be used as an alternative. Bolts & nuts for these parts/ components shall be of minimum 4.6 grade conforming to IS 6639 or equivalent International standards
 - 1.17.4.2 In case of fasteners of other materials viz. stainless steel, aluminium alloy, etc. are proposed to be used by the supplier, these shall conform to relevant Indian/ International standards and complete details shall be submitted by the supplier for review & approval by the Employer.

- 1.17.5 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.
- 1.17.7 The Supplier shall indicate the size & length of various bolts in the drawings, based on thickness of components connected, the nut and the washer, the length of shank, the threaded portion of bolts, etc. To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.
- 1.17.8 Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.
- 1.17.9 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 ISO 9001 services Quality System standard.
- 1.17.10 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 Contractor shall indicate the material proposed to be used for each and every component of hardware fitting stating clearly the class, grade or alloy designation of the material, manufacturing process & heat treatment details and the reference standards.
- 1.18.1 The details of materials for different component are listed as in Table-I

TABLE-1 (Details of Materials)

Sl. No.	Name of item	Material	Process of treatment	Reference Standard
1	Security Clips	Stainless Steel (AISI 304)/ Phosphor Bronze	-	ASTM A240/ IS-7811
2	Arcing Horn	Mild Steel Rod/ Tubular Type	Hot dip galvanised	IS 2062

Sl. No.	Name of item	Material	Process of treatment	Reference Standard
3	Ball Fittings, Socket,	Class-IV forged steel/ EN8D/ EN19	Drop forged & normalized Hot dip galvanised	IS 2004/ BS970
4	Shackles, links, clevis	Class-IV forged steel	Drop forged & normalized Hot dip galvanised	IS 2004
5	Yoke Plate, Sag Adjustment plate	Mild Steel	Hot dip galvanized	IS 2062
6(a)	Corona Control ring/ Grading ring	High Strength Al. Alloy tube 65032/ 63400 Type)	Heat treated (for Al)	IS 733
6(b)	Supporting Brackets & Mounting Bolts	High Strentgth Al Alloy 65032/ 63400 Type) or Mild Steel	Heat treated (for Al) / Hot dip galvanized	IS 733 IS2062
7	Turn Buckle	Class-IV forged steel	Forged hot dip galvanized	IS 2004
8(a)	Free centre type clamp/ Envelope type Clamp: Clamp Body, Keeper Piece	High Strength Al. Alloy 4600/ 65032	Casted or forged & Heat treated	IS 617/ IS 733
8(b)	Envelope type Clamp: U Bolts	Stainless Steel (AISI 304 or High Strength Al alloy 65032/ 63400	Heat treated (Al Alloy)	ASTM A240/ IS 733
9	P. A. rod	High strength Al alloy type 65032	Heat treatment during manufacturing	IS 733

10	AGS clamp (a) Supporting house	High strength Al. alloy 4600/ 65032	Casted or forged & heat treated.	IS 617, IS 733
Sl. No.	Name of item	Material	Process of treatment	Reference Standard
	(b) Al insert and retaining strap	High strength Al alloy type 65032 or equivalent	Forged and Heat treated	IS 733
	(c) Elastomer cushion	Neoprene/ Moulded on Al reinforcement		
11(a)	Dead End Assembly: Outer Sleeve	Aluminium Alloy 19500		IS 733
11(b)	Steel Sleeve	Forged Steel Class II	Hot Dip Galvanise d	IS 2004
		Mild Steel		IS 2062
12	Balancing weights	Mild Steel/ Cast iron MCI	Hot dip galvanised	IS 210/ IS 2062

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 High Voltage field. The Contractor 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/ IS 1367 (Part 13) and shall satisfy the tests mentioned in IS 2633.
- 1.19.4 Before ball fittings are galvanized, 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 as per STP.
- 1.19.6 Ball ends 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 or high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS 2486.

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.
- 1.19.10 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.
- 1.19.11 All fasteners shall have suitable corona free locking arrangement to guard against vibration loosening.
- 1.19.12 Welding of aluminum 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 aluminum alloys are not affected. All welds shall be properly finished as per good engineering practices.
- 1.19.11 **Drawings & Approvals**

- 1.19.12 Drawings:
- 1.19.13 After placement of award, the Contractor shall submit fully dimensioned drawing including all the components, as described below, to the PGCIL for approval. After submission of valid type test reports or successful completion of type tests and getting approval from the PGCIL, the Contractor shall submit the same drawings to the Employer for further distribution and field use at Employer's/ PGCIL end.
- 1.19.14 Fully dimensioned drawings of the complete insulator string hardware and their component parts showing clearly the following shall be submitted for approval. 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.
- 1.19.15 All drawings shall be identified by a drawing number and contract number and 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.
 - (iv) Marking
 - (v) Weight of assembly
 - (vi) Installation instructions, if any.
 - (vii) Design installation torque for the bolt or cap screw.
 - (ix) The compression dies number with recommended compression pressure. All other relevant terminal details.

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

2.2 Mid Span Compression Joint

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

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

2.3 T-Connector

T-Connector of compression type shall be used for jumper connection at transposition tower. It shall be manufactured out of 99.5% pure aluminium and shall be strong enough to withstand normal working loads. The T-connector shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation. The resistance of the connector when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor. The T-connector shall not permit slipping off, damage to or failure of complete conductor. The welded portions shall be designed for 30 kN axial tensile load. Leg sleeve of T-connector should be kept at an angle of 15 deg. from vertical and horizontal plane of the conductor in order to minimise jumper pull at the welded portion. The dimensions and dimensional tolerances of T-connector shall be as per Standard Technical Particulars.

2.4 Repair Sleeve

Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium and shall have a smooth surface. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation. The dimensions and dimensional tolerances of repair sleeve shall be as per Standard Technical Particulars.

2.5 Vibration Damper

2.5.1 Vibration dampers of 4R-stockbridge type with four (4) different resonances spread within the specified Aeolian frequency band width corresponding to wind speed of 1 m/s to 7 m/s shall be used at suspension and tension points on each conductor in each span along with bundle spacers to damp out Aeolian vibration as mentioned hereinafter.

2.5.2 Alternate damping systems or “Dogbone” dampers offering equivalent or better performance also shall be accepted 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.

2.5.3 One damper minimum on each side per Conductor/Sub-conductor for suspension points and two dampers minimum on each side per conductor/sub-conductor for tension points shall be used for ruling design span as given in relevant clause of section-I.

2.5.4 In case more dampers are recommended by the supplier, the payment shall be restricted to the number of dampers indicated above.

2.5.5 The clamp of the vibration damper shall be made of high strength aluminium alloy of grade 4600 as per IS 617. It shall be capable of supporting the damper and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the conductor without damaging the strands or causing premature fatigue failure of the conductor under the clamp. The clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the conductor when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and designed to prevent corrosion of threads or loosening in service.

2.5.6 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 drop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in the messenger cable shall be 19. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the

recommendations of IS 4826 for heavily coated wires.

- 2.5.7 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, shrinkage, inclusions and blowholes etc. The surface of the damper masses shall be smooth.
- 2.5.8 The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.
- 2.5.9 The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.
- 2.5.10 The vibration damper shall be capable of being installed and removed from energised line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the conductor at the designated torque without shearing or damaging of fasteners.
- 2.5.11 The supplier must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.
- 2.5.12 The vibration damper shall not have magnetic power loss more than that stipulated in the Standard Technical Particulars.
- 2.5.13 The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed under Annexure-A, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

Sl. No.	Description	Technical particulars
1.	Span length	
i)	Ruling design span	As given in section-I
ii)	Maximum span	1100 meters
iii)	Minimum span	100 meters
2.	Configuration	As per Section-I of this Specification
3.	Conductor/ sub-conductor tension	25% of UTS of conductor
4.	Armour rods used	Standard preformed armour rods/ AGS
5.	Maximum permissible dynamic strain	+/- 150 micro strains

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

2.5.15 The damper placement charts shall include the following

- (1) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per conductor per span.
- (2) Placement distances clearly identifying the extremities between which the distances are to be measured.
- (3) Placement recommendation depending upon type of suspension clamps (viz Free 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.

2.6 Bundle Spacer (for twin Bundle Conductors)

2.6.1 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.

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

2.6.3 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.

2.6.3.1 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.

- 2.6.3.2 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. In case more spacers are recommended by the supplier, the payment shall be restricted to the number of spacers indicated above.
- 2.6.4 The spacer offered by the Bidder shall satisfy the following requirements: -
 - 2.6.4.1 Spacer shall restore normal spacing of the sub conductors after displacement by wind, electromagnetic and the electrostatic forces under all operating conditions including the specified short circuit level without permanent deformation damage either to conductor or to the assembly itself. They shall have uniform grip on the conductor
 - 2.6.4.2 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 65032 or equivalent aluminium alloy and shall have minimum tensile strength of 35 kg/sq.mm. The ends of retaining rods should be ball ended. The rods shall be heat-treated to achieve specified mechanical properties and give proper resilience and retain the same during service.
 - 2.6.4.3 Four number of rods shall be applied on each clamp to hold the clamp in position. The length and diameter of preformed retaining rod shall be decided by suppliers as per design of the Bundle spacer. However, diameter and length of the rods shall be as per the STP.
 - 2.6.4.4 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 65032. The insert shall be duly heat treated and aged to retain its consistent characteristics during service.
 - 2.6.4.5 The clamp grooves shall be in uniform contact with the conductor over the entire surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, grit or other material, which cause damage to the conductor when the clamp is installed.
 - 2.6.4.6 The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.
 - 2.6.4.7 No rubbing, other than that of the conductor clamp hinges, shall take place between any parts of the spacer. Joint incorporating a flexible medium shall be such that there is no relative slip between them.

- 2.6.4.8 The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service.
- 2.6.4.9 The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance.
- 2.6.4.10 The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep.
- 2.6.4.11 The spacer assembly shall not have any projections, cuts, abrasions etc. or chattering parts which might cause corona or RIV.
- 2.6.4.12 The spacer tube shall be made of aluminium alloy of type 65032 or 63400.
- 2.6.4.13 Elastomer, if used, shall be resistant to the effects of temperature up to 95°C, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be of approved standard.
- 2.6.4.14 The spacer assembly shall have electrical continuity. The electrical resistance between the sub-conductor across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.
- 2.6.4.15 The spacer assembly shall have complete ease of installation and shall be capable of removal/ reinstallation without any damage.
- 2.6.4.16 The spacer assembly shall be capable of being installed and removed from the energised line by means of hot line technique.

2.5 **Spacer Damper**

- 2.5.1 Suitable spacer dampers for bundle conductor configuration for line (stipulated in relevant clause of section-I) shall be offered. The spacer damper covered by this specification shall be designed to maintain the bundle spacing of 457 mm under all normal operating conditions and to effectively control Aeolian vibrations as well as sub span oscillation and to restore conductor spacing after release of any external extraordinary load. The nominal sub conductor spacing shall be maintained within ± 5 mm.
- 2.5.2 The spacer damper shall restore the normal sub-conductor spacing due to displacement by wind, electromagnetic and electrostatic forces including the specified short circuit level without permanent deformation or damage either to bundle conductors or to spacer damper itself.
- 2.5.3 The design offered shall be presented as a system consisting of spacer dampers and their staggering scheme for spans ranging from 100 m to 1100 m. A vibration performance test shall be carried out on an experimental test line.

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

Sl.	Description	Technical Particulars
1	Configuration	Refer to Section-I for configuration of lines & mechanical properties of the conductor
1.	Span length	
i)	Ruling design span	As given in section-I
ii)	Maximum span	1100 meters
iii)	Minimum span	100 meters
3	Tension in each sub-conductor	25% of UTS of Conductor
4	Armour rods used	Yes
5	Maximum permissible dynamic strains	± 150 micro strains

- 2.5.4 Under the operating conditions specified, the spacer damper system shall adequately control Aeolian vibrations throughout the life of the transmission line with wind velocity ranging from 0 to 30 km per hour in order to prevent damage to conductor at suspension clamps, dead end clamps and spacer damper clamps.
- 2.5.5 The spacer damper system shall also control the sub-span oscillations in order to prevent conductor damage due to chaffing and severe bending stresses at the spacer damper clamps as well as suspension and dead-end clamps and to avoid wear to spacer damper components.
- 2.5.6 The spacer damper shall consist of a rigid central body called the frame linked to the conductor by articulated arms. terminated by elastomer lined or elastomer covered clamps and securely held by preformed retaining helical, factory-formed rods. The articulation shall be designed to provide elastic and damping forces under angular movement of the arms. The dynamic characteristics of the articulations shall be maintained for the whole life of the transmission line.
- 2.5.7 The clamping system shall be designed to provide firm but gentle and permanent grip while protecting the conductor against local static or dynamic stresses expected during normal operating conditions. The clamping system shall be designed to compensate for any reduction of conductor diameter due to creep.
- 2.5.8 Where elastomer surfaced clamps are used, the elastomer elements shall be firmly fixed to the clamp.

- 2.5.9 Four numbers of rods shall be applied on each clamp to hold the clamp in position. The retaining rods shall be designed for specific conductor size. They shall be made of high strength aluminium alloy of type 65032 or equivalent aluminium alloy having a minimum tensile strength of 35 kg/sq.mm. The end of armour rod shall be parrot billed. The rods shall be heat treated and aged to achieve specified mechanical properties and to retain the same during service. Each rod shall be marked in the middle with paint for easy application on the line. The length and diameter of preformed retaining rod shall be decided by suppliers as per design of the Spacer Damper. However, diameter and length of the rods shall be as per the STP.
- 2.5.10 The spacer damper body and clamps shall be cast/ forged from suitable high strength corrosion resistant aluminum alloy. The aluminium alloy shall be chosen in relation with the process used.
- 2.5.11 The rubber components involved in the design such as damping elements shall be made with rubber compound selected specifically for that particular application. The Bidder shall submit a complete list of physical and mechanical properties of the elastomer used.
- 2.5.12 The rubber components used shall have good resistance to the effects of temperature indicated in the Standard Technical Particulars and to ultraviolet radiation, ozone and other atmospheric contaminants. The rubber shall have good wear and fatigue resistance and shall be electrically semi conductive.
- 2.5.13 The spacer damper assembly shall have electrical continuity. The electrical resistance between the sub-conductors across the assembly in case of spacer damper involving elastomer surfaced clamps shall be suitably selected by the manufacturer to ensure satisfactory electrical performance and avoid deterioration of elastomer under service conditions.
- 2.5.14 The spacer damper assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.
- 2.5.15 The spacer damper assembly shall be capable of being installed and removed from the energized line by means of hot line techniques. The Supplier shall submit complete description of the installation, removal and reinstallation procedure.
- 2.5.16 A typical placement chart of spacer dampers for spans ranging from 100m to 1100m is indicated in table at ***Annexure-D***. Sub span spacing indicated in ***Annexure-D*** may be varied as per the manufacturer requirement, provided total no. of Spacer Damper in sub-span shall not be less than indicated in table at ***Annexure-D***. In case of tension towers, one additional Spacer Damper shall be placed within 10m of dead-end clamp. In case more Spacer dampers are recommended by the supplier, the payment shall be restricted to the number of Spacer dampers indicated in table at ***Annexure-D*** for different spans and one additional in case of tension towers.

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

2.6 **Rigid Spacer**

2.6.1 Jumpers at tension points shall also be fitted with Rigid spacers so as to limit the length of free conductor to 3.65 m and to maintain the sub conductor spacing of 450mm for twin conductor line and 457 mm for Triple/ Quad/ Hexa bundle lines. Supplier shall quote for rigid spacer for jumper. It shall meet all the requirements of spacer used in line except for its vibration performance. Rigid spacers requiring retaining rods shall not be quoted for jumpers.

2.6.2 The spacer offered by the Bidder shall satisfy the following requirement: -

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

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

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

2.6.2.4 The clamp grooves shall be in uniform contact with the conductor over the entire surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, grit or other material. which cause damage to the conductor when the clamp is installed.

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

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

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

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

- 2.6.7 Rigid spacers shall be acceptable only for jumpers.
- 2.6.8 The Rigid spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance.
- 2.6.9 The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep.
- 2.6.10 The Rigid spacer assembly shall not have any projections, cuts, abrasions etc. or chattering parts which might cause corona or RIV.
- 2.6.11 The spacer tube shall be made of extruded aluminium alloy of type 65032 or 63400. 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.
- 2.6.12 Elastomer, if used, shall be resistant to the effects of temperature up to 95°C, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be of approved standard.
- 2.6.13 The spacer assembly shall have electrical continuity. The electrical resistance between the sub-conductor across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.
- 2.6.14 The spacer assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.
- 2.6.15 The spacer assembly shall be capable of being installed and removed from the energised line by means of hot line technique.

2.7 Material and Workmanship

- 2.7.1 All the equipment shall be of the latest proven design and conform to the best modern practice adopted in the extra high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for transmission line applications of the rated voltage with bundle conductors and will give continued good performance.
- 2.7.2 The design, manufacturing process and quality control of all the materials shall be such as to achieve requisite factor of safety for maximum working load, highest mobility, elimination of sharp edges and corners, best resistance to corrosion and a good finish.
- 2.7.3 All ferrous parts shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised as per grade 4 of IS 1573. 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 610 gm/sqm and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanising unless otherwise specified.

- 2.7.4 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 as per STP.
- 2.7.5 In case of castings, the same shall be free from all internal defects like shrinkage, inclusion, blow holes cracks etc.
- 2.7.6 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localised heating phenomenon is averted.
- 2.7.7 No equipment shall have sharp ends or edges, abrasions or projections and shall not cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under all service conditions.
- 2.7.8 Particular care shall be taken during manufacture and subsequent handling to ensure smooth surface free from abrasion or cuts.
- 2.7.9 The fasteners shall conform to the requirements of IS 6639. All fasteners and clamps shall have corona free locking arrangement to guard against vibration loosening.

2.8 Compression Markings

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

2.9 Drawings

- 2.9.1 After placement of award, the Contractor shall submit fully dimensioned drawing including all the components, as described below, to the PGCIL for approval. After submission of valid type test reports or successful completion of type tests and getting approval from the PGCIL, the Contractor shall submit the same drawings to the PGCIL for further distribution and field use at Employer 's end

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

2.9.3 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. Marking
- iv. Weight of assembly
- v. Installation instructions, if any
- vi. Design installation torque for the bolt or cap screw
- vii. The compression die number with recommended compression pressure.
- viii. All other relevant technical details

3.0 **G.S. Earth wire Accessories**

3.1 **General**

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

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

3.2 **Mid Span Compression Joint**

3.2.1 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 resistance less

than 75% of resistance of equivalent length of earth wire. The dimensions and the dimensional tolerances of the joint shall be as stipulated in the Standard Technical Particulars.

3.3 Vibration Damper

- 3.3.1 Vibration dampers of 4R-Stockbridge type with four (4) different frequencies spread within the specified aeolian frequency band-width corresponding to wind speed of 1m/s to 7 m/s shall be used for suspension and tension points on each earth wire in each span to damp out aeolian vibrations as mentioned herein after.
- 3.3.2 Alternate damping systems or “Dogbone” dampers offering equivalent or better performance also shall be acceptable provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents to establish the technical suitability of alternate systems shall be furnished by the Supplier along with the bid.
- 3.3.3 One damper minimum on each side per earth wire at suspension points and two dampers on each side per earth wire at tension points shall be used for ruling design span as given is relevant clause of Section-I.
- 3.3.4 Incase more number of dampers per ruling design span are recommended by the supplier, the payment shall be restricted to the number of dampers specified in clause 3.3.3.
- 3.3.5 The clamp of the vibration damper shall be made of aluminium alloy. It shall be capable of supporting the damper during installation and prevent damage or chaffing of the earth wire during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the earth wire without damaging the strands or causing premature fatigue failure of the earth wire under the clamp. The clamp groove shall be in uniform contact with the earth wire over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or materials which could cause damage to the earth wire when the clamp is installed. Clamping bolts shall be provided with self locking nuts designed to prevent corrosion of the threads or loosening during service.
- 3.3.6 The messenger cable shall be made of high strength galvanised steel/stainless steel with a minimum strength of 135 Kg/sq.mm. It shall be of preformed and post formed quality in order to prevent subsequent drop of weights and to maintain consistent flexural stiffness of the cable in service. The number of strands in the messenger cable shall be 19. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion.
- 3.3.7 The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkages, inclusions and blow holes etc. The inside and outside surfaces of the damper masses shall be smooth.
- 3.3.8 The vibration analysis of the system, with and without damper, dynamic

characteristic of the damper as detailed under ***Annexure-A***, shall have to be submitted by the Bidder along with his bid. The technical particulars for vibration analysis and damping design of the system are as follows: -

Sl. No.	Description	Technical particulars
1.	Span length in meters	
i)	Ruling design span	As given in section-I
ii)	Maximum span	1100 meters
iii)	Minimum span	100 meters
2.	Configuration	As per Section-I of this Specification
3.	Tension of earthwire	25% of UTS of earthwire
4.	Armour rods used	Standard preformed armour rods/ AGS
5.	Maximum permissible dynamic strain	+/- 150 micro strains

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

3.3.10 The damper placement charts shall include the following:

- (1) Location of the dampers for various combinations of spans and line tensions clearly indicating number of dampers to be installed per earth wire per span.
- (2) Placement distances clearly identifying the extremities between which the distances are to be measured.
- (3) Placement recommendation depending upon type of suspension clamps (viz, free center type/ trunion type etc.)
- (4) The influence of mid span compression joints in the placement of dampers.

3.4 **Flexible Aluminium Bond**

The flexible aluminium bond shall be manufactured from multi strand multi wire fatigue resistant Aluminium alloy, conforming to IS 398 (Part 4) with a minimum cross-sectional area of 95 sq.mm and not less than 750 mm in length. The bond shall be flexible so as not to interfere with the clamp movement, shall be terminated with compressed lugs. 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 (Hex Round Hex) MS Bolt hot dip galvanised with nut and lock washer.

3.5 **Suspension Clamp**

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

3.5.2 At all suspension towers, suitable suspension clamps shall be used to

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

- 3.5.3 There shall be no sharp point in the clamps coming in contact with earth wire. There shall not be any displacement in the configuration of the earth wire strands nor shall the strands be unduly stressed in final assembly during working conditions.
- 3.5.4 The clamping piece and the clamp body shall be clamped by at least two U- bolts of size not less than 10 mm diameter having one nut and one 3 mm thick lock nut with washer on each of its limbs. Suspension clamps shall be provided with inverted type U-bolts. One limb of the U-bolt shall be long enough to accommodate the lug of the flexible Aluminium bond.
- 3.5.5 The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pin etc. The total drop of the suspension assembly from the center point of the attachment to the center point of the earth wire shall not exceed 150 mm. The design of the assembly shall be such that the direction of run of the earth wire shall be same as that of the conductor.
- 3.5.6 The complete assembly shall be guaranteed for slip and breaking strength of values indicated in the Standard Technical Particulars.

3.6 **Tension Clamp**

- 3.6.1 At all tension towers suitable compression type tension clamps shall be used to hold the required galvanised steel earth wire. Anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plates.
- 3.6.2 The clamps shall have adequate area of bearing surface to ensure positive electrical and mechanical contact and shall not permit any slip to the earth wire under working tension and vibration conditions. The angle of jumper terminal to be mounted should be 30 deg. with respect to the vertical line.
- 3.6.3 The clamps shall be made of mild steel with aluminium encasing. The steel should not crack or fail during compression. The Brinell hardness of steel sleeve shall not exceed 200. The steel sleeve shall be hot dip galvanised. The aluminium encasing shall have aluminium of purity not less than 99.5%. Filler aluminium sleeve shall also be provided at the end.
- 3.6.4 The complete assembly shall be so designed as to avoid undue bending in any part of the clamp and shall not produce any hindrance to the movements of the clamps in horizontal or vertical directions.
- 3.6.5 The slip strength of the assembly shall not be less than 95% of the

ultimate strength of the earth wire.

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

3.7 **Material and Workmanship**

Same as Clause 2.7 of this section

3.8 **Compression Marking**

Same as Clause 2.8 of this section

3.9 **Drawings**

Same as Clause 2.9 of this section

4.0 **Tests and Standards**

4.1 **Type Tests**

4.1.1 **On the complete Insulator String with Hardware Fittings**

a)	Power frequency voltage withstand test with corona control rings/ grading ring and arcing horns under wet condition <i>(for AC transmission line & DMR for HVDC line only)</i>	As per IEC 60383/ IEC60060-1
b)	DC voltage withstand test without corona control rings/ grading ring and arcing horns under wet condition <i>(for DC transmission line only)</i>	Annexure-A
c)	Switching surge voltage withstand test under wet condition <i>(for 400 kV & above voltage level line only)</i>	As per IEC 60383
d)	Impulse voltage withstand test under dry condition	As per IEC 60383
e)	Voltage distribution test <i>(for Disc Insulator string only)</i>	Annexure-A
f)	Corona and RIV test under dry condition <i>(for 400 kV & above voltage level line only)</i>	Annexure-A
g)	Mechanical Strength test	Annexure-A
h)	Vibration test	Annexure-A

Note: Applicability of above type tests on hardware fittings covered under BPS shall be as follows: -

a) 765 kV double circuit transmission line with Hex ZEBRA conductor

i)	Double 'I' suspension	All type test as per clause no. 4.1.1
ii)	Quadruple tension	
iii)	Single 'I' suspension pilot	All type test as per clause no. 4.1.1(a) to (g)
iv)	Single tension	
v)	Double 'I' suspension (River Crossing)	Type test as per clause no. 4.1.1 (g)
vi)	Quadruple Tension (River Crossing)	

b) 765 kV single circuit transmission line with Quad BERSIMIS conductor

i)	Double 'I' suspension	All type test as per clause no. 4.1.1
ii)	Single 'V' suspension	
iii)	Double 'V' suspension	
iv)	Quadruple tension	
v)	Single 'I' suspension pilot	
vi)	Single 'V' suspension pilot	All type test as per clause no. 4.1.1(a) to (g)
vii)	Single tension	
viii)	Double 'I' suspension (River Crossing)	Type test as per clause no. 4.1.1 (g)
ix)	Quadruple Tension (River Crossing)	

c) 400 kV transmission line with quad MOOSE conductor

i)	Double 'I' suspension	All type test as per clause no. 4.1.1
ii)	Quadruple tension	
iii)	Single 'I' suspension pilot	All type test as per clause no. 4.1.1(a) to (g)
iv)	Single tension	
v)	Double 'I' suspension (River Crossing)	Type test as per clause no. 4.1.1 (g)
vi)	Quadruple Tension (River Crossing)	

d) 400 kV transmission line with triple SNOWBIRD conductor

i)	Double 'I' suspension	All type test as per clause no. 4.1.1
ii)	Double tension	
iii)	Single 'I' suspension pilot	All type test as per clause no. 4.1.1(a) to (g)
iv)	Single tension	

e) 400 kV transmission line with twin LAPWING/ MOOSE conductor

i)	Single 'I' suspension	All type test as per clause no.
ii)	Double tension	4.1.1
iii)	Single 'I' suspension pilot	All type test as per clause no.
iv)	Single tension	4.1.1(a) to (g)
v)	Double 'V' suspension (River Crossing)	Type test as per clause no. 4.1.1 (g)
vi)	Triple Tension (River Crossing)	

f) 220 kV transmission line with single ZEBRA conductor

i)	Single 'I' suspension	All type test as per clause no.
ii)	Single tension	4.1.1 except c) & f)
iii)	Single 'I' suspension pilot	All type test as per clause no.
iv)	Double 'I' suspension	4.1.1(a) to (g) except c) & f)
v)	Double tension	

g) 220 kV transmission line with twin MOOSE conductor

i)	Single 'I' suspension	All type test as per clause no. 4.1.1 except c) & f)
ii)	Double tension	
iii)	Single 'I' suspension pilot	All type test as per clause no. 4.1.1(a) to (g) except c) & f)
iv)	Double 'I' suspension	

h) 132 kV transmission line with single PANTHER/ ZEBRA conductor

i)	Single 'I' suspension	All type test as per clause no. 4.1.1 except c) & f)
ii)	Single tension	
iii)	Single 'I' suspension pilot	All type test as per clause no. 4.1.1(a) to (g) except c) & f)
iv)	Double 'I' suspension	
v)	Double tension	

i) +500 kV HVDC transmission line with quad BERSIMIS/ LAPWING conductor

i)	Single 'V' suspension	All type test as per clause no. 4.1.1
ii)	Quadruple tension	
iii)	Double 'V' suspension	All type test as per clause no. 4.1.1(a) to (g)

j) +800 kV HVDC transmission line with hexa LAPWING conductor

i)	Single 'Y' suspension	All type test as per clause no. 4.1.1
ii)	Triple tension	
iii)	Single 'I' suspension Pilot	All type test as per clause no. 4.1.1(a) to (g)

k) +800 kV HVDC transmission line (DMR)

i)	Single 'I' suspension	All type test as per clause no. 4.1.1 except c) & f)
ii)	Double tension	

4.1.2

On Suspension Hardware Fittings only

a)	Visual Examination	IS 2486 (Part-I)
b)	Verification of Dimensions	IS 2486 (Part-I)
c)	Chemical Analysis of Materials	Annexure-A

d)	Magnetic power loss test for suspension assembly (for AC line only), if applicable	Annexure-A
e)	Slip Strength test on clamp	Annexure-A
f)	Mechanical Strength test on Suspension hardware fitting except clamp	Annexure-A
g)	Vertical damage load & Failure load test on suspension clamp	IEC 61284
h)	OZONE resistance Test on elastomer	IEC 61854, Clause 7.6.3
i)	Galvanising/ electroplating tests	Annexure-A

4.1.3

On Tension Hardware fittings only

a)	Visual Examination	IS 2486 (Part-I)
b)	Verification of Dimensions	IS 2486 (Part-I)
c)	Chemical Analysis of Materials	Annexure-A
d)	Electrical resistance test for dead end assembly	IS 2486-(Part-I)
e)	Heating cycle test for dead end Assembly	IS 2486 (Part-I)
f)	Mechanical strength test on hardware fitting except clamps	Annexure-A
g)	Slip strength test for dead end assembly	Annexure-A
h)	Galvanising/ electroplating tests	Annexure-A

4.1.4

Mid Span Compression Joint for Conductor and Earth wire

a)	Visual Examination	IS 2121(Part-II)
b)	Dimensional Verification	IS 2121(Part-II)
c)	Chemical Analysis of Materials	Annexure-A
d)	Electrical resistance test	IS 2121(Part-II)
e)	Heating cycle test	IS2121 (Part-II)
f)	Failing load test	Annexure-A
g)	Corona extinction voltage test (dry) (for 400 kV & above voltage level line only)	Annexure - A
h)	Radio interference voltage test (dry) (for 400 kV & above voltage level line only)	Annexure - A
i)	Galvanising test	Annexure-A

Note: 'Heating cycle', 'Corona extinction voltage', 'Radio interference voltage' tests are not applicable to Mid span compression joint for Earthwire

4.1.5

T-Connector for Conductor

a)	Visual Examination	IS 2121(Part-IV)
b)	Verification of Dimensions	IS 2121(Part-IV)
c)	Chemical Analysis of Materials	Annexure-A
d)	Electrical resistance test	IS 2121(Part-II)
e)	Heating cycle test	IS 2121 (Part-IV)
f)	Tensile test	IEC 61284; Clause 11.6.2
g)	Axial tensile load test on welded portion	Annexure-A
h)	Corona extinction voltage test (dry) <i>(for 400 kV & above voltage level line only)</i>	Annexure-A
i)	Radio interference voltage test (dry) <i>(for 400 kV & above voltage level line only)</i>	Annexure-A
i)	Galvanising test	Annexure-A

4.1.6

Repair Sleeve for Conductor

a)	Visual Examination	IS 2121(Part-II)
b)	Dimensional Verification	IS 2121(Part-II)
c)	Chemical Analysis of Materials	Annexure-A
d)	Failing load test	Annexure-A
e)	Corona extinction voltage test (dry) <i>(for 400 kV & above voltage level line only)</i>	Annexure-A
f)	Radio interference voltage test (dry) <i>(for 400 kV & above voltage level line only)</i>	Annexure-A

4.1.7

Flexible Aluminium Bond

a)	Visual Examination	IS 2121(Part-III)
b)	Dimensional Verification	IS 2121(Part-III)
c)	Chemical Analysis of Materials	Annexure-A
d)	Slip Strength Test	Annexure-A

e)	Galvanising test	Annexure-A

4.1.8

Vibration Damper for Conductor and Earth wire

a)	Visual Examination	IS 9708
b)	Verification of Dimensions	IS 9708
c)	Chemical Analysis of Materials	Annexure-A
d)	Resonance frequency test	IS 9708
e)	Dynamic characteristics test	Annexure-A
f)	Vibration analysis	Annexure-A
g)	Clamp slip test	Annexure-A
h)	Clamp bolt torque test	IS 9708
i)	Fatigue test	Annexure-A
j)	Mass pull off test	IS 9708
k)	Attachment of clamp to messenger cable	IEC 61897, Clause 7.9
l)	Damping efficiency test	IS 9708
m)	Magnetic power loss test (for AC line only), if applicable	Annexure-A
n)	Corona extinction voltage test (dry) (for 400 kV & above voltage level line only)	Annexure-A
o)	Radio interference voltage test (dry) (for 400 kV & above voltage level line only)	Annexure-A
p)	Galvanising/Electroplating test	Annexure-A
NOTE: 'Magnetic Power Loss', 'Corona extinction voltage', 'Radio interference voltage' tests are not applicable to Vibration damper for Earthwire		

4.1.9

Spacer Damper

(a)	Visual examination & verification of dimension, materials and mass	IEC:61854; Clause 7.1 & 7.2
(b)	Clamp slip test	Annexure-A
(c)	Performance Test*	
	(i) Aeolian	Annexure-A
	(ii) Sub span Oscillation	Annexure-A
(d)	Magnetic power loss test (if applicable)	Annexure-A
(e)	Characteristics of the Elastic & damping Properties	Annexure-A
(f)	Fatigue (sub - oscillation) test	IEC 61854; Clause

		7.5.7.2
(g)	Corona extinction voltage test (dry)	Annexure-A
(h)	Radio interference voltage test (dry)	Annexure-A
(i)	Compression & Tension test	Annexure-A
(j)	Ozone Resistance test on Elastomer	IEC 61854; Clause 7.6.3

4.1.10

Bundle Spacer/Rigid Spacer

(a)	Visual examination & verification of dimension, materials and mass	IEC 61854; Clause 7.1 & 7.2
(b)	Clamp slip test	Annexure-A
(c)	Clamp bolt tightening test (if applicable)	IEC 61854; Clause 7.5.3
d)	Vibration test	Annexure-A
	i) Vertical Vibration	
	ii) Longitudinal Vibration	
	iii) Sub span oscillation	
(e)	Magnetic power loss test (if applicable)	Annexure-A
(f)	Compression & Tension test	Annexure-A
(g)	Corona extinction voltage test (dry) (for 400 kV & above voltage level line only)	Annexure-A
(h)	Radio interference voltage test (dry) (for 400 kV & above voltage level line only)	Annexure-A
(i)	Ozone test	IEC 61854; Clause 7.6.3
<i>NOTE: 'Vibration Test' & 'Ozone Test' are not applicable to Rigid Spacers.</i>		

4.1.11

Earth wire Suspension Clamp Assembly

a)	Visual Examination	IS 2121(Part-III)
b)	Dimensional Verification	IS 2121(Part-III)
c)	Chemical Analysis of Materials	Annexure-A
d)	Mechanical Strength test	Annexure-A
e)	Slip strength test for suspension clamp	Annexure-A
f)	Galvanising test	Annexure-A

4.1.12

Earth wire Tension Clamp Assembly

a)	Visual Examination	IS 2121(Part-III)
b)	Dimensional Verification	IS 2121(Part-III)
c)	Chemical Analysis of Materials	Annexure-A
d)	Mechanical Strength test (excluding clamp)	Annexure-A

e)	Slip strength test for dead-end clamp	Annexure-A
f)	Electrical Resistance test	IS 2121 (Part-III)
g)	Galvanising test	Annexure-A

4.1.13 Type tests specified under Clause 4.1.1 to 4.1.12 shall not be required to be carried out if the same has been carried out if a valid test certificate is available for a similar design.

The test certificate shall be considered valid if,

- i) Tests conducted earlier is either 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 POWERGRID or Utility and
- ii) Type test reports contain valid Calibration reports of the relevant testing equipment and information pertaining to ratings, the relevant drawings, model number, test circuit, calculations (if any), photos, acceptance criteria/values specified in Technical Specification/relevant standards (IS/ IEC) and compliance to the same and
- iii) Tests should have been conducted on the samples manufactured from same manufacturing works within last 7 (seven) years as on the date of LOA.

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

Also, in case, hardware components of previously type tested hardware fittings are modified as per the attached standardized drawing, the suppliers shall be required to carry out Mechanical strength test of the entire string (without insulators) as per Clause 4.1.2 & 4.1.3 at no extra cost to the Employer. In case the tests have been conducted earlier than the above stipulated period or carried out on samples manufactured from any other manufacturing works or in case of revision/ amendment in the provisions/ test procedure of the IS/ IEC as referred in the TS or in the event of any discrepancy in the test report (i.e., due to non-inclusion of valid calibration certificate, desired information etc. or any test not applicable due to any design/ material/ manufacturing process change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the supplier at no extra cost to the Purchaser.

Further, in-case of non-availability of valid type test reports for 'Performance test' on Spacer Dampers, the type test shall not be required to be carried out if the spacer damper design offered under the package has been in successful operation for at least 3 years as on date of NOA on a transmission line having same conductor bundle configuration. Documentary evidence including supply record, performance certificate, etc. from respective utilities shall be submitted by the supplier in this regard.

**The performance tests conducted on Spacer Dampers as well as*

operational experience (in lieu of performance test) stipulated above with same Central Frame and damping system but with different clamping system shall also be considered valid.

4.2 Acceptance Tests

4.2.1 On Both Suspension and Tension Hardware Fittings

a)	Visual Examination	IS 2486 (Part-I)
b)	Verification of Dimensions	IS 2486 (Part-I)
c)	Galvanising/Electroplating test	Annexure-A
d)	Mechanical strength test of each component (excluding corona control rings gradingring and arcing horn)	Annexure-A
e)	Mechanical Strength test of welded joint	Annexure-A
f)	Mechanical strength test for corona control rings/ grading ring and arcing horn	BS 3288 (Part-I), Clause 7.3.2
g)	Test on locking device for ball and socket coupling	IS 2486 (Part-IV)
h)	Chemical analysis, hardness tests, grain size, inclusion rating & magnetic particle inspection for forgings/castings	Annexure-A

4.2.2 On Suspension Hardware Fitting only

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

4.2.3 On Tension Hardware Fittings Only

(a)	Slip strength test for dead end assembly	Annexure-A

4.2.4 Mid Span Compression Joint for Conductor and Earth wire

a)	Visual Examination	IS 2121(Part-II)
b)	Dimensional Verification	IS 2121(Part-II)
c)	Chemical Analysis of Materials	Annexure-A
d)	Galvanising test	Annexure-A

e)	Failing load test	Annexure-A
f)	Hardness test	Annexure-A

4.2.5 T-Connector for Conductor

a)	Visual Examination	IS 2121(Part-IV)
b)	Verification of Dimensions	IS 2121(Part-IV)
c)	Chemical Analysis of Materials	Annexure-A
d)	Axial tensile load test for welded portion	Annexure-A
e)	Tensile test	IEC 61284; Clause 11.6.2
f)	Galvanising test	Annexure-A

4.2.6 Repair Sleeve for Conductor

a)	Visual Examination	IS 2121(Part-II)
b)	Dimensional Verification	IS 2121(Part-II)
c)	Chemical Analysis of Materials	Annexure-A
d)	Failing load test	Annexure-A

4.2.7 Flexible Aluminium Bond

a)	Visual Examination	IS 2121(Part-III)
b)	Dimensional Verification	IS 2121(Part-III)
c)	Chemical Analysis of Materials	Annexure-A
d)	Slip Strength Test	Annexure-A

4.2.8 Vibration Damper for Conductor and Earthwire

a)	Visual Examination	IS 9708
b)	Verification of Dimensions	IS 9708
c)	Chemical Analysis of Materials	Annexure-A
d)	Galvanising/ Electroplating test	Annexure-A
e)	Clamp slip test	Annexure-A
f)	Clamp bolt torque test	IS 9708
g)	Resonance frequency test	IS 9708
h)	Strength of messenger cable	Annexure-A
i)	Dynamic characteristics test	Annexure-A
j)	Mass pull off test	IS 9708
k)	Attachment of clamp to messenger cable	IEC 61897, Clause 7.9

4.2.9 Spacer Damper/ Bundle Spacer/ Rigid Spacer

(a)	Visual examination & verification of dimension, materials and mass	IEC 61854; Clause 7.1 &

		7.2
(b)	Galvanising test	Annexure-A
(c)	Movement test (except for spacers for jumpers)	Annexure-A
(d)	Clamp slip test	Annexure-A
(e)	Clamp bolt tightening test (if applicable)	IEC 61854; Clause 7.5.3
(f)	Compression and tension test	Annexure-A
(g)	Assembly torque test	Annexure-A
(h)	Characteristics of the Elastic & damping Properties	Annexure-A
(i)	Hardness test for elastomer (if applicable)	Annexure-A
(j)	UTS of retaining rods (if applicable)	Annexure-A

4.2.10

Earth wire Suspension Clamp Assembly

a)	Visual Examination	IS 2121(Part-III)
b)	Dimensional Verification	IS 2121(Part-III)
c)	Chemical Analysis of Materials	Annexure-A
d)	Galvanising test	Annexure-A
e)	Mechanical Strength Test	Annexure-A
f)	Slip strength test for suspension clamp	Annexure-A

4.2.11

Earth wire Tension Clamp Assembly

a)	Visual Examination	IS 2121(Part-III)
b)	Dimensional Verification	IS 2121(Part-III)
c)	Chemical Analysis of Materials	Annexure-A
d)	Galvanising test	Annexure-A
e)	Mechanical Strength test (excluding clamp)	Annexure-A
f)	Slip strength test for dead-end clamp	Annexure-A

4.3

Routine Tests

4.3.1

For Hardware Fittings

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

4.3.2

For conductor and earthwire accessories

a)	Visual examination	IS 2121(Part-II/ III/ IV, as applicable)
b)	Dimensional verification	IS 2121(Part-II/ III/ IV, as applicable)

4.4

Tests During Manufacture

on all components as applicable

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

4.5

Testing Expenses

- 4.5.1 In the event of type testing, bidders shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that the tests can be completed in these laboratories within the time schedule
- 4.5.2 In case of failure in any type test, the supplier is either required to modify the design of the material & successfully carryout all the type tests as has been detailed out in Clause 4.1 of this specification or to repeat that particular type test at least three times successfully at his own expenses.
- 4.5.3 In case of type test on the complete insulator string, the Contractor has to arrange similar insulators at his own cost.
- 4.5.4 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.
- 4.5.5 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.
- 4.5.6 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.

- 4.5.7 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.

4.6 **Sample Batch for Type Testing**

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

- 4.6.2 Before sample selection for type testing the Contractor shall be required to conduct all the acceptance tests successfully in presence of Employer's representative. However, those acceptance tests, which are also required to be carried out afresh as the type test, shall not be required to be carried out.

4.7 **Schedule of Testing and Additional Tests**

- 4.7.1 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.

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

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

4.8 **Test Reports**

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

material shall start.

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

4.8.3 Record of routine test report shall be maintained by the Contractor at his works for periodic inspection by the PGCIL representative.

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

4.9 **Inspection**

4.9.1 The Employer 's representative PGCIL 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. Manufacturers of all the material and for conducting necessary tests as detailed herein.

4.9.2 The material for final inspection shall be offered by the Contractor only under packed condition as detailed in clause 4.10 of this part of the Specification. The engineer shall select samples at random from the packed lot for carrying out acceptance tests.

4.9.3 The Contractor shall keep the Employer/ PGCIL 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.

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

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

4.10 **Packing and Marking**

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

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

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

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

4.10.5 Each component of Hardware fittings and accessories shall be legibly and indelibly marked with trade mark of the manufacturer. However, in such type of component/ item, which consists of many parts and are being supplied in assembled condition (suspension clamp, vibration damper, spacer/ rigid spacer, spacer damper etc.), the complete assembly shall be legibly and

Indelibly marked on main body/on one of the parts. The symbol  / 
Alongwith the word 'TOP' shall be marked on the main body of the spacer Damper for installing spacer damper in correct position.

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

4.11 Standards

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

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

Sl. No.	Indian Standard	Title	International Standard
1	IS 209	Specification for zinc	
2	IS 398 (Part 2)	Aluminium Conductor for overhead transmission purpose- Specification: Aluminium Conductor, Galvanised Steel-Reinforced	
3	IS 398 (Part 4)	Aluminium Conductor for overhead transmission purpose: Aluminium Alloy Stranded Conductor (Aluminium-Magnesium-Silicon type)- Specification	

4	IS 398 (Part-5)	Aluminium Conductor for overhead transmission purpose- Specification: Aluminium Conductor, Galvanised Steel-Reinforced for Extra High voltage (400 kV and above)	
5	IS 398 (Part-6)	Aluminium Conductor for Overhead Transmission Purpose: High Conductivity Aluminium Alloy Stranded Conductors- Specification	
3	IS 1573	Electroplated Coating of Zinc on iron and Steel	
4	IS 2121 (Part-I)	Specification for Conductor and Earthwire Accessories for Overhead Power lines: Armour Rods, Binding wires & Tapes for Conductors	
5	IS 2121 (Part-II)	Specification for Conductor and Earthwire Accessories for Overhead Power lines: Mid-span Joints and Repair Sleeves for Conductors	
6	IS 2121 (Part 3)	Conductors and Earthwire Accessories for Overhead Lines: Accessories for Earthwire: Accessories for Earhwire- Specification	
7	IS 2121 (Part 4)	Conductors and Earthwire Accessories for Overhead Lines: Non-Tension Joints-Specification	
8	IS 2486 (Part-I)	Metal Fittings of Insulators for Overhead power Lines with Nominal Voltage greater than 1000 V: General Requirements and Tests	
9	IS 2486 (Part-II)	Insulator Fittings for Overhead Power Lines with Nominal Voltage greater than 1000 V-Specification: Dimensional Requirements	
10	IS 2486 (Part III)	Specification for Insulator Fittings for Overhead Power Lines with a Nominal Voltage greater than 1000 volts: Locking Devices	

11	IS 2486 (Part IV)	Specification for Insulator Fittings for Overhead Power Lines with a Nominal Voltage greater than 1000V: Tests for Locking Devices	
12	IS 2629	Recommended Practice for Hot Dip Galvanizing of Iron and Steel	
13	IS 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
14	IS 4826	Galvanised Coating on Round Steel Wires	
15	IS 6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	
16	IS 6639	Hexagonal Bolts for Steel Structures	
17	IS 9708	Specification for Stock Bridge Vibration Dampers for Overhead Power Lines	
18	IS 10162	Specification for Spacers Dampers for Twin Horizontal Bundle Conductors	
19	IS 8263	Method of Radio Interference Tests on High Voltage Insulators	
20		Ozone test on Elastomer	IEC 61284
21		Tests on insulators of Ceramic material or glass for overhead lines with a nominal voltage greater than 1000V	IEC 383-1993

The standards mentioned above are available from:

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

1.0 Tests on Complete Strings with Hardware Fittings

1.1 D.C Voltage Withstand test (Wet)

The procedure for this test be the same as specified in BS 137 (Part-I) Clause 3.4 and 3.5 except that the insulator string shall be tested without the Corona Control rings.

1.2 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 voltage across any disc shall not exceed as per table given below for different transmission line configuration: -

Transmission line configuration	Suspension string	Tension string
765 kV line	6.5%	6.5%
400 kV line	9%	10%
220 kV line	13%	14%
132 kV line	20%	20%

1.3 Corona Extinction Voltage Test (Dry)

The sample assembly consisting of complete insulator string when subjected to power frequency (for ac line) / DC voltage (for dc line) shall have a corona extinction voltage of not less than the requirement stipulated in the table below: -

Voltage Level	Maximum Height of the conductor above ground (m)	Minimum Corona extinction voltage (kV)
400 kV	8.84	320 (305 for RIV test)
765 kV	15	510
+500kV HVDC	Such that voltage gradient is not less than 22 kV/cm	550
+800kV HVDC	Such that voltage gradient is not less than 22 kV/cm	880

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: 60383.

1.4 Radio Interference Voltage Test (Dry)

Under the conditions as specified under (1.2) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 1000 micro volts at one MHz. The test procedure shall be in accordance with IS 8263.

1.5 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 loaded to reproduce design conditions. The testing programme varies with string and tower types according to following table:

String Type	Total Test Load* (kN)	Direction** of Load	Duration of Load (Min.)	Sequence of Testing***
132kV (SINGLE PANTHER)				
Double I Suspension (2X70kN)	94	1	5	1
	140	1	1	2
	F****	1	-	3
Single I Suspension (70kN)	47	1	5	1
	70	1	1	2
	F****	1	-	3
Single Tension (90 kN)	60	1	5	1
	90	1	1	2
	F****	1	-	3
Double Tension (2X90kN)	120	1	5	1
	180	1	1	2
	F****	1	-	3
220 kV (SINGLE ZEBRA)				
Double I Suspension (2X70kN)	94	1	5	1
	140	1	1	2
	F****	1	-	3
Single I Suspension (70kN)	47	1	5	1
	70	1	1	2
	F****	1	-	3
Single I Suspension Pilot (70kN)	47	1	5	1
	70	1	1	2
	F****	1	-	3

Single Tension (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Double Tension (2X120kN)	160	1	5	1
	240	1	1	2
	F****	1	-	3
220 kV (TWIN MOOSE)				
Single I Suspension (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single I Suspension Pilot (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single Tension (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Double Tension (2X160kN)	214	1	5	1
	320	1	1	2
	F****	1	-	3
400 kV (TWIN MOOSE)				
Single V (2x90kN)	80	2	5	1
	60	3	5	2
	60	4	5	3
	90	3	1	4
	F****	3	—	5
Single I Suspension (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single I Suspension Pilot (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single Tension (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Double Tension (2X160kN)	214	1	5	1
	320	1	1	2
	F****	1	-	3

400kV (TWIN LAPWING)				
Single I Suspension (160kN)	107	1	5	1
	160	1	1	2
	F****	1	-	3
Single I Suspension Pilot (160kN)	107	1	5	1
	160	1	1	2
	F****	1	-	3
Single Tension (160kN)	107	1	5	1
	160	1	1	2
	F****	1	-	3
Double Tension (2 X210kN)	281	1	5	1
	420	1	1	2
	F****	1	-	3
400kV (TRIPLE SNOWBIRD)				
Double I Suspension (2X120kN)	161	1	5	1
	240	1	1	2
	F****	1	-	3
Single I Suspension Pilot (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single Tension (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Double Tension (2 X210kN)	281	1	5	1
	420	1	1	2
	F****	1	-	3
400kV (QUAD MOOSE)				
Double I Suspension (2X160kN)	161	1	5	1
	240	1	1	2
	F****	1	-	3
Single I Suspension Pilot (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single Tension (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3

Quad n (4X160kN)	Tensio	429	1	5	1
		640	1	1	2
		F****	1	-	3
+/-500kV HVDC (QUAD BERSIMIS)					
Single V (2x210kN)		155	2	5	1
		130	3	5	2
		130	4	5	3
		210	3	1	4
		F****	3	-	5
Double V (2x2x210kN)		320	2	5	1
		280	3	5	2
		280	4	5	3
		420	3	1	4
		F****	3	-	5
Quadruple n (4X160 kN)	Tensio	429	1	5	1
		640	1	1	2
		F****	1	-	3
+500kV HVDC (QUAD LAPWING)					
Single V (2x210kN)		155	2	5	1
		130	3	5	2
		130	4	5	3
		210	3	1	4
		F****	3	-	5
Double V (2x2x210kN)		320	2	5	1
		280	3	5	2
		280	4	5	3
		420	3	1	4
		F****	3	-	5
Quadruple n (4X210 kN)	Tensio	560	1	5	1
		840	1	1	2
		F****	1	-	3
765kV S/C (QUAD BERSIMIS)					
Double I (2X160kN)		160	1	5	1
		240	1	1	2
		F****	1	1	3
Single V (2X210kN)		155	2	5	1
		130	3	5	2

	130	4	5	3
	210	3	1	4
	F****	3	—	5
Double V (2X2X210kN)	280	2	5	1
	260	3	5	2
	260	4	5	3
	420	3	1	4
	F****	3	—	5
Single Tension (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Quadruple Tension (4X210kN)	540	1	5	1
	840	1	1	2
	F****	1	—	3
Single I Pilot (120kN) & Single V Pilot (2X120kN)	80	1	5	1
	120	1	1	2
	F****	1	—	3
765kV D/C (HEXA ZEBRA)				
Double I Suspension (2X160kN)	214	1	5	1
	320	1	1	2
	F****	1	-	3
Single I Suspension Pilot (160kN)	107	1	5	1
	160	1	1	2
	F****	1	-	3
Single Tension (160kN)	107	1	5	1
	160	1	1	2
	F****	1	-	3
Quad Tension (4X210kN)	560	1	5	1
	840	1	1	2
	F****	1	-	3
±800kV HVDC (HEXA LAPWING)				
Single 'Y' suspension String for Pole conductor	340	2	5	1
	250	3	5	2
	250	4	5	3
	420	3	1	4
	F*****	3	-	5
	845	1	5	1

Triple Tension String for Pole conductor	1260	1	1	2
	F*****	1	-	3
Single I Pilot String for Pole conductor (160kN)	108	1	5	1
	160	1	1	2
	F*****	1	-	3
Single I Suspension for DMR (160kN)	108	1	5	1
	160	1	1	2
	F*****	1	-	3
Single I Suspension for DMR (210kN)	141	1	5	1
	210	1	1	2
	F*****	1	-	3
Double Tension String for DMR (2x210kN)	281	1	5	1
	420	1	1	2
	F*****	1	-	3

Notes:

* : The total test must be established gradually at a steady rate.

** : Direction of load

1. following string axis
2. following bisector of string angle.
3. Following with respect to vertical, half the string angle, along the axis of one of the arm of the V-string
4. Following with respect to vertical, half the string angle +15 deg, along the axis of one of the arm of the V-string

*** The insulator string must be completely unloaded and examined, then the proper direction of loading established before proceeding to the next sequential test.

**** : F denotes Failure load

The insulators string shall be deemed acceptable if, for all test loads except failure load F, the string components do not show any visual signs of deformation or fracture, and the same components may be disassembled by hand, except for removal of cotter pins and initial loosening of the nuts. The failure load F shall be recorded and must be greater than all previous test loads.

1.6

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.

2.0 **Tests on Hardware Fittings**

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

The sample shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave. This test shall be carried out as per Clause 12.0 of IEC 61284. An alternating current over the range as stipulated below (per sub-conductor) shall be passed through a suitable length of conductor and the power losses shall be measured both with and without the fittings assembled on the conductor. Armour rods shall be applied to the conductor if they are used in service. The reading of the wattmeter with and without five suspension clamps shall be recorded and tabulated graphical form. The test is passed if the average power loss for suspension clamp at given ampere is less than or equal to the value indicated in the Standard Technical Particulars.

Conductor name	Alternating current range
ACSR PANTHER	200 amps to 500 amps
ACSR ZEBRA/ MOOSE/ SNOWBIRD/ BERSIMIS/LAPWING	400 amps to 800 amps

2.2 **Slip Strength Test for Suspension Clamp**

The Clamp slip strength test shall be carried out as per Clause no. 11.1.1 of IS 2486 (Part-1) by keeping the clamp at minimum specified slip strength for one minute and considering slip strength as specified in the Standard Technical Particular (STP).

2.3 **Mechanical Strength Test for Suspension/Tension Hardware Fittings except clamp**

The complete string excluding insulator, arcing horn, corona control ring, grading ring and suspension assembly/ dead end assembly shall be loaded to

reproduce design conditions. The testing programme varies with string and tower types according to following table:

String Type	Total Test Load* (kN)	Direction** of Load	Duration of Load (Min.)	Sequence of Testing***
132kV (SINGLE PANTHER)				
Double I Suspension (2X70kN)	94	1	1	1
	140	1	1	2
	F****	1	-	3
Single I Suspension (70kN)	47	1	1	1
	70	1	1	2
	F****	1	-	3
Single Tension (90 kN)	60	1	1	1
	90	1	1	2
	F****	1	-	3
Double Tension (2X90kN)	120	1	1	1
	180	1	1	2
	F****	1	-	3
220 kV (SINGLE ZEBRA)				
Double I Suspension (2X70kN)	94	1	1	1
	140	1	1	2
	F****	1	-	3
Single I Suspension (70kN)	47	1	1	1
	70	1	1	2
	F****	1	-	3
Single I Suspension Pilot (70kN)	47	1	1	1
	70	1	1	2
	F****	1	-	3
Single Tension (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Double Tension (2X120kN)	160	1	1	1
	240	1	1	2
	F****	1	-	3
220kV (TWIN MOOSE)				
Single I Suspension	80	1	1	1
	120	1	1	2

(120kN)	F****	1	-	3

Single I Suspension Pilot (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Single Tension (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Double Tension (2X160kN)	214	1	1	1
	320	1	1	2
	F****	1	-	3
400kV (TWIN MOOSE)				
Single V (2x90kN)	80	2	1	1
	90	2	1	2
	F****	2	—	3
Single I Suspension (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Single I Suspension Pilot (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Single Tension (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Double Tension (2X160kN)	214	1	1	1
	320	1	1	2
	F****	1	-	3
400kV (TWIN LAPWING)				
Single I Suspension (160kN)	107	1	1	1
	160	1	1	2
	F****	1	-	3
Single I Suspension Pilot (160kN)	107	1	1	1
	160	1	1	2
	F****	1	-	3
Single Tension (160kN)	107	1	1	1
	160	1	1	2
	F****	1	-	3
Double Tension (2 X210kN)	281	1	1	1
	420	1	1	2

	F****	1	-	3
400kV (TRIPLE SNOWBIRD)				
Double I Suspension (2X120kN)	161	1	1	1
	240	1	1	2
	F****	1	-	3
Single I Suspension Pilot (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Single Tension (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Double Tension (2 X210kN)	281	1	1	1
	420	1	1	2
	F****	1	-	3
400kV (QUAD MOOSE)				
Double I Suspension (2X160kN)	161	1	1	1
	240	1	1	2
	F****	1	-	3
Single I Suspension Pilot (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Single Tension (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Quad Tension (4X160kN)	429	1	1	1
	640	1	1	2
	F****	1	-	3
+/-500kV HVDC (QUAD BERSIMIS)				
Single V (1x210kN)	176	2	1	1
	263	2	1	2
	F****	2	-	3
Double V (2x210kN)	352	2	1	1
	525	2	1	2
	F****	2	-	3
Quadruple Tension (4X160 kN)	482	1	1	1
	720	1	1	2
	F****	1	-	3

+/-500kV HVDC (QUAD LAPWING)				
Single V (1x210kN)	176	2	1	1
	263	2	1	2
	F****	2	-	3
Double V (2x210kN)	352	2	1	1
	525	2	1	2
	F****	2	-	3
Quadruple Tension (4X210 kN)	616	1	1	1
	920	1	1	2
	F****	1	-	3
765kV S/C (QUAD BERSIMIS)				
Double I (2X160kN)	181	1	1	1
	270	1	1	2
	F****	1	1	3
Single V (2X210kN)	188	2	1	1
	280	2	1	2
	F****	2	—	3
Double V (2X2X210kN)	332	2	1	1
	495	2	1	2
	F****	2	—	3
Single Tension (120kN)	80	1	1	1
	120	1	1	2
	F****	1	-	3
Quadruple Tension (4X210kN)	616	1	1	1
	920	1	1	2
	F****	1	-	3
Single I Pilot (120kN)	80	1	1	1
	120	1	1	2
	F****	1	—	3
Single V Pilot (2X120kN)	140	2	1	1
	208	2	1	2
	F****	2	—	3
765kV D/C (HEXA ZEBRA)				
Double I Suspension (2X160kN)	235	1	1	1
	350	1	1	2
	F****	1	-	3
	107	1	1	1

Single I Suspension Pilot (160kN)	160	1	1	2
	F****	1	-	3
Single Tension (160kN)	107	1	1	1
	160	1	1	2
	F****	1	-	3
Quad Tension (4X210kN)	616	1	1	1
	920	1	1	2
	F****	1	-	3
±800kV HVDC (HEXA LAPWING)				
Single 'Y' suspension String for Pole conductor	340	2	1	1
	505	2	1	2
	F*****	2	-	3
Triple Tension String for Pole conductor	884	1	1	1
	1320	1	1	2
	F*****	1	-	3
Single I Pilot String for Pole conductor (160kN)	108	1	1	1
	160	1	1	2
	F*****	1	-	3
Single I Suspension for DMR (160kN)	108	1	1	1
	160	1	1	2
	F*****	1	-	3
Single I Suspension for DMR (210kN)	141	1	1	1
	210	1	1	2
	F*****	1	-	3
Double Tension String for DMR (2x210kN)	281	1	1	1
	420	1	1	2
	F*****	1	-	3

Notes:

* : The total test must be established gradually at a steady rate.

** : Direction of load

1. following string axis
2. following bisector of string angle.

*** : The hardware assembly must be completely unloaded and examined, then the proper direction of loading established before proceeding to the next sequential test.

****: F denotes Failure load

The hardware components shall be deemed acceptable if, for all test loads except failure load F, the string components do not show any visual signs of deformation or fracture, and the same components may be disassembled by hand, except for removal of cotter pins and initial loosening of the nuts. The failure load F shall be recorded and must be greater than all previous test loads.

2.4 Galvanising /Electroplating Test on clamp & fittings

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

2.5 Slip Strength Test of dead end assembly

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 2486 (Part-I) except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor and retained for one minute at this load. There shall be no movement of the conductor relative to the fittings and no failure of the fittings during this one minute period.

2.6 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.

2.7 Tests for Forging Casting and Fabricated Hardware

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

2.8 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 the values indicated in the Standard Technical Particulars.

2.9 Proof Load Test (Routine 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.

- 2.10 **Mechanical Strength Test of Each Component (Acceptance Test)**
Each component shall be subjected to a load equal to 50 % 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.
- 2.11 **Resilience test for armour rod set**
The test shall be carried out as per Clause no. 7.11 of IS 2121 (Part-1) except slip strength after resilience shall be carried out as per clause 2.2 above.
- 2.12 **Electrical resistance test for armour rod set**
The test shall be carried out as per Clause no. 7.5 of IS 2121 (Part-1) except the conductivity of the armour rods shall be as specified in the STP.
- 3.0 **Tests on Conductor and Earth wire Accessories**
- 3.1 **Mid span compression joint for conductor/ earthwire & Repair sleeve for conductor**
- a) **Failing load Test of Mid span compression joint for conductor/ earthwire & Repair sleeve for conductor**
The test shall be carried out as per IS 2121 (Part-II), clause 6.4 except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor and retained for one minute at this load. There shall be no movement of the conductor relative to the fittings and no failure of the fittings during this one-minute period.
- b) **Galvanising Test on Mid span compression joint**
The test shall be carried out as per Clause no. 6.7 of IS 2121 (Part-II) except that standard preece test shall also be carried out and the results obtained shall satisfy the requirements of this specification.
- c) **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.
- 4.0 **T-Connector for Conductor**
- a) **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 the value indicated in the Standard Technical Particulars.

b) Galvanising Test

The test shall be carried out as per Clause no. 6.7 of IS: 2121- (Part-IV) except that standard pre-ecc test shall also be carried out and the results obtained shall satisfy the requirements of this specification.

4.1 Flexible Aluminum Bond

a) Slip Strength Test

On applying a load of 3 kN between the two ends, stranded flexible aluminium 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.

b) Galvanising Test

The test shall be carried out as per Clause no. 5.7 of IS: 2121- (Part-III) except that standard pre-ecc test shall also be carried out and the results obtained shall satisfy the requirements of this specification.

4.2 Vibration Damper for conductor and Earth wire

(a) Dynamic Characteristics Test (As Type 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 range from $0.18/d$ to $1.4/d$, where d is the conductor/ Earthwire diameter in meters. The damper assembly shall be vibrated vertically with a ± 1 mm amplitude upto 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 dampers shall be conducted.
- (ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
- (iii) The above mean reactance response curve should lie within following limits:

Conductor name	Range of mean reactance
ACSR LAPWING	0.227 f to 0.908 f
ACSR MOOSE	0.191 f to 0.762 f
ACSR ZEBRA	0.135 f to 0.540 f
ACSR PANTHER	0.0991 f to 0.495 f
7/3.66 mm GS EARTHWIRE	0.060 f to 0.357 f
7/3.15 mm GS EARTHWIRE	0.050 f to 0.300 f
7/4.5 mm GS EARTHWIRE	0.084 f to 0.504 f

- (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 conductor/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 2.5.13 and 3.3.8 of this part of the Specification. The tension shall be taken as 25% of RTS of conductor/ earth wire for a span ranging from 100 m to 1100 m.
- (ii) The self damping factor and flexural stiffness (EI) for conductor and earthwire shall be calculated on the basis of experimental results. The details of experimental analysis with these data should be furnished.
- (iii) The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.
- (iv) Examine the aeolian vibration level of the conductor/earthwire with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.
- (v) From vibration analysis of conductor/earthwire without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the aeolian vibration levels exceed the specified limits shall be determined.
- (vi) From vibration analysis of conductor/earthwire with damper/dampers

installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment points and the antinodes on the conductor/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 fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30 m. The conductor/earthwire shall be tensioned at 25% of RTS of conductor/earthwire and shall not be equipped with protective armour rods at any point. Constant tension shall be maintained within the span by means of lever arm arrangement. After the conductor/earthwire has been tensioned, clamps shall be installed to support the conductor/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 conductor/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 test shall be carried out as per Clause 7.9 of IS-9708. Further, 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 $\pm 25/f$ mm, where f is the frequency in Hz.

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

The clamp slip test as mentioned hereinabove shall be repeated after fatigue test without 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.

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

d) Magnetic Power Loss Test for Vibration Damper

The sample shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave. This test shall be carried out as per Clause 12.0 of IEC:61284. An alternating current over the range as stipulated below (per subconductor) shall be passed through a suitable length of conductor and the power losses shall be measured both with and without the fittings assembled on the conductor. The reading of the wattmeter with and without five units shall be recorded and tabulated graphical form. The test is passed if the average power loss for vibration damper at given ampere is less than or equal to the value indicated in the Standard Technical Particulars.

Conductor name	Alternating current range
ACSR Panther	200 amps to 500 amps
ACSR Zebra/ Moose/ Lapwing	400 amps to 800 amps

e) Galvanising/ Electroplating test on Vibration damper

The test shall be carried out as per Clause no. 7.11 of IS: 9708 except that standard preece test shall also be carried out and the results obtained shall satisfy the requirements of this specification.

f) Dynamic Characteristics Test (Acceptance Test)

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

Vibration Damper of - 1 Sample for 1000 Nos. & below
Conductor

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

The acceptance criteria will be as follows

- (i) The above dynamic characteristics curve for reactance & phase angle will be done for frequency range of ranging from $0.18/d$ to $1.4/d$ where d is the conductor diameter in meters. The damper assembly shall be vibrated vertically with a ± 1 mm amplitude upto 15 Hz frequency and beyond 15 Hz at ± 0.5 mm
- (ii) If all the individual curve for dampers are within the envelope as already mentioned for type test for reactance & phase angle, the lot passes the test.
- (iii) If individual results do not fall within the envelope, averaging of characteristics shall be done.
- (a) Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.
- (b) Similar averaging shall be done for phase angle.
- (c) Average force Vs frequency and average phase Vs frequency curves shall be plotted on graph paper. Curves of best fit shall be drawn for the entire frequency range.
- (d) The above curves shall be within the envelope specified.

g) 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

4.3 Spacer Damper, Bundle spacer & Rigid Spacer

(a) Performance Test

One very important quality of a spacer damper is its ability to control Aeolian vibrations and subspan oscillations within acceptable limits. Performance testing shall be carried out on an experimental test line, as described in Clause 2.5, Section-VI. After testing, there shall not be any slippage greater than 3mm on conductors, loosening of components or damage to conductors or spacer damper components.

i) Aeolian Vibrations

Under the specified operating conditions, the spacer damper shall control Aeolian vibrations in order to prevent damage to conductors either at suspensions clamp or at the spacer damper clamps. For measurements and evaluation purpose, the following criteria shall apply:

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

ii) Subspan Oscillations

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

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

- In any individual subspan, the peak to peak amplitude of each subconductor shall never exceed 350mm.
- In any individual subspan, the RMS value (Y_{rms}) of each oscillation measurement sample shall be such that:
 $f \cdot Y_{rms} < 80 \text{ mm/sec.}$

Where

Y_{rms} = antinode amplitude (mm)

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

$f = (1/2L) \sqrt{T/m}$

L = subspan length (m)

T = Conductor tension (N)

m = conductor mass (kg/m)

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

$f \cdot Y_{rms} < 70 \text{ mm/sec.}$

The wind sector is defined as a combination of 5 km/hr wind speed range and 10° wind direction range.

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

(b) Clamp Slip Test (for Spacer Damper, Bundle Spacer & Rigid Spacer)

The Longitudinal slip test shall be carried out. The spacer damper assembly shall be installed as per conductor bundle configuration (as stipulated in relevant clause of section -I) at a tension of 20% of its rated tensile strength for ACSR Zebra/Moose/snowbird/Bersimis & 54 kN for Lapwing conductor. In case of spacer for jumper, the clamp of sample shall be tightened with a specified tightening torque. One of the sample

clamps, when subjected to a longitudinal pull parallel to the conductor axis for a minimum duration of one minute. The minimum slip under longitudinal pull varies with clamp type as per the values stipulated in the Standard Technical Particulars.

In order to determine the effect of conductor creep with the spacer dampers only, the conductor shall be re-tensioned to 35% of RTS (in case of ACSR Lapwing conductor shall be re-tensioned to 81 kN) without further tightening the spacer damper clamps and the clamp slip test shall be re-performed. The minimum slip under longitudinal loads shall not be less than 80% of the values given in the Standard Technical Particulars.

Similar testing shall be performed of the other clamps of the same sample. For spacer dampers only, such clamp slip tests shall also be conducted after each of the vibration tests mentioned in Clause 3.4 (a) but under longitudinal loading corresponding to 80% of the values given in the Standard Technical Particulars.

(c) Characteristic of the Elastic and Damping Properties Test

The test shall be carried out by stiffness-damping method as per clause 7.5.5(A) of IEC: 61854. The purpose of this test is to obtain quantitative information regarding the dynamic characteristic of the spacer damper. The values obtained during this test will serve as references to evaluate the behaviour of the same spacer damper under the fatigue test.

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

The test shall be performed on three samples.

d) Compression and Tension Tests (for Spacer Damper, Bundle Spacer & Rigid spacers)

The test shall be carried out as per clause 7.5.4.2 of IEC: 61854. Three samples of spacer/spacer dampers shall be subjected to a compression and tension test. A compressive load as specified in the Standard Technical Particulars shall first be applied and held for five minutes. Then a tensile load as specified in the Standard Technical Particulars shall be applied on the same pair of arms. The test shall be repeated on the other pair of arms. The acceptance criteria shall be as per IEC:61854.

e) Magnetic Power Loss Test (for Spacer Damper, Bundle Spacer & Rigid spacers)

The sample shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave. This test shall be carried out as per Clause 12.0 of IEC:61284. An alternating current over the range of 400 amps to 800 amps (per subconductor) shall be passed through a suitable length of conductor and the power losses shall be measured both with and without the fittings assembled on the conductor. The reading of the wattmeter with and without five units shall be recorded and tabulated graphical form. The test is passed if the average power loss for spacer damper/ spacer at given ampere is less than or equal to the value indicated in the

Standard Technical Particulars.

f) Galvanising Test on Spacer damper, Bundle spacer & Rigid spacer

The test shall be carried out as per Clause no. 5.16 of IS: 10162 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.

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

h) 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.

i) 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 the values indicated in the Standard Technical Particulars.

j) 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.

k) Vibration Tests on Bundle Spacer

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 paralleled to its initial static position by applying a tension 25% of RTS of the 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 same sample on the same test span. The samples shall withstand the vibration tests without slipping on the conductor. loosening, damage or failure of component parts. After each vibration test, clamp slip test shall be carried out as per the procedure given in Clause No. 3.4 (b).

- (i) Longitudinal Vibration Test The stationary conductor and the vibrating conductor/equivalent diameter of aluminum 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.

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

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

(iii) Sub-span Oscillation Test

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

3.6 Corona Extinction Voltage Test (Dry) on conductor accessories
same as clause 1.3 of Annexure A.

3.7 Radio Interference Voltage Test (Dry) on conductor accessories
same as clause 1.4 of Annexure A.

3.8 Earthwire Suspension/Tension Clamp Assembly

a) Mechanical Strength Test for Suspension/ Tension Clamp Assembly

The suspension/ tension clamp 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 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 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 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) Slip Strength Test for Suspension Clamp Assembly

The Clamp slip strength test shall be carried out as per Clause no. 5.4a) of IS: 2121 (Part-III) by keeping the clamp at minimum specified slip strength for one minute and considering slip strength as specified in the Standard Technical Particular (STP) enclosed with this specification at Annexure C.

c) Slip Strength Test of dead end assembly

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

4 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.

5 Tests on All components (As applicable)

a) Chemical Analysis of Zinc used for Galvanizing

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

b) Tests for Forgings

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

c) Tests on Castings

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

Annexure-B

A) Standardized Technical Particulars of Hardware Fittings 765 kV D/C Transmission Line with ACSR ZEBRA conductor

1. Suspension hardware fittings for ACSR Zebra Conductor

Sl.	Description	Unit	Particulars/ Value		
			Double 'I'	Single 'I' PILOT	
			AGS clamp	Free Centre clamp	Envelope clamp
1.	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 500 amperes	Watt	4		8
2.	Slipping strength of suspension assembly	KN	16 - 24		16 - 24
3.	Particulars of standard/ AGS preformed armour rod set for suspension assembly				
	a) No. of rods per set	No.	12		NA
	b) Direction of lay		Right hand		NA
	c) Overall length after fitting on conductor	mm	2080	2540	NA
	d) Diameter of each rod	mm	7.87		NA
	e) Tolerance in				
	i) Diameter of each rod	±mm	0.10		NA
	ii) Length of each rod	±mm	25		NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13		NA
	f) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032		NA
	g) Minimum UTS of each rod	Kg/mm ²	35		NA
4.	Particulars of Elastomer (For AGS Clamp only)				
	a) Type of elastomer		Chloroprene / Neoprene Rubber	NA	NA
	b) Shore hardness of elastomer		65 to 80	NA	NA
	c) Temperature range for which elastomer is designed		Upto 95° C	NA	NA

	d) Moulded on insert		Yes	NA	NA
5.	Minimum Mechanical strength of suspension fitting (excluding suspension clamp)	KN	350 kN		160 kN
6.	Mechanical strength of suspension clamp	KN	70 kN		70 kN
7.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute		

2. Tension hardware fittings for ACSR Zebra Conductor

Sl.	Description	Unit	Particulars/ Value
			Tension String
1.	Mechanical strength of Tension fitting (excluding dead end clamp)	KN	Single Tension: 160kN Quadruple Tension: 920 kN
2.	Type of dead-end assembly		Compression
3.	Compression pressure	MT	100
4.	Maximum electrical resistance of dead- end assembly as a percentage of equivalent length of Conductor	%	75
5.	Slip strength of dead-end assembly	KN	123.8
6.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

B) Standardized Technical Particulars of Hardware Fittings 765 kV S/C Transmission Line with ACSR BERSIMIS conductor

1. Suspension hardware fittings for ACSR BERSIMIS Conductor

Sl.	Description	Unit	Particulars/ Value		
			Suspension Strings		Suspension PILOT Strings
			Single 'V' / Double 'V' / Double 'I'		Single 'I' / Single 'V'
			AGS clamp	Free Centre clamp	Envelope clamp
1.	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 500 amperes	Watt	4		8
2.	Slipping strength of suspension assembly	KN	20-29		20-29
3.	Particulars of standard/ AGS preformed armour rod set for suspension assembly				
	a) No. of rods per set	No.	13		NA
	b) Direction of lay		Right hand		NA
	c) Overall length after fitting on conductor	mm	2235	2540	NA
	d) Diameter of each rod	mm	9.27		NA
	e) Tolerance in				
	i) Diameter of each rod	±mm	0.10		NA
	ii) Length of each rod	±mm	25		NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13		NA
	f) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032		NA
	g) Minimum UTS of each rod	Kg/m ^{m²}	35		NA
4.	Particulars of Elastomer (For AGS Clamp only)				
	a) Type of elastomer		Chloroprene / Neoprene Rubber	NA	NA
	b) Shore hardness of elastomer		65 to 80	NA	NA

	c) Temperature range for which elastomer is designed		Upto 95° C	NA	NA
	d) Moulded on insert		Yes	NA	NA
5.	Mechanical strength of suspension fitting (excluding suspension clamp)	KN	Single 'V': 235 kN Double 'V': 470 kN Double 'I': 270 kN		130 kN
6.	Mechanical strength of suspension clamp	KN	Single 'V': 70kN Double 'V': 120 kN Double 'I': 70 kN		70kN
7.	Purity of Zinc used for galvanising	%	99.95		99.95
8.	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) All others: 6 dips of 1 minute		

2. Tension hardware fittings for Quad ACSR BERSIMIS Conductor

Sl.	Description	Unit	Particulars/ Value
			Quadruple Tension String
1.	Mechanical strength of Tension fitting (excluding dead end clamp)	KN	920
2.	Type of dead-end assembly		Compression
3.	Compression pressure	MT	100
4.	Maximum electrical resistance of dead-end assembly as a percentage of equivalent length of Conductor	%	75
5.	Slip strength of dead-end assembly	KN	146.3
6.	Purity of Zinc used for galvanising	%	99.95
7.	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

**c) Standardized Technical Particulars of Hardware Fittings for 400 kV
Transmission Line with Quad ACSR MOOSE Conductor**

1. Suspension hardware fittings for Quad ACSR MOOSE conductor					
Sl.	Description	Unit	Particulars / Value		
			<u>Double 'I'</u>		<u>Single 'I' Pilot</u>
			AGS clamp	Free centre clamp	Envelope clamp
1.	Maximum magnetic power loss of suspension assembly at sub conductor current of 600 amperes, 50Hz AC	Watt	4		8
2.	Slipping strength of suspension assembly (clamp torque Vs slip curve shall be enclosed)	kN	20-29		
3.	Particulars of standard/AGS Standard / AGS preformed armour rod set for suspension assembly				
	a) No. of rods per set	No.	12		NA
	b) Direction of lay		Right Hand		NA
	c) Overall length after fitting on conductor	mm	2235	2540	NA
	d) Diameter of each rod	mm	9.27		NA
	e) Tolerance in				NA
	i) Diameter of each rod	mm	0.10		NA
	ii) Length of each rod	±mm	25		NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13		NA
	g) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032		NA
h) UTS of each rod	Kg/ m m ² (Min)	35		NA	
4.	Particulars of Elastomer (For AGS Clamp only)				
	a) Type of elastomer		Chloroprene / Neoprene	NA	NA
	b) Shore hardness of elastomer		65 - 80	NA	NA
	c) Temperature range for which elastomer is designed	°C	Upto 95°C	NA	NA
	d) Moulded on insert		Yes	NA	NA

5.	Mechanical Strength of Suspension fitting (excluding suspension clamp)	KN	240	120
6.	Mechanical Strength of suspension clamp.		70	70
7.	Purity of Zinc used for galvanising	%	As per IS:209 / IS 13229	
8.	Min. No. of dips in standard preece test the ferrous parts can withstand	No	a) Fasteners: 4 dips of 1 min b) Spring washers: 3 dips of 1 min c) All others: 6 dips of 1 min	

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

D) Standardized Technical Particulars of Hardware Fittings for 400 kV Transmission Line with twin ACSR MOOSE Conductor

1.	Suspension hardware fittings for twin ACSR MOOSE conductor					
Sl.	Description	Unit	Particulars/ Value			
			Single "I" Suspension Fittings with		Double "V" Suspension Fittings with (AACSR MOOSE Conductor)	
			AGS clamp	Free Centre clamp	AGS clamp	Free Centre clamp
						Envelope clamp

				p			
1.	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 600 amperes	Watt	4		4		8
2.	Slipping strength of suspension assembly	KN	20-29		20-29		20-29
3.	Particulars of standard/ AGS preformed armour rod set for suspension assembly						
	a) No. of rods per set	No.	12		12		NA
	b) Direction of lay		Right hand		Right hand		NA
	c) Overall length after fitting on conductor	mm	2235	2540	2235	2540	NA
	d) Diameter of each rod	mm	9.27		9.27		NA
	e) Tolerance in						
	i) Diameter of each rod	±mm	0.10		0.10		NA
	ii) Length of each rod	±mm	25		25		NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13		13		NA
	f) Type of Aluminium alloy used for manufacture of PA rod set		6061/65032		6061/65032		NA
	g) Minimum UTS of each rod	Kg/mm ²	35		35		NA
4.	Particulars of Elastomer (For AGS Clamp only)						
	a) Type of elastomer		Chloro prene/ Neoprene	NA	Chloro prene/ Neoprene	NA	NA
			Rubber		Rubber		
	b) Shore hardness of elastomer		65 to 80	NA	65 to 80	NA	NA
	c) Temperature range for which elastomer is designed		Upto 95° C	NA	Upto 95° C	NA	NA
	d) Moulded on insert		Yes	NA	Yes	NA	NA
5.	Mechanical strength of suspension fitting (excluding suspension clamp)	KN	120		2 x160 (along one limb)		120

6.	Mechanical strength of suspension clamp	KN	70	120	70
7.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute		

1.	Tension hardware fittings for twin ACSR MOOSE conductor				
Sl.	Description	Unit	Particulars/ Value		
			Single Tension	Double Tension	Triple Tension (ACSR MOOSE Conductor)
1.	Mechanical strength of Tension fitting (excluding dead end clamp)	KN	120	2x160	3x160
2.	Type of dead-end assembly		Compression		
3.	Compression pressure	MT	100		
4.	Maximum electrical resistance of dead- end assembly as a percentage of equivalent length of Conductor	%	75		
5.	Slip strength of dead-end assembly	KN	153.2		214 (ACSR 'MOOSE' to be used)
6.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		

b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

E) Standardized Technical Particulars of Hardware Fittings for 400 kV Transmission Line with triple ACSR SNOWBIRD Conductor

Transmission Line with triple ACSR ONEWIRE conductor					
Sl.	Description	Unit	Particulars / Value		
			<u>Double 'I'</u>		<u>Single 'I' Pilot</u>
			AGS clamp	Free centre clamp	Envelope clamp
1.	Maximum magnetic power loss of suspension assembly at sub conductor current of 600 amperes, 50Hz AC	Watt	4		8
2.	Slipping strength of suspension assembly (clamp torque Vs slip curve shall be enclosed)	kN	20-29		
3.	Particulars of standard/AGS Standard / AGS preformed armour rod set for suspension assembly				
	a) No. of rods per set	No.	11		NA
	b) Direction of lay		Right Hand		NA
	c) Overall length after fitting on conductor	mm	2083	2083	NA
	d) Diameter of each rod	mm	7.87		NA
	e) Tolerance in				NA
	i) Diameter of each rod	±mm	0.10		NA
	ii) Length of each rod	±mm	25		NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13		NA
	g) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032		NA
h) UTS of each rod	Kg/ m m ² (Min)	35		NA	
4.	Particulars of Elastomer (For AGS Clamp only)				

	a) Type of elastomer		Chloroprene / Neoprene	NA	NA
	b) Shore hardness of elastomer		65 - 80	NA	NA
	c) Temperature range for which elastomer is designed	°C	Upto 95°C	NA	NA
	d) Moulded on insert		Yes	NA	NA
5.	Mechanical Strength of Suspension fitting (excluding suspension clamp)	KN	240		120
6.	Mechanical Strength of suspension clamp.	kN	70		70
7.	Purity of Zinc used for galvanising	%	As per IS:209 / IS 13229		
8.	Min. No. of dips in standard preece test the ferrous parts can withstand	No	a) Fasteners: 4 dips of 1 min b) Spring washers: 3 dips of 1 min c) All others: 6 dips of 1 min		

TENSION HARDWARE FITTINGS TRIPLE ACSR SNOWBIRD CONDUCTOR

Sl.	Description	Unit	Particulars / Value	
			Single Tension	Double Tension
1.	Mechanical Strength of Tension fittings (excluding dead end clamp)	kN	120	420
2.	Type of Dead-End assembly		Compression	
3.	Compression Pressure	MT	100	
4.	Maximum electrical resistance of dead-end assembly as a percentage of equivalent length of Conductor	%	75	
5.	Slip strength of dead-end assembly	kN	112	
6.	Purity of Zinc used for galvanising	%	As per IS:209 / IS 13229	
7.	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos	a) Fasteners: 4 dips of 1 min b) Spring washers: 3 dips of 1 min c) All others: 6 dips of 1 min	

F) Standardized Technical Particulars of Hardware Fittings for 220 kV Transmission Line with ACSR ZEBRA conductor

1. Suspension hardware fittings for ACSR ZEBRA Conductor

Sl.	Description	Unit	Particulars/ Value				
			Single "I" Suspension Fittings with		Double "I" Suspension Fittings with		Single suspension n Pilot Fitting with
			AGS clamp	Free Centre clamp	AGS clamp	Free Centre clamp	Envelope clamp
1.	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 500 amperes	Watt	2	2	2	2	4
2.	Slipping strength of suspension assembly	KN	16-24	16-24	16-24	16-24	16-24
3.	Particulars of standard/ AGS preformed armour rod set for suspension assembly						
	a) No. of rods per set	No.	12	12	12	12	NA
	b) Direction of lay		Right hand	Right hand	Right hand	Right hand	NA
	c) Overall length after fitting on conductor	mm	2080	2540	2080	2540	NA
	d) Diameter of each rod	mm	7.87	7.87	7.87	7.87	NA
	e) Tolerance in						
	i) Diameter of each rod	±mm	0.10	0.10	0.10	0.10	NA
	ii) Length of each rod	±mm	25	25	25	25	NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13	13	13	13	NA
	f) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032	6061/ 65032	6061/ 65032	6061/ 65032	NA
	g) Minimum UTS of each rod	Kg/mm ²	35	35	35	35	NA
4.	Particulars of Elastomer (For AGS Clamp only)						
	a) Type of elastomer		Chloroprene/ Neoprene	NA	Chloroprene/ Neoprene	NA	NA

			Rubber		Rubber		
	b) Shore hardness of elastomer		65 to 80	NA	65 to 80	NA	NA
	c) Temperature range for which elastomer is designed		Upto 95° C	NA	Upto 95° C	NA	NA
	d) Moulded on insert		Yes	NA	Yes	NA	NA
5.	Mechanical strength of suspension fitting (excluding suspension clamp)	KN	70		2 x 70		70
6.	Mechanical strength of suspension clamp	KN	70		70		70
7.	Galvanising						
a)	Weight of Zinc coating for steel parts	gm/m ²	610				
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209: 1992) or 98.5 (IS 13229:1991)				
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute				

2. Tension hardware fittings for ACSR ZEBRA Conductor

Sl.	Description	Unit	Particulars/ Value	
			Single Tension	Double Tension
1.	Mechanical strength of Tension fitting (excluding dead end clamp)	KN	120	2x120
2.	Type of dead-end assembly		Compression	
3.	Compression pressure	MT	100	
4.	Maximum electrical resistance of dead-end assembly as a percentage of equivalent length of Conductor	%	75	
5.	Slip strength of dead-end assembly	KN	123.80	
6.	Galvanising			
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610	
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)	
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute	

G) Standardized Technical Particulars of Hardware Fittings for 132 kV Transmission Line with ACSR PANTHER Conductor

1. Suspension hardware fittings for ACSR PANTHER Conductor

Sl.	Description	Unit	Particulars/ Value			
			Single "I" Suspension Fittings with		Double "I" Suspension Fittings with	
			AGS clamp	Free Centre clamp	AGS clamp	Free Centre clamp
1.	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 350 amperes	Watt	2	2	2	2
2.	Slipping strength of suspension assembly	KN	11-16	11-16	11-16	11-16
3.	Particulars of standard/ AGS preformed armour rod set for suspension assembly					
	a) No. of rods per set	No.	11	11	11	11
	b) Direction of lay		Right hand	Right hand	Right hand	Right hand
	c) Overall length after fitting on conductor	mm	1760	1930	1760	1930
	d) Diameter of each rod	mm	6.35	6.35	6.35	6.35
	e) Tolerance in					
	i) Diameter of each rod	±mm	0.10	0.10	0.10	0.10
	ii) Length of each rod	±mm	16	16	16	16
	iii) Difference of length between the longest and shortest rod in a set	±mm	13	13	13	13
	f) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032	6061/ 65032	6061/ 65032	6061/ 65032
	g) Minimum UTS of each rod	Kg/mm ²	35	35	35	35
4.	Particulars of Elastomer (For AGS Clamp only)					
	a) Type of elastomer		Chloroprene/Neoprene Rubber	NA	Chloroprene/Neoprene Rubber	NA
	b) Shore hardness of elastomer		65 to 80	NA	65 to 80	NA
	c) Temperature range for which elastomer is designed		Upto 95° C	NA	Upto 95° C	NA
	d) Moulded on insert		Yes	NA	Yes	NA

5.	Mechanical strength of suspension fitting (excluding suspension clamp)	KN	70	2 x 70
6.	Mechanical strength of suspension clamp	KN	70	70
7.	Galvanising			
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610	
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)	
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute	

2. Tension hardware fittings for ACSR PANTHER Conductor

Sl.	Description	Unit	Particulars/ Value	
			Single Tension	Double Tension
1.	Mechanical strength of Tension fitting (excluding dead end clamp)	KN	90	2 X 90
2.	Type of dead-end assembly		Compression	
3.	Compression pressure	MT	100	
4.	Maximum electrical resistance of dead-end assembly as a percentage of equivalent length of Conductor	%	75	
5.	Slip strength of dead-end assembly	KN	85.2	
6.	Galvanising			
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610	
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)	
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute	

H) **Standardized Technical Particulars of Hardware Fittings for ± 800 kV HVDC Transmission Line with ACSR LAPWING conductor**

1. Suspension hardware fittings for ACSR LAPWING Conductor

Sl.	Description	Unit	Particulars/ Value		
			Suspension Strings		
			Single 'Y'		
			AGS clamp	Free Centre clamp	Single I PILOT
1.	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 500 amperes	Watt	NA		NA
2.	Slipping strength of suspension assembly	KN	20-29		20-29
3.	Particulars of standard/ AGS preformed armour rod set for suspension assembly				NA
	a) No. of rods per set	No.	14		NA
	b) Direction of lay		Right hand		NA
	c) Overall length after fitting on conductor	mm	2235	NA	
	d) Diameter of each rod	mm	9.27		NA
	e) Tolerance in				
	i) Diameter of each rod	±mm	0.10		NA
	ii) Length of each rod	±mm	25		NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13		NA
	f) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032		NA
	g) Minimum UTS of each rod	Kg/mm ²	35		NA
4.	Particulars of Elastomer (For AGS Clamp only)				
	a) Type of elastomer		Chloroprene/ Neoprene Rubber	NA	NA
	b) Shore hardness of elastomer		65 to 80	NA	NA
	c) Temperature range for which elastomer is designed		Upto 95° C	NA	NA
	d) Moulded on insert		Yes	NA	NA
5.	Mechanical strength of suspension fitting (excluding suspension clamp)	KN	Single 'Y' : 505 kN		160kN

6.	Mechanical strength of suspension clamp	KN	Single 'Y' : 130kN	70kN
7.	Purity of Zinc used for galvanising	%	99.95	
8.	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) All others: 6 dips of 1 minute	

2. Tension hardware fittings for Hexa ACSR LAPWING Conductor

Sl.	Description	Unit	Particulars/ Value
			Triple Tension String
1.	Mechanical strength of Tension fitting (excluding dead end clamp)	KN	1320
2.	Type of dead-end assembly		Compression
3.	Compression pressure	MT	100
4.	Maximum electrical resistance of dead- end assembly as a percentage of equivalent length of Conductor	%	75
5.	Slip strength of dead-end assembly	KN	178.6
6.	Purity of Zinc used for galvanising	%	99.95
7.	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

i) **Standardized Technical Particulars of Hardware Fittings for metallic return Conductor with ACSR LAPWING conductor**

1. Suspension hardware fittings for Metallic Return Conductor

Sl.	Description	Unit	Particulars/ Value	
			Single "I" Suspension Fittings with	
			AGS clamp	Free Centre clamp
1.	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 350 amperes	Watt		
2.	Slipping strength of suspension assembly	KN	20-29	20-29
3.	Particulars of standard/ AGS preformed armour rod set for suspension assembly			
	a) No. of rods per set	No.	14	14
	b) Direction of lay		Right hand	Right hand
	c) Overall length after fitting on conductor	mm	2235	2385
	d) Diameter of each rod	mm	9.27	9.27
	e) Tolerance in			
	i) Diameter of each rod	±mm	0.10	0.10
	ii) Length of each rod	±mm	25	25
	iii) Difference of length between the longest and shortest rod in a set	±mm	13	13
	f) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032	6061/ 65032
	g) Minimum UTS of each rod	Kg/mm ²	35	35
4.	Particulars of Elastomer (For AGS Clamp only)			
	a) Type of elastomer		Chloroprene/Neoprene Rubber	NA
	b) Shore hardness of elastomer		65 to 80	NA
	c) Temperature range for which elastomer is designed		Upto 95° C	NA
	d) Moulded on insert		Yes	NA
5.	Mechanical strength of suspension fitting (excluding suspension clamp)	KN	160	
6.	Mechanical strength of suspension clamp	KN	120	
7.	Galvanising			

a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

2. Tension hardware fittings for Metallic Return Conductor

Sl.	Description	Unit	Particulars/ Value
			Double Tension
1.	Mechanical strength of Tension fitting (excluding dead end clamp)	KN	420
2.	Type of dead-end assembly		Compression
3.	Compression pressure	MT	100
4.	Maximum electrical resistance of dead-end assembly as a percentage of equivalent length of Conductor	%	75
5.	Slip strength of dead-end assembly	KN	178.6
6.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

J) Accessories for ACSR ZEBRA conductor for 765 kV transmission line with Hexa ZEBRA conductor

1. Repair sleeve for ACSR Zebra Conductor

Sl.	Description	Unit	Particulars/ Value
1.	Material		Aluminium of minimum purity 99.5%
2.	Dimension of Aluminum sleeve Before compression		
i)	Inside diameter	mm	31.00 ± 0.5
ii)	Outside diameter	mm	48.00 ± 1.0
iii)	Length	mm	275.00 ± 5.0
3.	Dimensions of Aluminum Sleeve After compression		
i)	Outside dimension (Corner to corner)	mm	47.00 ± 0.5
ii)	Outside dimension (face to face)	mm	41.00 ± 0.5
4.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	510
5.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 510 kV (rms) under dry condition	Micro Volts (μV)	1000

2. Mid span compression Joint for ACSR Zebra Conductor

Sl.	Description	Unit	Particulars/ Value	
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>
1.	Material of Joint		Aluminium of purity 99.5%	Mild Steel (Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinell hardness)	BHN	From 100 to 200	
3.	Dimension of sleeve Before compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Inside diameter	Mm	31.00 ± 0.5	10.00 ± 0.2
ii)	Outside diameter	Mm	48.00 ± 1.0	20.00 ± 0.5
iii)	Length	Mm	710 ± 5	241 ± 5
4.	Dimensions of Sleeve after compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Outside dimension (Corner to corner)	Mm	47.00 ± 0.5	19.00 ± 0.5
ii)	Outside dimension (face to face)	Mm	41.00 ± 0.5	16.00 ± 0.5
5.	Slip strength	KN	123.8	

6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75
7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	510
8.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 510 kV (rms) under dry condition	Micro Volts	1000
9.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

3. T-connector for ACSR ZEBRA Conductor

Sl.	Description	Unit	Particulars/ Value
1.	Material		Aluminium of purity 99.5%
2.	Dimension of Aluminum sleeve Before compression		
	i) Inside diameter	mm	31.00 ± 0.5
	ii) Outside diameter	mm	48.00 ± 1.0
	iii) Length	mm	400.00 ± 5.0
3.	Dimensions of Aluminum Sleeve after compression		
	i) Outside dimension (Corner to corner)	mm	47.00 ± 0.5
	ii) Outside dimension (face to face)	mm	41.00 ± 0.5
4.	Axial tensile strength of welded portion of T-connector	KN	30
5.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	510
7.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 510 kV (rms) under dry condition	Micro Volts	1000

4. HEX SPACER DAMPER FOR ACSR ZEBRA CONDUCTOR for 765kV Trans.Lines

Sl.	Description	Unit	Particulars / Value		
1.	Type of Clamps		Preformed rods.		
2.	Type of Damping element		Spring / Elastomer / EPDM		
3.	Material of				
	(a) Clamp		Al Alloy IS:4600 or Equivalent for Casting & Al Alloy 6061 or Equivalent (for Forging)		
	(b) Body		Al Alloy 4600 or Equivalent for Casting & Al Alloy 6061 or Equivalent (for Forging)		
4.	Elastomer (<i>if used</i>)				
	(a) Shore hardness		65 - 80		
	(b) Temp. range for which designed	°C	Upto 95°C		
5.	Minimum ultimate tensile strength of spacer				
	(a) Compressive load	kN	14		
	(b) Tensile load	kN	7.0		
6.	Slipping strength of spacer clamp				
	(a) Before vibration test	kN	Clamp type	Longitudinal Load (kN)	Maxm Slip permitted (mm)
			Preformed rods	2.5	12
	(b) After vibration test	kN	80% of the above values		
7.	Maximum magnetic power loss of at sub conductor current of 500 amperes, 50Hz AC	Watts	Below 1 watt.		
8.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	510		
9.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 510 kV (rms) Microvolts under dry condition	µV	Below 1000		
10.	Galvanising				

a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

5.HEX RIGID SPACER FOR ACSR ZEBRA CONDUCTOR for 765kV Trans.Lines

Sl.	Description	Unit	Particulars / Value		
1.	Material of				
	(a) Clamp		Al Alloy IS:4600 or Equivalent		
	(b) Body		Galvanised Steel / Al Alloy 4600 or Equivalent		
2.	Elastomer (<i>if used</i>)				
	(a) Shore hardness		65 - 80		
	(b) Temp. range for which designed	°C	Upto 95°C		
3.	Minimum ultimate tensile strength of spacer				
	(a) Compressive load	kN	14		
	(b) Tensile load	kN	7.0		
4.	Slipping strength of spacer clamp	kN	Clamp type	Longitudinal Load (kN)	Maxm Slip permitted (mm)
			Metal - Metal Bolted	6.5	1
			Rubber loaded	2.5	2.5
5.	Maximum magnetic power loss of at sub conductor current of 500 amperes, 50Hz AC	Watts	Below 1 watt.		
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	510		
7.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 510 kV (rms) Microvolts under dry condition	µV	Below 1000		
8.	Galvanising				

a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

K) Accessories for ACSR BERSIMIS conductor for 765 kV transmission line with Quad BERSIMIS conductor

1. Mid span compression Joint for ACSR BERSIMIS Conductor

Sl.	Description	Unit	Particulars/ Value	
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>
1.	Material of Joint		Aluminium of purity 99.5%	Mild Steel (Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200	
3.	Weight of Zinc coating for steel sleeve	gm/m ²	610	
4.	Dimension of sleeve Before compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Inside diameter	mm	37.40 ± 0.5	8.10 ± 0.2
ii)	Outside diameter	mm	58.4 ± 1.01.0	20.70 ± 0.5
iii)	Length	mm	865 ± 5	220 ± 5
5.	Dimensions of Sleeve after compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Outside dimension (Corner to corner)	mm	57.40 ± 0.5	20.20 ± 0.5
ii)	Outside dimension (face to face)	mm	49.70 ± 0.5	17.50 ± 0.5
iii)	Length	mm	938 (approx)	250 (approx)
5.	Slip strength	KN	146.3	
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75	
7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	510	
8.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 510 kV (rms) under dry condition	Micro Volts	1000	

2. Repair sleeve for ACSR BERSIMIS Conductor

Sl.	Description	Unit	Particulars/ Value
1.	Material		Aluminium of minimum purity 99.5%
2.	Dimension of Aluminum sleeve Before compression		
i)	Inside diameter	Mm	37.40 ± 0.5
ii)	Outside diameter	Mm	58.4 ± 1.1.
iii)	Length	Mm	530 ± 5
3.	Dimensions of Aluminum Sleeve After compression		
i)	Outside dimension (Corner to corner)	Mm	57.40 ± 0.5
ii)	Outside dimension (face to face)	Mm	949.70 ± 0.5
iii)	Length	Mm	570 (approx)
4.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	510
5.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 510 kV (rms) under dry condition	Micro Volts (μV)	1000

3. QUAD SPACER DAMPER FOR QUAD ACSR BERSIMIS CONDUCTOR

Sl.	Description	Unit	Particulars / Value
1.	Type of Clamps		Preformed rods.
2.	Type of Damping element		Spring / Elastomer / EPDM
3.	Material of		
	(a) Clamp		Al Alloy IS:4600 or Equivalent for Casting & Al Alloy 6061 or Equivalent (for Forging)
	(b) Body		Al Alloy 4600 or Equivalent for Casting & Al Alloy 6061 or Equivalent (for Forging)
4.	Elastomer (<i>if used</i>)		
	(a) Shore hardness		65-80
	(b) Temp. range for which designed	°C	Upto 95°C
5.	Minimum ultimate tensile strength of spacer		
	(a) Compressive load	kN	15
	(b) Tensile load	kN	7.5
6.	Slipping strength of spacer clamp		

	(a) Before vibration test	kN	Clamp type	Longitudinal Load (kN)	Maxm Slip permitted (mm)
			Preformed rods	2.5	12
	(b) After vibration test	kN	80% of the above values		
7.	Maximum magnetic power loss of at sub conductor current of 500 amperes, 50Hz AC	Watts	Below 1 watt.		
8.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	510		
9.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 510 kV (rms) Microvolts under dry condition	μV	Below 1000		
10.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute		

4. QUAD RIGID SPACER FOR QUAD ACSR BERSIMIS CONDUCTOR

Sl.	Description	Unit	Particulars / Value
1.	Material of		
	(a) Clamp		Al Alloy IS:4600 or Equivalent
	(b) Body		Galvanised Steel / Al Alloy 4600 or Equivalent
2.	Elastomer (<i>if used</i>)		
	(a) Shore hardness		65 - 80
	(b) Temp. range for which designed	°C	Upto 95°C
3.	Minimum ultimate tensile strength of spacer		
	(a) Compressive load	kN	15
	(b) Tensile load	kN	7.5

4.	Slipping strength of spacer clamp	kN	Clamp type	Longitudinal Load (kN)	Maxm Slip permitted (mm)
			Metal - Metal Bolted	6.5	1
			Rubber loaded	2.5	2.5
5.	Maximum magnetic power loss of at sub conductor current of 500 amperes, 50Hz AC	Watts	Below 1 watt.		
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	510		
7.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 510 kV (rms) Microvolts under dry condition	μ V	Below 1000		
8.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute		

L) Accessories for ACSR MOOSE conductor for 400 kV transmission line

1. Mid span compression Joint for ACSR MOOSE Conductor

Sl.	Description	Unit	Particulars/ Value	
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>
1.	Material of Joint		Aluminium of purity 99.5%	Mild Steel (Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200	
3.	Weight of Zinc coating for steel sleeve	gm/m ²	610	
4.	Dimension of sleeve Before compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Inside diameter	mm	34.00 $\pm$ 0.5	11.10 $\pm$ 0.2
ii)	Outside diameter	mm	54.00 $\pm$ 1.0	21.00 $\pm$ 0.5
iii)	Length	mm	735 $\pm$ 5	250 $\pm$ 5

5.	Dimensions of Sleeve after compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Outside dimension (Corner to corner)	mm	53.00 ± 0.5	20.20 ± 0.5
ii)	Outside dimension (face to face)	mm	46.00 ± 0.5	17.50 ± 0.5
iii)	Length	mm	785 (approx)	286 (approx)
6.	Slip strength	KN	153.2	
7.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75	
8.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320	
9.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000	

2. Repair sleeve for ACSR MOOSE Conductor

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

3. T-connector for ACSR MOOSE Conductor

Sl.	Description	Unit	Particulars/ Value
1.	Material		Aluminium of purity 99.5%
2.	Dimension of Aluminum sleeve Before compression		
i)	Inside diameter	mm	34.00 ± 0.5
ii)	Outside diameter	mm	54.00 ± 1.0
iii)	Length	mm	400.00 ± 5.0
3.	Dimensions of Aluminum Sleeve after compression		

	i) Outside dimension (Corner to corner)	mm	53.00 ± 0.5
	ii) Outside dimension (face to face)	mm	46.00 ± 0.5
4.	Axial tensile strength of welded portion of T-connector	KN	30
5.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
7.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

4. Vibration Damper for ACSR MOOSE conductor (For twin bundle conductor line only)

Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/mild steel/Zinc alloy duly hot dip galvanised
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/m m ²	135
5.	Slip strength of stranded messenger cable (mass pull off)	KN	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	5 to 40
8.	Maximum magnetic power loss per vibration damper watts for 600 amps, 50 Hz Alternating Current	Watts	1
9.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
10.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

11.	Percentage variation in reactance after fatigue test in comparison with that. before fatigue test	%	+/-40 (Maximum)
12.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
13.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

5. Bundle Spacer for ACSR MOOSE conductor (For twin bundle conductor line only)

Sl.	Description	Unit	Particulars/ Value		
1.	Type of Bundle Spacer		Armour grip type		
2.			<u>Insert</u>	<u>Main body</u>	<u>Retaining rods (if any)</u>
(i)	Materials of components		Alum i num alloy 6061 / 65032	Tube Alumin u m alloy 6063/6 3 400; 6061/ 65032	Aluminum alloy 6061/65032
(ii)	Manufacturing process of component parts		Forged	Tube-extrusion	Heat treatment during manufacturing
3.	Retaining rods (if used)				
	(a) Number of retaining rods used for each spacer	no.	8		
	(b) Diameter	mm	7.87-0.1		
	(c) Length	mm	1100+15		
	(d) Minimum UTS of rods	Kg/mm ²	35		
4.	Elastomer				
	(a) Type		Chloroprene/Neoprene		
	(c) Moulded on insert		Yes		

	(d) Shore hardness		65 to 80
	(e) Thickness on insert	mm	5(Average)
	(f) Temp. range for which designed	°C	95
5.	Minimum ultimate tensile strength of spacer		
	(a) Compressive load	kN	14
	(b) Tensile load	kN	7
6.	Slipping strength of spacer clamp		
	a) Before vibration test	KN	2.5
	b) After vibration test	KN	2
7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
8.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro volts	1000

6. Rigid Spacer for Jumper for ACSR MOOSE conductor (For twin bundle conductor line only)

Sl.	Description	Unit	Particulars/ Value
1.	Material of component parts		
	(a) Clamp		Aluminum alloy (4600)
	(b) Main body		Galvanised Steel / Al Alloy 4600 or Equivalent
2.	Elastomer (<i>if used</i>)		
	(a) Shore hardness		65 - 80
	(b) Temp. range for which designed	°C	Upto 95°C
3.	Minimum ultimate tensile strength of spacer		
	(a) Compressive load	kN	14
	(b) Tensile load	kN	7.0
4.	Slipping strength of spacer clamp	kN	2.5
5.	Maximum Magnetic power loss per spacer for 600 Amps, 50 Hz Alternating Current	Watts	1
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
7.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro volts	1000

7. Quad Spacer Damper for ACSR MOOSE conductor

Sl.	Description	Unit	Particulars / Value		
1.	Type of Clamps		Preformed rods.		
2.	Type of Damping element		Spring / Elastomer / EPDM		
3.	Material of				
	(a) Clamp		Al Alloy IS:4600 or Equivalent for Casting & Al Alloy 6061 or Equivalent (for Forging)		
	(b) Body		Al Alloy 4600 or Equivalent for Casting & Al Alloy 6061 or Equivalent (for Forging)		
4.	Elastomer (<i>if used</i>)				
	(a) Shore hardness		65 - 80		
	(b) Temp. range for which designed	°C	Upto 95°C		
5.	Minimum ultimate tensile strength of spacer				
	(a) Compressive load	kN	14		
	(b) Tensile load	kN	7.0		
6.	Slipping strength of spacer clamp				
	(a) Before vibration test	kN	Clamp type	Longitudinal Load (kN)	Maximum Slip permitted (mm)
			Preformed rods	2.5	12
	(b) After vibration test	kN	80% of the above values		
7.	Maximum magnetic power loss of at sub conductor current of 600 amperes, 50Hz AC	Watt	Below 1 watt.		
8.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320		
9.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) Microvolts under dry condition	µV	Below 1000		
10.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		

c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

8. Quad Rigid Spacer for Jumper for ACSR MOOSE conductor

Sl.	Description	Unit	Particulars / Value		
1.	Material of				
	(a) Clamp		Al Alloy IS:4600 or Equivalent		
	(b) Body		Galvanised Steel / Al Alloy 4600 or Equivalent		
2.	Elastomer (<i>if used</i>)				
	(a) Shore hardness		65 - 80		
	(b) Temp. range for which designed	°C	Upto 95°C		
3.	Minimum ultimate tensile strength of spacer				
	(a) Compressive load	kN	14		
	(b) Tensile load	kN	7.0		
4.	Slipping strength of spacer clamp	kN	Clamp type	Longitudinal Load (kN)	Maxm Slip permitted (mm)
			Metal - Metal Bolted	6.5	1
			Rubber loaded	2.5	2.5
5.	Maximum magnetic power loss of at sub conductor current of 600 amperes, 50Hz AC	Watts	Below 1 watt.		
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320		
7.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) Microvolts under dry condition	µV	Below 1000		
8.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		

c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

M) Accessories for ACSR Snowbird Conductor for 400 kV

transmission line Mid span compression Joint

Sl.	Description	Unit	Particulars/ Value	
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>
1.	Material of Joint		Aluminium of purity 99.5%	Mild Steel (Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinell hardness)	BHN	From 100 to 200	
3.	Weight of Zinc coating for steel sleeve	gm/m ²	610	
4.	Dimension of sleeve Before compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Inside diameter	mm	33.00 ± 0.5	7.00 ± 0.2
ii)	Outside diameter	mm	54.00 ± 1.0	19.20 ± 0.5
iii)	Length	mm	735 ± 5	250 ± 5
5.	Dimensions of Sleeve after compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Outside dimension (Corner to corner)	mm	53.00 ± 0.5	20.20 ± 0.5
ii)	Outside dimension (face to face)	mm	46.00 ± 0.5	17.50 ± 0.5
iii)	Length	mm	785 (approx)	286 (approx)
6.	Slip strength	KN	112	
7.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75	
8.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320	
9.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000	

Repair sleeve

Sl.	Description	Unit	Particulars/ Value
1.	Material		Aluminium of minimum purity 99.5%
2.	Dimension of Aluminum sleeve Before compression		
	i) Inside diameter	mm	33.00 ± 0.5
	ii) Outside diameter	mm	54.00 ± 1.0
	iii) Length	mm	300.00 ± 5.0
3.	Dimensions of Aluminum Sleeve after compression		
	i) Outside dimension (Corner to corner)	mm	53.00 ± 0.5
	ii) Outside dimension (face to face)	mm	46.00 ± 0.5
	iii) Length	mm	330.00(Approx.)
4.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
5.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

TRIPLE SPACER DAMPER FOR TRIPLE ACSR SNOWBIRD CONDUCTOR

Sl.	Description	Unit	Particulars / Value
1.	Type of Clamps		Preformed rods.
2.	Type of Damping element		Spring / Elastomer / EPDM
3.	Material of		
	(a) Clamp		Al Alloy IS:4600 or Equivalent for Casting & Al Alloy 6061 or Equivalent (for Forging)
	(b) Body		Al Alloy 4600 or Equivalent for Casting & Al Alloy 6061 or Equivalent (for Forging)
4.	Elastomer (<i>if used</i>)		
	(a) Shore hardness		65 - 80
	(b) Temp. range for which designed	°C	Upto 95°C
5.	Minimum ultimate tensile strength of spacer		
	(a) Compressive load	kN	14
	(b) Tensile load	kN	7.0
6.	Slipping strength of spacer clamp		

	(a) Before vibration test	kN	Clamp type	Longitudinal Load (kN)	Maxm Slip permitted (mm)
			Preformed rods	2.5	12
	(b) After vibration test	kN	80% of the above values		
7.	Maximum magnetic power loss of at sub conductor current of 600 amperes, 50Hz AC	Watt	Below 1 watt.		
8.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320		
9.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) Microvolts under dry condition	μV	Below 1000		
10.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute		

TRIPLE RIGID SPACER FOR TRIPLE ACSR SNOWBIRD CONDUCTOR

Sl.	Description	Unit	Particulars / Value		
1.	Material of				
	(a) Clamp		Al Alloy IS:4600 or Equivalent		
	(b) Body		Galvanised Steel / Al Alloy 4600 or Equivalent		
2.	Elastomer (<i>if used</i>)				
	(a) Shore hardness		65 - 80		
	(b) Temp. range for which designed	°C	Upto 95°C		
3.	Minimum ultimate tensile strength of spacer				
	(a) Compressive load	kN	14		
	(b) Tensile load	kN	7.0		

4.	Slipping strength of spacer clamp	kN	Clamp type	Longitudinal Load (kN)	Maxm Slip permitted (mm)
			Metal - Metal Bolted	6.5	1
			Rubber loaded	2.5	2.5
5.	Maximum magnetic power loss of at sub conductor current of 600 amperes, 50Hz AC	Watts	Below 1 watt.		
6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320		
7.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) Microvolts under dry condition	μ V	Below 1000		
8.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute		

T-connector

Sl.	Description	Unit	Particulars/ Value
1.	Material		Aluminium of purity 99.5%
2.	Dimension of Aluminum sleeve Before compression		
	i) Inside diameter	mm	33.00 $\pm$ 0.5
	ii) Outside diameter	mm	54.00 $\pm$ 1.0
	iii) Length	mm	400.00 $\pm$ 5.0
3.	Dimensions of Aluminum Sleeve after compression		
	i) Outside dimension (Corner to corner)	mm	53.00 $\pm$ 0.5
	ii) Outside dimension (face to face)	mm	46.00 $\pm$ 0.5
4.	Axial tensile strength of welded portion of T-connector	KN	30
5.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75

6.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
7.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

N) Accessories for ACSR ZEBRA conductor for 220 kV transmission line

1. Mid span compression Joint

Sl.	Description	Unit	Particulars/ Value	
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>
1.	Material of Joint		Aluminium of minimum purity 99.5%	Mild Steel (Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinell hardness)	BHN	From 100 to 200	
3.	Dimension of sleeve Before compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Inside diameter	mm	31.00 ± 0.5	10.00 ± 0.2
ii)	Outside diameter	mm	48.00 ± 1.0	20.00 ± 0.5
iii)	Length	mm	710 ± 5	241 ± 5
4.	Dimensions of Sleeve after compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Outside dimension (Corner to corner)	mm	47.00 ± 0.5	19.00 ± 0.5
ii)	Outside dimension (face to face)	mm	41.00 ± 0.5	16.00 ± 0.5
5.	Slip strength	KN	123.8	
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75	
7.	Galvanising			
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610	
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)	
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute	

2. Repair sleeve

Sl.	Description	Unit	Particulars/ Value
1.	Material		Aluminium of minimum purity 99.5%
2.	Dimension of Aluminum sleeve Before compression		
i)	Inside diameter	mm	31.00 ± 0.5
ii)	Outside diameter	mm	48.00 ± 1.0
iii)	Length	mm	275.00 ± 5.0
3.	Dimensions of Aluminum Sleeve after compression		
i)	Outside dimension (Corner to corner)	mm	47.00 ± 0.5
ii)	Outside dimension (face to face)	mm	41.00 ± 0.5

3. Vibration Damper

Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/ mild steel hot dip galvanised / Zinc alloy
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm ²	135
5.	Slip strength of stranded messenger cable (mass pull off)	KN	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	5 to 45
8.	Maximum magnetic power loss per vibration damper watts for 500 amps, 50 Hz Alternating Current	Watts	1
9.	Percentage variation in reactance after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)

10.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
11.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

O) Accessories for ACSR PANTHER conductor for 132 kV transmission line

1. Mid span compression Joint for ACSR PANTHER Conductor

Sl.	Description	Unit	Particulars/ Value	
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>
1.	Material of Joint		Aluminium of minimum purity 99.5%	Mild Steel (Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200	
3.	Dimension of sleeve Before compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Inside diameter	mm	23.00 ± 0.5	9.50 ± 0.2
ii)	Outside diameter	mm	38.00 ± 1.0	18.00 ± 0.5
iii)	Length	mm	610 ± 5	203 ± 5
4.	Dimensions of Sleeve after compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Outside dimension (Corner to corner)	mm	37.00 ± 0.5	17.40 ± 0.5
ii)	Outside dimension (face to face)	mm	32.00 ± 0.5	15.10 ± 0.5
5.	Slip strength	KN	85.2	

6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75
7.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

2. Repair sleeve for ACSR PANTHER Conductor

Sl.	Description	Unit	Particulars/ Value
1.	Material		Aluminium of minimum purity 99.5%
2.	Dimension of Aluminum sleeve Before compression		
i)	Inside diameter	mm	23.00 ± 0.5
ii)	Outside diameter	mm	38.00 ± 1.0
iii)	Length	mm	241.00 ± 5.0
3.	Dimensions of Aluminum Sleeve after compression		
i)	Outside dimension (Corner to corner)	mm	37.00 ± 0.5
ii)	Outside dimension (face to face)	mm	32.00 ± 0.5

3. Vibration Damper for ACSR PANTHER Conductor

Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
a)	Damper masses		Cast iron/ mild steel hot dip galvanised / Zinc alloy
b)	Clamp		Aluminum alloy 4600
c)	Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/m m ²	135
5.	Slip strength of stranded messenger cable (mass pull off)	KN	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	5 to 45
8.	Maximum magnetic power loss per vibration damper watts for 350 amps, 50 Hz Alternating Current	Watts	1
9.	Percentage variation in reactance after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
10.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
11.	Galvanising		
	a) Minimum weight of Zinc coating for steel parts	gm/m ²	610
	b) Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
	c) Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

P)Accessories for ACSR Lapwing conductor for ±800 kV HVDC Transmission Line.

Mid span compression Joint for ACSR Lapwing				
Sl.	Description	Unit	Particulars/ Value	
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>
1.	Material of Joint		Aluminium of purity 99.5%	Mild Steel (Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 120 to 200	
3.	Weight of Zinc coating for steel sleeve	gm/m ²	610	
4.	Dimension of sleeve Before compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Inside diameter: Nominal Tolerance	mm mm	41 ± 0.5	10 ± 0.5

ii)	Outside diameter: Nominal Tolerance	mm mm	64 ± 1.0	21 ± 0.5
iii)	Length	mm	As per design*	As per design*
*As per design to meet specified strength requirement (Min. Length- Al-Sleeve-860mm, Steel Sleeve-225mm)				
5.	Dimensions of Sleeve after compression		<u>Aluminum sleeve</u>	<u>Steel sleeve</u>
i)	Outside dimension (Corner to corner)	mm	As per design	As per design
ii)	Outside dimension (face to face)	mm	As per design	As per design
iii)	Length	mm	As per design	As per design
5.	Slip strength	KN	178.6	
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75	
7.	Minimum corona Extinction voltage kV (rms) under a voltage gradient of 22 kV/cm on conductor under dry condition	kV	880	
8.	Maximum Radio Interference Voltage at 1 MHz when subjected to conductor surface gradient of 22 kV/cm (positive) under dry condition	Micro Volts	1000	

Repair sleeve for ACSR LAPWING Conductor

Sl.	Description	Unit	Particulars/ Value
1.	Material		Aluminium of minimum purity 99.5%
2.	<u>Dimension of Aluminum sleeve Before compression</u>		
i)	Inside diameter: Nominal Tolerance	mm mm	41 ± 0.5
ii)	Outside diameter: Nominal Tolerance	mm	64 ±1.0
iii)	Length	mm	As per design
*As per design to meet specified strength requirement (Min. Length- 495mm)			
3.	<u>Dimensions of Aluminum Sleeve After compression</u>		
i)	Outside dimension (Corner to corner)	Mm	As per design
ii)	Outside dimension (face to face)	Mm	As per design
iii)	Length	Mm	As per design

4.	Minimum corona Extinction voltage kV (rms) under a voltage gradient of 22 kV/cm on conductor under dry condition	kV	880
5.	Maximum Radio Interference Voltage at 1 MHz when subjected to conductor surface gradient of 22 kV/cm (positive) under dry condition	Micro Volts (μ V)	1000

Q) Accessories for 7/3.66 mm GS Earthwire for 400 kV and 765 kV transmission line

1. Mid span compression Joint for 7/3.66 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value		
			<u>Aluminium / Filler Sleeve</u>	<u>Steel Sleeve</u>	
1.	Material of Joint		Aluminium of minimum purity 99.5%	Mild Steel (Fe-410, IS:2062)	
2.	Range of Hardness of the steel sleeve (Brinell hardness)	BHN	From 100 to 200		
3.	Weight of Zinc coating	gm/m ²	610		
4.	Dimension of sleeve Before compression				
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>	<u>Alu filler sleeve</u>
i)	Inside diameter	mm	22.00 ± 0.5	11.50 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	32.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	400 ± 5	230 ± 5	60 ± 5
5.	Dimensions of Sleeve after compression				
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>	
i)	Outside dimension (Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
iii)	Length	mm	430 (approx)	265 (approx)	
6.	Slip strength	KN	65		
7.	Maximum resistance of the compressed unit expressed, as	%	75		
	percentage of the resistance of equivalent length of bare Earthwire				

2. Flexible AL Bond for 7/3.66 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value

1.	Stranding		19(12+6+1)/dia2.54
2.	Cross sectional area	Sq.mm	95
3.	Length of aluminium cable	mm	750+5
4.	Material of lugs		Aluminum alloy
5.	Bolt Size		
	i) Diameter	mm	16
	ii) Length	mm	40

3. Vibration Damper for 7/3.66 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/mild steel/Zinc alloy duly hop dip galvanised
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm ²	135
5.	Slip strength of stranded messenger cable (mass pull off)	kN	2.5
6.	Slipping strength of damper clamp		
	(a) Before fatigue test	kN	2.5
	(b) After fatigue test	kN	2
7.	Resonance frequencies range	Hz	10 to 60
8.	Percentage variation in reactance after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
9.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)

4. Suspension Clamp for 7/3.66 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Material of components		
	(a) Shackle		Forged Steel
	(b) Clamp Body & Keeper		Malleable cast iron / SGI
	(c) U- Bolt		Mild Steel
2.	Total Drop (Maximum)	mm	150
3.	Breaking Strength (Minimum)	kN	25

4.	Slipping Strength	kN	12 to 17
5.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

5. Tension Clamp for 7/3.66 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value		
1.	Material of components				
	(i) Anchor Shackle		Forged Steel		
	(ii) Compression Clamp				
	a) Steel Sleeve		Mild Steel		
	b) Aluminium sleeve		Aluminium of purity 99.5%		
	c) Aluminium Filler sleeve		Aluminium of purity 99.5%		
2.	Range of Hardness of the steel sleeve (Brinell hardness)	BHN	120-200		
3.	Dimension of sleeve Before compression				
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>	<u>Aluminium filler sleeve</u>
i)	Inside diameter	mm	22.00 ± 0.5	11.50 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	30.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	245 ± 5	205 ± 5	25.0
4.	Dimensions of Sleeve after compression				
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>	
i)	Outside dimension (Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
5.	Slip strength	KN	65		
6.	Minimum Breaking strength of assembly (excluding clamp)	KN	70		
7.	Compression Pressure	Ton	100		
8.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS		

			13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

R) Accessories for 7/3.15 mm GS Earthwire for 220 kV and 132 kV transmission line

1. Mid span compression Joint for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value		
			Aluminium / Filler Sleeve	Steel Sleeve	
1.	Material of Joint		Aluminium of minimum purity 99.5%	Mild Steel (Fe-410, IS:2062)	
2.	Range of Hardness of the steel sleeve (Brinell hardness)	BHN	From 100 to 200		
3.	Dimension of sleeve Before compression				
			Aluminium Sleeve	Steel Sleeve	Alu filler sleeve
i)	Inside diameter	mm	22.00 ± 0.5	10.00 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	30.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	315 ± 5	230 ± 5	25 ± 2
4.	Dimensions of Sleeve after compression				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension (Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
5.	Slip strength	KN	53.20		
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare Earthwire	%	75		
7.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		

c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

2. Flexible AL Bond for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Stranding		19(12+6+1)/dia2.54
2.	Cross sectional area	Sq.mm	95
3.	Length of aluminium cable	mm	750+5
4.	Material of lugs		Aluminum alloy
5.	Bolt Size		
	i) Diameter	mm	16
	ii) Length	mm	40

3. Vibration Damper for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/ mild steel hot dip galvanised / Zinc alloy
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/m m ²	135
5.	Slip strength of stranded messenger cable (mass pull off)	kN	2.5
6.	Slipping strength of damper clamp		
	(a) Before fatigue test	kN	2.5
	(b) After fatigue test	kN	2
7.	Resonance frequencies range	Hz	10 to 60
8.	Percentage variation in reactance after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
9.	Percentage variation in power dissipation after fatigue test in comparison with that before	%	+/-40 (Maximum)

	fatigue test		
10.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

4. Suspension Clamp for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Material of components		
	(a) Shackle		Forged Steel
	(b) Clamp Body & Keeper		Malleable cast iron / SGI
	(c) U- Bolt		Mild Steel (Fe 410, IS 2062)
2.	Total Drop (Maximum)	mm	150
3.	Breaking Strength (Minimum)	kN	25
4.	Slipping Strength	kN	9 to 14
5.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

5. Tension Clamp for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Material of components		
	(i) Anchor Shackle		Forged Steel
	(ii) Compression Clamp		
	a) Steel Sleeve		Mild Steel (Fe 410, IS 2062)
	b) Aluminium sleeve		Aluminium of purity 99.5%
	c) Aluminium Filler sleeve		Aluminium of purity 99.5%
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	100-200
3.	Dimension of sleeve Before compression		
			Aluminium Sleeve Steel Sleeve Alu filler sleeve

i)	Inside diameter	mm	22.00 ± 0.5	10.00 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	30.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	220 ± 5	180 ± 5	25.0±2
4.	Dimensions of Sleeve after compression				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension (Corner to Corner)	mm	29.40 ± 0.5		20.20 ± 0.5
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5		17.50 ± 0.5
5.	Slip strength	KN	53.20		
6.	Minimum Breaking strength of assembly (excluding clamp)	KN	70		
7.	Compression Pressure	Ton	100		
8.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute		

S)Accessories for 7/4.5 mm GS Earthwire for ±800 kV transmission line

Mid span compression Joint for 7/4.5 mm GS Earthwire					
Sl.	Description	Unit	Particulars/ Value		
			<u>Aluminium / Filler Sleeve</u>	<u>Steel Sleeve</u>	
1.	Material of Joint		Aluminium of minimum purity 99.5%	Mild Steel (Fe-410, IS:2062)	
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200		
3.	Weight of Zinc coating	gm/m ²	610		
4.	Dimension of sleeve Before compression				
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>	<u>Alu filler sleeve</u>
i)	Inside diameter: Nominal Tolerance	mm mm	24-28 ± 0.5	14-15 ± 0.5	14-15 ± 0.5
ii)	Outside diameter: Nominal	Mm mm	32-38 ± 0.5	24-27 ± 0.5	24-27 ± 0.5

	Tolerance				
iii)	Length	mm	As per design*	As per design *	As per design *
	* As per design to meet specified strength requirement (Minimum length-Al-Sleeve-525mm, Steel sleeve-345mm, Alu filler tube-50mm)				
5.	Dimensions of Sleeve after compression				
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>	
i)	Outside dimension (Corner to Corner)	mm	As per design	As per design	
ii)	Outside dimension (face to face)	mm	As per design	As per design	
iii)	Length	mm	As per design	As per design	
6.	Slip strength	KN	100.9		
7.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare Earthwire	%	75		

2. Flexible AL Bond for 7/4.5 mm GS Earthwire			
Sl.	Description	Unit	Particulars/ Value
1.	Stranding		19(12+6+1)/dia2.54
2.	Cross sectional area	Sq.mm	95
3.	Length of aluminium cable	mm	750+5
4.	Material of lugs		Aluminum alloy
5.	Bolt Size		
	i) Diameter	mm	16
	ii) Length	mm	40
3. Vibration Damper for 7/4.5 mm GS Earthwire			
Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/mild steel/Zinc alloy duly hop dip galvanised
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm ²	135

5.	Slip strength of stranded messenger cable (mass pull off)	kN	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	%	+/-25(Maximum)
9.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-25 (Maximum)

4. Suspension Clamp for 7/4.5 mm GS Earthwire			
Sl.	Description	Unit	Particulars/ Value
1.	Material of components		
	(a) Shackle		Forged Steel
	(b) Clamp Body & Keeper		Malleable cast iron / SGI
	(c) U- Bolt		Mild Steel
2.	Total Drop (Maximum)	mm	150
3.	Breaking Strength (Minimum)	kN	45
4.	Slipping Strength	kN	19 to 27
5.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	610
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

Tension Clamp for 7/4.5 mm GS Earthwire			
Sl.	Description	Unit	Particulars/ Value
1.	Material of components		
	(i) Anchor Shackle		Forged Steel
	(ii) Compression Clamp		
	a) Steel Sleeve		Mild Steel
	b) Aluminium sleeve		Aluminium of purity 99.5%
	c) Aluminium Filler sleeve		Aluminium of purity 99.5%

3.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	120-200		
4.	Dimension of sleeve Before compression				
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>	<u>Alu filler sleeve</u>
i)	Inside diameter: Nominal Tolerance	mm mm	24-28 ± 0.5	14-14.5 ± 0.5	14-14.5 ± 0.5
ii)	Outside diameter: Nominal Tolerance	mm mm	32-38 ± 0.5	24-28 ± 0.5	24-28 ± 0.5
iii)	Length	mm	As per design	As per design	As per design
5.	Dimensions of Sleeve after compression				
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>	
i)	Outside dimension (Corner to Corner)	mm	As per design	As per design	
ii)	Outside dimension (face to face)	mm	As per design	As per design	
6.	Slip strength	KN	100.9		
7.	Minimum Breaking strength of assembly (excluding clamp)	KN	120		
8.	Compression Pressure	Ton	100		

Annexure-C

TYPICAL PLACEMENT CHART FOR SPACER DAMPER																				
Span in Meter	No.	Sub Span In meter																		
100	2	34	31	35																
105	2	34	40	31																
110	2	34	45	31																
115	2	34	50	31																
120	2	34	55	31																
125	2	34	60	31																
130	2	34	65	31																
135	2	39	65	31																
140	2	39	65	36																
145	3	34	39	44	28															
150	3	35	40	45	30															
155	3	36	41	47	31															
160	3	37	43	48	32															
165	3	39	44	49	33															
170	3	40	45	50	35															
175	3	40	47	53	35															
180	3	40	50	55	35															
185	3	40	52	58	35															
190	3	40	55	60	35															
195	3	40	57	63	35															
200	3	39	65	58	38															
205	4	37	50	40	46	32														
210	4	38	51	41	47	33														
215	4	36	53	42	50	34														
220	4	39	45	55	44	37														
225	4	39	45	55	49	37														
230	4	39	50	55	49	37														
235	4	39	49	57	52	38														
240	4	39	55	59	50	37														
245	4	39	55	65	49	37														
250	4	39	65	50	58	38														
255	4	40	65	54	61	35														
260	5	40	48	44	52	41	35													
265	5	40	49	45	54	42	35													
270	5	37	52	45	50	47	39													
275	5	36	56	45	55	44	39													
280	5	38	60	46	54	43	39													
285	5	38	60	49	55	44	39													
290	5	38	62	50	56	45	39													

Note: In case of tension towers, one additional Spacer Damper shall be placed within 10m of dead end clamp.

295	5	38	64	51	57	46	39													
300	5	38	62	53	57	51	39													
305	5	38	64	56	60	48	39													
310	5	38	62	55	60	56	39													
315	5	40	62	54	59	65	35													
320	6	40	45	55	49	43	53	35												
325	6	40	46	56	50	44	54	35												
330	6	40	47	57	51	45	55	35												
335	6	38	55	50	45	51	57	39												
340	6	38	57	51	46	52	57	39												
345	6	38	57	52	44	55	60	39												
350	6	38	59	52	44	55	63	39												
355	6	38	58	52	45	60	63	39												
360	6	40	53	62	57	52	61	35												
365	6	40	54	63	58	53	62	35												
370	6	40	55	65	59	54	62	35												
375	7	40	56	47	52	43	48	54	35											
380	7	40	57	47	53	44	49	55	35											
385	7	40	58	48	54	44	50	56	35											
390	7	40	58	49	55	45	51	57	35											
395	7	38	52	57	50	55	45	59	39											
400	7	40	60	51	56	47	53	58	35											
405	7	40	61	52	57	47	54	59	35											
410	7	40	62	52	58	48	55	60	35											
415	7	40	62	54	59	50	55	60	35											
420	7	40	63	54	60	50	57	61	35											
425	7	40	56	62	58	53	57	60	39											
430	7	40	57	64	58	52	57	63	39											
435	7	40	59	63	60	55	58	61	39											
440	7	40	59	64	61	56	59	62	39											
445	8	40	46	56	50	58	54	49	57	35										
450	8	40	48	56	51	59	54	49	58	35										
455	8	40	48	57	52	60	55	50	58	35										
460	8	39	58	55	52	49	53	56	61	37										
465	8	39	59	56	53	50	54	57	60	37										
470	8	39	60	57	54	51	54	57	61	37										
475	8	39	63	60	54	47	55	58	62	37										
480	8	40	52	61	55	64	58	53	62	35										
485	8	40	53	61	56	64	59	54	63	35										
490	9	40	58	48	43	51	56	47	53	59	35									
495	9	40	58	48	44	52	57	48	54	59	35									
500	9	40	59	49	44	52	58	48	55	60	35									

Note: In case of tension towers, one additional Spacer Damper shall be placed within 10m of dead end clamp.

505	9	40	59	50	45	53	59	48	55	61	35									
510	9	40	60	51	45	54	59	49	55	62	35									
515	9	40	61	51	46	54	59	51	56	62	35									
520	9	40	61	51	46	55	60	52	57	63	35									
525	9	40	62	52	47	56	61	51	57	64	35									
530	9	39	62	56	59	53	57	51	55	60	38									
535	9	39	65	56	59	53	57	51	55	62	38									
540	9	40	64	54	49	57	63	54	59	65	35									
545	9	40	65	55	49	59	63	54	60	65	35									
550	10	40	53	58	48	55	45	52	60	48	56	35								
555	10	40	53	58	49	56	46	52	60	49	57	35								
560	10	40	54	59	50	56	47	53	60	49	57	35								
565	10	40	55	60	51	57	47	53	60	50	57	35								
570	10	40	55	61	51	57	48	54	61	51	57	35								
575	10	40	55	61	51	59	49	54	62	51	58	35								
580	10	37	59	52	58	51	56	61	54	60	53	39								
585	10	37	62	52	59	51	56	61	55	60	53	39								
590	10	37	64	52	59	51	56	61	55	63	53	39								
595	10	37	65	53	59	52	56	62	55	64	53	39								
600	10	37	65	54	59	53	57	61	56	64	55	39								
605	10	37	65	55	60	53	57	61	56	64	58	39								
610	10	37	65	56	63	54	57	60	56	64	59	39								
615	10	39	65	59	62	54	57	61	56	64	58	40								
620	11	40	58	51	61	54	49	59	52	45	55	61	35							
625	11	40	58	52	61	55	49	60	52	45	56	62	35							
630	11	40	59	52	62	56	49	60	53	46	56	62	35							
635	11	40	59	53	62	56	50	61	53	46	57	63	35							
640	11	39	54	61	55	60	52	58	53	57	51	60	40							
645	11	39	54	62	56	61	52	59	53	58	51	60	40							
650	11	39	55	62	57	61	53	59	54	58	52	60	40							
655	11	39	55	63	57	62	53	60	54	59	52	61	40							
660	11	39	56	63	58	62	54	60	55	59	53	61	40							
665	11	39	57	65	58	62	54	62	55	59	53	61	40							
670	11	39	57	65	58	64	54	62	55	60	53	63	40							
675	11	39	58	65	59	64	55	62	56	60	54	63	40							
680	11	39	60	64	62	63	55	62	57	60	56	62	40							
685	12	40	60	50	57	62	53	58	49	54	60	50	57	35						
690	12	40	61	51	58	62	53	59	49	55	60	50	57	35						
695	12	40	61	51	58	63	54	59	50	55	61	50	58	35						
700	12	40	61	51	58	63	55	60	50	56	61	51	59	35						
705	12	39	62	55	63	54	61	52	59	53	57	60	50	40						
710	12	39	62	56	63	55	61	53	59	54	57	60	51	40						

Note: In case of tension towers, one additional Spacer Damper shall be placed within 10m of dead end clamp.

715	12	39	63	56	64	55	62	53	60	54	57	61	51	40						
720	12	39	63	57	64	56	62	54	60	55	59	53	58	40						
725	12	39	64	57	65	56	63	54	61	55	60	53	58	40						
730	12	39	64	58	65	57	63	55	61	56	60	54	58	40						
735	13	40	56	61	53	48	56	62	53	47	57	52	60	55	35					
740	13	40	56	61	54	48	57	62	54	47	57	52	61	56	35					
745	13	40	57	63	54	49	57	62	54	47	57	52	62	56	35					
750	13	40	58	63	55	50	57	62	54	48	58	53	61	56	35					
755	13	40	58	63	55	50	58	63	54	48	58	53	63	57	35					
760	13	40	58	65	55	50	59	64	55	48	58	53	63	57	35					
765	13	40	59	65	56	51	59	64	55	49	59	53	63	57	35					
770	13	40	60	65	56	51	59	64	56	49	59	54	64	58	35					
775	13	40	60	65	56	52	59	64	56	50	60	55	65	58	35					
780	13	40	65	58	53	59	54	60	55	61	56	62	55	63	39					
785	14	40	61	55	49	58	53	47	56	61	51	58	48	53	60	35				
790	14	40	61	56	49	59	53	47	56	63	51	59	48	53	60	35				
795	14	40	62	56	50	59	53	47	56	63	52	59	49	54	60	35				
800	14	40	63	56	50	59	54	48	57	63	52	59	49	55	60	35				
805	14	40	63	57	51	60	54	48	57	63	52	59	50	55	61	35				
810	14	40	63	57	51	60	55	48	57	63	54	61	50	55	61	35				
815	14	40	64	57	52	60	55	49	58	63	54	61	51	55	61	35				
820	14	40	64	58	52	61	55	49	58	64	54	61	51	56	62	35				
825	14	40	64	58	52	61	56	49	59	64	55	61	52	57	62	35				
830	14	40	65	58	53	62	56	49	59	64	55	62	52	57	63	35				
835	15	40	53	61	56	50	46	54	61	57	51	60	54	45	51	61	35			
840	15	40	53	62	56	51	46	54	61	57	51	61	55	45	52	61	35			
845	15	40	54	62	57	51	46	54	62	57	52	61	55	46	52	61	35			
850	15	40	54	62	58	51	46	54	63	57	52	61	56	46	53	62	35			
855	15	40	54	62	58	52	46	55	63	58	52	61	56	47	53	63	35			
860	15	40	55	63	58	52	47	55	63	58	53	62	56	47	53	63	35			
865	15	40	55	64	59	52	47	55	64	58	53	62	57	47	54	63	35			
870	15	40	56	64	59	53	47	56	64	59	53	62	57	47	54	64	35			
875	15	40	56	64	59	53	48	56	65	59	54	63	57	48	54	64	35			
880	15	40	56	65	60	53	48	56	65	60	54	63	58	48	54	65	35			
885	15	40	56	65	60	53	48	56	65	60	55	64	58	50	55	65	35			
890	15	40	65	55	64	57	63	59	49	60	50	61	51	62	52	63	39			
895	15	40	65	55	64	58	63	59	50	60	51	61	52	62	53	63	39			
900	16	40	58	51	61	56	51	61	55	49	60	52	63	57	51	45	55	35		
905	16	40	58	52	62	57	52	61	55	49	60	52	63	57	52	45	55	35		
910	16	40	58	52	62	57	52	62	56	50	60	53	63	57	52	46	55	35		
915	16	40	59	52	63	58	53	62	56	50	60	54	63	57	52	46	55	35		
920	16	40	60	52	63	58	53	62	56	51	60	54	63	58	53	46	56	35		

Note: In case of tension towers, one additional Spacer Damper shall be placed within 10m of dead end clamp.

925	16	40	60	53	63	58	53	63	57	51	61	54	64	58	53	46	56	35			
930	16	40	60	53	64	59	53	63	57	51	61	55	64	58	53	48	56	35			
935	16	40	61	53	64	59	54	64	57	51	61	55	65	58	53	48	57	35			
940	16	40	61	54	64	59	54	64	57	52	62	55	65	59	54	48	57	35			
945	17	40	53	47	56	51	61	56	50	60	53	48	57	62	51	46	57	62	35		
950	17	40	53	47	56	51	61	56	51	60	54	48	57	63	52	47	57	62	35		
955	17	40	54	47	57	51	62	57	51	61	54	48	57	63	52	47	57	62	35		
960	17	40	54	48	57	52	62	57	51	61	54	49	57	63	53	48	57	62	35		
965	17	40	54	48	57	52	62	57	52	61	55	49	58	63	53	48	58	63	35		
970	17	40	55	48	58	53	63	58	52	61	55	49	58	63	53	48	58	63	35		
975	17	40	55	49	58	53	63	58	52	61	55	49	59	64	53	48	59	64	35		
980	17	40	55	49	58	53	63	58	52	62	56	50	59	64	54	49	59	64	35		
985	17	40	55	49	59	54	64	58	53	62	56	50	59	64	54	49	59	65	35		
990	17	40	55	49	59	54	64	58	53	63	56	51	59	65	55	49	60	65	35		
995	17	40	56	50	59	54	64	59	53	63	56	51	60	65	55	50	60	65	35		
1000	18	40	45	50	59	52	62	57	52	62	57	48	53	61	56	51	44	54	62	35	
1005	18	40	45	50	60	53	63	57	52	63	58	48	53	61	56	51	44	54	62	35	
1010	18	40	45	50	60	53	63	57	52	63	58	49	53	62	57	51	45	54	63	35	
1015	18	40	46	51	60	54	63	57	52	63	58	49	54	62	57	51	45	55	63	35	
1020	18	40	46	51	61	54	64	58	53	63	58	49	54	62	57	52	45	55	63	35	
1025	18	40	47	51	61	54	64	59	53	63	58	49	55	62	58	52	45	56	63	35	
1030	18	40	47	51	61	54	64	59	54	64	59	50	55	62	58	53	45	56	63	35	
1035	18	40	47	52	61	55	64	59	54	64	59	50	55	63	58	53	46	56	64	35	
1040	18	40	47	52	61	55	64	59	54	64	59	50	55	64	59	54	47	57	64	35	
1045	18	40	47	53	61	56	64	59	54	65	60	50	55	65	59	54	47	57	64	35	
1050	18	40	48	53	61	56	64	59	55	65	60	51	56	65	59	54	47	57	65	35	
1055	19	40	53	61	56	49	44	53	62	56	52	61	56	50	60	54	45	50	56	62	35
1060	19	40	53	61	56	49	44	54	62	57	52	62	56	51	60	54	45	50	57	62	35
1065	19	40	53	62	57	50	44	54	63	57	52	62	56	51	61	54	45	50	57	62	35
1070	19	40	54	62	57	50	45	54	63	57	52	62	57	51	61	55	45	50	57	63	35
1075	19	40	54	62	57	50	45	55	64	58	53	62	57	51	61	55	45	50	58	63	35
1080	19	40	54	63	57	50	45	55	64	58	53	62	57	52	62	55	46	51	58	63	35
1085	19	40	55	63	58	51	46	55	64	58	53	63	57	52	62	55	46	51	58	63	35
1090	19	40	55	64	59	51	46	55	65	59	53	63	57	52	62	55	46	51	58	64	35
1095	19	40	56	64	59	52	46	55	65	59	53	64	57	52	62	55	47	51	59	64	35
1100	19	40	56	64	59	52	47	56	65	59	53	64	58	52	63	55	47	52	59	64	35

Note: In case of tension towers, one additional Spacer Damper shall be placed within 10m of dead end clamp.

SECTION-VI B

CLAMP FITTINGS AND ACCESSORIES FOR HTLS CONDUCTOR

(Strikeout/Delete whichever is not applicable)

**TECHNICAL
SPECIFICATIONS
SECTION-VI B
CLAMP FITTINGS AND ACCESSORIES FOR HTLS CONDUCTOR**

**TECHNICAL
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**TECHNICAL
SPECIFICATIONS**

SECTION- VI B

CLAMP FITTINGS AND ACCESSORIES FOR HTLS CONDUCTOR

1.0 Technical Description of Clamp Fittings for HTLS Conductor

1.1 General

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

1.2 The fittings shall be suitable for attachment to suspension and tension insulator strings along with hardware fittings. For owner supplied fittings 2.5

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

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

1.3 Corona and RI Performance

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

1.4 Maintenance

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

1.5 Split Pins

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

1.6 Suspension Assembly

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

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

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

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

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

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

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

1.7 Free Centre Type Suspension Clamp

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

1.7.1 Standard Preformed Armour Rod Set

- 1.7.1.1 The Preformed Armour Rods Set shall be used to minimise the stress developed in the sub-conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs, chafing and abrasion from suspension clamp and localised heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.
- 1.7.1.2 The preformed armour rods set shall have right hand lay and the inside diameter of the helix shall be less than the outside diameter of the conductor to have gentle but permanent grip on the conductor. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions etc.
- 1.7.1.3 The pitch length of the rods shall be determined by the Bidder but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.
- 1.7.1.4 The length and diameter of each rod shall be furnished by the bidder in the GTP. The tolerance in length of the rods between longest and shortest rods in complete set should be within the limits specified in the relevant Indian/ International Standards. The ends of armour rod shall be parrot billed.
- 1.7.1.5 The number of armour rods in each set shall be as per supplier's design to suit HTLS conductor offered. Each rod shall be marked in the middle with paint for easy application on the line.
- 1.7.1.6 The armour rod shall not loose their resilience even after five applications.
- 1.7.1.7 The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS) & Minimum tensile strength shall not be less than 35kg/mm².

1.8 Armour Grip Suspension Clamp

- 1.8.1 The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminium reinforcements and AGS preformed rod set.
- 1.8.2 Elastomer insert shall be resistant to the effects of temperature up to designed maximum conductor temperature guaranteed by the bidder corresponding to peak current, Ozone, ultraviolet radiations and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS performed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene insert.
- 1.8.3 The supplier shall submit relevant type/ performance test certificates as per applicable standard/product specifications for elastomer to confirm suitability of the offered elastomer for the specified application.

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

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

1.9 **Envelope Type Suspension Clamp**

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

1.10 **Dead end Assembly**

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

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

1.10.3 Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions and shall bear the words 'COM PRESS FIRST' suitably inscribed near the point on each assembly where the compression begins. If the dead-end assembly is designed for intermittent die compressions it shall bear identification marks 'COMPRESSION ZONE' AND 'NON-COMPRESSION ZONE' distinctly with arrow marks showing the direction of compressions and knurling marks showing the end of the zones. The letters, number and other markings on the finished clamp shall be distinct and legible. The dimensions of dead-end assembly before & after compression along with tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification. These shall be guaranteed in the relevant schedules of bid.

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

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

conform to the relevant Indian/International standards

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

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

- 1.11.1 All bolts and nuts shall conform to IS 6639. All bolts and nuts shall be galvanised as per IS 1367 (Part-13)/ IS 2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.
- 1.11.2 Bolts upto M16 and having length upto 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS 12427. Bolts should be provided with washer face in accordance with IS 1363 (Part-1) to ensure proper bearing.
- 1.11.3 Nuts should be double chamfered as per the requirement of IS 1363 Part-III 1984. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4 mm oversize on effective diameter for size upto M16.
- 1.11.4 Fully threaded bolts shall not be used for parts/components requiring shear/tensile strength. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts. Bolts & Nuts for these parts/components shall be of minimum 5.6 grade conforming to IS 1367 or equivalent International standards.
 - 1.11.4.1 For parts/ components requiring grip strength viz. arcing horn, corona rings & dead-end jumper assembly, fully threaded bolts can be used as an alternative. Bolts & nuts for these parts/ components shall be of minimum 4.6 grade conforming to IS 6639 or equivalent International standards
 - 1.11.4.2 In case of fasteners of other materials viz. stainless steel, aluminium alloy, etc. are proposed to be used by the supplier, these shall conform to relevant Indian/International standards and complete details shall be submitted by the supplier for review & approval by the Employer.
- 1.11.5 All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but no further. It shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.
- 1.11.6 Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanised. The thickness of washers shall conform to IS 2016.

- 1.11.7 The Supplier shall indicate required size & length of various bolts in the drawings based on thickness of components connected, the nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.
- 1.11.8 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three times its diameter.
- 1.11.9 Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.
- 1.11.10 To ensure effective in-process Quality control it is essential that the manufacturer should have all the testing facilities for tests like weight of zinc coating, shear strength, other testing facilities etc, in-house. The manufacturer should also have proper Quality Assurance system which should be in line with the requirement of this specification and IS 9001 services Quality System standards.
- 1.11.11 Fasteners of grade higher than 8.8 are not to be used and minimum grade for bolt shall be 5.6.

1.12 **Materials**

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

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

1.13 **Workmanship**

- 1.13.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for the applicable voltage level of transmission lines and will give continued good performance. For Employer's review of the offered design of clamps/ fittings, the supplier shall submit document/ design details of similar type of clamps/ fittings used in past for similar type of HTLS conductor application.
- 1.13.3 The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and corners to limit corona and radio-interference, best resistance to corrosion and a good finish.
- 1.13.4 All ferrous parts including fasteners shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised. The bolt threads shall be undercut to take care of the increase in diameter due to galvanising. Galvanising shall be done in accordance with IS 2629/ IS 1367 (Part-13) and shall

satisfy the tests mentioned in IS 2633. Fasteners shall withstand four dips while spring washers shall withstand three dips of one minute duration in the standard Preece test. Other galvanised materials shall have a minimum average coating of zinc equivalent to 600 gm/sqm, shall be guaranteed to withstand at least six successive dips each lasting one (1) minute under the standard preece test for galvanising.

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

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

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

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

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

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

1.14 **Bid Drawings**

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

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

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

The drawings shall include:

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

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

TABLE-1
(Details of Materials)

Sl. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks
1.	Security Clips	Stainless Steel/ Phosphor Bronze	-	AISI 304 IS781 1	
2.	For Free Centre /Envelope type clamps				
(a)	Clamp Body, Keeper Piece	Al. Alloy 4600	Casted & Heat treated	IS 617	
		Al. Alloy 65032	Forged & Heat treated	IS 733	
		Al Alloy ENAW6082	Forged & Heat treated	EN 573-3	
(b)	Cotter bolts	Mild Steel	Hot dip galvanised	IS-2062	

(c)	Shackles	Forged Steel (Class-IV)	Hot dip galvanised	IS-2004	
(d)	U Bolts	Stainless Steel		AISI	
		Al alloy 65032	Forged & Heat treated	IS 733	
(e)	P. A. Rod	Al. Alloy 65032	Extruded & Heat treated	IS 733	
3.	For AGS type clamp				
(a)	Supporting House	Al. Alloy 4600	Casted & Heat treated	IS:617	
		Al alloy 65032	Forged & Heat treated	IS 733	
(b)	Al insert & Retaining strap	Al. Alloy 4600	Casted & Heat treated	IS:617	
		Al alloy 65032	Forged & Heat treated	IS 733	
(c)	Elastomer	Moulded on Al. reinforcement			
4.	For Dead End Assembly & Mid Span Compression Joint				
(a)	Outer Sleeve (for Annealed Aluminium Conductor)	Al Alloy 19500	Extruded	IS 733	
(b)	Outer Sleeve (for Aluminium alloy Conductor)	Al Alloy 19500	Extruded	IS 733	
		Al Alloy 63400	Extruded & heat treated	IS 733	
		Al Alloy 6060		EN 573-3	
(c)	Steel Sleeve	Mild Steel	Hot Dip Galvanised	IS-2062	
		Forged Steel (Class-II)		IS-2004	
5	For Repair Sleeve				
(a)		Al Alloy 19500	Extruded	IS 733	
6	For T-Connector				
		Al Alloy 19500	Extruded	IS 733	
		Al Alloy 63400	Extruded & heat treated	IS 733	
		Al Alloy 6060		EN 573-3	
7	For Rigid Spacer				
	Clamp Body, Keeper Piece, Frame	Al. Alloy 4600	Casted & Heat treated	IS 617	
		Al. Alloy 65032	Forged & Heat treated	IS 733	

		Al Alloy ENAW6082	Forged & Heat treated	EN 573-3	
	Al Tube	Al Alloy 63400	Extruded & heat treated	IS 733	
		Al. Alloy 65032		IS 733	
8	For Spacer Damper				
(a)	Clamp Body, Keeper Piece,	Al. Alloy 4600	Casted & Heat treated	IS 617	
	Frame & Al Insert	Al. Alloy 65032	Forged & Heat treated	IS 733	
		Al Alloy ENAW6082	Forged & Heat treated	EN 573-3	
9	For Vibration Damper				
(a)	Clamp Body, Keeper Piece	Al. Alloy 4600	Casted & Heat treated	IS 617	
(b)	Damper Mass	Cast Iron/Steel			
(c)	Messenger Cable	High strength galvanised steel/stain less Steel			
10.	Yoke Plate	Mild Steel	Hot dip galvanized	IS-2062	
11 (a)	Corona Control ring/ Grading ring	Al. Alloy 65032	Extruded & Heat treated	IS 733	Mechanical strength of welded joint shall not be less than 20 KN
		Al. Alloy 63400	Extruded & Heat treated	IS 733	
		Al. Alloy 63401	Extruded & Heat treated	IS 5082	
11 (b)	Supporting Brackets & Mounting Bolts	Al Alloy 65032/63400	Heat treated	IS 733	
		Mild Steel	Hot dip galvanized	IS 2062	

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

2.0 Accessories for the HTLS Conductor

2.1 General

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

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

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

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

2.2 Mid Span Compression Joint

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

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

2.3 T-Connector

T-Connector of compression type shall be used for jumper connection at transposition tower. It shall be manufactured out of 99.5% pure aluminium/ aluminium alloy and shall be strong enough to withstand normal working loads as well as able to withstand the continuous maximum operating temperature of conductor. The T-connector shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation. The resistance of T-connector when compressed on the conductor shall not be more than 75% of the resistance of equivalent length of conductor. The T-connector shall not permit slipping off, damage to or failure of complete conductor. The welded portions shall be designed for 30 kN axial

tensile load. Leg sleeve of T-connector should be kept at an angle of 15 deg. from vertical and horizontal plane of the conductor in order to minimise jumper pull at the welded portion. The dimensions of T-connector along with tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification.

2.4 Repair Sleeve

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

2.5 Vibration Damper

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

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

2.5.3 The clamp of the vibration damper shall be made of high strength aluminium alloy 4600. It shall be capable of supporting the damper and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the conductor without damaging the strands or causing premature fatigue failure of the conductor under the clamp. The

clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the conductor when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and designed to prevent corrosion of threads or loosening in service.

- 2.5.4 The messenger cable shall be made of high strength galvanised steel/stain less steel with a minimum strength of 135 kg/mm². It shall be of preformed and post-formed quality in order to prevent subsequent drop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in the messenger cable shall be 19. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS 4826 for heavily coated wires.
- 2.5.5 The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blowholes etc. The surface of the damper masses shall be smooth.
- 2.5.6 The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.
- 2.5.7 The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.
- 2.5.8 The vibration damper shall be capable of being installed and removed from energised line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the conductor at the designated torque without shearing or damaging of fasteners.
- 2.5.9 The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.
- 2.5.10 The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed under Annexure-A, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

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

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

2.5.12 The damper placement charts shall include the following

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

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

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

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

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

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

- 2.6.2.3 Any nut used shall be locked in such manner so as to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded.
- 2.6.2.4 Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened.
- 2.6.2.5 The clamp grooves shall be in uniform contact with the conductor over the entire surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, grit or other material which cause damage to the conductor when the clamp is installed.
- 2.6.2.6 For the spacer involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.
- 2.6.2.7 Universal type bolted clamps, covering a range of conductor sizes, will not be permitted.
- 2.6.2.8 No rubbing, other than that of the conductor clamp hinges or clamp swing bolts, shall take place between any parts of the spacer. Joint incorporating a flexible medium shall be such that there is no relative slip between them.
- 2.6.2.9 The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service.
- 2.6.2.10 The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance.
- 2.6.2.11 The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep.
- 2.6.2.12 The spacer assembly shall not have any projections, cuts, abrasions etc. or chattering parts which might cause corona or RIV.
- 2.6.2.13 The spacer tube shall be made of aluminium alloy 65032/63400. If fasteners of ferrous material are used, they shall conform to and be galvanised conforming to relevant Indian Standards.
- 2.6.2.14 Elastomer, if used, shall be resistant to the effects of temperature upto the designed maximum temperature specified for the conductor, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be as per relevant Indian/International standard. The supplier shall submit relevant type/ performance test certificate as per applicable standard/ product specification for elastomer to confirm suitability of the offered elastomer for the specified application.

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

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

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

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

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

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

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

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

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

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

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

conductor diameter due to creep.

- 2.7.8 Bolted type clamps shall allow installation without removal of the bolts or the clamps from clamp body. Locking mechanism shall be suitable to prevent bolt loosening. Clamp locking devices with small loose components shall not be accepted. Nut cracker, hinged open or boltless type clamps are acceptable provided adequate grip can be maintained on the conductor.
- 2.7.9 Bolts and nuts shall be of mild steel, stainless steel, or high strength steel in accordance with the design of the spacer damper.
- 2.7.10 Where elastomer lined clamps are used, the elastomer elements shall be firmly fixed to the clamp. In case of elastomer covered clamps, the insert should be forged from aluminium alloy 65032 or equivalent having minimum tensile strength of 25 kg/mm². The insert shall be moulded on the insert surface. The insert shall be duly heat treated and aged to retain its consistent characteristics during service. The grain flow of the forged insert shall be in the direction of the maximum tension and compression loads experienced.
- 2.7.11 In case of Spacer dampers with pre-formed rods, the articulated arms shall be terminated by elastomer lined or elastomer covered clamps and securely held by pre-formed retaining helical, factory formed rods. Minimum four (4) no. of rods shall be applied on each clamp to hold the clamp in position. These rods shall be designed for specific conductor size & shall be made of high strength aluminium alloy 65032 or equivalent having a minimum tensile strength of 35 kg/mm². The rods shall be parrot bill ended. The rods shall be heat treated and aged to achieve specified mechanical properties and to retain the same during service. The length of the rods shall be such that the ends fall inside the imaginary square whose sides are vertical and horizontal outer tangents to the conductor sections.
- 2.7.12 The spacer damper body shall be cast/ forged from suitable high strength corrosion resistant aluminum alloy. The aluminium alloy shall be chosen in relation with the process used.
- 2.7.13 The rubber components involved in the design such as damping elements shall be made with rubber compound selected specifically for that particular application. The Contractor shall submit a complete list of physical and mechanical properties of the elastomer used. This list shall make reference to all applicable Indian/International standards.
- 2.7.14 The rubber components used shall have good resistance to the effects of temperature up to the designed maximum temperature of the conductor and to ultraviolet radiation, ozone and other atmospheric contaminants. The rubber shall have good wear and fatigue resistance and shall be electrically semi-conductive.

- 2.7.15 The spacer damper assembly shall have electrical continuity. The electrical resistance between the sub-conductors across the assembly in case of spacer damper involving elastomer surfaced clamps shall be suitably selected by the manufacturer to ensure satisfactory electrical performance and avoid deterioration of elastomer under service conditions.
- 2.7.16 The spacer damper assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.
- 2.7.17 The spacer damper assembly shall be capable of being installed and removed from the energized line by means of hot line techniques. The Supplier shall furnish the complete description of the installation, removal and reinstallation procedure.
- 2.7.18 A typical placement chart of spacer dampers for spans ranging from 100m to 1100m is indicated in table at Annexure-D. Sub span spacing indicated in Annexure-D may be varied by the manufacturer as per requirement, provided total no. of Spacer Damper in sub-span shall not be less than indicated in table at Annexure-D. In case of tension towers, one additional Spacer Damper shall be placed within 10m of dead end clamp. In case more Spacer dampers are recommended by the supplier, the payment shall be restricted to the number of Spacer dampers indicated in table at Annexure-D for different spans and one additional in case of tension towers.
- 2.7.19 The staggering scheme shall be such that no sub span shall be greater than 65 m and no end sub span shall be longer than 40 m & the spacer dampers be unequally distributed along the span to achieve sufficient detuning of adjacent sub spans for oscillations of sub span mode and to ensure bundle stability for wind speeds up to 60 km/hr.
- 2.7.20 In case of Spacer Damper with bolted clamps, the manufacturer/ supplier shall supply free of cost 25 number fixed setting torque wrench (of torque as per spacer damper design) along with 1st batch of supply of spacer dampers for installation of spacer damper on the line by the tower contractors.
- 2.7.21 The Bidder shall furnish all the relevant technical documents in supports of the staggering scheme recommended for the spacer damper.

2.8 **Material and Workmanship**

- 2.8.1 All the equipment shall be of the latest proven design and conform to the best modern practice adopted in the extra high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for intended voltage level of transmission line application and will give continued good performance at all service conditions. For

employer's review of the offered design of accessories, the supplier shall submit document/ design details of similar type of accessories used in past for similar type of HTLS conductor application.

- 2.8.2 The design, manufacturing process and quality control of all the materials shall be such as to achieve requisite factor of safety for maximum working load, highest mobility, elimination of sharp edges and corners, best resistance to corrosion and a good finish.
- 2.8.3 All ferrous parts shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised as per grade 4 of IS 1573. The bolt threads shall be undercut to take care of increase in diameter due to galvanising. Galvanising shall be done in accordance with IS 2629/ IS 1367 (Part-13) and satisfy the tests mentioned in IS 2633. Fasteners shall withstand four dips while spring washers shall withstand three dips. Other galvanised materials shall have a minimum average coating of Zinc equivalent to 600 gm/sqm and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanising unless otherwise specified.
- 2.8.4 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The zinc used for galvanising shall be of grade Zn 99.95 as per IS 209.
- 2.8.5 In case of castings, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc.
- 2.8.6 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localised heating phenomenon is averted.
- 2.8.7 No equipment shall have sharp ends or edges, abrasions or projections and shall not cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under all service conditions.
- 2.8.8 Particular care shall be taken during manufacture and subsequent handling to ensure smooth surface free from abrasion or cuts.
- 2.8.9 The fasteners shall conform to the requirements of IS 6639. All fasteners and clamps shall have corona free locking arrangement to guard against vibration loosening.

2.9 **Compression Markings**

Die compression areas shall be clearly marked on each equipment designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' suitably inscribed on each equipment where the compression begins. If the equipment is designed for intermittent die

compressions, it shall bear the identification marks 'COMPRESSION ZONE' and 'NON-COMPRESSION ZONE' distinctly with arrow marks showing the direction of compression and knurling marks showing the end of the zones. The letters, number and other markings on finished equipment shall be distinct and legible.

2.10 **Bid Drawings**

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

2.10.2 The drawings shall include

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

2.10.3 Placement charts for spacer/spacer damper and damper

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

3.0 **Tests and Standards**

3.1 **Type Tests**

3.1.1 **On Suspension Clamp for HTLS Conductor**

a)	Visual Examination	IS 2486 (Part-1)

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

3.1.2 On Dead end Tension Assembly for HTLS Conductor

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

3.1.3 On Mid Span Compression Joint for HTLS Conductor

a)	Visual Examination	IS 2121 (Part-II)
b)	Dimensional Verification	IS 2121 (Part-II)
c)	Chemical analysis of materials	Annexure-A
d)	Electrical resistance test	IS 2121 (Part-II)
e)	Heating cycle test	Annexure-A
f)	Slip strength test	Annexure-A
g)	Thermal Profile test	Annexure-A

h)	Corona extinction voltage test (dry) (for 400 kV and above voltage level only)	Annexure-A
i)	Radio interference voltage test (dry) (for 400 kV and above voltage level only)	Annexure-A
j)	Ageing test on filler (if applicable)	Annexure-A
k)	Galvanizing test	Annexure-A

3.1.4 T-Connector for HTLS Conductor

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

3.1.5 Repair Sleeve for HTLS Conductor

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

g)	Radio interference voltage test (dry) <i>(for 400 kV and above voltage level only)</i>	Annexure-A

3.1.6 Vibration Damper for HTLS Conductor

a)	Visual Examination	IS 9708
b)	Dimensional Verification	IS 9708
c)	Verification of Resonance Frequencies	Annexure-B
d)	Mass pull off test	IS 9708
e)	Chemical analysis of materials	Annexure-A
f)	Dynamic characteristics test*	Annexure-A
g)	Vibration analysis	Annexure-A
h)	Clamp slip test	Annexure-A
i)	Clamp bolt torque test	IS 9708
j)	Fatigue tests	Annexure-A
k)	Magnetic power loss test	Annexure-A
l)	Thermal Profile test	Annexure-A
m)	Corona extinction voltage test (dry) <i>(for 400 kV and above voltage level only)</i>	Annexure-A
n)	Radio interference voltage test (dry) <i>(for 400 kV and above voltage level only)</i>	Annexure-A
o)	Damper efficiency test	IS 9708
p)	Galvanising/Electroplating test	Annexure-A

* Applicable for 4 R stockbridge dampers. For alternate type of vibration dampers (permitted as per clause 2.5.2), as an alternative to dynamic characteristic test, damper efficiency test as per IEEE-664 Power Manual may be proposed/ carried out by the supplier.

3.1.7 Rigid Spacer for jumper for twin HTLS Conductor

a)	Visual Examination	IS 10162
b)	Dimensional Verification	IS 10162

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

3.1.8

Spacer Damper for twin HTLS Conductor

a)	Visual Examination	IS 10162
b)	Dimensional Verification	IS 10162
c)	Movement Test	IS 10162
d)	Resilience Test (if applicable)	IS 10162
e)	Clamp bolt torque test	IS 10162
f)	Assembly Torque test	IS 10162
g)	Chemical analysis of materials	Annexure-A
h)	Clamp slip test	Annexure-A
i)	Vibration Test	Annexure-A
	(i) Vertical Vibration	IS 10162
	(ii) Longitudinal Vibration	IS 10162
	(iii) Sub-span oscillation	IS 10162
j)	Dynamic characteristics test	Annexure-A
k)	Fatigue tests	Annexure-A
l)	Magnetic power loss test (if applicable)	Annexure-A

m)	Compressive and tension Test	Annexure-A
n)	Thermal Profile test	Annexure-A
o)	Corona extinction voltage test (dry) <i>(for 400 kV and above voltage level only)</i>	Annexure-A
p)	Radio interference voltage test (dry) <i>(for 400 kV and above voltage level only)</i>	Annexure-A
q)	Ozone test on elastomer	Clause 7.6.3, IEC 61854
r)	Log decrement test	Annexure-A
s)	Galvanising Test	Annexure-A

3.1.9

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

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

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

In case the tests have been conducted earlier than the above stipulated period or carried out on samples manufactured from any other manufacturing works or in case of revision/ amendment in the provisions/ test procedure of the IS/IEC as referred in the TS or in the event of any discrepancy in the test report (i.e. due to non-inclusion of valid calibration certificate, desired information etc. or any test not applicable due to any design/ material/

manufacturing process change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the supplier at no extra cost to the Purchaser.

3.2 Acceptance Tests

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

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

3.2.2 On Suspension Clamp fitting for HTLS Conductor

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

3.2.3 On Tension Clamp Fitting for HTLS Conductor

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

3.2.4 On Mid Span Compression Joint for HTLS Conductor

a)	Visual examination and dimensional verification	IS 2121 (Part-II), Clause 6.2, 6.3 7 6.7
b)	Chemical analysis of materials	Annexure-A

c)	Galvanising test	Annexure-A
d)	Hardness test	Annexure-B
e)	Ageing test on filler (if applicable)	Annexure-A

3.2.5 On T-Connector for HTLS Conductor

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

3.2.6 On Repair Sleeve for HTLS Conductor

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

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

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

3.2.8 On Vibration Damper for HTLS conductor

a)	Visual examination and dimensional verification	IS 9708

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

3.3 Routine Tests

3.3.1 For Hardware Fittings

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

3.3.2 For conductor accessories

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

3.4 Tests During Manufacture on all components as applicable

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

3.5 Testing Expenses

3.5.1 As indicated in clause 3.1.8 no type test charges shall be payable.

3.5.2 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.

3.5.3 The entire cost of type tests, acceptance and routine tests and tests during manufacturing specified herein shall be treated as included in the quoted Ex- works.

3.5.4 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 material & facilities to be ready for testing the expenses incurred by the Employer's for re-deputation shall be deducted from contract price.

3.5.5 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 testing in India and at least 6 weeks advance in case of testing abroad) of the scheduled date of testing during which the Employer will arrange to depute his representative to be present at the time of carrying out the tests.

3.6 **Sample Batch For Type Testing**

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

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

3.7 **Schedule of Testing and Additional Tests**

3.7.1 The Bidder has to indicate the schedule of following activities in their bids

- (a) Submission of drawing for approval.
- (b) Submission of Quality Assurance programme for approval.
- (c) Offering of material for sample selection for type tests.
- (d) Type testing.

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

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

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

3.8 Test Reports

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

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

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

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

3.9 Inspection

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

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

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

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

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

3.10 Packing and Marking

3.10.1 All material shall be packed in strong and weather resistant wooden

cases/crates. The gross weight of the packing shall not normally exceed 200 Kg to avoid handling problems.

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

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

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

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

main body of the spacer damper for installing spacer damper in correct position.

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

3.11 Standards

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

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

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

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

The standards mentioned above are available from:

Reference Abbreviation	Name and Address

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

ANNEXURE - A

1.0 Tests on Hardware Fittings

1.1 Magnetic Power Loss Test for Suspension Assembly

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

1.2 Mechanical Strength Test of Each Component

Each component shall be subjected to a load equal to the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. The component shall then again be loaded to 50% of UTS and the load shall be further

increased at a steady rate till the specified UTS and held for one minute. No fracture should occur. The applied load shall then be increased until the failing load is reached and the value recorded.

1.3 Mechanical Strength Test of Welded Joint

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

1.4 Slip Strength Test for Suspension Clamp

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

1.5 Heating Cycle Test

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

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

1.6 Slip strength test for dead end assembly

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

1.7 Shore Hardness Test for Elastomer Cushion for AG Suspension Assembly

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

1.8 Proof Load Test

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

1.9 Tests for Forging Casting and Fabricated Hardware

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

test will be as in the Quality Assurance programme.

1.10 Resilience test for armour rod set

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

2.0 Slip Strength Test on Mid Span Compression Joint

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

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

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

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

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

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

2.3 Vibration Damper

(a) Dynamic Characteristics, Test

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

- (i) Force Vs frequency

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

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

Acceptance criteria for vibration damper.

- (i) The above dynamic characteristics test on five dampers shall be conducted.
 - (ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
 - (iii) The above mean reactance response curve should lie within following limits:
 For ACSR Zebra equivalent HTLS Conductor: $0.135 f$ to $0.54 f$ Kg/mm, where f is frequency in Hz.
 For ACSR Panther equivalent HTLS Conductor: $0.0991 f$ to $0.495 f$, where f is frequency in Hz.
 - (iv) The above mean phase angle response curve shall be between 25° to 130° within the frequency range of interest.
 - (v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
 - (vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.
- (b) Vibration Analysis
- The vibration analysis of the HTLS conductor shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be considered for the purpose of analysis: -
- (i) The analysis shall be done for single conductor without armour rods as per the parameters given under clause 2.5.13 of this part of the Specification. The tension corresponding to 25% of UTS of the HTLS conductor shall be taken for a span ranging from 100 m to 1100.
 - (ii) The self-damping factor and flexural stiffness (EI) for HTLS

conductor shall be calculated on the basis of experimental results. The details for experimental analysis with these data should be furnished.

- (iii) The power dissipation curve obtained from Dynamic Characteristics Test shall be used for analysis with damper.
- (iv) Examine the aeolian vibration level of the conductor with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.
- (v) From vibration analysis of conductor without damper, anti-node vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.
- (vi) From vibration analysis of conductor with damper/ dampers installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment points and the antinodes on the conductor shall be determined. In addition to above damper clamp vibration amplitude and anti-node vibration amplitudes shall also be examined.

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

(c) Clamp Slip and Fatigue Tests

(i) Test Set Up

The clamp slip and fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30

m. The conductor shall be tensioned at tension corresponding to 25% of UTS of the HTLS conductor. Constant tension shall be maintained within the span by means of lever arm arrangement. After the conductor has been tensioned, clamps shall be installed to support the conductor at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the conductor. There shall be no loose parts, such as suspension clamps, U-bolts on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control

as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) Clamp Slip test

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

(iii) Fatigue Test

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

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

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

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

After the above tests, the damper shall be removed from conductor and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristic of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose,

or damaged part. There shall not be significant deterioration or wear of the damper. The conductor under clamp shall also be free from any damage.

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

- (1) There shall not be any frequency shift by more than ± 2 Hz for frequencies lower than 15 Hz and ± 3 Hz for frequencies higher than 15 Hz.
- (2) The force response curve shall generally lie within guaranteed % variation in reactance after fatigue test in comparison with that before fatigue test by the Contractor.
- (3) The power dissipation of the damper shall not be less than guaranteed % variation in power dissipation before fatigue test by the Contractor. However, it shall not be less than minimum power dissipation which shall be governed by lower limits of reactance and phase angle indicated in the envelope.

2.4

Spacer/ Spacer Damper

(a) Vibration Tests (for Spacer Damper only)

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

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

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

(i) Longitudinal Vibration Test

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

(ii) Vertical Vibration Test

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

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

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

(iii) Sub-span Oscillation Test

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

b) Clamp Slip Test

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

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

c) Compressive and tensile test

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

d) Dynamic Characteristic Test (for Spacer Damper only)

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

The test will consist in the application of sinusoidal movement of the spacer-damper articulation and measuring the force (F), displacement

(X) and phase angle ($\emptyset$) between these two, from these values, the stiffness (K) and the damping factor (n) will be calculated.

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

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

The test shall be performed on three samples.

e) Fatigue Test (for Spacer Damper only)

The purpose of this test is to evaluate the capacity of the spacer

damper to sustain without damage the cyclic movements which can be induced by vibrations.

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

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

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

f) Log Decrement test (for spacer damper only)

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

The log decrement test shall be made with initial peak to peak amplitude of four to six times the conductor diameter in the middle of the sub-span being considered. The conductor shall be excited in a horizontal one loop per sub-span resonant mode with a slow and steady build up of amplitude that minimises harmonics and other distortions. After achieving a steady state motion, the conductor excitation shall be discontinued leaving the conductor undisturbed. The motion shall be recorded until it reduces to amplitude of half of the conductor diameter. The logarithmic (log) decrement shall be the value for a minimum reduction of 80 % in amplitude. The minimum acceptable log decrement average for

five or more excitation shall be
0.04 based upon the following formula for decay.

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

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

2.5 Magnetic Power Loss Test

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

2.6 Thermal Profile test

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

2.7 Ageing Test on Filler (if applicable)

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

2.8 Corona Extinction Voltage Test (Dry)

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

2.9 Radio Interference Voltage Test (Dry)

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

2.10 Chemical Analysis Test

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

2.11 Galvanising/ Electroplating Test

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

3.0 Tests on All components (As applicable)

3.1 Chemical Analysis of Zinc used for Galvanizing

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

3.2 Tests for Forgings

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

3.3 Tests on Castings

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

ANNEXURE-B

Acceptance Tests

1. Mid Span Compression Joint

(a) Hardness Test

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

2. T-Connector

(a) Axial Tensile Load Test for Welded Portion

Same as clause 2.2 of Annexure-A.

3. Vibration Damper

(a) Verification of Resonance Frequencies

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

(b) Clamp Slip Test

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

(c) Strength of the Messenger Cable

The messenger cable shall be fixed in a suitable tensile testing

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

(d) **Mass Pull off Test**

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

(e) **Dynamic Characteristics Test**

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

- (i) 1 Sample for 1 000 Nos. & below
- (ii) 3 Samples for lot above 1 000 & up to 5000 nos.
- (iii) Additional 1 sample for every additional 1500 pieces abov5000.

The acceptance criteria will be as follows

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

4.

Spacer/ Spacer Damper

(a) **Test Set up**

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

(b) **Compressive and Tensile Test**

The spacer assembly shall withstand ultimate compressive load of 14 kN and tensile load of 7.0 kN applied between sub-conductor bundle and held for one minute without failure. Line distance between clamps

shall be recorded during each of the compression and tension test. Measurement shall be recorded at (i) no load (ii) with load (iii) after release of load. The centre line distance under load shall be within ± 100 mm of the nominal design spacing. After release of load it shall be possible to retain the clamps at their original position using only slight hand pressure. There shall be no deformation or damage to the spacer assembly which would impair its function of maintaining the normal spacing.

(c) **Clamp Slip Test**

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

(d) **Hardness test for Elastomer**

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

(e) **UTS of Retaining Rods**

The ultimate tensile strength of the retaining rods shall be measured. The value shall not be less than 35 kg/mm^2 .

SECTION-VIIA

CONDUCTOR

(Strikeout/Delete whichever is applicable)

**TECHNICAL
SPECIFICATIONS
SECTION-VIIA
CONDUCTOR**

CONTENTS

Clause No.	Description
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Annexure-B4	Standard Technical Particulars for AL59 Conductor

**TECHNICAL
SPECIFICATIONS
SECTION-VIIA
CONDUCTOR**

1. Technical Description of Conductor

1.1 Details of Conductor

1.1.1 The Conductor shall generally conform to IS 398 (relevant part) except where otherwise specified herein.

1.1.2 Standard Technical Particulars

The Standard Technical Particulars (STP) of the ACSR, AACSR, AAAC and AL59 conductors are enclosed at Annexure-B1, B2, B3 and B4 respectively of this section. The values indicated in the STP are the minimum and/or maximum values required to be met by the supplier.

1.2 Workmanship

1.2.1 All the aluminium/ aluminium alloy and/or steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions, etc., after drawing and also after stranding.

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

1.2.3 The steel strands shall be hot dip galvanised and shall have a minimum zinc coating as indicated in the STP for ACSR/ AACSR conductors. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand number of dips in Standard Preece test as indicated in STP. The steel wire rods shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in IS 398 (relevant part) except where otherwise specified herein.

1.2.4 The steel strands shall be pre-formed and post formed in order to prevent spreading of strands in the event of cutting of complete core. Care shall be

taken to avoid, damages to galvanisation during pre-forming and post-forming operation.

1.3 Joints in Wires

1.3.1 Aluminium / Aluminium alloy Wires

1.3.1.1 During stranding, no aluminium/ aluminium alloy wire welds shall be made for the purpose of achieving the required conductor length.

1.3.1.2 No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor.

1.3.1.3 Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand as per STP.

1.3.2 Steel Wires

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

1.4 Tolerances

The manufacturing tolerances to the extent indicated in the STP shall be permitted in the diameter of individual aluminium/ Aluminium alloy and steel strands and lay-ratio of the conductor.

1.5 Materials

1.5.1 Aluminium for ACSR Conductor

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity and copper content as per the values indicated in the STP. They shall have the same properties and characteristics as prescribed in IS 398 (relevant part) except where otherwise specified herein.

1.5.2 Aluminium Alloy for AAAC and AACSR Conductor

The aluminium alloy strands shall be hard drawn from heat treated aluminium alloy redraw rods conforming to type B as per the values indicated in the STP.

They shall have the same properties and characteristics as prescribed in IS 398 (relevant part) except where otherwise specified herein.

The strands shall be of Aluminium-Magnesium-Silicon alloy of electrical conductivity of minimum 53% IACS. The Aluminium alloy wires shall be subjected to artificial aging (precipitation treatment) in order to attain the specified tensile properties and conductivity.

1.5.3 Aluminium Alloy for AL59 Conductor

The wire material shall be an aluminium alloy meeting the requirements as per the values indicated in the STP. They shall have the same properties and characteristics as prescribed in IS 398 (relevant part) except where otherwise specified herein.

1.5.4 Steel for ACSR and AACSR Conductors

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the STP.

The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in as prescribed in IS 398 (relevant part) except where otherwise specified herein.

1.5.5 Zinc

The zinc used for galvanizing shall be electrolytic High-Grade Zinc of purity as indicated in the STP. It shall conform to and satisfy all the requirements of IS 209.

1.6 Standard Length

1.6.1 The standard length of the conductor shall be as indicated in the STP. All lengths outside this limit of tolerance shall be treated as random lengths. Not less than 90% of the total quantity of the conductor shall be supplied in standard lengths.

1.6.2 Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of such random lengths shall not be more than 10% of the total quantity ordered. At any point, the cumulative quantity supplied of such random lengths shall not be more than 12.5% of the total cumulative quantity supplied including such random lengths. However, the last 20% of the quantity ordered shall be supplied only in standard lengths as specified.

1.6.3 However, for AACSR type conductor, the same shall be manufactured & supplied keeping in view tower schedules, section lengths, special crossings etc. and the drum schedules shall be submitted to Employer for review & approval.

1.6.4 The purchaser reserves the right to place orders for the lengths above the standard length on the same terms and conditions applicable for the standard lengths during the pendency of the Contract.

2.0 Tests and Standards

2.1 Type Tests

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

a)	DC resistance test on stranded conductor	Annexure-A
b)	UTS test on stranded conductor	
c)	Corona extinction voltage test (dry) <i>(Applicable for 220 kV or above voltage level only)</i>	
d)	Radio interference voltage test (dry) <i>(Applicable for 220 kV or above voltage level only)</i>	

2.1.1 Type tests specified under Clause 2.1 shall not be required to be carried out if supplier has conducted these tests earlier on the same conductor & same bundle configuration (applicable for tests 'c' & 'd') and valid type test certificates are available. The test certificate shall be considered valid if,

- Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/ IEC vide 25/ 17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of POWERGRID or utility and
- Type test reports contain valid Calibration reports of the relevant testing equipment and information pertaining to ratings, the relevant drawings, model number, test circuit, calculations (if any), photos, acceptance criteria/values specified in Technical Specification/relevant standards (IS/ IEC) and compliance to the same and
- Tests conducted on the samples of conductor manufactured from same manufacturing works within 10 (ten) years as on the date of NOA for the package.

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

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

2.2

Acceptance Tests

a)	Visual and dimensional check on drum	Annexure-A
b)	Visual check for joints, scratches etc. and length measurement of conductor by rewinding	
c)	Measurement of diameters of individual Steel and Aluminium strands	
d)	Check for lay-ratios of various layers	
e)	Galvanizing test on steel strands	
f)	Torsion and Elongation tests on steel strands	
g)	Breaking load test on steel and Aluminium strands	IS 398 (Part 2 or Part 5 as applicable)
h)	Breaking load test & Elongation test on Aluminium Alloy strands	IS 398 (Part 4 or Part 6 as applicable)
i)	Wrap test on Steel & Aluminium strands	IS 398 (Part 2 or Part 5 as applicable)
j)	Wrap test on Aluminium Alloy strands	IS 398 (Part 4 or part 6 as applicable)
k)	DC resistance test on Aluminium strands	Annexure-A
l)	DC resistance test on Aluminium Alloy strands of AAAC/ AACSR conductor	Annexure-A
m)	Resistivity Test on Aluminium Alloy strands of Al59 conductor	IS 398 (Part 6)
n)	Procedure qualification test on welded joint of Aluminium/ Aluminium Alloy strands	Annexure-A
o)	Drum strength test (steel drum)	Annexure-A
p)	Barrel Batten strength test (wooden drum)	Annexure-A

q)	UTS test on stranded conductor	Annexure-A
r)	DC Resistance test on stranded conductor	Annexure-A

Note:

1. All the above tests except (n) shall be carried out on Aluminium and steel strands after stranding only.
2. The tests mentioned at (q) & (r) above shall be carried out after every 3 years for each stranding machine from which samples are offered. These tests shall however, not be required to be carried out till 3 years from the date of type testing for the stranding machine for which valid test certificates are available

2.2.1 The acceptance tests pertaining to conductor only shall be repeated on one conductor sample taken from site in presence of POWERGRID's representative for each 500 km progressive supply or part thereof. The tests shall be carried out by the supplier at his cost at its own premises or any other tests centre having required facilities. The sample shall be selected by POWERGRID's site representative and the tests shall be witnessed by POWERGRID's QA&I representative. In case of evidence of non-compliance, it shall be binding on the part of the supplier to prove compliance of the items to the technical specification by repeat tests, or correction of deficiencies, or replacement of defective items all, without any extra cost to the purchaser.

2.3 Routine Test

a)	Check to ensure that the joints are as per Specification
b)	Check that there are no cuts, fins etc. on the strands
c)	Check that drums are as per Specification
d)	All acceptance test as mentioned above to be carried out on aluminium/ aluminium alloy and steel strands of 20% of drums

2.4 Tests During Manufacture

a)	Chemical analysis of zinc used for galvanizing	Annexure-A
b)	Chemical analysis of Aluminium used for making Aluminium/ Aluminium alloy strands	
c)	Chemical analysis of steel used for making steel strands	

2.5 Testing Expenses

2.5.1 In the event of type testing, bidder shall ensure that adequate facilities are available in the laboratories and the tests can be completed in

these laboratories within the time schedule.

2.5.3 In case of failure in any type test, the supplier is either required to manufacture fresh sample lot and repeat the entire tests successfully once or repeat that particular type test three times successfully on the sample selected from the already manufactured lot at his own expense. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

2.5.4 The entire cost of testing for the type, acceptance, routine tests and tests during manufacture specified herein shall be treated as included in the quoted unit price of conductor, except for the expenses of the inspector/purchaser's representative.

2.5.5 In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of inspector/purchaser's representative shall be to the supplier's account. Also, if on receipt of the supplier's notice of testing, the purchaser's representative does not find the test samples or testing facilities/equipment ready for testing, the expenses incurred by the purchaser for re-deputation shall be to the supplier's account.

2.6 Additional Tests

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

2.6.2 The purchaser also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at supplier's premises or at any other test center. In case of evidence of non-compliance, it shall be binding on the part of supplier 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 purchaser.

2.7 Sample Batch for Type Testing

2.7.1 In case the type tests are required to be carried out, the samples for type testing shall be manufactured in accordance with the Standard Manufacturing Quality Plan.

2.7.2 The supplier shall offer at least three drums for selection of sample required for conducting all the type tests.

2.7.3 The supplier is required to carry out all the acceptance tests successfully in presence of purchaser's representative before sample selection.

2.8 Test Reports

- 2.8.1 In case type tests have been carried out earlier by the supplier and valid type test reports are available as specified in clause 2.1.1 above, the supplier shall submit one copy of the test report along with approval letter issued by POWERGRID or utility.
- 2.8.2 In case fresh type tests have been carried out under the package, the type test reports shall be furnished in original along with two copies. One copy will be returned duly certified by the purchaser.
- 2.8.2 The commercial production of the conductor can be taken up by the supplier after clearance from the purchaser.
- 2.8.3 Record of routine test reports shall be maintained by the supplier at his works for periodic inspection by the purchaser's representative.
- 2.8.4 Test Certificates of tests during manufacture shall be maintained by the supplier. These shall be produced for verification as and when desired by the purchaser.

2.9 Inspection

- 2.9.1 The purchaser's representative/PGCIL shall at all times be entitled to have access to the works and all places of manufacture, where conductor shall be manufactured and representative shall have full facilities for unrestricted inspection of the supplier's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.
- 2.9.2 The supplier shall keep the purchaser informed in advance of the time of starting and of the progress of manufacture of conductor in its various stages so that arrangements can be made for inspection.
- 2.9.3 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the purchaser in writing. In the latter case also, the conductor shall be dispatched only after satisfactory testing for all tests specified herein have been completed.
- 2.9.4 The acceptance of any quantity of material shall in no way absolve the supplier of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection if such material is later found to be defective.

2.10 Test Facilities

- 2.10.1 The following test facilities shall be available at the supplier's works:
- a) Various testing and measuring equipment for carrying out specified

acceptance tests, routine tests and tests during manufacture inter alia including tensile testing machine, resistance measurement facilities, torsion & wrap testing machine, dimension checking instruments viz. digital Vernier and micrometer etc., galvanizing test instruments viz. digital electrometer and standard preece test etc., burette, digital thermometer, barometer etc.

b) Digital mili/micro ohm meter along with standard resistance for calibration of resistance bridges.

c) Spectrometer, if supplier has its own properzi mill

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

2.11 Packing

2.11.1 The conductor shall be supplied in returnable, painted steel drums of adequate strength, constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The supplier shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.

2.11.2 One standard length shall be wound on each drum. The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5 KN.

2.11.3 The standard drawing of the drum for ACSR, AAAC and AL59 types of conductors is enclosed with the specification. The Bidder shall supply the conductor in the drum conforming to the specification drawing. After preparation of steel surface according to IS 9954, synthetic enamel paint shall be applied after application of one coat of primer.

~~2.11.4 The ownership of the empty conductor drums shall lie with the conductor supplier who shall ultimately take back the empty conductor drums from the erection contractor's designated stores at project site(s) after the running out of conductor from the drums.~~

~~2.11.5 The erection contractor shall intimate the conductor supplier and employer regarding empty steel drums at their designated stores. Necessary coordination for taking back the empty steel drums in this regard shall be done by the conductor supplier with the erection contractor.~~

~~2.11.6 The empty drums shall be taken back by the conductor supplier from the stores of erection contractor as & when these are available after usage~~

~~of conductor. Conductor supplier shall be required to take back the empty steel drum within a period of one month from date of information by erection contractor regarding availability of the drums at erection contractor stores. However, 2% of the total drums shall not be returned to the conductor supplier as these may be used for storage of spare conductor by the purchaser.~~

~~2.11.7 The steel drums may get damaged and/ or wear & tear during transportation, normal handling & operation at site, which shall be rectified by the conductor supplier before re-use. However, 2% of the total drums shall not be returned on account of damages / wastage for which no compensation will be payable. The wastage beyond 2% shall be reimbursed by erection contractor. Thus, 4% of total drums shall not be returnable to the conductor supplier.~~

2.11.8 Solid Polypropylene sheet of minimum 5mm thickness shall be used for outer covering of conductor. Outside the covering, there shall be minimum two binders consisting of hoop iron/galvanised steel wire. Two numbers of additional binders per drum shall also be supplied for re-wrapping the polypropylene sheet with each lot of conductor and 5 nos. crimping machines with the first lot of conductor for crimping the binders at site. As an alternative, supplier may use wooden lagging of minimum 50 mm thickness for outer covering of conductor without any extra financial implication to the purchaser.

2.11.9 As an alternative to returnable steel drum, bidder may supply the conductor in non-returnable wooden drums. However, for bid evaluation purpose, both types of drums shall be treated at par .

2.11.10 The standard drawing of the wooden drum for ACSR, AAAC and AL59 types of conductors is also enclosed with the specification. The Bidder shall supply the conductor in the drum conforming to the specification drawing.

2.11.11 The wooden drums shall generally conform to IS 1778, except as otherwise specified hereinafter. All wooden components shall be manufactured out of seasoned soft wood, free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the conductor. Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts. Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The nails shall not protrude above the general surface and shall not have exposed sharp edges or allow the battens to be released due to corrosion.

2.11.12 Before reeling, card board or double corrugated or thick bituminized water- proof bamboo paper shall be secured to the drum barrel and

inside of flanges of the drum by means of a suitable commercial adhesive material over which HDPE sheet to be provided. In case of steel drum, for securing HDPE sheet onto the bamboo paper & drum flanges, the HDPE sheet shall be secured onto the drum by means of a commercial adhesive/self-locking nylon cable zip ties such that there is no protrusion above the general surface that may cause damage to the conductor strands. After reeling the conductor, the exposed surface of the outer layer of conductor shall be wrapped with thick plastic sheet secured using adhesive tapes to preserve the conductor from ingress of water, dirt, grit and damages during storage, transport and handling. Medium grade craft/ crepe/polythene paper shall be used in between the layers of conductor.

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

2.12 Marking

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

- (a) Contract/Specification number.
- (b) Name and address of the consignee.
- (c) Manufacturer's name and address.
- (d) Drum number
- (e) Size of conductor
- (f) Length of conductor in meters
- (g) Arrow marking for unwinding
- (h) Position of the conductor end (For Wooden Drums only)
- (i) Number of turns in the outer most layer.
- (j) Gross weight of the drum (with protective lagging in case of wooden drums) including conductor.
- (k) Weight of empty drum (with protective lagging in case of wooden drums).
- (l) Net weight of the conductor in the drum.
- (m) CIP No.

The above should be indicated in the packing list also. To accommodate the above details, conductor manufacturer may suitably design the plate size larger than that specified in the standard drum drawing, if required.

2.13 Verification of Conductor Length

The purchaser reserves the right to verify the length of conductor after

unreeling. The quantity for verification shall be between a minimum of five percent (5%) to a maximum of ten percent (10%) in a lot offered for inspection. The actual quantity will be discussed and mutually agreed to by the supplier & purchaser.

2.14 Standards

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

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

Sl. No.	Indian Standard	Title
1	IS 209	Specification for zinc
2	IS 398 (Part 1)	Specification for Aluminium Conductors for Overhead Transmission Purposes
3	IS 398 (Part 2)	Aluminum Conductor Galvanised Steel Reinforced
3	IS 398 (Part 4)	All Aluminum Alloy Conductor
4	IS 398 (Part 5)	Aluminum Conductor Galvanised Steel-Reinforced for Extra High Voltage (400 KV) and above
5	IS 398 (Part 6)	Aluminium Conductors for Overhead Transmission Purposes High Conductivity Aluminum Alloy Stranded Conductors —Specification
6	IS 1778	Reels and Drums for Bare Conductors
7	IS 1521	Method of Tensile Testing of Steel Wire
8	IS 2629	Recommended Practice for Hot Dip Galvanising of Iron and Steel
9	IS 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles
10	IS 4826	Galvanised Coating on Round Steel Wires
11	IS 6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and steel articles
12	IS 8263	Method of Radio Interference Tests on High Voltage Insulators

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BIS/IS	Bureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001 INDIA

Annexure-A

1 DC Resistance Test on Stranded Conductor

On a conductor sample of minimum 5m length two contact-clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge or digital ohm-metre of sufficient accuracy by placing the clamps initially zero metre and subsequently one metre apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20°C as per IS 398. The test results shall conform to the requirements specified in the STP.

2 UTS Test on Stranded Conductor

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample of conductor of minimum 5 m length between fixing arrangement suitably fixed on a tensile testing machine. The load shall be increased at a steady rate upto 50% of minimum specified UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall be increased at steady rate to 100% of the UTS of conductor and held for one minute. The Conductor sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and this value shall be recorded.

3 Corona Extinction Voltage Test

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

Line Configuration	No of conductor s per Bundle	Sub-conducto r Spacing (mm)	Maximum Height of the conductor above ground (m)	Minimum Corona extinction voltage (kV)
220 kV	1	NA	7	154
400 kV with twin bundle conductor	2	450	8.84	320
400 kV with Triple bundle conductor	3	457	8.84	320

400 kV with Quad bundle conductor	4	457	8.84	320
765 kV with Quad bundle conductor	4	457	15	510
765 kV with Hexa bundle conductor	6	457	15	510
± 500 kV HVDC Bipole line with Quad bundle conductor	4	457	12.5 *	550
± 800 kV HVDC Bipole line with Hexa bundle conductor	6	457	18 *	880

* Height shall be suitably adjusted so as to achieve a surface gradient of 22 kV/cm on the conductors.

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

4 Radio Interference Voltage Test

Under the conditions as specified under (1.2) above, the conductor samples shall have radio interference voltage below 1000 microvolts at one MHz when subjected to 50HZ AC Voltage (line to ground under dry conditions) as per following table:

Line Voltage	Applicable Voltage for RIV test (kV)
220 kV	154
400 kV	305
765 kV	510
± 500 kV HVDC Bipole line with Quad bundle conductor	550
± 800 kV HVDC Bipole line with Hexa bundle conductor	880

This test may be carried out with corona control rings and arcing horns. The test procedure shall be in accordance with IEC-60437.

5 Visual and Dimensional Check on Drums

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this Specification.

6 Visual Check for Joints, Scratches etc. and length measurement of conductor by rewinding

Conductor drums shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and that the conductor generally conform to the requirements of this Specification.

7 Measurement of diameters of individual Steel and Aluminium/ Aluminium alloy strands

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

8 Check for Lay-ratios of Various Layers

The lay-ratios of various layers shall be checked to ensure that they conform to the requirements of this Specification.

9 Galvanizing Test

The test procedure shall be as specified in IS 398. The material shall conform to the requirements of this Specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

10 Torsion and Elongation Tests on Steel Strands

The test procedures shall be as per IS 398. In torsion test, the number of complete twists before fracture shall not be less than that indicated in the STP. In case test sample length is less or more than 100 times the stranded diameter of the strand, the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number. In elongation test, the elongation of the strand, for a gauge length of 250 mm after stranding, shall not be less than the value specified in STP.

11 DC resistance test on Aluminium strands

DC resistance test on individual strands (after stranding) shall be done as per test procedure specified in IS 398 (part 2 or part 5 as applicable). The measured resistance value corrected at 20°C shall conform to the value specified in STP.

12 DC resistance test on Aluminium Alloy strands of AAAC/ AACSR conductor

DC resistance test on individual strands (after stranding) shall be done as per test procedure specified in IS 398 (part 4). The measured resistance value corrected at 20°C shall conform to the value specified in STP.

13 Procedure Qualification test on welded Aluminium/ Aluminium alloy

Two Aluminium/ Aluminium alloy wire shall be welded as per the standard quality plan and shall be subjected to tensile load. The breaking strength of the welded joint of the wire shall not be less than the breaking strength of

individual strands.

14 Drum Strength Test (Steel Drum)

The test shall be conducted as per IS 15976 on one drum of each lot offered for inspection with one standard length of conductor wound on the drum.

15 Barrel Batten Strength Test (Wooden Drum)

The test shall be conducted as per IS 1778 on one drum of each lot offered for inspection. Barrel batten strength shall not be less than 300 Kg.

16 Chemical Analysis of Zinc

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

17 Chemical Analysis of Aluminium/ Aluminium Alloy

Samples taken from the aluminium/ Aluminium alloy ingots/rods shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in the Specification.

18 Chemical Analysis of Steel

Samples taken from the steel rods shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in the Specification.

Standard Technical Particulars for ACSR Conductors

Sl. No.	Description	Unit	Standard Technical Particulars					
			ACSR LAPWING	ACSR BERSIMIS	ACSR SNO WBIRD	ACSR MOOSE	ACSR ZEBRA	ACSR PANTHER
1.0	Construction							
1.1	Stranding and wire diameter							
a)	Aluminium wire		45/4.78 mm	42/4.57 mm	42/3.99 mm	54/3.53 mm	54/3.18 mm	30/3.00 mm
b)	Steel wire		7/3.18 mm	7/2.54 mm	7/2.21 mm	7/3.53 mm	7/3.18 mm	7/3.00 mm
1.2	Layer & no. of wire							
a)	Steel core		1	1	1	1	1	1
b)	1 st steel layer		6	6	6	6	6	6
c)	1 st Aluminium alloy layer		9	8	8	12	12	12
d)	2 nd Aluminium alloy layer		15	14	14	18	18	18
e)	3 rd Aluminum alloy layer		21	20	20	24	24	NA
2.0	Raw Materials							
2.1	Aluminium							
a)	Minimum purity of Aluminium	%	99.50					
b)	Maximum copper content	%	0.04					
2.2	Steel wires/ rods							
a)	Carbon	%	0.50 to 0.85					

Sl. No.	Description	Unit	Standard Technical Particulars					
			ACSR LAPWING	ACSR BERSIMIS	ACSR SNOWBIRD	ACSR MOOSE	ACSR ZEBRA	ACSR PANTHER
b)	Manganese	%	0.50 to 1.10					
c)	Phosphorous	%	Not more than 0.035					
d)	Sulphur	%	Not more than 0.045					
e)	Silicon	%	0.10 to 0.35 (Max.)					
2.3	Zinc							
a)	Minimum purity of Zinc	%	99.95					
3.0	Aluminum strands after stranding							
3.1	Diameter							
a)	Nominal	mm	4.78	4.57	3.99	3.53	3.18	3.00
b)	Maximum	mm	4.81	4.60	4.02	3.55	3.20	3.02
c)	Minimum	mm	4.75	4.54	3.96	3.51	3.16	2.98
3.2	Minimum breaking load of strand							
a)	Before stranding	KN	2.87	2.64	2.12	1.57	1.29	1.17
b)	After stranding	KN	2.73	2.51	2.02	1.49	1.23	1.11
3.3	Max. resistance of 1 m length of strand at 20°C	Ohm	0.001595	0.001746	0.002295	0.002921	0.003604	0.004053
4.0	Steel strand after stranding							
4.1	Diameter							
a)	Nominal	mm	3.18	2.54	2.21	3.53	3.18	3.00

Sl. No.	Description	Unit	Standard Technical Particulars					
			ACSR LAPWING	ACSR BERSIMIS	ACSR SNOWBIRD	ACSR MOOSE	ACSR ZEBRA	ACSR PANTHER
b)	Maximum	mm	3.24	2.59	2.25	3.59	3.24	3.06
c)	Minimum	mm	3.12	2.49	2.17	3.47	3.12	2.94
4.2	Minimum breaking load of strand							
a)	Before stranding	KN	10.43	6.87	4.74	12.86	10.43	9.29
b)	After stranding	KN	9.91	6.53	4.49	12.22	9.91	8.83
4.3	Galvanising							
a)	Minimum weight of zinc coating per Sqm	gm	250	230	230	250	250	240
b)	Minimum number of dips that the galvanised strand can with stand in the standard preece test	Nos.	2 of one minute & 1 of half minute	2 of one minute	2 of one minute & 1 of half minute			
c)	Min. No. of twists in gauge length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)	Nos	16	16	16	16	16	16
d)	Min. elongation of the steel strand (after stranding) for a gauge length of 250 mm (after break)	%	3.5	3.5	3.5	3.5	3.5	3.5
5.0	Stranded Conductor							
5.1	Overall diameter	mm	38.22	35.04	30.57	31.77	28.62	21.00
5.2	Sectional area of Aluminium	sq. mm	807.5	688.9	525.2	528.5	428.9	212.1

Sl. No.	Description	Unit	Standard Technical Particulars											
			ACSR LAPWING		ACSR BERSIMIS		ACSR SNOWBIRD		ACSR MOOSE		ACSR ZEBRA		ACSR PANTHER	
5.3	Total sectional area	sq. mm	863.1		724.4		552.1		597.0		484.5		261.5	
5.4	Minimum UTS of the conductor	kN	188.0		154.0		118.0		161.20		130.32		89.67	
5.5	Lay ratio of outer steel & Aluminium layer		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
a)	1 st steel layer	mm	30	18	24	16	24	16	18	16	18	13	28	16
b)	1 st Aluminium layer	mm	17	10	16	10	16	10	14	12	17	10	16	10
c)	2 nd Aluminium layer	mm	16	10	16	10	16	10	13	11	16	10	14	10
d)	3 rd Aluminum layer	mm	13	10	13	10	14	10	12	10	14	10	NA	NA
5.6	Maximum DC resistance of the conductor at 20°C	ohm/km	0.0358		0.04242		0.05516		0.05552		0.06868		0.1390	
5.7	Standard length of the conductor	m	1800		2100		2100		2100		2200		2300	
5.8	Tolerance on Standard length	%	± 5											
5.9	Direction of lay of outer layer		Right Hand											
5.10	Linear mass of the conductor													
a)	Standard	kg/km	2667		2181		1657		2004		1621		974	
b)	Minimum	kg/km	2628		2142		1632		1969		1589		954	
	Maximum	kg/km	2707		2221		1682		2040		1653		993	

Annexure-B2

Standard Technical Particulars for AACSR Conductors

Sl. No.	Description	Unit	Standard Technical Particulars					
			AACSR LAPWING	AACSR BERSIMIS	AACSR SNOWBIRD	AACSR MOOSE	AACSR ZEBRA	AACSR Earthwire
1.0	Construction							
1.1	Stranding and wire diameter							
a)	Aluminium Alloy wire		45/4.78 mm	42/4.57 mm	42/3.99 mm	54/3.53 mm	54/3.18 mm	16/2.86 mm
b)	Steel wire		7/3.18 mm	7/2.54 mm	7/2.21 mm	7/3.53 mm	7/3.18 mm	19/2.48 mm
1.2	Layer & no. of wire							
a)	Steel core		1	1	1	1	1	1
b)	1 st steel layer		6	6	6	6	6	6
c)	2 nd steel layer		NA	NA	NA	NA	NA	12
d)	1 st Aluminium alloy layer		9	8	8	12	12	16
e)	2 nd Aluminium alloy layer		15	14	14	18	18	NA
f)	3 rd Aluminum alloy layer		21	20	20	24	24	NA
2.0	Raw Materials							
2.1	Aluminium alloy							
a)	Silicon	%	0.50-0.90					

Sl. No.	Description	Unit	Standard Technical Particulars					
			AACSR LAPWING	AACSR BERSIMIS	AACSR SNOWBIRD	AACSR MOOSE	AACSR ZEBRA	AACSR Earthwire
b)	Magnesium	%	0.60-0.90					
c)	Iron	%	0.50 (Max)					
d)	Copper	%	0.10 (Max)					
e)	Manganese	%	0.03 (Max)					
f)	Chromium	%	0.03 (Max)					
g)	Zinc	%	0.10 (Max)					
h)	Boron	%	0.06 (Max)					
i)	Other element (each)	%	0.03 (Max)					
j)	Other element (Total)	%	0.10 (Max)					
k)	Aluminium	%	Remainder					
2.2	Steel wire/ rod							
a)	Carbon	%	0.50-0.85					
b)	Manganese	%	0.50-1.10					
c)	Phosphorous	%	Not more than 0.035					
d)	Sulphur	%	Not more than 0.045					
e)	Silicon	%	0.10 to 0.35 (Max.)					
2.3	Zinc							
a)	Minimum purity of Zinc	.%	99.95					
3.0	Aluminum alloy strands after stranding							

Sl. No.	Description	Unit	Standard Technical Particulars					
			AACSR LAPWING	AACSR BERSIMIS	AACSR SNOWBIRD	AACSR MOOSE	AACSR ZEBRA	AACSR Earthwire
3.1	Diameter							
a)	Nominal	mm	4.78	4.57	3.99	3.53	3.18	2.86
b)	Maximum	mm	4.81	4.61	4.03	3.55	3.20	2.89
c)	Minimum	mm	4.75	4.53	3.95	3.51	3.16	2.83
3.2	Minimum breaking load of strand							
a)	Before stranding	KN	5.54	5.07	3.88	3.02	2.46	1.98
b)	After stranding	KN	5.27	4.82	3.68	2.87	2.34	1.88
3.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.001868	0.002034	0.00265	0.003388	0.004175	0.005167
4.0	Steel strands after stranding							
4.1	Diameter							
a)	Nominal	mm	3.18	2.54	2.21	3.53	3.18	2.48
b)	Maximum	mm	3.24	2.57	2.25	3.59	3.24	2.53
c)	Minimum	mm	3.12	2.51	2.17	3.49	3.12	2.43
4.2	Minimum breaking load of strand							
a)	Before stranding	KN	10.43	6.87	5.04	12.86	10.43	6.63
b)	After stranding	KN	9.91	6.53	4.79	12.22	9.91	6.30
4.3	Galvanising							

Sl. No.	Description	Unit	Standard Technical Particulars													
			AACSR LAPWING		AACSR BERSIMIS		AACSR SNOWBIRD		AACSR MOOSE		AACSR ZEBRA		AACSR Earthwire			
a)	Minimum weight of zinc coating per sqm.	gm	250		220		230		250		240		220			
b)	Minimum number of dips that the galvanised strand can with stand in the standard preece test	Nos.	2 of one minute & 1 of half minute		2 of one minute		2 of one minute & 1 of half minute						2 of one minute			
c)	Min. No. of twists in gauge length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)	Nos	16													
d)	Min. elongation of the steel strand (after stranding) for a gauge length of 250 mm (after break)	%	3.5													
5.0	Stranded Conductor															
5.1	Overall diameter	mm	38.22		35.04		30.57		31.77		28.62		18.12			
5.2	Sectional area of Aluminium alloy	sq. mm	807.5		689.5		525.2		528.5		428.9		102.8			
5.3	Total sectional area	sq. mm	863.1		725.0		552.1		597.0		484.5		194.6			
5.4	Minimum UTS of the conductor	kN	289.1		232		178.2		224.64		181.5		143.22			
5.5	Lay ratio of outer steel & Aluminium alloy layer		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min		
a)	1 st Steel layer	mm	30	18	24	16	18	16	18	16	18	16	28	18		

Sl. No.	Description	Unit	Standard Technical Particulars											
			AACSR LAPWING		AACSR BERSIMIS		AACSR SNOWBIRD		AACSR MOOSE		AACSR ZEBRA		AACSR Earthwire	
b)	2 nd Steel layer		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	24	16
c)	1 st Aluminium alloy layer	mm	17	10	17	12	14	12	14	12	14	12	14	10
d)	2 nd Aluminium alloy layer	mm	16	10	16	10	13	11	13	11	13	11	NA	NA
e)	3 rd Aluminum alloy layer	mm	13	10	13	10	12	10	12	10	12	10	NA	NA
4.5	Maximum DC resistance of the conductor at 20°C	ohm/km	0.0414		0.0481		0.060		0.0624		0.07689		0.3291	
4.6	Direction of lay of outer layer		Right Hand											
4.7	Linear mass of the conductor													
a)	Standard	kg/km	2663		2181		1655		1996		1621		1005	
b)	Minimum	kg/km	2619		2142		1634		1963		1589		980	
c)	Maximum	kg/km	2708		2221		1684		2032		1653		1030	

Annexure-B3

Standard Technical Particulars for AAAC Conductors

Sl. No.	Description	Unit	Standard Technical Particulars		
			AAAC MOOSE	AAAC ZEBRA	AAAC PANTHER
1.0	Construction				
1.1	Stranding and wire diameter				
a)	Aluminium Alloy wire		61/3.55 mm	61/3.19 mm	37/3.15 mm
1.2	Layer & no. of wire				
a)	Aluminium alloy core		1	1	1
b)	1 st Aluminium alloy layer		6	6	6
c)	2 nd Aluminium alloy layer		12	12	12
d)	3 rd Aluminum alloy layer		18	18	18
e)	4 th Aluminium alloy layer		24	24	NA
2.0	Raw Materials				
2.1	Aluminium alloy				
a)	Silicon	%	0.50-0.90		
b)	Magnesium	%	0.60-0.90		
c)	Iron	%	0.50 (Max)		
d)	Copper	%	0.10 (Max)		
e)	Manganese	%	0.03 (Max)		
f)	Chromium	%	0.03 (Max)		
g)	Zinc	%	0.10 (Max)		
h)	Boron	%	0.06 (Max)		
i)	Other element (each)	%	0.03 (Max)		
j)	Other element (Total)	%	0.10 (Max)		
k)	Aluminium	%	Remainder		
3.0	Aluminum alloy strands after Stranding				
3.1	Diameter				
a)	Nominal	mm	3.55	3.19	3.15
b)	Maximum	mm	3.59	3.22	3.18
c)	Minimum	mm	3.51	3.16	3.12
3.2	Minimum breaking load of strand				

Sl. No.	Description	Unit	Standard Technical Particulars					
			AAAC MOOSE		AAAC ZEBRA		AAAC PANTHER	
a)	Before stranding	KN	2.92		2.47		2.41	
b)	After stranding	KN	2.77		2.35		2.29	
3.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.003362		0.004103		0.00429	
4.0	Stranded Conductor							
4.1	Overall diameter	mm	31.95		28.71		22.05	
4.2	Total sectional area	sq. mm	604		487.5		288.3	
4.3	Minimum UTS of the conductor	kN	159.80		135.6		84.71	
4.4	Lay ratio of aluminium alloy layer		Max	Min	Max	Min	Max	Min
a)	1 st Aluminium alloy layer	mm	17	10	17	10	17	10
b)	2 nd Aluminium alloy layer	mm	16	10	16	10	16	10
c)	3 rd Aluminum alloy layer	mm	15	10	15	10	14	10
d)	4 th Aluminium alloy layer	mm	14	10	14	10	NA	NA
4.5	Maximum DC resistance of the conductor at 20°C	ohm/km	0.05506		0.06815		0.1182	
4.6	Standard length of the conductor	m	2100		2200		2300	
4.7	Tolerance on Standard length	%	± 5					
4.8	Direction of lay of outer layer		Right Hand					
4.9	Linear mass of the conductor							
a)	Standard	kg/km	1666		1345		795	
b)	Minimum	kg/km	1632		1318		778	
c)	Maximum	Kg/km	1699		1371		809	

Annexure-B4

Standard Technical Particulars for AL59 Conductors

Sl. No.	Description	Unit	Standard Technical Particulars					
			AL59 MOOSE		AL59 ZEBRA		AL59 PANTHER	
1.0	Construction							
1.1	Stranding and wire diameter							
a)	Aluminium Alloy wire		61/3.31 mm		61/3.08 mm		37/3.08 mm	
1.2	Layer & no. of wire							
a)	Aluminium alloy core		1		1		1	
b)	1 st Aluminium alloy layer		6		6		6	
c)	2 nd Aluminium alloy layer		12		12		12	
d)	3 rd Aluminum alloy layer		18		18		18	
e)	4 th Aluminium alloy layer		24		24		NA	
2.0	Aluminum alloy strands after Stranding							
2.1	Diameter							
a)	Nominal	mm	3.31		3.08		3.08	
b)	Maximum	mm	3.34		3.11		3.11	
c)	Minimum	mm	3.28		3.05		3.05	
2.2	Minimum breaking load of strand							
a)	Before stranding	KN	2.15		1.86		1.86	
b)	After stranding	KN	2.04		1.77		1.77	
2.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.003376		0.003899		0.003899	
2.4	Minimum Elongation on 250 mm (Before & after stranding)	%	2		2		2	
3.0	Stranded Conductor							
3.1	Overall diameter	mm	29.79		27.72		21.56	
3.2	Total sectional area	sq. mm	525		454		276	
3.3	Minimum UTS of the conductor	kN	124.70		108.00		65.47	
3.4	Lay ratio of Aluminium alloy layer		Max	Min	Max	Min	Max	Min
a)	1 st Aluminium alloy layer	mm	17	10	17	10	17	10
b)	2 nd Aluminium alloy layer	mm	16	10	16	10	16	10
c)	3 rd Aluminum alloy layer	mm	15	10	15	10	14	10

Sl. No.	Description	Unit	Standard Technical Particulars					
			AL59 MOOSE		AL59 ZEBRA		AL59 PANTHER	
d)	4 th Aluminium alloy layer	mm	14	10	14	10	NA	NA
3.5	Maximum DC resistance of the conductor at 20°C	ohm/km	0.0566		0.0653		0.1075	
3.6	Standard length of the conductor	m	2100		2200		2300	
3.7	Tolerance on Standard length	%	± 5					
3.8	Direction of lay of outer layer		Right Hand					
3.9	Linear mass of the conductor							
a)	Standard	kg/km	1449		1254		759	
b)	Minimum	kg/km	1420		1229		744	
c)	Maximum	kg/km	1478		1279		774	

SECTION-VII B

HTLS CONDUCTOR

**TECHNICAL
SPECIFICATIONS
SECTION-VII B
HTLS CONDUCTOR**

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**TECHNICAL
SPECIFICATIONS
SECTION-VII B
HTLS CONDUCTOR**

1.0 Description of High Temperature Low Sag (HTLS) Conductor and its Technical Requirements

The offered HTLS Conductor shall be capable of providing the specified ampacity at a continuous operating conductor temperature not exceeding the maximum permissible operating temperature of the offered HTLS Conductor and without exceeding the level of maximum permissible sag as specified in Section-I. The physical and operating performance requirements of the transmission line with HTLS conductor are mentioned below. The bidder shall offer HTLS conductor complying with these specified requirements. The Bidder shall indicate technical particulars and details of construction of the proposed conductor in the relevant GTP schedule of BPS. During detailed engineering stage, the contractor shall submit detailed calculation in support of the various parameter quoted by them in the Guaranteed Technical Particulars and the same shall be verified to establish compliance with the specified requirements i.e. Current Carrying Capacity, DC/AC Resistance, Physical dimensional, Sag-Tension etc. In case any changes are required in the design of HTLS conductors to comply with the stipulated requirement of the technical specification during detailed engineering, the same shall be carried out without any extra cost to Employer.

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

1.1 Physical Requirements

Physical dimensions i.e. overall diameter and mass of complete conductor shall be as specified in Section- I. Direction of lay of outer layer shall be right hand.

1.2 Operating performance requirements

1.2.1 The design of HTLS conductor shall be suitable for operation at a steady state conductor temperature experienced for a conductor/ sub-conductor AC current flow as specified in the section- I under the ambient conditions based on ampacity calculations mentioned in clause 1.4.

1.2.2 The HTLS conductor shall be suitable for continuous operation without any deterioration of its electrical, mechanical & metallurgical properties up to the maximum permissible conductor temperature guaranteed by the bidder in the GTP Schedule. However, the maximum permissible conductor temperature for continuous operation shall not be considered more than 210⁰ C.

1.2.3 Maximum permissible conductor temperature for short term operations including permissible duration of such short-term operation shall also be furnished by the bidder in the GTP Schedule.

1.2.4 The UTS of conductor declared in the GTP Schedule shall be guaranteed UTS of conductor at room temperature. Further, UTS of conductor achieved at elevated temperature (i.e. at the designed maximum steady state conductor temperature corresponding to the specified ampacity) shall not be less than 70% of UTS declared in the GTP.

1.3 Sag-Tension Requirements

1.3.1 Sag of the offered HTLS conductor at designed maximum temperature (i.e. the conductor surface temperature corresponding to the specified current per conductor/ sub-conductor under ambient conditions specified at 1.4) should not be more than that specified in Section- I. Sag of the offered HTLS conductor at minimum temperature shall not be less than the minimum values specified in section-I.

1.3.2 Tension shall not exceed the maximum limit in all sag tension conditions specified in Section-I.

1.3.3 For the purpose of design calculations for GAP type HTLS conductor, temperature at everyday condition as specified in Section-I shall be considered as knee point temperature.

1.4 Current Carrying Capacity /Ampacity Requirements

The offered HTLS conductor shall be suitable to carry minimum specified Amperes of 50 Hz alternating current under the ambient conditions specified below & maximum conductor sag as specified in Section-I while satisfying other specified technical requirements/ parameters: -

Ambient Conditions	Parameter
Elevation above sea level	0 meter
Ambient temperature	45 ⁰ C
Solar absorption coefficient	0.8
Solar Radiation	1045 watt/sqm
Emissivity Constant	0.45
Wind velocity considering angle between wind & axis of conductor as 90 degrees	0.56 m/sec
Effective angle of incidence of sun's rays	90 ⁰

The calculations for Ampacity shall generally be based on IEEE Standard 738-2012 in SI units except otherwise specified herein.

For calculation of the radial temperature gradient within the conductor, effective thermal conductivity (kth) shall be considered as 1 watt/m-°C. Further, conductor sag at designed maximum temperature shall be calculated considering

temperature of core corresponding to the designed maximum temperature of conductor, irrespective of the magnitude of radial temperature gradient.

AC resistance of the offered HTLS conductor shall be calculated on the basis of *Chapter-2, EPRI AC Transmission Line Reference Book - 200 kV and Above* or the method specified below:

$R_{ac} = R_{dc} \times (1 + 0.00519 \times (mr)^n \times k_1 + k_2)$ where,

$mr = 0.3544938 / (R_{dc})^{1/2}$

if $mr < 2.8$, then $n = 4 - 0.0616 + 0.0896 \times mr - 0.0513 \times (mr)^2$

if $mr > 2.8 < 5.0$, then $n = 4 + 0.5363 - 0.2949 \times mr + 0.0097 \times (mr)^2$

$k_1 = \{\cos(90(d/D)^p)\}^{12.35}$ where,

$p = 0.7 + 0.11 \times mr - 0.04 \times mr^2 + 0.0094 \times mr^3$

$k_2 =$

- 0.15 for single aluminium layer HTLS conductor
- = 0.03 for three aluminium layer HTLS conductor
- = 0.003 for two or four aluminium layer HTLS conductor
- = 0 for composite core type HTLS conductor where,

$D =$ conductor outer diameter in metres $d =$ conductor inner

diameter in metres

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

1.5 Sag Tension calculations

1.5.1 Sag-Tension calculations for the offered HTLS conductor can be carried out by using PLSCAD. Following values shall be considered for the purpose of sag- tension calculations: -

- (i) Final values of modulus of elasticity of Aluminium/ Aluminium Alloy/ Core, Coefficient of Linear Expansion of Aluminium/ Aluminium Alloy/ Core, Stress-Strain coefficients & Creep coefficients of aluminium/ aluminium alloy / core in the cable data (.wir file) used for calculation of sag in PLSCAD shall be based on either of the following: -
 - a) Existing '.wir' files for offered conductor as available on PLS website.
 - b) A file derived from existing standard file for conductor of equivalent/ near equivalent stranding.
 - c) A file derived from type test conducted on conductor of same stranding.

In each of the above cases, proper justification in the form of test reports/ calculations/ print out of '.wir' file as available on PLS website, etc. shall be required to be submitted during detailed engineering.

- (ii) PLSCAD Sagging criteria/ conditions shall be based on the sag tension limits specified in Section-I and shall be carried out in a

manner that the specified sag-tension limits are met in “After Creep” as well as in “After Load” condition.

- 1.5.2 Various conductor parameters (viz. modulus of elasticity, coefficient of linear expansion, stress-strain and creep, etc.) considered above in the sag tension calculation shall be verified during detailed engineering based on type tests conducted.
- 1.5.3 The Contractor shall also furnish sag & tensions under no wind for various temperatures starting from 0⁰ C to designed maximum temperature in steps of 5⁰ C for all the spans as per detailed survey during detailed engineering.
- 1.5.4 After award of the contract, the Contractor shall submit Sag Tension calculations corresponding to various conditions given in Section-I for all the spans as per detailed survey.
- 1.5.5 In case of re-conductoring projects, the Sag of offered HTLS conductor at design maximum temperature under nil wind condition shall not exceed the corresponding sag of existing conductor for any of the spans of the line(s) being re-conductored.

1.6 **Workmanship**

- 1.6.1 All the conductor strands shall be smooth, uniform and free from all imperfections, such as spills and splits, cracks, die marks, scratches, abrasions, rust etc.
- 1.6.2 The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protrusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

1.7 **Joints in Wires**

1.7.1 **Aluminium/ Aluminium Alloy Wires**

- 1.7.1.1 During stranding, no Aluminium/ Aluminium Alloy wire welds shall be made for the purpose of achieving the required conductor length.
- 1.7.1.2 No joint shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer(s) of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of Aluminium/ Aluminium Alloy wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other Aluminium Alloy wire of the completed conductor. A

record of such joints for each individual length of the conductor shall be maintained by the Contractor for Employer's review.

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

1.7.2 Core/ Core Wires

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

1.8 Tolerances

Manufacturing tolerances on the dimensions to the extent of one percent ($\pm 1\%$) shall be permitted for individual strands and the complete conductor. In case manufacturing tolerances more than one percent ($\pm 1\%$) is proposed for individual strands of a particular conductor as per applicable Indian/ International standard, the same may be permitted subject to submission of supporting documents/ details by the Contractor while approval of GTP during detailed engineering. In case of composite core conforming to ASTM B987, the tolerances shall be ± 0.05 mm as per ASTM B987.

1.9 Materials

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

1.9.1 Aluminium/ Aluminium Alloy layers

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

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

1.9.2 Core

- 1.9.2.1 The core wire strand(s) shall be of galvanized steel/ Invar wires/ or Zinc-5% Aluminium-Mischmetal alloy coated steel/ Invar wires or aluminium clad steel/ Invar wires or composite materials etc. and shall have properties conforming to the technical performance requirements of the finished conductor. In case, the temperature of core corresponding to the designed maximum temperature of the offered HTLS conductor exceeds

180° C, ordinary zinc coating/ galvanizing of the Steel/ Invar core wires shall not be accepted and only aluminium clad or Mischmetal coated wires shall be permitted. Bidder shall furnish properties and composition of the core wire strand(s) in the schedule GTP of BPS. The properties & composition of core wires guaranteed by the bidder shall be based on the relevant published Indian/International Standards, wherever applicable. However, in no case, the guaranteed values for torsion & elongation of Steel/ Invar core of the offered HTLS Conductor shall be less than as indicated below:

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

- 1.9.2.2 The zinc used for galvanizing of core (if used) shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS 209. The minimum mass of zinc coating shall conform to the requirements of relevant standard. Zinc-5% Aluminium -Mischmetal alloy coating, if used, shall conform to and satisfy all the requirements of ASTM B 803 / B 958.
- 1.9.2.3 The aluminium cladding of wires shall be of aluminum having purity not less than 99.5 % and shall be thoroughly bonded to the core wire strand(s). The minimum conductivity of offered aluminium clad wire shall be 14% of IACS. The minimum thickness of aluminium cladding shall be 3% & 5% of nominal wire diameter, for 14% & 20% IACS conductivity respectively.
- 1.9.2.4 Where composite material conforming to ASTM B987 is offered for core, the material shall be either of high strength grade or extra high strength grade. The materials shall be of such proven quality that its properties are not adversely influenced by the normal operating conditions of transmission line in tropical environment conditions as experienced by the existing line. The bidder shall provide adequate details including specifications/ test reports/ operating experience details/ performance certificates etc. in support of the suitability of the offered materials.

1.10 Standard Length

- 1.10.1 The standard length of the conductor shall be indicated in the guaranteed technical particulars of offer. A tolerance of $\pm 5\%$ on the standard length offered by the Bidder shall be permitted. Standard Length shall not be more than 2500 meters. All lengths outside this limit of tolerance shall be treated as random lengths.

- 1.10.2 Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of such random lengths shall not be more than 10% of the total quantity ordered. At no point, the cumulative quantity supplied of such random lengths shall be more than 12.5% of the total cumulative quantity supplied including such random lengths. However, the last 20% of the quantity ordered shall be supplied only in standard lengths as specified.
- 1.10.3 During implementation stage, supply of HTLS conductors by contractor in 3 or 4 different standard lengths depending upon actual tower schedule/ site conditions, may be permitted based on approval by site in-charge.
- 1.10.4 Bidder shall also indicate the maximum single length, above the standard length, he can manufacture in the guaranteed technical particulars of offer. This is required for special stretches like river crossing etc. The Employer reserves the right to place orders for the above lengths on the same terms and conditions applicable for the standard lengths during the pendency of the Contract.

2.0 Tests and Standards

2.1 Type Tests

2.1.1 Type Tests on Stranded Conductor/ Core

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

i) On complete Conductor

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

k)	Temperature Cycle Test	Annexure-A
l)	Salt Spray Test (applicable for stranded composite core conductors having galvanic protection layer not conforming to ASTM B987)	Annexure-A

ii) **On Conductor Strand/core**

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

2.1.2 Type tests specified under Clause 2.1.1 shall not be required to be carried out if a valid test certificate is available for the offered design. The test certificate shall be considered valid if,

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

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

In case the tests have been conducted earlier than the above stipulated period or carried out on samples manufactured from any other manufacturing works or in case of revision/ amendment in the provisions/ test procedure of the IS/ IEC as

referred in the TS or in the event of any discrepancy in the test report (i.e. due to non-inclusion of valid calibration certificate, desired information etc. or any test not applicable due to any design/ material/ manufacturing process change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the supplier at no extra cost to the purchaser.

2.2 Acceptance Tests

a)	Visual and dimensional check on drum	Annexure-A
b)	Visual check for joints scratches etc. and length measurement of conductor by rewinding	Annexure-A
c)	Dimensional check on core strands and Aluminium/ Aluminium Alloy strands	Annexure-A
d)	Check for lay-ratios of various layers	Annexure-A
e)	Galvanising test on core strands (if applicable)	Annexure-A
f)	Coating Test on Zinc-5% Al-Mischmetal alloy coating (if applicable)	ASTM B803/ B958
g)	Adherence of Coating Test on Zinc-5% Al-Mischmetal alloy coating (if applicable)	ASTM B803/ B958
h)	Thickness of aluminum on aluminium clad wires	Annexure-A
i)	Torsion and Elongation tests on core strands	Annexure-A
j)	Breaking load test on core strands and Aluminium/ Aluminium Alloy strands	Annexure-A
k)	Wrap test on core strands (if applicable) and Aluminium/ Aluminium Alloy strands	IEC 60888 & IEC 60889
l)	Minimum conductivity test on thermal resistant Aluminium Alloy/ Aluminium strands	IEC 60889
m)	Procedure qualification test on welded joint of Aluminium/ Aluminium Alloy strands	Annexure-A
n)	Heat resistance test on Aluminium Alloy strands (Not applicable for Annealed Aluminium)	Annexure-A
o)	Ageing test on filler (if applicable)	Annexure-A
p)	Minimum conductivity test on aluminium clad core wires (if applicable)	Annexure-A
q)	Glass transition temperature test on composite core/ core wires (if applicable)	Annexure-A
r)	Flexural Strength test on composite core/ core wires (if applicable)	Annexure-A
s)	Bending test on composite core (if applicable)	Annexure-A

t)	Galvanic Protection Barrier Layer Thickness test on composite core (applicable for composite core conductors having galvanic barrier layer conforming to ASTM B987)	ASTM B987

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

2.3 Routine Test

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

2.4 Tests During Manufacture

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

2.5 Testing Expenses

- 2.5.1 As indicated in Clause 2.1.2, no type test charges shall be payable to the Contractor.
- 2.5.2 In the event of type testing, bidder shall ensure that adequate facilities are available in the proposed laboratories and the tests can be completed in these laboratories within the time schedule.
- 2.5.3 In case of failure in any type test the Contractor is either required to manufacture fresh sample lot and repeat the entire test successfully once or repeat that particular type test three times successfully on the sample 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.
- 2.5.4 Contractor shall indicate the laboratories in which they propose to conduct the type tests, if required. They shall ensure that adequate facilities are available in the laboratories and the tests can be completed in these laboratories within the time schedule guaranteed by them.

- 2.5.5 The entire cost of testing for the acceptance and routine tests and Tests during manufacture specified herein shall be treated as included in the quoted unit price of conductor, except for the expenses of the inspector/ Employer's representative.
- 2.5.6 In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/ Employer's representative shall be deducted from the contract price. Also, if on receipt of the Contractor's notice of testing, the Employer's representative does not find material/ testing facilities to be ready for testing the expenses incurred by the Employer for re-deputation shall be deducted from contract price.
- 2.5.7 The Contractor shall intimate the Employer about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of testing in India) and at least 6 weeks in advance (in case of testing abroad) of the schedule date of testing during which the Employer will arrange to depute his representative to be present at the time of carrying out the tests.
- 2.6 **Additional Tests**
- 2.6.1 The Employer reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier's premises, at site or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the materials comply with the Specifications.
- 2.6.2 The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test centre. In case of evidence of non- compliance, it shall be binding on the part of Contractor to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items all without any extra cost to the Employer.
- 2.7 **Sample Batch for Type Testing**
- 2.7.1 The Contractor shall offer material for selection of samples for type testing only after getting Quality Assurance Plan approved from Employer's Quality Assurance Deptt. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Employer.
- 2.7.2 The Contractor shall offer at least three drums for selection of sample required for conducting all the type test.

2.7.3 The Contractor is required to carry out all the acceptance tests successfully in presence of Employer's representative before sample selection.

2.8 Test Reports

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

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

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

2.9 Inspection

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

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

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

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

2.10 Test Facilities

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

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

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

2.11 Packing

- 2.11.1 The conductor shall be supplied in non-returnable, strong, wooden drums provided with lagging of adequate strength, constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Supplier shall be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS 1778, except as otherwise specified hereinafter.
- 2.11.2 The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5 KN.
- 2.11.3 The standard drawing of the wooden/steel drum for HTLS conductors is enclosed with the specification. The Bidder should submit drum drawing during detailed engineering for approval after incorporating standard length and dimensions required as per standard drawing.
- 2.11.4 For conductor, one standard length shall be wound on each drum.
- 2.11.5 All wooden components shall be manufactured out of seasoned soft wood free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the conductor.
- 2.11.6 The flanges shall be of two-ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75mm. Where a slot is cut in the flange to receive the inner end of the conductor the entrance shall be in line with the periphery of the barrel.
- 2.11.7 The wooden battens used for making the barrel of the conductor shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the conductor.

- 2.11.8 Barrel studs shall be used for the construction of drums. The flanges shall be holed and the barrel supports slotted to receive them. The barrel studs shall be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing.
- 2.11.9 Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.
- 2.11.10 The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.
- 2.11.11 Before reeling, card board or double corrugated or thick bituminised water-proof bamboo paper shall be secured to the drum barrel and inside of flanges of the drum by means of a suitable commercial adhesive material over which HDPE sheet to be provided. In case of steel drum, for securing HDPE sheet onto the bamboo paper & drum flanges, the HDPE sheet shall be secured onto the drum by means of a commercial adhesive/self-locking nylon cable zip ties such that there is no protrusion above the general surface that may cause damage to the conductor strands. After reeling the conductor, the exposed surface of the outer layer of conductor shall be wrapped with thick plastic sheet secured using adhesive tapes to preserve the conductor from dirt, grit and damage during storage, transport and handling. Medium grade craft/crepe/polythene paper shall be used in between the layers of conductor. Additionally, in case of Annealed aluminium being used for aluminium layers of offered HTLS conductor, medium grade kraft paper of 90 to 100 mm width shall be wrapped over HTLS conductor during production and re-winding such that the no conductor layer is directly in contact with other side, below & upper conductor layers in a drum.
- 2.11.12 A minimum space of 75 mm for conductor shall be provided between the inner surface of the external protective tagging and outer layer of the conductor.
- 2.11.13 Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp, edges or allow the battens to be released due to corrosion.
- 2.11.14 The nuts on the barrel studs shall be tack welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.
- 2.11.15 A steel collar shall be used to secure all barrel studs. This collar shall be located between the washers and the steel drum and secured to the central steel plate by welding.

- 2.11.16 Outside the protective lagging, there shall be minimum of two binder consisting of hoop iron/galvanised steel wire. Each protective lagging shall have two recesses to accommodate the binders.
- 2.11.17 The conductor ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the conductor layers during transit and handling.
- 2.11.18 As an alternative to wooden drum, Supplier may also supply the conductors in returnable/ non-returnable painted steel drums. After preparation of steel surface according to IS 9954, synthetic enamel paint shall be applied after application of one coat of primer. Wooden/Steel drum will be treated at par for evaluation purpose and accordingly the Bidder should quote in the package.
- 2.11.19 In case of returnable steel drums for conductor, following clauses shall apply:
- a) The Ownership of the empty conductor drums shall lie with the conductor Supplier who shall ultimately take back the empty conductor drum from the Project site(s) from the erection contractor's designated stores after the running out of conductor from the drum.
 - b) The erection contractor shall intimate the Conductor supplier and Employer regarding empty steel drums at their designated stores. Necessary coordination for taking back the empty steel drums in this regard shall be done by the Conductor Supplier with the erection Contractor.
 - c) The empty drum shall be taken back by the conductor supplier from the stores of erection contractor as & when these are available after usage of conductor. Conductor Supplier shall be required to take back the empty steel drum within a period of one month from date of information by erection contractor regarding availability of the drums at erection contractor stores. However, 2% of the total drums shall not be returned to the conductor Supplier as these may be used for storage of spare conductor by the Employer.
 - d) The steel drums may get damage and wear & tear due to transportation, normal handling & operation at site, which shall be rectified by the conductor Contractor before re-use. However, 2% of the total drums shall not be returned on account of damages/ wastage for which no compensation will be payable. The wastage beyond 2% shall be reimbursed by Erection Contractor.

Thus, 4% of total drums shall not be returnable to the conductor Supplier.

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

2.12 **Marking**

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

- (a) Contract/Specification number.
- (b) Name and address of the consignee.
- (c) Manufacturer's name and address.
- (d) Drum number
- (e) Size of conductor
- (f) Length of conductor in meters
- (g) Arrow marking for unwinding
- (h) Position of the conductor end (For Wooden Drums only)
- (i) Number of turns in the outer most layer.
- (j) Gross weight of the drum (with protective lagging in case of wooden drums) including conductor.
- (k) Weight of empty drum (with protective lagging in case of wooden drums).
- (l) Net weight of the conductor in the drum.
- (m) CIP No.

The above should be indicated in the packing list also.

2.13 **Verification of Conductor Length**

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

2.14 **Standards**

- 2.14.1 The conductor shall conform to the following Indian/International Standards, which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification.
- 2.14.2 In the event of the supply of conductor conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

Sl. No.	Indian Standard	Title	International Standard
1	IS 209:1992	Specification for zinc	
2	IS 398:1982	Specification for Aluminium Conductors for Overhead Transmission Purposes	
3	IS 398 (Part-II): 1990	Aluminum Conductor Galvanised Steel Reinforced	
4	IS 398 (Part-IV)	Aluminium Alloy stranded conductor	
5	IS 398 (Part-V): 1992	Aluminum Conductor Galvanised Steel- Reinforced For Extra High Voltage (400 KV) and above	
6	IS 1778:1980	Reels and Drums for Bare Conductors	
7	IS 1521:1991	Method of Tensile Testing of Steel Wire	
8	IS 2629:1990	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
9	IS 2633:1992	Method of Testing Uniformity of Coating on Zinc Coated Articles	
10	IS 4826:1992	Galvanised Coating on Round Steel Wires	
11	IS 6745:1990	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	
12	IS 8263:1990	Method of Radio Interference Tests on High Voltage Insulators	
13	IS 9997:1988	Aluminium Alloy Redraw Rods	
14		Zinc Coated steel wires for stranded Conductors	IEC 60888

15		Hard drawn Aluminium wire for overhead line conductors	IEC 60889
16		Aluminium clad steel wires	IEC 61232
17		Method of measurement of resistivity	IEC 60468

		of metallic materials	
18		IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors	IEEE 738:2012
19		Thermal resistant Aluminium Alloy	IEC 62004
20		Carbon Fibre Composite core (CFCC/TS) for use in Overhead Electrical Conductors	ASTM B987-20
21		Standard Specification for High Strength Zinc-5% Aluminium-Mischmetal alloy coated steel core wire for use in Overhead Electrical Conductors	ASTM B803
22		Standard Specification for Extra-High Strength and Ultra-High Strength Class A Zinc-5% Aluminium- Mischmetal alloy coated steel core wire for use in Overhead Electrical Conductors	ASTM B958

The standards mentioned above are available from: -

Reference Abbreviation	Name and Address
BS	British Standards, British Standards Institution 101, Pentonville Road, N - 19-ND UK
IEC/CISPR	International Electro technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de verembe, Geneva SWITZERLAND
BIS/IS	Bureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA
ISO	International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK.
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017 U.S.A.
ASTM	ASTM International 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959 USA

1. Tests on Conductor

1.1 UTS Test on Stranded Conductor at a) room temperature and b) elevated temperature

a) UTS test on stranded conductor at room temperature*

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

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

b) UTS test on stranded conductor at elevated temperature

UTS Test on Stranded Conductor shall be conducted as per clause no. 1.1(a) specified above keeping conductor temperature at the designed maximum temperature.

1.2 Corona Extinction Voltage Test

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

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

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

1.3 Radio Interference Voltage Test

Under the conditions as specified under (1.2) above, the conductor samples

shall have radio interference voltage below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 305 kV line to ground under dry conditions for 400kV and 154 kV line to ground under dry conditions for 220 kV. This test may be carried out with corona control rings and arcing horns. The test procedure shall be in accordance with IEC-60437.

1.4 D.C. Resistance Test on Stranded Conductor

On a conductor sample of minimum 5m length two contact-clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge or using micro ohm meter of suitable accuracy by placing the clamps initially zero metre and subsequently one metre apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20⁰ C as per IS 398 (Part-IV)/(Part-V). The resistance corrected at 20⁰ C shall conform to the requirements of this Specification.

1.5 Creep test

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

The conductor temperature shall be maintained at 20⁰ C for 1000 hours. The elongation/ creep strain of the conductor during this period shall be measured and recorded at end of 1 hour, 10 hour, 100 hour and subsequently every 100 hour upto 1000 hours time period.

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

1.6 Sheaves Test (applicable for Composite core conductors only)

The conductor sample of minimum length of 35 meter shall be tensioned at 20 % of the UTS; pulley diameter shall be not more than 32 times that of the conductor; angle between the pulleys shall be 20 degrees. The conductor shall be passed over the pulleys 36 times at a speed of 2 m/sec. After this test UTS test on the conductor shall be carried out as mentioned above at clause 1.1 of Annexure-A. In the case of polymer composite core conductors, the core shall be inspected for damage by subjecting the core to a dye penetration test as per ASTM B987 section 14. Dye penetrant exposure time shall be 30±0 minutes.

1.7 Radial Crush Test

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

wires (after stranding).

1.8 Torsional Ductility Test

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

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

1.9 Aeolian Vibration Test

The conductor and supporting hardware shall be loaded to 25% of UTS. A dynamometer, load cell, calibrated beam or other device shall be used to measure the conductor tension. Some means should be provided to maintain constant tension to allow for temperature fluctuations during the testing. The overall span between system terminations shall be a minimum of 30 m. The span shall be supported at a height such that the static sag angle of the cable to horizontal is (1.5 ± 0.5) deg in the active span. Means shall be provided for measuring and monitoring the mid-loop (antinode) vibration amplitude at a free loop, not a support loop. An electronically controlled shaker shall be used to excite the conductor in the vertical plane. The shaker armature shall be securely fastened to the conductor so it is perpendicular to the conductor in the vertical plane. The shaker should be located in the span to allow for a minimum of six vibration loops between the suspension assembly and the shaker. The test shall be carried out at one or more resonance frequencies (more than 10 Hz). The amplitude (peak-to-peak) at the antinode point shall be one third of conductor diameter. The assembly shall be vibrated for not less than 10 million cycles without any failure. After the test, the conductor should not exhibit any damage (broken strands). The conductor shall be tested as per clause 1.1 of Annexure-A to demonstrate that it retains at least 95% UTS.

1.10 Temperature Cycle Test

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

Test Methods: -

- Conductor Sample of minimum 10m length.
- Mechanical tension, 20 % UTS, marks on the conductor at the edge of the conductor.
- 100 cycles from room temperature up to designed maximum temperature. Hold at designed maximum temperature $\pm 2.5^{\circ}$ C for 5

minutes.

- After the above mentioned 100 cycle, the Mechanical tension shall be increased up to 70 % UTS at room temperature and kept at this tension for 24 hours. Thereafter, release to 20% UTS
- This cycling test shall be repeated 5 times.
- During the test, temperature of connectors, conductor and resistance are recorded according to ANSI C 119.
- A breaking load test as per clause 1.1 of Annexure-A shall be applied at the end of the test. Conductor strength has to be higher than 95 % UTS.
- In case of polymer composites, after thermal cycling, the flexural strength and the Glass Transition temperature (T_g) shall not degrade by more than 10 % of the value guaranteed in GTP. Flexural strength shall be obtained on the basis of test procedure indicated at 1.32 below. The value of T_g after the test, shall however, in no case be less than the temperature of core corresponding to the designed maximum temperature of conductor.

1.11 Heat Resistance test on Aluminium Alloy wire (Not applicable for Annealed Aluminium)

The test shall be carried out as per Clause 7.3.6 of IEC 62004. The breaking strength of the wire after heating shall not be less than the 90% of the breaking strength before heating: -

1.12 Bending test on aluminium clad core wire (if applicable)

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

1.13 Compression test on aluminium clad wires (if applicable)

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

1.14 Coefficient of linear expansion for core

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

1.15 Brittle fracture test for polymer composite core only

The core sample shall be tensioned to approx. 25 % of UTS with simultaneous application of 1N-HNO₃ acid directly in contact with naked polymer composite core for 96 hrs. The contact length of acid shall not be less than 40mm and

thickness around the core not less than 10mm. After 96 hours, the core shall withstand UTS test as per ASTM B-987.

1.16 Visual and Dimensional Check on Drums

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

1.17 Visual Check for Joints, Scratches etc.

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

1.18 Dimensional Check on Core Wires and Aluminium/ Aluminium Alloy Wires

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this Specification. Diameter of formed wires shall be determined as per clause 6.3.1.2 of IEC 62420.

1.19 Check for Lay-ratios of Various Layers

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

1.20 Galvanising Test

The test procedure shall be as specified in IEC 60888. The material shall conform to the requirements of this Specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

1.21 Aluminum thickness on aluminum clad wires (if applicable)

The thickness of aluminium of the specimen shall be determined by using suitable electrical indicating instruments operating on the permeameter principle, or direct measurement. Measurements shall be read to three decimal places, and number rounded to two decimal places is considered as measured thickness. For reference purposes, direct measurement shall be used to determine aluminium thickness on specimens taken from the end of the coils.

1.22 Torsion and Elongation Tests on Core wire/ Composite core

The test procedures for Torsion and Elongation Tests on Core wires shall be as per clause No. 6.3.3 and 6.3.2 b) of IEC 61232 respectively. In torsion test, the number of complete twists before fracture shall not be less than the value specified in the GTP on a length equal to 100 times the standard diameter of the strand. In case test sample length is less or more than 100 times the stranded diameter of the strand, the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number. In elongation test, the elongation at fracture of the strand shall not be less than the value specified in the GTP for

a gauge length of 250 mm.

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

i) **Elongation Test**

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

ii) **Torsion Test**

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

1.23 Breaking load test on Aluminium/ Aluminium Alloy & Core wires/composite core and D.C Resistance test on Aluminium/ Aluminium Alloy wire

The above tests shall be carried out as per IEC 60888/ 60889 and the results shall meet the requirements of the specification.

1.24 Wrap test on Core wires (Not applicable for composite core)

The wrap test on core strands shall meet the requirements of IEC 60888. In case of aluminium clad core wire, the same shall be wrapped around a mandrel of diameter of five times that of the strand to form a helix of eight turns. The strand shall be unwrapped. No breakage of strand shall occur.

1.25 Minimum conductivity test on thermal resistant aluminium alloy wire

Resistivity test as per IEC 60468/IEC 60889 shall be conducted to confirm minimum conductivity as per specification requirement.

1.26 Procedure Qualification test on welded Aluminium/ Aluminium Alloy wire

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

1.27 Ageing Test on Filler (if applicable)

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

1.28 Aluminium conductivity test on aluminium clad wire (if applicable)

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

1.29 Glass Transition Temperature Test on composite core/ core wire (if applicable)

Test shall be conducted as per ASTM B987. The minimum glass transition temperature shall be either (i) the temperature of core corresponding to the designed maximum temperature of the offered HTLS conductor + 35⁰ C or (ii) minimum glass transition temperature as per ASTM B987 i.e. 180⁰ C+ 25⁰ C; Whichever is lower.

In case, the temperature of core corresponding to the designed maximum temperature of the offered HTLS conductor is more than the minimum glass transition temperature as per ASTM B987 i.e. more than 180⁰ C, the test shall be conducted as per ASTM B987 & the minimum glass transition temperature shall be the temperature of core corresponding to the designed maximum temperature of the offered HTLS conductor + 25⁰ C.

1.30 Flexural Strength Test for composite core/ core wires

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

1.31 Bending Test on Polymer Composite Core (as Type Test)

Bending test on polymer composite core (CFC) before stranding shall be performed as per ASTM B987/B987M-17 on polymer composite core samples taken from composite core at conductor manufacturing unit before stranding of conductor. Alternatively, supplier may carry out bending test on polymer composite core (CFC) before stranding on the samples taken at the core manufacturing unit, from the same reel being supplied to conductor manufacturer subject to proper traceability of the same at the conductor manufacturers works.

Bending test on polymer composite core (CFC) shall also be performed as per ASTM B987/B987M-17 on polymer composite core samples taken from stranded conductor. For test after stranding the diameter of cylindrical mandrel shall be as following:

For high strength grade CFC: 60 times the diameter of CFC

For Extra high strength grade CFC: 70 times the diameter of CFC

1.32 Bending test on polymer composite core (as Acceptance test)

Bending test on polymer composite core (CFC) shall be performed as per ASTM B987/ B987M-17 on polymer composite core samples taken from stranded conductor. For test after stranding the diameter of cylindrical mandrel shall be as following:

- 1) For high strength grade CFC: 60 times the diameter of CFC
- 2) For Extra high strength grade CFC: 70 times the diameter of CFC

1.33 Salt Spray Test

The test shall be performed as per ASTM B117 on 3 samples of conductor, each 1 m in length. The three samples shall be simultaneously subjected to salt spray exposure in an environmental chamber for 1000 hours. After this test, the individual strands and composite core shall be subjected to visual examination and tensile strength test as per ASTM B-987. There shall be no pitting, corrosion or deterioration on any component of the conductor after 1000 hours of salt-spray exposure. The individual strands of aluminium/ aluminium alloy and the composite core shall retain 95% of the strength guaranteed in GTP.

1.34 Chemical Analysis of Aluminium/ Aluminium Alloy and Steel/ Invar Core Wires

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

1.35 Chemical Analysis of Zinc

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

SECTION-VIII

COMPOSITE LONG ROD INSULATOR

(Strike out/Delete whichever is not applicable)

**TECHNICAL
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**TECHNICAL
SPECIFICATIONS**

SECTION-VIII

COMPOSITE LONG ROD INSULATOR

1.0 Technical Description of Composite Long Rod Insulators

1.1 Details of Composite Long Rod Insulators

1.1.1 The insulators of the strings shall consist of composite long rod insulators for transmission system application in a very heavily polluted environment. Couplings shall be ball and socket type.

1.1.2 The unit rates of insulators are indicated in, Bidder quote as per Bid conditions, such composite insulators which have proven use under foggy/humid operational conditions in polluted industrial environment combined with smoke and dust particles. The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing satisfactorily. The Bidder shall also submit certified test report for an accelerated ageing test of 5000 hours such as that described in IEC 62730 (2012).

1.1.3 Insulators shall have sheds of the “open aerodynamic profile without any under ribs” with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC 60815.

1.1.4 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string along with hardware fittings shall be as per the standard technical particulars enclosed at ***Annexure-B***.

1.1.5 Dimensional Tolerance of Composite Insulators

The tolerances on all dimensions e.g. diameter, length shall be allowed as follows:

$\pm (0.04d + 1.5)$ mm when $d \leq 300$ mm.

$\pm (0.025d + 6)$ mm when $d > 300$ mm with a maximum tolerance of ± 50 mm

Where, d being the dimensions in millimeters for diameter, length as the case may be.

The tolerance in creepage distance shall be based on design dimensions and their tolerances. However, no negative tolerance shall be applicable to creepage distance specified in ***clause 1.1.4***.

1.2 Interchangeability

The composite long rod insulators inclusive of the ball & socket connection shall be standard design suitable for use with the hardware fittings of any make conforming to relevant Indian standards.

1.3 Corona and RI Performance

All surfaces shall be clean, smooth, without cuts, abrasions or projections. No part shall be

subjected to excessive localized pressure. The insulator and metal parts shall be so designed and manufactured that it shall avoid local corona formation and shall not generate any radio interference beyond specified limit under the operating conditions.

1.4 Maintenance

- 1.4.1 The long rod insulators offered shall be suitable for employment of hot line maintenance technique so that usual hot line operation can be carried out with ease, speed and safety.
- 1.4.2 All insulators shall be designed to facilitate cleaning and insulators shall have the minimum practical number of sheds and grooves. All grooves shall be so proportioned that any dust deposit can be removed without difficulty either by wiping with a cloth or by remote washing under live line condition.

1.5 Materials

1.5.1 Core

It shall be a glass-fiber reinforced (FRP rod) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. Glass fibers and resin shall be optimized. The rod shall be electrical grade corrosion resistant (ECR), boron free, glass and shall exhibit both high electrical integrity and high resistance to acid corrosion.

1.5.2 Housing & Weather sheds

The FRP rod shall be covered by a sheath of HTV silicone rubber compound of a thickness of minimum 5 mm for $\pm 320\text{kV}$ & above HVDC applications and minimum 3 mm for other voltage levels and AC applications. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. In case any anti-fungal and avian replant admixtures/ additives are added by the manufacturer in the material, the details shall be included by the manufacturers in their MQP. It shall be extruded or directly molded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique to be followed with detailed procedure and sampling shall be furnished by the Supplier and finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile. The weather sheds shall be vulcanized to the sheath (extrusion process) or molded as part of the sheath (injection molding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection molding shall be at high temperature & high pressure. Any seams/ burrs protruding axially along the insulator, resulting from the injection molding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC 60587. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

1.5.3 End Fittings

End fittings transmit the mechanical load to the core. They shall be made of forged steel or cast steel; however, for socket ends malleable cast iron spheroidal graphite may also be used. They shall be connected to the rod by means of a controlled compression technique. The manufacturer shall have in-process Acoustic emission arrangement or some other arrangement to ensure that there is no damage to the core during crimping. This verification shall be in-process and done on each insulator. The system of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The end fitting shall either be over-moulded or shall be sealed by a flexible silicone rubber compound. The sealing shall stick to both housing and metal end fitting. The sealing must be

humidity proof and durable with time.

End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

1.5.4 Grading Rings

Grading rings shall be used at each side of the insulators for ± 800 kV HVDC Insulators (420 kN & 160 kN) and at line end for metallic return insulators (160 & 210 kN) for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. Covered grading rings (having minimum 2 mm thickness) shall be provided on tower side of vertical portion (II-portion) of 420 kN Insulators to be used in "Y-string" & 160 kN suspension Pilot insulator strings, of ± 800 kV HVDC lines, at cross-arm/ cold end as per the drawing attached at Section- III of Technical specification to reduce deposition of bird excreta on polymer insulator sheds.

For upto 765 kV voltage level, Grading rings shall be used for each composite insulator unit as per Standard Technical particulars enclosed at **Annexure-B** for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. For Covered grading rings (having minimum 2 mm sheet thickness of the cover) shall be provided on suspension insulator strings at cross-arm/ cold end as per Standard Technical particulars enclosed at Annexure-B and drawing attached in the relevant section of Technical specification to reduce deposition of bird excreta on polymer insulator sheds.

The covered grading ring shall have sloping surface so as to facilitate natural cleaning/ removal of any deposition on its surface. The open type grading ring shall essentially be a round extruded Aluminium Alloy tube of minimum 50 mm diameter, minimum wall thickness of 2.5 mm. The fixing arms of the grading ring shall consist of a holder & a keeper. While the holder shall be either welded or riveted on the corona ring, the keeper shall be bolted onto the holder. To avoid possibility of loosening/ opening of grading ring during service, suitable additional locking measures viz. Lock nut/ bolt patch/ locking washer etc. shall be provided by the supplier. Gap between holder & keeper shall be kept uniformly as 32 mm for up to 120 kN and 36 mm for 160 kN & 210 kN.

The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/ corona cutting/ exceeding of permissible electrical stress of material. Also, for ensuring correct installation of grading rings, a proper slot shall be provided at the outside edge of the End fittings and on grading ring holders. The design of the grading rings shall be such that it will only fit in the designated slot facing correct installation direction. The position of the slots shall be at suitable distance on end fittings to ensure acceptable levels of radio and TV noise and voltage gradient on and within the insulator.

The insulator supplier shall furnish design calculations using appropriate electric field software showing electric field at surface of housing, inside housing & core and at the interface of housing and metal fittings with the proposed placement and design of corona. The electric field for dry uncontaminated polymer insulators shall not be more than following critical values

- i) Internal to the fiberglass rod & rubber weather shed material: 30 kV/cm (rms).
- ii) Surface E-field magnitudes on weather shed material: 4.5 kV/cm (rms) measured 0.5 mm above the surface of the sheath.
- iii) Surface E-field magnitudes on end-fittings & corona rings: 21 kV/cm (rms)

Grading rings shall be capable of installation and removal with hot line tools without disassembling any other part of the insulator assembly.

The design & supply of grading rings shall be in the scope of the composite insulator supplier.

Supplier shall supply extra 10% quantities of grading rings as O&M spares at no extra cost to the Purchaser.

- 1.5.5 Bolts and nuts for grading rings shall be galvanized as per IS 1367 (Part 13)/ IS 2629. Fully threaded bolts confirming to relevant Indian Standard shall be used. Dimensions of bolts/ nuts shall be M10x50mm. Bolts shall be of minimum 4.6 grade.

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

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

TABLE-1: (Details of Materials)

Sl. No.	Item	Material treatment	Reference Material Grade
1	Ball End	Forged Steel	Forged Steel, Class 4 as per IS 2004
			Forged Steel, EN8D as per BS970
			41Cr4 as per ISO 683-18-1996 or EN10083-3-2006
		Cast Steel	C40 as per EN-10083-2
			C45 as per EN-10083-2
2	Socket End	Forged Steel	Forged Steel, Class 4 as per IS 2004
			Forged Steel, EN8D as per BS970
			41Cr4 as per ISO 683-18-1996 or EN10083-3-2006
		Cast Steel	C40 as per EN-10083-2
			C45 as per EN-10083-2
		Spheroidal Graphite Cast Iron	SGCI-450/10 as per IS 1865:1991
3	Ring	Covered type: Aluminium Casting	LM6 as per BS 1490/ 4600 as per IS 617
		Open type: Aluminium Extrusion	High Strength Al. Alloy, 63400 as per IS 733, 63401 as per IS 5082
	Holder	Mild Steel	E410 as per IS-2062
		Cast Steel	C45, EN-10083-2
			65-35 as per ASTM A27
			A 1020 ASTM A732

4	/ Keeper	Aluminium Extrusion	High Strength Al. Alloy, 63400 as per IS 733, 63401 as per IS 5082
		Aluminium Casting (for holder only)	LM6 as per BS 1490/ 4600 as per IS 617 (min. 8 mm thickness)
5	Silicone Rubber	High Temperature Vulcanised (HTV) Silicone Rubber	

1.6 Workmanship

- 1.6.1 All the materials shall be of latest design and conform to the best modern practices adopted in the extra high voltage field. Bidders shall offer only such insulators as are guaranteed by him to be satisfactory and suitable for transmission lines specified and will give continued good service.
- 1.6.2 The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners to limit corona and radio interference.
- 1.6.3 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.
- 1.6.4 The core shall be sound and free of cracks, impurities and voids that may adversely affect the insulators.
- 1.6.5 Weather sheds/ Housing shall be uniform in quality. It shall be free from voids and impurities. Weather sheds/ Housing shall be clean, sound, smooth and free from gross defects and excessive flashing at parting lines.
- 1.6.6 End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.
- 1.6.7 All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 600 gm/sqm. and shall be in accordance with the requirement of ISO:1461 (E) and shall satisfy the tests mentioned in ISO:1460 (E).

However, under marine/extreme environment/coastal areas, as specifically , the end fittings shall have a minimum average coating of zinc equivalent of 790 gm /sqm (equivalent to 110 microns) of surface area and the steel holder/ keeper shall have a minimum overall zinc coating of 900 gm/ sqm of surface area. Also, in such case, stainless steel bolts/ nuts shall only be used.

Spring washers shall be electro-galvanised. Stainless steel washer may be used as an alternative.

The zinc used for galvanizing shall be of purity of 99.95%. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be

guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test. However, fasteners shall withstand four dips while spring washers shall withstand three dips under the standard preece test. The galvanizing shall be carried out only after any machining.

- 1.6.8 The supplier shall guarantee that there shall not be any failure/ de-capping/ breaking of insulators on line under normal operating condition. In the event of any failure/ de-capping/ breaking of insulators during the first ten years of service, Supplier shall supply to the Purchaser free of cost spare insulators equal to 10 times the failed insulator quantity. .

2.0 **Equipment Marking**

- 2.1 Each composite long rod unit shall be legibly and indelibly marked with the trade mark of the manufacturer, name of POWERGRID and month & year of manufacture. The guaranteed combined mechanical and electrical strength shall be indicated in kilo Newton followed by the word 'kN' to facilitate easy identification and to ensure proper use. Holder of grading rings shall be legibly and indelibly marked with trade mark of the composite insulator supplier.

- 2.2 One 10 mm thick ring or 20 mm thick spot of suitable quality of paint shall be marked on the cap/ end fitting of each composite long rod of particular strength for easy identification of the type of insulator. The paint shall not have any deteriorating effect on the insulator performance. Following codes shall be used as identification mark:

For 70 KN long rod unit	:	Black
For 90 KN long rod unit	:	Red
For 120 KN long rod unit	:	Yellow
For 160 KN long rod unit	:	Green
For 210kN long rod unit	:	Blue
For 420 KN long rod unit	:	Purple

3.0 **Bid Drawings**

- 3.1 The Bidder shall furnish full description and illustration of the material offered.

- 3.2 The Bidder shall furnish along with the bid the outline drawing of each insulator unit along with grading rings including a cross sectional view of the long rod insulator unit. The drawing shall include but not limited to the following information:

- (a) Major Dimensions with manufacturing tolerances
- (b) Number of sheds
- (c) Minimum Creepage distance with positive tolerance
- (d) Protected creepage distance
- (e) Unit mechanical and electrical characteristics
- (f) Size and weight of ball and socket parts
- (g) Weight of composite long rod units
- (h) Materials

- 3.3 After placement of award, the Supplier shall submit full dimensioned

insulator drawings containing all the details as given in Clause No. 3.2 above, in four (4) copies to Purchaser for approval. After getting approval from Purchaser, the Supplier shall submit 10 more copies of the same drawing along with a soft copy to the Purchaser/ PGCIL for further distribution and field use at Purchaser's/ PGCIL end.

3.4 After placement of award the Supplier shall also submit fully dimensioned insulator crate drawing for different type of insulators.

4.0 Tests and Standards

4.1 Type Tests

The required type tests on composite longrod units, components, materials and complete strings are stipulated hereunder.

The specified type tests under the following clause shall not be required to be carried out if a valid test certificate is available for a similar design. The tests certificate shall be considered valid if:

- i) Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of POWERGRID or utility and
- ii) Type test reports contain valid Calibration reports of the relevant testing equipment and information pertaining to ratings, the relevant drawings, model number, test circuit, calculations (if any), photos, acceptance criteria/values specified in Technical Specification/relevant standards (IS/ IEC) and compliance to the same. and
- iii) Tests should have been conducted on the samples manufactured from same manufacturing works within last 5 (five) years as on the date of LOA.

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

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

4.1.1 On the complete composite Long Rod Insulator String with Hardware Fittings:

Sl. No.	Tests	Ref	Strings on which test to be conducted

a)	Power frequency / DC voltage withstand test with corona control rings/grading ring and arcing horns under wet condition	IEC 383: 1993/ IEC 60-1	All strings that shall be used in the transmission line portion covered under the package
b)	Switching surge voltage withstand test under wet condition (applicable for 400kV & above voltage level)	IEC 383:1993	
c)	Impulse voltage withstand test under dry condition	IEC 383:1993	
d)	Corona (AC/ DC) and RIV test under dry condition (applicable for 400kV & above voltage level)	Annexure-A	
e)	Mechanical Strength test	Annexure-A	
f)	Vibration test	Annexure-A	
g)	AC Salt-fog pollution withstand test/ DC Pollution withstand test	Annexure-A	

Note: Tests indicated at f) & g) shall not be required to be carried out on Pilot strings for all voltage levels, DIS & DT strings of 132 & 220kV (single ZEBRA) TL and Single Tension strings of 220 kV (twin MOOSE), 400kV & 765 kV TL.

Altitude correction factor (For altitude mentioned in Section-1A) as per IEC- 60071-2 shall be considered in the specified voltage withstand values for above tests.

These type tests on the insulator string assembly shall not be required to be repeated due to use of specified size of grading rings even in case valid type test reports for the offered composite longrod insulator strings are available with different size of grading rings.

4.1.2 On Composite Insulator Units

(a)	Tests on interfaces and connections of metal fittings	IS 16784
(b)	Assembled core load time test	IS 16784
(c)	Damage limits proof test and test of tightness of interface between end fittings and insulator housing.	IS 16784
(d)	High Pressure washing test	Annexure-A
(e)	Brittle fracture resistance test	Annexure-A

(f)	Dye penetration test	IS 16784 & IEC 62217:2012
(g)	Water diffusion test	IS 16784
(h)	Tracking and erosion test	IS 16784
(i)	Hardness test	IS 16784
(j)	Accelerated weathering test	IS 16784
(k)	Flammability test	IS 16784
(l)	Silicone content test	Annexure-A
(m)	Recovery of Hydrophobicity test	Annexure-A
(n)	Torsion test	Annexure-A

Hardness test, accelerated weathering test & Flammability test, specified under Clause No.4.1.2 above shall be conducted on housing/ weather shed of anyone rating of composite long rod Insulator for the same type of material.

4.2 Acceptance Tests

4.2.1 For Composite Long Rod Insulators

a)	Verification of dimensions	IS 16784
b)	Galvanising test	IEC 60383
c)	Verification of end fittings	IS 16784
d)	Recovery of Hydrophobicity	Annexure-A
e)	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IS 16784
f)	Tests on interfaces and connections of metal fittings	IS 16784
g)	Silicone content test	Annexure-A
h)	Brittle Fracture Resistance Test	Annexure-A
i)	Dye Penetration Test	IS 16784
j)	Water Diffusion Test	IS 16784

The test 4.2.1 (f) to (j) shall be carried out as acceptance test on any one lot.

In the event of failure of the sample to satisfy the acceptance test(s) specified in 4.2 above, the retest procedure shall be as per IS 16784

4.3 Routine Tests

4.3.1 For Composite Long Rod Insulator Units

a)	Visual Examination	IS 16784
b)	Mechanical routine test	IS 16784

4.4 Tests During Manufacture

On all components as applicable

a)	Chemical analysis of zinc used for galvanizing	Annexure-A
b)	Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings.	Annexure-A
c)	Chemical analysis hardness tests and magnetic particle inspection for forgings	Annexure-A
d)	Tracking and erosion test on insulating material	IEC 60587

4.5 Testing Expenses

- 4.5.1 As mentioned under clause 4.1 above, no type test charges shall be payable to the supplier.
- 4.5.2 For Type Tests which involves the tests on the complete insulator string with hardware fitting, standard hardware fittings similar to existing insulator strings shall be arranged and used by the insulator supplier at his own cost.
- 4.5.3 In case of failure in any type test the supplier is either required to modify the design of the material & successfully carryout all the type tests as has been detailed out in Clause 4.1 of this specifications or to repeat that particular type test at least three times successfully at his own expenses.
- 4.5.4 Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities 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.
- 4.5.5 The entire cost of testing for acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted price.
- 4.5.6 In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/ Purchaser's representative shall be deducted from the contract price. Also, if on receipt of the Supplier's notice of testing, the Purchaser's representative does not find the material or test setup /equipments to be ready for testing, the expenses incurred by the Purchaser for re- deputation shall be deducted from contract price.
- 4.5.7 The Supplier shall intimate the Purchaser about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of testing in India) and at least 6 weeks advance (in case of testing abroad) of the scheduled date of testing during which the Purchaser will arrange to depute his representative to be present at the time of carrying out the tests.

4.6 Sample Batch for Type Testing

- 4.6.1 The Supplier shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Purchaser.

The Supplier 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 Purchaser.

- 4.6.2 Before sample selection for type testing, the Supplier shall be required to conduct all the acceptance tests successfully in presence of Purchaser's representative. However, those acceptance tests, which are also required to be carried out afresh as type test, shall not be required to be carried out as acceptance test for sample selection for type testing.

4.7 Schedule of Testing

- 4.7.1 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.

4.8 Additional Tests

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

- 4.8.2 The Purchaser also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test center. In case of evidence of non-compliance, it shall be binding on the part of the Supplier 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 Purchaser.

4.9 Guarantee

The Supplier of insulators shall guarantee overall satisfactory performance of the insulators.

4.10 Test Reports

- 4.10.1 Copies of type test reports shall be furnished in at least six (6) copies alongwith one original. One copy shall be returned duly certified by the Purchaser/ PGCIL only after which the commercial production of the concerned material shall start.

- 4.10.2 Copies of acceptance test reports shall be furnished in at least six (6) copies. One copy shall be returned duly certified by the Purchaser/ PGCIL, only after which the material shall be dispatched.

- 4.10.3 Record of routine test reports shall be maintained by the Supplier at his works for Periodic inspection by the Purchaser's representative. Test certificates of test during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Purchaser.

4.11 Inspection

- 4.11.1 The PGCIL/ NHIDCL representative shall at all times be entitled to have

access to the works and all places of manufacture, where insulator, and its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Supplier's and sub-Supplier's works, raw materials, manufacture of the material and for conducting necessary test as detailed herein.

- 4.11.2 The material for final inspection shall be offered by the Supplier only under packed condition as detailed in clause No.4.12 of the specification. The Purchaser shall select samples at random from the packed lot for carrying out acceptance tests. The lot should be homogeneous and should contain insulators manufactured in 3- 4 consecutive weeks.
- 4.11.3 The Supplier shall keep the Purchaser informed in advance of the time of starting and the progress of manufacture of material in their various stages so that arrangements could be made for inspection.
- 4.11.4 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the PGCIL Engineer I/C in writing. In the latter case also, the material shall be dispatched only after satisfactory testing for all tests specified herein have been completed.
- 4.11.5 The acceptance of any quantity of material shall in no way relieve the Supplier of his responsibility for meeting all the requirements of the specification and shall not prevent subsequent rejection, if such material is later found to be defective.

4.12 Packing and Marking

- 4.12.1 All insulators shall be packed in suitable PVC/ plastic tubes of atleast 3 mm thickness or water-resistant packing material and the packaging shall not break during storage & transportation even in overhang condition during transportation. Further, last 20% quantity of insulators shall be packed in PVC/ plastic tubes only to ensure long storage of about 5 years. The packing shall provide protection against rodent. The Supplier shall furnish detailed design of the packing. For marine transportation, crates shall be palletized.
- 4.12.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.
- 4.12.3 Suitable cushioning, protective padding, or dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.
- 4.12.4 All packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each case/crate shall have all the markings stenciled on it in indelible ink.
- 4.12.5 The Supplier shall guarantee the adequacy of the packing and shall be responsible for any loss or damage during transportation, handling, storage and installation due to improper packing.
- 4.12.6 #To prevent birds from pecking the insulators installed on transmission lines before charging, removable plastic/ polyethylene/ polypropylene covers for 10% of the insulators of each rating shall be supplied by the manufacturer.

These covers should have provisions/ attachments for easy removal from the installed insulators and is in addition to the normal packing provided by the manufacturer.

(# Clause 4.12.6, not applicable for insulator replacement/ AM packages)

4.13 Standards

The insulator strings and its components shall conform to the following Indian/ International Standards which shall mean latest revision, with amendments/ changes adopted and published, unless specifically stated otherwise in the Specification.

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

Sl. No.	Indian Standard	Title	International Standard
1	IS 209	Specification for zinc	
2	IS 406	Method of Chemical Analysis of Slab Zinc	
3	IS 731	Porcelain insulators for overhead Power lines with a nominal voltage greater than 1000 V	
Sl. No.	Indian Standard	Title	International Standard
4	IS 2071 Part (I), (Part(II) Part(III)	Methods of High Voltage Testing	
5	IS 2486 Part- I Part- II Part- III	Specification for Insulator fittings for Overhead Power Lines with a nominal voltage greater than 1000V General Requirements and Tests Dimensional Requirements Locking Devices	
6	IS 2629	Recommended Practice for Hot, Dip Galvanisation for iron and	

		steel	
7	IS 2633	Testing of Uniformity of Coating of zinc coated articles	
8	IS 6745	Determination of Weight of Zinc Coating on Zinc coated iron and steel articles	
9	IS 8263	Methods of RI Test of HV insulators	
10	IS 8269	Methods for Switching Impulse test on HV insulators	
11		Thermal Mechanical Performance test and mechanical performance test on string insulator units	IEC 60575
12		Salt Fog Pollution Voltage Withstand Test	IEC 60507
14		Selection and dimensioning of high voltage insulators intended for use in polluted conditions: Polymer Insulators for AC systems	IEC 60815-3
15		Tests on insulators of Ceramic material or glass or glass for overhead lines with a nominal voltage greater than 1000V	IEC 60383
16		Composite string insulator units for overhead lines with a nominal voltage above 1000V : Standard strength classes and end fittings	IEC 61466-1
Sl. No.	Indian Standard	Title	International Standard
17		Composite string insulator units for overhead lines with a nominal voltage above 1000V : Dimensional and electrical characteristics	IEC 61466-2

18		Electrical Insulating materials used under severe ambient conditions - Test methods for evaluating resistance to tracking and erosion	IEC 60587
19		Polymeric insulators for indoor and outdoor use with nominal voltage greater than 1000V- General definitions, tests, methods and acceptance criteria.	IEC 62217
20	IS 16784:2018	Insulators for Overhead Lines – Composite Suspension and Tension Insulators for a.c. Systems with a Nominal Voltage Greater Than 1 000 V – Definitions, Test Methods and Acceptance Criteria	

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BS	British Standards, British Standards Institution 101, Pentonville Road, N-19-ND, UK
IEC/CISPR	International Electro technical Commission, Bureau Central de la Commission, electro Technique internationale, 1 Rue de verembe, Geneva, SWITZERLAND
BIS/IS	Beureau Of Indian Standards. ManakBhavan, 9, Bahadur Shah ZafarMarg, New Delhi - 110001.INDIA
ISO	International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017 U.S.A.
ASTM	American Society for Testing and Materials, 1916 Race St. Philadelphia, PA19103 USA

1.0 Tests on Complete Strings with Hardware Fittings

1.1 **Corona Extinction Voltage Test (Dry)**

The sample assembly consisting of complete insulator string when subjected to power frequency/ DC voltage shall have a corona extinction voltage of not less than the requirement stipulated in the table below: -

Voltage Level	Maximum Height of the conductor above ground (m)	Min. Corona extinction voltage (kV)
400 kV	8.84	320 (305 for RIV test)
765 kV	15	510
+/-500kV HVDC	Such that voltage gradient is not less than 22kV/cm	550
+/-800kV HVDC	Such that voltage gradient is not less than 22kV/cm	880

There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC: 60383.

1.2 **RIV Test (Dry)**

Under the conditions as specified under (1.1) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 1000 micro volts at one MHz. The test procedure shall be in accordance with IS: 8263/ IEC 60437.

1.3 **Mechanical Strength Test**

1.3.1 **Mechanical Strength Test for insulator strings.**

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 loaded to reproduce design conditions. The testing programme varies with string and tower types according to following table:

String Type	Total Test Load * (kN)	Direction** of Load	Duration of Load (Min.)	Sequence of Testing ***
132kV (SINGLE PANTHER)				
Double I Suspension	94	1	5	1
	140	1	1	2
	F****	1	-	3

Single I Suspension	60	1	5	1
	90	1	1	2
	F****	1	-	3
Single Tension	60	1	5	1

	90 F****	1 1	1 -	2 3
Double Tension	120 180 F****	1 1 1	5 1 -	1 2 3
220 kV (SINGLE ZEBRA)				
Single I Suspension	47 70 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot	47 70 F****	1 1 1	5 1 -	1 2 3
Double I Suspension	94 140 F****	1 1 1	5 1 -	1 2 3
Single Tension	80 120 F****	1 1 1	5 1 -	1 2 3
Double Tension	160 240 F****	1 1 1	5 1 -	1 2 3
220 kV (TWIN MOOSE)				
Single I Suspension	80 120 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot	80 120 F****	1 1 1	5 1 -	1 2 3
Single Tension	80 120 F****	1 1 1	5 1 -	1 2 3
Double Tension	214 320 F****	1 1 1	5 1 -	1 2 3
400kV (TWIN MOOSE)				
Single V	80 60	2 1	5 5	1 2

	90 F****	1 1	1 —	3 4
Single I Suspension	80 120 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot	80 120 F****	1 1 1	5 1 -	1 2 3
Single Tension	80 120 F****	1 1 1	5 1 -	1 2 3
Double Tension	214 320 F****	1 1 1	5 1 -	1 2 3
400kV (TRIPLE SNOWBIRD)				
Double I Suspension	161 240 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot	80 120 F****	1 1 1	5 1 -	1 2 3
Single Tension	80 120 F****	1 1 1	5 1 -	1 2 3
Double Tension	281 420 F****	1 1 1	5 1 -	1 2 3
400kV (QUAD MOOSE)				
Double I Suspension	161 240 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot	80 120 F****	1 1 1	5 1 -	1 2 3
Single Tension	80 120 F****	1 1 1	5 1 -	1 2 3
Quad Tension	429 640 F****	1 1 1	5 1 -	1 2 3
+/-500kV HVDC (QUAD BERSIMIS)				

Single V	155	2	5	1
	130	3	5	2
	130	4	5	3
	210	3	1	4
	F****	3	-	5
Quadruple Tension (160 kN)	429	1	5	1
	640	1	1	2
	F****	1	-	3
+/-500kV HVDC (QUAD LAPWING)				
Single V	155	2	5	1
	130	3	5	2
	130	4	5	3
	210	3	1	4
	F****	3	-	5
Quadruple Tension (210 kN)	560	1	5	1
	840	1	1	2
	F****	1	-	3
765kV S/C (QUAD BERSIMIS)				
Double I	160	1	5	1
	240	1	1	2
	F****	1	1	3
Single V	155	2	5	1
	130	3	5	2
	130	4	5	3
	210	3	1	4
	F****	3	—	5
Double V	280	2	5	1
	260	3	5	2
	260	4	5	3
	420	3	1	4
	F****	3	—	5
Single Tension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Quadruple Tension	540	1	5	1
	840	1	1	2
	F****	1	—	3
Single I & V Pilot	80	1	5	1
	120	1	1	2
	F****	1	—	3
765kV D/C (HEXA ZEBRA)				
Double I Suspension	214	1	5	1
	320	1	1	2

	F****	1	-	3
Single I Suspension Pilot	107	1	5	1
	160	1	1	2
	F****	1	-	3
Single Tension	107	1	5	1
	160	1	1	2
	F****	1	-	3
Quad Tension	560	1	5	1
	840	1	1	2
	F****	1	-	3
±800kV HVDC				
Single 'Y' suspension	340	2	5	1
	250	3	5	2
	250	4	5	3
	420	3	1	4
	F****	3	-	5
Triple Tension String	845	1	5	1
	1260	1	1	2
	F****	1	-	3
Single I Pilot	108	1	5	1
	160	1	1	2
	F****	1	-	3
132kV Metallic Return Strings				
Single I	108	1	5	1
	160	1	1	2
	F****	1	-	3
Double Tension	242	1	5	1
	420	1	1	2
	F****	1	-	3

Notes:

* : The total test must be established gradually at a steady rate.

** : Direction of load

1. following string axis
2. Following bisector of string angle.
3. Following with respect to vertical, half the string angle, along the axis of one of the arm of the Vstring
4. Following with respect to vertical, half the string angle +15 deg, along the axis of one of the arm of the Vstring

*** : The insulator string must be completely unloaded and examined, then the proper direction of loading established before proceeding to the next sequential test.

****: F denotes Failure load

The insulator string shall be deemed acceptable if, for all tests loads except failure load, the string components do not show any visual signs of deformation or fracture, and the same components may be disassembled by hand, except for removal of cotter pins and initial loosening of the nuts. The failure load shall be recorded and must be greater than all previous tests loads.

1.4 **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 each sub-conductor tensioned at 25% of conductor UTS shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductor throughout the duration of the test. Vibration dampers shall not be used on the test span. All 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 insulators shall be examined for looseness of pins and cap or any crack. The hardware shall be examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and insulators after the vibration test. The insulators shall be subjected to the Mechanical performance test as per relevant standards.

1.5 **AC Salt-fog pollution withstand test**

This test shall be carried out in accordance with IEC: 60507. The salinity level for composite long rod insulators shall be 160 kg/m³ NaCl.

1.6 **DC pollution withstand test**

This test shall be carried out as per IEC 61245 with solid layer method. The D.C. pollution withstand voltage (negative) shall be 500kV for ± 500 kV HVDC insulators as applicable at average ESDD of 0.1 mg / sq cm.

For ± 800 kV HVDC, the D.C. pollution withstand voltage (negative) shall be 800 kV as applicable at average ESDD of 0.1 mg / sq. cm. The test is to be performed on Single suspension 'Y' String and Triple tension string preferably in the same configuration. However, in case of laboratory limitations to carry out the test in tension mode for Triple tension strings, the test may be carried out in vertical mode at the same ESDD level.

2.0 **Composite Longrod Insulator Units**

2.1 **Brittle Fracture Resistance Test**

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO₃ acid directly in contact with naked FRP rod. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm. The rod shall withstand 80% of SML for 96 hours.

2.2 **Recovery of Hydrophobicity Test**

- (1) The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC classification. Dry the sample surface.
- (2) Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester, Holding the

electrode approximately 3mm from the sample surface, slowly move the electrode over an area approximately 1" x 1". Continue treating this area for 2-3 minutes, operating the tester at maximum output.

- (3) Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.
- (4) Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 - HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

2.3 Silicone content test

Minimum content of silicone as guaranteed by supplier shall be verified through FT-IR spectroscopy & TGA analysis or any other suitable method mutually agreed between Purchaser & Supplier in Quality Assurance Programme.

2.4 High Pressure washing test

The washing of a complete insulator of each E&M rating is to be carried out at 3800kPa with nozzles of 6mm diameter at a distance of 3m from nozzles to the insulator. The washing shall be carried out for 10 minutes. There shall be no damage to the sheath or metal fitting to housing interface. The verification shall be 1 minute wet power frequency withstand test at 275kV r.m.s for 132 KV, 460kV r.m.s for 220 KV & Metallic return insulators, 680 kV r.m.s for 400 KV & 830kV r.m.s for 765 KV Lines and 1 minute DC withstand test at -500 kV DC for ± 500 kV HVDC & -800 kV DC for ± 800 kV HVDC insulators.

2.5 Torsion Test

Three complete insulators of each E&M rating shall be subjected to a torsional load of 55 Nm. The torsional strength test shall be made with test specimen adequately secured to the testing machine. The torsional load shall be applied to the test specimen through a torque member so constructed that the test specimen is not subjected to any cantilever stress. The insulator after torsion test must pass the Dye Penetration Test as per IS 16784.

3.0 Tests on All components (As applicable)

3.1 Chemical Analysis of Zinc used for Galvanizing

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

3.2 Tests for Forgings

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

3.3 Tests on Castings

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

Annexure-B

Standard Technical Particulars of Composite Long Rod Insulators:

Sl. No.	Description		Unit	132kV AC	220kV AC (single ZEBRA)		220 kV AC (Twin MOOSE)		400kV			
				90 KN	70 KN	120 KN	120KN	160KN	90KN	120KN	160KN	210KN
1	Size and Designation of Ball & Socket assembly		mm	16 mm (Alt-B)	16 mm (Alt-B)	20 mm	20 mm	20 mm	16mm (Alt-B)	20 mm	20 mm	24 mm
2	Core diameter*		mm	20	20	20	20	24	20	20	24	24
3	Nominal length		mm	1450	2030	2175	2030	2210	3335	3335	3910	3910
4	Minimum Creepage distance		mm	4495	7595	7595	7595	7595	13020	13020	13020	13020
5	No. of grading rings (min.)		Nos.	1	1	1	1	1	2	2	2	2
6	Nominal Diameter of grading ring	Covered ring ***	mm	—	—	--	--	--	300	300	300	300
		Other rings	200	200	200	200	200	200	300	300	300	300
7	Depth of grading ring (open type)		mm	105-125	105-125	105-125	105-125	140-150	105-125	105-125	140-150	140-150

[illegible]

6	Nominal	Covered ring ***	mm	300	300	300	300	300	As per Manufacturers' specification
		Other rings	mm	370	370	370	370	370	As per Manufacturers' specification

Sl. No.	Description		Unit	765kV			±500kV HVDC		+/-800kV HVDC		Metallic return	
				120KN	160KN	210KN	160 kN	210 kN	160 kN	420 kN	160 kN	210 kN
	Diame ter of gradin g ring											
7	Depth of grading ring (open type)	mm		125-155	125-155	140-155	-	-	As per Manufacturers' specification			

Note:

* The core dia of composite insulators mentioned at Row No.2 is for indicative purpose. The bidder shall offer composite long rod insulators of suitable core dia, not less than the value specified above, to meet specified E&M and torsion strength requirements.

* For offered core dia, less than indicated in table above, the bidder shall submit documentary evidence of past supplies & satisfactory operation of the same for minimum period of three years. However, the overall string length shall be within the limits specified in the drawing.

*** Covered ring shall be required for Single I/ Double I suspension insulator strings only.

Standard Technical Particulars of Insulator Strings

1) Standardized Technical Particulars of 132 kV Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular Value			
			Single 'I' suspension string	Double 'I' suspension string	Single Tension string	Double Tension string
1.0	No. of Insulator Units	Nos.	1X1	2X1	1X1	2X1
2.0	pf withstand voltage under wet condition	kV (rms)	275			
3.0	Impulse withstand voltage (dry)	kV	650			
a)	Positive	p	650			
b)	Negative	kV				
		p				
4.0	Dry Arcing distance	mm	1200			
5.0	Mechanical strength	KN	90	2 X 90	90	2 x 90

2) Standardized Technical Particulars of 220 kV Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular Value				
			Single 'I' suspension string	Single 'I' suspension Pilot string	Double 'I' suspension string	Single Tension string	Double Tension string
1.0	No. of Insulator Units	Nos.	1X1	1X1	2X1	1X1	2X1
2.0	pf withstand voltage under wet condition	kV (rms)	460				
3.0	Impulse withstand voltage (dry)	kV	1050				
a)	Positive	p	1050				
b)	Negative	kV					
		p					
4.0	Dry Arcing distance	mm	1800				
5.0	Mechanical strength	KN	70	70	2X 70	120	2X120

3) Standardized Technical Particulars of 2200 kV D/C (twin Moose) Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular value			
			Single 'I' Suspension	Single 'I' Suspension PILOT	Single Tension	Double Tension
1.0	No. of Insulator Units	Nos.	1 x 1	1 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	460			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV	1050			
b)	Negative (Peak)	kV	1050			
5.0	Dry Arcing distance	mm	1800			
6.0	Mechanical strength	kN	120	120	120	2x160

4) Standardized Technical Particulars of 400 kV D/C (Twin Moose) Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular Value				
			Single V Suspen s ion	Single 'I' Suspen s ion	Single 'I' Suspension PILOT	Single Tensio n	Double Tensio n
1.0	No. of Insulator Units	Nos.	2X1	1 x 1	1 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	680				
3.0	Switching withstand voltage (dry)						
a)	Positive (Peak)	kV	1050				
b)	Negative (Peak)	kV	1050				
4.0	Impulse withstand voltage (dry)						
a)	Positive (Peak)	kV	1550				
b)	Negative (Peak)	kV	1550				
5.0	Dry Arcing distance	mm	3050				
6.0	Mechanical strength	kN	90	120	120	120	2X160

5) Standardized Technical Particulars of 400 kV D/C (Triple Snowbird) Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular Value			
			Double 'I' Suspension	Single 'I' Suspension PILOT	Single Tension	Double Tension
1.0	No. of Insulator Units	Nos.	2 x 1	1 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms	680			
3.0	Switching withstand voltage (dry)					
a)	Positive (Peak)	kV	1050			
b)	Negative (Peak)	kV	1050			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV	1550			
b)	Negative (Peak)	kV	1550			
5.0	Dry Arcing distance	mm	3050			
6.0	Mechanical strength	kN	2 X 120	120	120	2X210

6) Standardized Technical Particulars of 400 kV D/C (Quad Moose) Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular Value			
			Double 'I' Suspension	Single 'I' Suspension PILOT	Single Tension	Quadruple Tension
1.0	No. of Insulator Units	Nos.	2 x 1	1 x 1	1 x 1	4 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	680			
3.0	Switching withstand voltage (dry)					
a)	Positive (Peak)	kV	1050			
b)	Negative (Peak)	kV	1050			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV	1550			
b)	Negative (Peak)	kV	1550			
5.0	Dry Arcing distance	mm	3050			
6.0	Mechanical strength	kN	2X120	120	120	4X160

7) Standardized Technical Particulars of 765 kV S/C Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular Value						
			Single 'V' Suspension	Double 'I' Suspension	Double 'V' Suspension	Single 'V' Suspension PILOT	Single 'I' Suspension PILOT	Single Tensio	Quadruple Tension
1.0	No. of Insulator Units	Nos.	2 x 2	2 x 2	2x 2 x	2 x 2	1 x 2	1 x 2	4 x 2
2.0	pf withstand voltage under wet condition	kV (rms)	830						
3.0	Switching withstand voltage (dry)								
a)	Positive (Peak)	kV	1550						
b)	Negative (Peak)	kV	1550						
4.0	Impulse withstand voltage (dry)								
a)	Positive (Peak)	kV	2400						
b)	Negative (Peak)	kV	2400						
7.0	Dry Arcing distance	mm	5100						
8.0	Mechanical strength	kN	210 along	240	2 x 210 along	120 along	120	1 x 120	4 x 210

8) Standardized Technical Particulars of 765 kV D/C Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular Value			
			Double 'I' Suspension	Single 'I' Suspension PILOT	Single Tension	Quadruple Tension
1.0	No. of Insulator Units	Nos.	2x 2	1 x 2	1 x 2	4 x 2
2.0	pf withstand voltage under wet condition	kV (rms)	830			
3.0	Switching withstand voltage (dry)					
a)	Positive (Peak)	kV	1550			
b)	Negative (Peak)	kV	1550			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV	2400			
b)	Negative (Peak)	kV	2400			
5.0	Dry Arcing distance	mm	5100			
6.0	Mechanical strength	kN	2X 160	160	160	4 x 210

9) Standardized Technical Particulars of +/-500kV HVDC Insulator strings

Sl. No	Description	Unit	Standard Technical Particular Value		
			Single 'V' Suspension string	Quad Tension string (Quad Bersimis)	Quad Tension string (Quad Lapwing)
1.0	No. of Insulator Units	Nos.	2 X 2	4X2	4X2
2.0	DC withstand voltage under wet condition	kV	550 (negative)		
3.0	Impulse withstand voltage (dry)				
	Positive / Negative	kV _p	1800/1800		
4.0	Switching Withstand voltage (dry)				
	Positive / Negative	kV _p	1000/1000		
5.0	Dry Arcing distance	mm	3050		
6.0	Mechanical strength	kN	2 X 210	4X 160	4 X 210

10) Standardized Technical Particulars of +/-800kV HVDC Insulator strings

Sl. No.	Description	Unit	± 800kV HVDC Strings			132kV Metallic Return Strings	
			Single 'Y' Suspension string	Triple Tension string	Single I Suspension Pilot string	Single 'I' Suspension string	Double Tension string
1.0	No. of Insulator Units	Nos.	2 x 2 (V-portion) & 1 x 2 (II-portion)	3X3	1X3	1x1	2x1
2.0	Mechanical strength of complete insulator string along with hardware fittings	kN	420 (along one limb of V-portion and along II portion)	3 x 420	1x160	160	2 x 210

3.0	DC withstand volt-age for DC / Power frequency withstand voltage for metallic return of string with arcing horns, corona control rings/grading rings under wet condition	kV (rms)	800 (negative)	460
4.0	Impulse withstand voltage (dry)			
	Positive / Negative	kV _p	2250 / 2250	1050

Sl. No.	Description	Unit	± 800kV HVDC Strings			132kV Metallic Return Strings	
			Single 'Y' Suspension string	Triple Tension string	Single I Suspension Pilot string	Single 'I' Suspension string	Double Tension string
1.0	No. of Insulator Units	Nos.	2 x 2 (V-portion) & 1 x 2 (II-portion)	3X3	1X3	1x1	2x1
5.0	Switching Withstand voltage (dry)						
	Positive / Negative	kV _p	1850 / 1850			-	
6.0	Minimum corona extinction voltage under dry condition	kV	880			-	
7.0	Radio interference voltage at one MHZ when the string subjected to conductor surface gradient of 22kV/cm (+/- DC)	Micro volt	<1000			-	
8.0	DC pollution withstand voltage test	kV	800 (negative)			-	

SECTION-IX

PILE FOUNDATION

(Strikeout/ Delete whichever is not applicable)

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SPECIFICATIONS
SECTION-IX
PILE FOUNDATION
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**TECHNICAL
SPECIFICATIONS
SECTION- IX
PILE FOUNDATION**

1.0 Scope and General Information

1.1 General

This section covers the specification for pile foundation work if required.

1.2 Applicable When Design of Pile foundation is in Contractor's Scope

1.2.1 Scope

1.2.1.1 The work to be performed under this specification consists of design of pile foundation as per soil investigation reports, design criteria & other hydrological parameters, boring in all kinds of soil including weathered rock, fissured rock, hard rock, shale etc., providing and installation of cast-in-situ RCC vertical bored piles of diameter of 750/ 1000/ 1200/ 1500 mm of suitable length as per design, providing all labor, materials, supervision, dewatering, scaffolding, platforms, boring and construction equipment's & machineries, tools, tackles and plants, supplies, power, fuel, transportation on land and water, all incidental items not shown or specified but reasonably implied or necessary for successful and timely completion of work including Contractor's supervision in strict accordance with IS Codes, Employer's design criteria and specifications. The nature of work shall generally involve design, construction/ installation of cast-in-situ RCC vertical bored piles of suitable diameter of any length, pile caps, pedestals, tie beam (if required) etc. as per the site condition & Geo-technical investigation/ hydrological reports and also co-ordination with tower erection contractor for setting of stubs/ fixing of anchor bolts (as the case may be) for River crossing locations and installation of earthing for installed pile foundations. After review of each design/ drawing by the employer, the same shall be vetted by reputed institutions like IIT/NIT etc., which shall be finally approved by Employer based on the recommendation of the institution.

1.2.1.2 The bidder shall furnish in their bid complete data regarding his previously designed & successfully installed pile foundation experience and method of installation of the pile foundations, complete list of equipment's, tools and tackles, rigs, men, materials to be deployed for the work etc. Bidder has to furnish one sample calculation for one pile foundation designed/ got designed & installed successfully along with the bid. The above data is for

assessing the present design capability of the Bidder and should not be construed as review/ approval of correctness of drawings/ designs by the Employer. Subsequent to the award,

Successful Bidder shall have to comply to the technical specifications irrespective of the drawings/ designs submitted at the bidding stage without any financial implication to the Employer.

- 1.2.1.3 The rates quoted by bidder in the BPS shall be treated as firm. In case any significant deviation from the input parameters is noticed during the actual execution at site and the Employer considers it to be fit for change of price, mutually agreed rates for the pile foundation shall be derived on the basis of rates available in the Contract.
- 1.2.1.4 The Bidder's offer should be based on the mobilization of at least one no. piling rig for each tower location together with all associated working gangs, tool etc. (including at least one no. of Rotary Hydraulic drilling rig capable of boring suitable diameter piles up-to designed depth below existing ground level with necessary tools/ accessories for boring). However, if extra rigs are required to be deployed by the Contractor to match with the project construction schedule, the same shall be deployed without any additional cost to the Employer. The contractor has to execute the complete job as per soil strata actually encountered at the time of construction.
- 1.2.1.5 The Contractor shall be responsible for the soundness of the above pile foundations designed & installed/ constructed by them.
- 1.2.1.6 After completion of installation/ construction of piles, pile integrity test shall be conducted for each pile by the contractor, in presence of Employer's representative, to establish its soundness. The numbers and procedure for conducting of pile integrity test is given briefly at **Clause 4.0** of this Section. Cost of carrying these tests is deemed to be included in the price quoted by the bidder for pile design & installation. Bidder has to quote the price accordingly.
- 1.2.1.7 The setting of stub/ fixing of foundation anchor bolts (as indicated in the drawing) shall be the responsibility of the Contractor.
- 1.2.1.8 The Bidder shall quote against the quantity furnished in BPS. Approach road, provision of platforms/ barges etc. for construction/ installation of pile foundations is deemed to be included in the scope of works. No deviation in this respect will be acceptable and any bid quoted based on different Bill of Quantities shall be liable for rejection.

1.2.2 **Sub-soil Data**

The detailed soil investigation for the river crossing locations where pile foundations are envisaged shall be carried out by the Employer and provided to the bidders.

1.2.3 Design and Drawings

The Contractor shall develop the pile foundation design and drawing based on the soil investigation report, site conditions for the particular location and design criteria as mentioned below and submit for employer's approval as per mentioned in *Clause no. 1.2.1.1* above.

1.2.4 Design Criteria for Pile Foundation

1.2.4.1 General

The pile design shall be done in accordance with the latest version of IS 2911 (Part- I/ Section 2).

1.2.4.2 Spacing of piles

The minimum center to center spacing of piles shall be as following:

- a) Piles in rock / Resting on rock: 2 times diameter of pile.
- b) Piles deriving the capacity mainly from end bearing i.e. good value of ϕ ($\phi \geq 30^\circ$): 2.5 times diameter of pile.

For all other type of soils (where the load carrying capacity of the pile is mainly due to friction): 3 times diameter of pile.

1.2.4.3 Mean Scour Depth

- a) The mean depth of scour below HFL for the design of Pile located in/ around river shall be taken as per Clause 703 of IRC 78: 2014 or Lacey formula.
- b) Formula given in Clause 703 of IRC 78 shall be used for natural channel or river with defined boundary whereas Lacey formula shall be used for rivers with undefined boundaries. The maximum discharge/ maximum velocity furnished by CWC/ Local Authority/ Employer shall be used for determination of Scour depth.
- c) Silt factor shall be calculated based on weighted mean diameter (in mm) of the particle size of silt furnished by soil investigating agency based on laboratory test result of samples collected from bore hole for particular location for river bed/ bank obtained upto level of anticipated deepest scour.

1.2.4.4 Maximum Scour Depth:

- a) For Piles located in midstream/ near the river bank/ erodible strata/ location prone to erosion due to river course meandering, maximum depth of Scour shall be taken as 2 (two) times of the mean scour depth. The portion of pile upto Scour depth shall not be considered for calculating capacity of pile.
- b) If piles are provided for location other than river/ bank of the river/ erodible strata, where possibility of scouring is nil/ negligible and corrected SPT value is not more than 10, the soil upto that depth shall not be considered to provide any support to pile system/ group.

1.2.4.5 Fixity

- a) Piles shall be designed as per Annexure 'C' of IS 2911 (Part 1/Sec 2) for Lateral load. To calculate fixed head moment ' M_F ' of the equivalent cantilever, Pile embedded into pile cap shall be treated as partially fixed (i.e., restrained against rotation, not restraint against position). Accordingly, equivalent length of cantilever piles shall be taken as 1.2 times of total virtual cantilever length (i.e. $E + Z_F$) of pile.
- b) Then fixed end moment given in Clause 6.5.2 & C-4.3 of Annexure 'C' of IS 2911(Part I/Sec 2: 2010) shall be

$$M_F = 0.6 \times H \times (E + Z_F)$$

Where H = lateral load in kN

E = cantilever length above ground/ bed to the point of load application, in m

ZF = depth to point of fixity

1.2.4.6 Factor of Safety (F.O.S)

- a) Factor of Safety is the ratio of ultimate load capacity of a pile to safe load on the pile.
- b) The Ultimate load capacity of Pile/ pile group shall be determined as per Clause 6.3 and Annexure-B of IS 2911 (Part 1/Sec 2):2010 using Static formula.
- c) Minimum F.O.S as per Clause 6.8 of IS 2911 (Part 1/Sec 2) using static formula shall be considered.

1.2.4.7 Bearing Capacity factors

Bearing Capacity factors shall be as per IS 2911 (Part 1/sec 2): 2010.

1.2.4.8 Other design parameters

Other design parameters such as Angle of wall friction (δ), Earth pressure coefficient (K), Effective over burden (P_{DI}), Embedment of pile in pile cap, Stiffness factors (T & R) and Socket length of pile in weathered / soft rock /hard rock shall be as per IS 2911 (Part 1/ Sec 2):2010.

1.2.5 Billing Breakup

For progressive payments, the billing break-up shall be made during execution.

1.3 Applicable When Design of Pile foundation is not in Contractor's Scope and Employer shall provide construction drawings to the Contractor

1.3.1 Scope

- 1.3.1.1 The work to be performed under this specification consists of boring in all kinds of soil including weathered rock, fissured rock, hard rock, shale etc., providing and installation of cast-in-situ RCC vertical bored piles of diameter, as specified in BPS, providing all labor, materials, supervision, dewatering, scaffolding, platforms, boring and construction equipment's & machineries, tools, tackles and plants, supplies, power, fuel, transportation on land and water, all incidental items not shown or specified but reasonably implied or necessary for successful and timely completion of work including Contractor's supervision in strict accordance with IS Codes, drawings and specifications. The nature of work shall generally involve construction/installation of cast-in-situ RCC vertical bored piles of specified diameter, pile caps, pedestals, tie beam (if required) etc. as per the Employer's construction drawings and also co-ordination with tower erection contractor for setting of stubs/ fixing of anchor bolts (as the case may be) for River crossing locations
- 1.3.1.2 The bidder shall furnish in their bid complete data regarding method of installation of the pile foundations, complete list of equipment's, tools and tackles, rigs, men, materials to be deployed for the work etc.
- 1.3.1.3 The Bidder's offer should be based on the mobilization of at least one no. piling rig for each tower location together with all associated working gangs, tool etc. (including at least one no. of Rotary Hydraulic drilling rig capable of boring of specified diameter piles up-to designed depth below existing ground level with necessary tools/accessories for boring). However, if extra rigs are required to be deployed by the Contractor to match with the project construction schedule, the same shall be deployed without any additional cost to the Employer. The contractor has to execute the complete job as per soil strata actually encountered at the time of construction.

- 1.3.1.4 The Contractor shall be responsible for the soundness of the above pile foundations designed & installed/constructed by them.
- 1.3.1.5 After completion of installation/ construction of piles, pile integrity test shall be conducted for each pile by the contractor, in presence of Employer's representative, to establish its soundness. The numbers and procedure for conducting of pile integrity test. Cost of carrying these tests is deemed to be included in the price quoted by the bidder for pile design & installation. Bidder has to quote the price accordingly.
- 1.3.1.6 The setting of stub/ fixing of foundation anchor bolts (as indicated in the drawing) shall be the responsibility of the Contractor.
- 1.3.1.7 The Bidder shall quote based on the provisional Bill of Quantities (BOQ) furnished in the Bid Proposal Sheet (B.P.S). No deviation in this respect will be acceptable and any bid quoted based on different Bill of Quantities shall be liable for rejection. However, the payment will be made as per actual quantity executed as per Employer's design & drawing based on the unit rates for items quoted.

1.3.2 **Sub-soil Data**

The detailed soil investigation for the locations where pile foundations are envisaged shall be carried out by the Contractor (if mentioned in the BPS).

1.3.3 **Design and Drawings**

Employer shall develop the pile foundation design based on the soil investigation report for the particular location. The construction drawings required for execution of pile foundations shall be given to the contractor as per site requirement during execution stage.

1.4 **Table of compliance**

Bidder shall use one copy of this section of Technical Specifications to indicate compliance status. Within the right-hand margin, Bidder shall indicate compliance status to each paragraph along with a cross-reference to its proposal and an index key for any explanation or comment.

In addition, The Bidder shall annotate the Table of contents of the above stated volume to provide a high-level summary of compliance status, in both cases, the following symbols, and no others, shall be used:

C- Bid complies with all requirements in the adjacent paragraph

A-Bid is not compliant with the requirements in the adjacent paragraph, but a functional alternative is proposed.

X- Bid takes exception to the requirements of the adjacent paragraph and no functional alternative is proposed.

Only one symbol shall be assigned to a paragraph and shall indicate the worst- case level of compliance for that paragraph. The annotation may be hand written.

Bidder shall underline, on the compliance copy, all requirements to which exceptions have been taken (X) or to which alternatives have been proposed (A).

Each alternative shall be clearly and explicitly described. Such descriptions shall use the same paragraph numbering as the bid document sections addressed by the alternatives. All alternative descriptions shall be in one contiguous section of the Bidder's proposal, preferably in the same volume, and titled "Alternatives". A separate section titled "Exceptions" should be provided containing any discussion or explanation Bidder chooses to provide concerning exceptions taken.

Alternatives which do not substantially comply with the intent of the bid documents will be considered exceptions.

The Employer will assess the merits of each alternative and exception and will be the sole judge as to their acceptance.

2.0 Construction of Bored Cast-In-Situ Pile Foundation

2.1 General Requirement

2.1.1 The specification covers the technical requirements for piling work, general description of work, quality and workmanship. In every case, work shall be carried out to the satisfaction of the Employer in accordance with the Technical Specifications and conform to location, lines, grades and cross sections shown on the construction drawing or as directed by the Employer. The specifications are not, however, intended to cover all the minute details and the work shall be executed according to the specified Indian Codes. In absence of the IS Codes, work shall be executed according to the best prevailing local Public Works Department practice or to the recommendations of the relevant International Standards or to the instructions of the Employer. This specification shall have precedence in case anything contrary to this is stated anywhere in this Bid Document. In case of conflict between the Specification and Codes, the former shall prevail.

2.1.2 The work shall include mobilization of all necessary equipments, providing necessary engineering supervision through qualified and technical personnel,

Skilled and unskilled labour, etc. as required to carry out the complete piling work. The minimum capacities of some key equipment are listed below. However, bidder has to furnish information regarding the equipments they intend to deploy for the project as per Performa stipulated in the relevant schedules of the BPS: -

Sl. No.	Description	Capacity
1.	Tripod height	6m to 10m (clear drop)
2.	Rig (winch) capacity	3 T to 5T

3.	Weight of chisel	2T to 3T
4.	Mud pump capacity	15 HP to 25 HP
5.	Dia. of outlet pipe for bentonite	2.5 inch
6	Hydraulic rotary drilling rig along with all Accessories	Minimum torque of 12T

Note: Bidder may have to provide higher capacity equipments than mentioned above, as per the actual requirement for the execution of the job, without any additional financial implication to Employer.

2.2 **Layout and Levels**

2.2.1 Layout and levels of structures etc. shall be made by the Contractor, at his own cost, from the general grid of the plot and the bench marks given by the Employer. The Contractor shall make his own arrangements, at his own cost, for locating the co-ordinates and position of piles as per approved drawings and for determining the Reduced Level (R.L.) of the locations with respect to the single bench mark indicated by the Employer. Two established reference lines in mutually perpendicular direction shall be indicated to the Contractor. The Contractor shall provide at site all the required survey instruments, materials and men to Employer for verification of the detailed layout and correctness of the layout and levels to the satisfaction of the Employer so that the work can be carried out accurately according to specifications and approved drawings. The contractor shall be solely responsible for the correctness of layout and levels. Approach road details also to be included in the layout.

2.3 **Site Preparation**

This section of the specification covers site preparation of the areas as indicated in the drawings.

2.3.1 The area shall be stripped to remove roots of grass, rubbish and slush, shrubs or other organic materials. Spoiled materials shall be burnt or removed to approved disposal areas on or near the job site as directed by the Employer.

2.4 Properties of Construction Materials

This clause specifies the properties of common building materials unless otherwise mentioned in the drawings or schedule of items.

All materials viz., cement, steel, aggregates, water etc. which are to be used for pile construction are detailed below. However, aggregates more than 20mm shall not be used, except for lean concrete.

2.4.1 Coarse aggregates/ Stone

2.4.1.1 All coarse aggregates shall be as per IS 383 consisting of hard, strong, compact grained and durable pieces of crushed stone having uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. Coarse aggregates should be of angular shape & rectangular surface and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles, adherent coatings, clinkers, slag, mica and any other materials liable to affect the strength, durability or appearance of concrete. The surface of a freshly broken stone shall be bright, clean, and free from any dull, chalky or earthy appearance. Coarse aggregates with round surface shall not be used. Coarse aggregates shall not absorb more than 5% of its weight of water after 24 hours immersion. Samples shall be submitted by the Contractor and approved samples shall be retained by the Employer for comparison of bulk supply.

2.4.1.2 Sieving and washing of aggregates by approved method shall be carried out wherever required.

2.4.1.3 Grading of coarse aggregate shall generally conform to IS 383 and shall be such as to produce a dense concrete of the specified proportions and strength and of consistency that will work readily into position without segregation.

2.4.1.4 The maximum size of aggregate shall be as follows unless specified otherwise:

- i) Reinforced concrete with very narrow space: 10mm
- ii) Reinforced concrete & Plain Concrete : 20mm
- iii) Lean Concrete 1:3:6 or 1:4:8 : 40mm

2.4.2 Cement

Cement used shall generally be ordinary Portland Cement conforming to the latest Indian Standard Code IS 8112 or IS 12269. Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS 1489 or Portland Slag Cement conforming to IS 455 can also be used. The Contractor shall submit the manufacturer's certificate, for each consignment of cement procured, to the Employer. However, Employer reserves

the right to direct the Contractor to conduct tests for each batch/ lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Employer. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the Employer. Sulphate Resistant Cement shall be used if Sulphate content is more than the limits specified in IS 456, as per Geotechnical investigation report and as mentioned in the construction drawing. No additional payment shall be made for using Sulphate Resistant Cement.

For foundation in creek, exposed to sea water/ coastal environment, or buried aggressive soil areas, tidal zone etc., ready mix concrete/ design mix concrete using Portland Pozzolana Cement conforming to IS 1489 shall preferably be used.

2.4.3 Sand

Sand shall be hard, durable, clean and free from any adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale or other laminated materials, in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of concrete or to cause corruptions to any metal in contact with such concrete. In no case the cumulative percentage of impurities in sand shall be more than 5% by weight. All sand shall be properly graded. Unless otherwise directed by the Employer all sand shall pass through IS Sieve no. 2.36

mm. Sand for concrete shall conform to IS 383.

2.4.4 Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc. Potable water is generally considered fit for use. Water to be used shall comply with the requirements of IS 456. Average 28 days compressive strength of at least three 15 cm. cubes of concrete prepared with proposed water shall not be less than 90% of average strength of three similar cubes prepared with distilled water. PH of water shall generally be not less than 6.

2.4.5 Reinforcement

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings which may impair proper bond. Reinforcement shall conform to IS 1786 for deform and cold twisted bars (Fe 500/ Fe500D). If mentioned in the approved drawing, epoxy coated reinforcement shall conform to IS 13620. Thermo Mechanically Treated (TMT) bars (equivalent grade) in place of cold twisted bars are also accepted. Hard drawn steel wire shall conform to IS

432. Hard drawn steel wire fabric shall conform to IS 1566. All steel bars including and above 6mm diameter shall be of tested for quality. Substitution of reinforcement, other than those mentioned above, shall not be permitted without the prior approval of the Employer. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of approved foundation drawings and Specifications. Spacers, chairs, stays, hangers and annealed steel wire for bending etc. as may be necessary, should be used for proper completion of foundation job. Spacers or chairs should be placed at a maximum spacing of 1 m and closer spacing shall be provided wherever necessary.

For foundation in creek, exposed to sea water /coastal environment, or buried aggressive soil areas, tidal zone etc., epoxy coated reinforcement conforming to IS 13620 shall be used.

2.5 Storage & Handling of construction Materials

All materials shall be stored by the Contractor in a manner aiding convenient access for identification and inspection at all times. The storage arrangements shall be subject to the approval of the Employer. Storage of materials shall be as described in IS 4082.

All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Employer shall not be used for concrete, and shall be removed from site immediately, failing which, the Employer will get the materials removed and the cost thereof shall be recovered from contract price. The Contractor shall maintain up to date accounts of receipt, issue and balance (stock wise) of all materials.

2.5.1 Cement

The cement shall be stored in dry enclosed shed, well away from the walls and insulated from the floor to avoid contact with moisture. The cement shall be stacked in easily countable stacks to facilitate removal of first in first out basis. The cement bags shall be gently kept on the floor to avoid leakage of cement from the bags. Sub-standard or partially set cement shall be immediately removed from the site as soon as it is detected. Cement stored for period beyond 90 days shall be tested before use.

2.5.2 Coarse Aggregates and Sand

All coarse aggregates & sand shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other

injurious substance at any stage. Aggregate of different sizes shall be kept in separate and easily measurable stacks. If so desired by the Employer, aggregates from different sources shall be stacked separately with proper care to prevent intermixing.

2.5.3 Reinforcement

For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colors. Steel reinforcement shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting in case of storage time exceeding one month. In store, reinforcement bar shall be stacked above ground level by at least 150mm either on brick/cement/stone platform

or concrete/brick planks.

2.6 Cement Concrete

2.6.1 General

2.6.1.1 This section of the specification deals with cement concrete, plain or reinforced, and covers the requirement for concrete mix design, strength and quality, pouring at all levels, forming, protection, curing finishing, admixtures, inserts and other miscellaneous works.

2.6.1.2 The provisions of IS 456 shall be complied with, unless permitted otherwise. Any other Indian Standard Code shall form the part of the specification to the extent it has been referred to or applicable within this specification.

2.6.1.3 The Contractor shall furnish all labour, material and equipment to form, place and finish all structural concrete, concrete works and miscellaneous items complete, as described herein.

2.6.2 Admixtures

2.6.2.1 The admixtures in concrete for promoting workability, improving strength or for any other purpose shall be used only after the written permission from the Employer. The Admixtures shall conform to IS 9103.

2.6.2.2 Admixtures should not impair durability of concrete nor combined with the constituent to neither form harmful compounds nor increase the risk of corrosion of reinforcement.

2.6.2.3 Addition of admixtures should not reduce the specified strength of concrete in any case. The workability, compressive strength and the slump loss of concrete

with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

2.6.2.4 The chloride content of admixtures shall be independently tested for each batch before acceptance.

2.6.2.5 If two or more admixtures are used simultaneously in the same concrete mix, data shall be provided to assess their interaction and to ensure their compatibility.

2.6.2.6 In case admixtures are used in the concrete for any structure, fresh mix design shall be done considering the admixture with the specific approval from Employer. No extra payment shall be made to the Contractor on this account.

2.6.3 **Grades of Concrete**

2.6.3.1 The minimum grade of concrete to be used for piling shall be M25 with minimum cement content 400 kg/m³ and maximum water cement ratio of 0.5. Concrete shall conform to the controlled design mix as specified in IS 456. For lean concrete of nominal mixes of 1:3:6 and/ or 1:4:8 (with aggregates of nominal size 40 mm maximum, by weight converted to equivalent volume) shall also be used as per field quality plan. The concrete in aggressive surroundings due to presence of sulphate, etc., shall conform to IS 456. The slump of concrete shall be maintained between 150 to 180 mm.

2.6.3.2 The Contractor shall carry out concrete mix design in accordance with IS 10262 and submit mix design calculations and get them approved from the Employer well in advance of installation of pile foundations. The Contractor shall carry out adequate number of tests in accordance with IS 456 to ensure concrete of the minimum specified strength at requisite workability (i.e. slump).

2.6.3.3 For foundation in creek, exposed to sea water /coastal environment, or buried aggressive soil areas, tidal zone etc., Grade of Concrete as mentioned in BPS shall be used. In addition, two numbers of coats of bituminous painting of minimum

1.6 kg/m² per coat shall be applied on all the exposed faces of the foundation (i.e. pedestal/chimney/ tie beam & base slab/ pile cap). Cost of bituminous painting shall be deemed to be included in the unit rate of the concrete/ unit rate of pile foundation.

For concreting under water, Slump of concrete shall be 100 -150 mm recorded by suitable method.

2.6.4 **Workmanship**

All workmanship shall be according to the current Industry standard and best practices.

Before starting a pour the Contractor shall obtain the approval of the Employer

in a in“Pour Card” maintained for this purpose. He shall obtain complete instructions about the material and proportions to be used, Slump/ workability, quantity of water per unit weight of cement, number of test cubes to be taken, type of finishing to be done, any admixture to be added, any limitation on size of pour and stopping of concrete in case of premature stopping of pours.

Mixing of Concrete

- 2.6.4.1 All design mix concrete shall be mixed in mechanically operated mixer of an approved size and type capable of ensuring a uniform distribution on the materials through the mass. However, contractor can also use central batching plant situated within the area allocated for the Contractor's particular use.
- 2.6.4.2 The proportions of sand, coarse aggregate, cement and water shall be as determined by the mix design. However, in case of nominal mix concrete (for lean concrete only) the proportions of sand, coarse aggregate, cement and water shall be fixed. The proportions, as determined for design mix concrete and shall always be approved by the Employer. The quantities of the cement, sand and coarse aggregates shall be determined by weight. The water shall be measured accurately after giving proper allowance for surface water present in the aggregate for which regular check shall be made by the Contractor.
- 2.6.4.3 The water shall not be added to the mix until all the cement and aggregates consisting the batch are already in the drum and dry mixed for at least one minute. Mixing of each batch shall be continued until there is a uniformity in colour and consistency but in no case shall mixing be done for less than two (2) minutes and at least forty (40) revolutions after all the materials and water are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Employer. Mixers shall not be loaded above their rated capacity as it prevents thorough mixing. If there is segregation after unloading from the mixer the concrete should be remixed.
- 2.6.4.4 The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used and it shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Employer to allow for loss in the drum.
- 2.6.5 **Conveying Concrete**
 - 2.6.5.1 Concrete shall be handled and conveyed from the place of mixing to the place of final laying as rapidly as practicable, by approved means, before the initial setting

of the cement starts. Concrete should be conveyed in such a way as will prevent segregation of Concrete which may occur during transportation of concrete. In

case of any such segregation during transport, the concrete shall be re-mixed. During very hot or cold weather, if directed by the Employer, concrete shall be transported in deep containers, having mortar leak proof, which will reduce the rate of water loss by evaporation and loss of heat. Conveying equipment for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipment shall be kept free from set concrete.

2.6.6 **Placing of Concrete**

- a) Formwork and placement of reinforcement shall be approved in writing by the Employer before concrete is placed. The forms shall be well wetted and oil shavings, dirt and water that may have collected at the bottom shall be removed before concrete is placed. Concrete shall be deposited in its final position without segregation, re-handling or flowing. The interval between adding the water to the dry materials in the mixer and the completion of the final placing inclusive of compaction of the concrete shall be well within the initial setting time for the particular cement in use or as directed by the Employer. As far as possible, concrete shall be placed in the formwork by means approved by the Employer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1800 mm shall have to be approved by the Employer. Once the concrete is deposited in its final position, it shall not be disturbed. Care should be taken to avoid displacement of reinforcement or movement of formwork.
- b) The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete.
- c) After the concrete has been placed it shall be spread and thoroughly compacted by approved mechanical vibration to a maximum subsidence without segregation and thoroughly worked around reinforcement or other embedded fixtures into the correct form and shape. Vibrators shall not be used for pushing and shoveling concrete into adjoining areas. Vibrators must be operated by experienced men and over-vibration shall not be permitted. Head tamping in some case may be allowed subject to the approval of the Employer. Care must be taken to ensure that the inserts, fixtures, reinforcement and form work are not displaced or disturbed during placing of concrete. No concrete shall be placed in open while it rains. If there has been any sign of washing of cement and sand, the concrete shall be entirely removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete. Tie beams, pile caps, footings shall be poured in one

operation normally, in special circumstances with the approval of the Employer these can be poured in horizontal layers not exceeding 500 mm in depth. When poured in layers, it must be ensured that the under layer, is not already hardened. Blending of under layer if any, shall be effectively removed.

- d) Wherever vibration has to be applied externally the design of formwork and the disposition of vibrators shall receive special consideration to ensure efficient compaction and to avoid surface blemishes.

2.6.7 Inserts

All anchors, anchor bolts, inserts, stubs, etc. and any other items those are required to be embedded in the concrete shall be placed in correct position before pouring. Extra care shall be taken during pouring operation to maintain their position as indicated in the drawings. These inserts shall be welded to the nearest reinforcement to keep them in position and all such welding shall be deemed to be included in the unit rate quoted and no extra payment shall be made on this account.

2.6.8 Blockouts

Blockouts in concrete as indicated in the drawing or as directed by the Employer shall be provided wherever required. No extra payment shall be made to the Contractor on this account.

2.6.9 Repairs and Finishes of Concrete

All concrete surfaces shall have even and clean finish, free from honeycombs, air bubbles, fins or other blemishes. The formwork joints marks for concrete work exposed to view shall be rubbed with carborandum stone and defects patched up with a paste of 1-part sand and 1-part cement and cured. The finish shall be made to the satisfaction of the Employer.

The unit rate of pile foundation/ unit rate of concrete (as the case may be) work shall be inclusive of the cost of cleaning and finishing exposed surface as mentioned above.

2.7 Reinforcement Steel

This section of the specification shall cover providing reinforcement steel and its cleaning, bending, binding, placing with arrangements for chairs, supports and suitable covers for all reinforced concrete works, below and above ground level as per drawings and specifications.

2.7.1 General Requirements

- 2.7.1.1 Reinforcement steel of same type & grade shall be used for structural reinforcement work as detailed in the drawing released by the Employer. No work shall be commenced without proper verification with the bar-bending schedule provided in the drawing.
- 2.7.1.2 Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated on the drawings and as per specifications. The reinforcement shall be either plain or deformed steel bars or welded wire fabric conforming to relevant IS specifications.
- 2.7.1.3 Any adjustment in reinforcement to suit field conditions and construction joints other than shown on drawings shall be subjected to the approval of Employer.

2.7.2 Bending

- 2.7.2.1 Unless otherwise specified, reinforcement steel shall be bent in accordance with procedure specified in IS 2502. Bends and shapes shall comply strictly with the dimensions in the approved Bar Bending Schedule. Contractor shall be entirely responsible for its correctness. Bars correctly bend shall only be used.
- 2.7.2.2 No reinforcement shall be bent when in position in the work without approval of the Employer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Re-bending can be done only if approved by the Employer. Reinforcement bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent unless otherwise approved.

2.7.3 Placing in position

- 2.7.3.1 All reinforcement shall be accurately fixed and maintained in position as shown on the drawings by approved means as mild steel chairs, and/or concrete spacer blocks. Bars intended to be in contact, at crossing points, shall be securely bond together at all such points by two number No.20G annealed soft-iron wire.

Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be so spaced that the main bars do not sag perceptibly between adjacent spacers.

- 2.7.3.2 The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be checked by the Employer for accuracy of placement and cleanliness and necessary correction as directed by him shall be carried out. The

cover for concrete over the

reinforcements shall be as shown on the approved drawings unless otherwise directed by the Employer. Care should be taken to ensure that projecting ends of ties and other embedded metal do not encroach into the concrete cover. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar 1:2 (one-part cement: two parts sand) by volume and cured for at least (7) days. The sizes and locations of the concrete blocks shall be approved by the Employer.

- 2.7.3.3 Longitudinal reinforcement in pile shall be high yield strength cold twisted deformed steel bars conforming to IS 1786. Thermo-mechanically Treated (TMT) bars (equivalent grade) in place of Cold twisted deformed steel bars are also accepted. Lateral reinforcement in pile shall be of Tor Steel conforming to IS 432 (Part-I).
- 2.7.3.4 The longitudinal reinforcement shall project 52 times its diameter above cut-off level unless otherwise indicated in the drawing.
- 2.7.3.5 The minimum diameter of the links or spirals bar shall be 8mm and the spacing of the links or spiral shall not be less than 150mm and in no case more than 250 mm. The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing.
- 2.7.3.6 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible, number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment, these shall preferably be assembled before lowering into casing tube/ pile bore by providing necessary laps as per IS 456.
- 2.7.3.7 The minimum clear distance between the two adjacent main reinforcement bars shall normally be 100 mm for the full depth of cage, unless otherwise specified.
- 2.7.3.8 The laps in the reinforcement shall be such that the full strength of the bar is effective across the joint and the reinforcement cage is of sound construction. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS 456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller will guide the lap length.
- 2.7.3.9 Laps shall be staggered as far as practicable and as directed by the Employer. Not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (Center to Center).
- 2.7.3.10 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers, as required, without any additional cost to the Employer.

- 2.7.3.11 Minimum clear cover to the reinforcement shall be 75 mm unless otherwise mentioned.
- 2.7.3.12 Unless otherwise specified by the Employer, reinforcement shall be placed within the following tolerance as specified in IS 456: -
 - a) For effective depth 200mm or less +10mm
 - b) For effective depth more than 200mm +15mm

The cover shall in no case be reduced by more than one-third of specified cover or 5mm whichever is less.

- 2.7.3.13 Welding of reinforcement bars shall be avoided. However, welding may be done in specific case subject to prior permission from the Employer/ prior written consent of Engineer-in-charge. Welding must be staggered and shall be done in accordance with IS 2751. Couplers as per IS 16172 may be used for jointing of reinforcement bars.

2.8 Construction of Pile Cap, Pedestal, Tie Beam etc.

The Contractor shall deploy all labour, equipment, tools & tackles and materials required for complete execution of the work in accordance with the drawings and as described herein.

2.8.1 Excavation

- 2.8.1.1 The Contractor shall control the grading in the vicinity of all excavation so that the surface of the ground will be properly slopped or diked to prevent surface water from running into the excavated areas during construction.
- 2.8.1.2 Excavation shall include the removal of all materials required to execute the work properly and shall be made with sufficient clearance to permit the placing, inspection and setting of forms and completion of all works for which the excavation was done.
- 2.8.1.3 Side and bottoms of excavation shall be cut sharp and true, undercutting shall not be permitted. Each side of excavation shall be used in lieu of formwork for placement of concrete unless authorized, in special cases, by the Employer, where limitation of space for larger excavation necessitate such decision.
- 2.8.1.4 When machines are used for excavation, the last 300mm before reaching the required level shall be excavated by hand or by such equipment that will leave the soil at the required final level, in its natural conditions.

- 2.8.1.5 Suitability for bearing of the bottoms of excavations shall be determined by the Employer.
- 2.8.1.6 The bottom of excavation shall be trimmed to the required level and when carried below such levels, by error, shall be brought to level by filling with lean concrete 1:4:8 mix, with aggregate of 40mm maximum nominal size at no additional cost to the Employer.
- 2.8.1.7 The Contractor shall be responsible for assumptions and conclusions regarding the nature of materials to be excavated and the difficulty of making and maintaining the required excavations and performing the work required as shown on the drawing and in accordance with these specifications. The Contractor shall be responsible for any damage to any part of the work and property caused by collapse of sides of excavations. Materials may be salvaged, if it can be done with safety for the work and structure, as approved by the Employer.

However, no extra claim shall be entertained for materials not salvaged or any other damage to Contractor's property as a result of the collapse. He shall not be entitled to any claim for redoing the excavation as a result of the same.

- 2.8.1.8 Excavations for foundations specified shall be carried out at least 75mm or as specified in relevant drawings below the bottom of structural concrete and then be brought to the required level by placing lean concrete of 1:4:8 mix or as specified in drawings with aggregate of 40mm maximum nominal size.
- 2.8.1.9 When excavation requires coffer dams, sheet piling, bracing, sheeting, shoring, draining, dewatering etc. the Contractor shall have to provide the same as required and the cost there of shall be included in the unit rate quoted for the item of excavation and contractor shall submit necessary drawings showing arrangement and details of proposed installation and shall not proceed until he has received approval from the Employer.
- 2.8.1.10 The Contractor shall have to constantly pump out the water collected in pits due to rain water, springs, seepage etc. and maintain dry working conditions at no extra cost to the Employer.
- 2.8.1.11 For the purpose of excavation in earthwork, all types of soil including kankar, morum, shingle and boulders up to 150mm size are included and no separate payment shall be made for different type of soils encountered.

2.8.2 Form work

2.8.2.1 General

- 2.8.2.1.1 If it is so desired by the Employer, the Contractor shall prepare, before commencement of the actual work, design and drawings for form work and centering and get them approved by the Employer. The form work shall conform to the shape, alignment and dimensions as shown in the drawings.

Form work shall be composed of steel and/or best quality shuttering wood of non- absorbent type or plywood. Timber shall be free from significant knots and shall be of medium grain as far as possible and hard woods shall be used as caps and wedges under or over posts. Plywood or equivalent shall be used where specified to obtain smooth surfaces for exposed concrete work. Struts shall generally be mild steel tubes, and strong sal ballis of 150mm in diameter or above. Bamboos, small diameter ballis, etc. shall not be used unless approved by the Employer in specified cases.

Supports or props should not be supported on an un-propped lower suspended floor or beam unless calculations are submitted to the Employer to confirm the strength of the lower floor or beam and no propping shall be taken out until the Employer approval has been given.

- 2.8.2.1.2 The form work shall be true and rigid and thoroughly braced both horizontally and diagonally. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as well as working load. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration, without appreciable deflection, bulging, distortion or loosening off its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of mortar. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of Employer immediately and rectified free of charge as directed by him. To achieve the desired rigidity, the bolts, space blocks, the wires and clamps as approved by the Employer shall be used but they must in no way impair the strength of concrete or leave stains or marks on the finished surface, where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Bolts passing completely through liquid retaining walls/ slabs for the purpose of securing and aligning the formwork should not be used.

- 2.8.2.1.3 Temporary openings for cleaning, inspection and for pouring concrete may be provided at the base of vertical forms and as may be directed by the Employer. The temporary openings shall be so formed that they can be conveniently closed when required and must not leave any mark on the concrete.

2.8.2.2 Cleaning and Treatment of Forms

- 2.8.2.2.1 All forms shall be thoroughly cleaned of old concrete wood shavings, saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before the concrete is poured. Along with wire brushes, brooms, etc. compressed air jet and/or water jet shall be kept handy for cleaning, if directed by the Employer.
- 2.8.2.2.2 Before shuttering is placed in position the form surface in contact with concrete shall be treated with approved non-standing oil or composition of other material approved by the Employer. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or existing concrete surface. They shall not be allowed to accumulate at the bottom of the shuttering.
- 2.8.2.2.3 If formwork for pedestal/ chimney is erected for the full height of the section, as placing of concrete proceeds, wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment of the formwork and to allow it to be removed gradually without jarring the concrete.

2.8.2.3 Removal of Forms

- 2.8.2.3.1 The Contractor shall begin the removal of formwork only after approval of Employer. He shall place on record the date on which the concrete is placed in different parts of the work and the date of the removal of formwork there from. This record shall be checked and countersigned by the Employer. The Contractor shall be responsible for the safe removal of formwork but the Employer may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of formwork or loading shall be entirely reconstructed without any extra cost to Employer.
- 2.8.2.3.2 Forms for various types of structural components shall not be removed before the minimum periods specified below which shall also be subject to the approval of the Employer.
- 2.8.2.3.3 No supporting forms shall be removed suddenly in such manner as to create shock loading. Forms for sides shall not be removed before 2 days. Bottom forms shall not be removed before 28 days unless this period is reduced with specified concurrence of the Employer.

However, in any case, formwork shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected to, at the time of removal of forms.

2.8.2.4 Re-use of Forms

Before re-use, all forms shall be thoroughly scrapped cleaned and joints, etc. shall be examined, when necessary repaired and inside surface treated as specified. Formwork shall not be used/ re-used, if declared unfit or unserviceable by the Employer.

2.8.3 Back Filling

2.8.3.1 General Requirement

- 2.8.3.1.1 After completion of foundation footings, pile caps, pedestals, tie beams and other constructions below the elevation of the grades, and prior to back filling, all forms of temporary shoring, timber etc. shall be removed and the excavation cleaned of all trash, debris and perishable materials, back filling shall begin only with the approval of the Employer.
- 2.8.3.1.2 The soil to be used for back filling purpose shall be inorganic material and shall be free from any foreign substance which can harm or impair the strength of footing in any manner. In any case the soil to be used for back filling purpose shall have the prior approval of the Employer.
- 2.8.3.1.3 The soil to be used for back filling purpose shall be either from the excavated earth or from the borrow pits, as directed by the Employer. The soil may have to be brought from a distance up to 2 km. By the shortest haulage route as approved by the Employer. If directed by the Employer, the excavated earth from the adjoining areas (which is to be disposed-off up to a distance of 500 meters by manual labour) shall be used as for back filling purpose.
- 2.8.3.1.4 Back filling shall not be dropped directly upon or against any structure where there is danger of displacement or damage.
- 2.8.3.1.5 Back filling shall be placed in horizontal layers not to exceed 200mm in thickness. Each layer shall be compacted with proper moisture content and with such equipment as may be required to obtain a density equal to or greater than 95% of maximum dry density as determined by the relevant Indian Standard. The method of compaction shall be subject to the approval of the Employer. Pushing of earth for back filling shall not be adopted under any circumstances.
- 2.8.3.1.6 On completion of structures, the earth surrounding them shall be accurately finished to line and grade as shown on the drawings or as per the instruction of the Employer. Finished surface shall be free of irregularities and depressions and shall be within 50mm of the specified level.

2.8.3.1.7 Any additional quantity of back filling, if required, beyond the excavation payment line shall be done by the contractor at his own expense.

2.8.4 **Construction Joints**

- a) When the work is to be interrupted, the concrete shall be rebated at the joint to such shape and size as may be required by the Employer or as shown on the drawings. All vertical construction joints shall be made with stone boards, which are rigidly fixed and slotted to allow for the passage of the reinforcing steel. If desired by the Employer, keys and/or dowel bars shall be provided at the construction joints. Construction joints shall be provided in positions as shown or described on the drawing. Where it is not described, the joints shall be in accordance with the following:
 - i) In a column, the joint shall be formed about 75mm below the lowest soffit of the beams framing into it.
 - ii) Concrete in tie beam shall be placed throughout without a joint, but if the provision or a joint is unavoidable, the joint shall be vertical and at the middle of the span.
 - iii) In forming a joint, concrete shall not be allowed to slope away to thin edge. The locations of construction joints shall be planned by the Contractor well in advance of pouring and have to be approved by the Employer.
- b) Before fresh concrete is placed, the cement skin of the partially hardened concrete shall be thoroughly removed and surface made rough by hacking, sand blasting, water jetting, air jetting or any other method as directed by the Employer. The rough surface shall be thoroughly wetted for about two hours and shall be dried and coated with 1:1 freshly mixed cement sand slurry immediately before placing the new concrete. The new concrete shall be worked against the prepared surface before the slurry sets. Special care shall be taken to see that the first layer of concrete placed after a construction joint is thoroughly rammed against the existing layer. Old joints during pour shall be treated with 1:1 freshly made cement sand slurry only after removing all loose materials.
- c) The unit rate of pile foundation/ unit rate of concrete work (as the case may be) shall include the cost of construction joints.

2.8.5 **Curing and Protection of Concrete**

Newly placed concrete shall be protected by approved means from rain, sun & wind. Concrete placed below ground level shall be protected from falling earth during and after placing. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground or with water leaking from such ground during placing of concrete and for a period of three days or as

otherwise instructed by the Employer after placing of concrete. The ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage. Adequate steps shall be taken to prevent floatation or flooding. Steps, as approved by the Employer, shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration etc. which may impair the strength or durability of the concrete.

All fresh concrete shall be covered with a layer of Hessian or similar absorbent material and kept constantly wet for a period of seven days or more from the date of placing of concrete as per directions of the Employer. Curing can also be made by ponding. Concrete shall be cured by flooding with water of minimum 25mm depth for the period mentioned above. Steps shall also be taken to protect immature concrete from damage by debris by excessive loading, vibrations, abrasions, deleterious ground water, mixing with earth or foreign materials, floatation etc. that may impair the strength and durability of the concrete. Approved curing compound can be used with the permission of the Employer. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

2.9 Pile Installation

Installation of piles shall be carried out as per pile layout drawings, installation criteria and in line with the specification.

2.9.1 Equipment and Accessories

- 2.9.1.1 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub soil conditions, ground water conditions and the method of casting, etc. These shall be of standard type and shall have the approval of the Employer.
- 2.9.1.2 The capacity of the rig shall be adequate so as to reach the specified founding level.
- 2.9.1.3 Provision shall be kept for chiseling within the pile bore, as specified in this specification. Chiseling shall be carried out only with the approval of Employer. The contractor must have the provision of equipment/ accessories which can bore in the hard rock strata if required, without any additional cost implication to the Employer.

2.9.2 Installation Criteria

- 2.9.2.1 The Contractor while boring the pile bore, shall constantly collect the bore spoils and these shall be compared with the layer wise soil classifications reported in the bore-log details of the location, reported in the soil investigation report. Should there be any variation between the two soil classifications, these shall be immediately reported to the Employer.
- 2.9.2.2 Whenever the rock strata are encountered in the pile bore, the Contractor shall immediately report the matter to the Employer and shall take up the work of rock chiseling or any other suitable method only after the certification/ approval of the Employer. Since the piles are required to be terminated in the firm/ hard strata and as stipulated in the construction drawing the Contractor shall demonstrate such founding strata and seek approval of the Employer before terminating the piles.
- 2.9.2.3 The pile should be socketed and founded in good rock only. Whenever rock strata is encountered at any pile bore and the level of good rock (i.e. rock strata is not highly fractured and weathered and core recovery is not less than 80% with RQD 70%) is different than that is given in the Geotechnical Investigation report, in that case to establish the level of good rock, core drilling is necessary to be carried out at least upto 5m depth in rock strata encountered by the contractor without any additional cost implication to Employer and no time extension will be permitted on this account.
- 2.9.2.4 In order to verify the terminating depth, where rock strata is met with, the rock samples obtained from the bore spoils of pile shall also be tested for point load strength index and these shall then be compared/ correlated to the values of uniaxial compression strength test shown in the soil investigation report. Accordingly, the termination of piles in the socketing zone shall be done with prior approval of the Employer.

2.9.3 Control of position and alignment

- 2.9.3.1 Piles shall be installed vertically as accurately as possible as per the construction drawing. The permissible limits for deviation with respect to position and inclination/alignment shall conform to IS 2911 (Part I/Sec. 2), as reproduced below.
- 2.9.3.2 Maximum permissible deviation in alignment is 1.5%. Piles should not deviate more than 75mm or D/10 whichever is more from their positions at the working level. In case of piles deviating beyond these limits, the piles should be replaced or supplemented by one or more additional piles including the revised cap size (as the situation may be) at no additional cost to the Employer. Any extra claim whatsoever from the contractor on this account shall not be entertained.

2.9.4 Boring

- 2.9.4.1 Boring operations shall be done by rotary or percussion type drilling rigs using Direct Mud Circulation (DMC), Reverse Mud Circulation (RMC) methods or grab method. In soft clays and loose sands bailer method, if used, shall be used with caution to avoid the effect of suction. In cohesive soils, use of water for boring shall be restricted to a minimum, while boring in cohesion less deposits water level in the bore hole shall be maintained at or slightly above the standing water table.

Boring operations by any of the above methods shall be done using drilling mud. The bidder shall be required to furnish along with their bid, complete details regarding the installation of piles and the method by which they wish to install the piles.

- 2.9.4.2 The Contractor shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used, bentonite slurry shall be pumped through drill rods by means of high-pressure pumps. The cutting tools shall have suitable pores for the bentonite slurry to flow out at high pressure. If the Contractor fails to make proper bore for any reason, the Contractor has to modify the boring technique and switchover to other boring methods as approved by the Employer at no extra cost to the Employer.
- 2.9.4.3 Working level shall be above the pile cut off level. After the initial boring of about 1.0 to 2.0m temporary guide casing shall be lowered in the pile bore. The diameter of guide casing shall be of such diameter to give the necessary finished diameter of the concrete pile. The center line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 2.0m length. Additional length of guide casing shall be used depending on the conditions of the strata, ground water level etc. as required by the Employer without any additional cost to the Employer.
- 2.9.4.4 Use of drilling mud (bentonite slurry) for stabilising the sides of the pile bore is necessary wherever subsoil is likely to collapse in the pile bore. Drilling mud to be used shall meet the requirement as given in ***Annexure-A***.
- 2.9.4.5 The bentonite slurry and the cuttings, which are carried to the surface by the rising flow of the slurry shall pass through settling tanks of adequate size to remove the sand and spoils from the slurry before the slurry is re-circulated back to the boring. The bentonite slurry mixing and re-circulation plant shall be suitably designed and installed.
- 2.9.4.6 The bentonite slurry shall be maintained at 1.5m above the ground water level during boring operations and till the pile is concreted. When DMC or RMC method

is used the bentonite slurry shall be under constant circulation till start of concreting.

- 2.9.4.7 Size of cutting tools shall be such that so as to achieve required diameter of pile as per design drawing.

2.9.5 **Chiseling**

Chiseling, if required, may be resorted to with the permission of the Employer below the socketing horizon. The chiseling tool or bit shall be of adequate size and weight so as to reach the desired depth.

2.9.6 **Cleaning of Pile bore**

- 2.9.6.1 After completion the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge/ bored material, debris of rock/boulder etc. Necessary checks shall be made as given in this Section to confirm the thorough cleaning of the pile bore.

- 2.9.6.2 Pile bore shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

- 2.9.6.3 Pile bore spoil along with used drilling mud shall be disposed-off from site up to 2 km or as directed by the Employer.

2.9.7 **Adjacent Structures**

When working near existing structures care shall be taken to avoid any damage to such structures.

2.9.8 **Concreting**

- 2.9.8.1 Concreting shall not be done until the Employer is satisfied that the bearing strata (soil/rock) met with the termination level of pile, satisfied the installation criteria/ approved founding depth.

- 2.9.8.2 The time between the completion of boring and placing of concrete shall not exceed 8 hrs for piles upto 25 meter length and 12 hrs for piles above 25 meter length. In case the time of interval exceeds specified time, the pile bore shall be abandoned. However, the Employer may allow concreting, provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth, and clean the pile bore properly. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

- 2.9.8.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.
- 2.9.8.4 Proper placement of the reinforcement cage to its full length shall be ensured before concreting.
- 2.9.8.5 Entire concreting in pile bores shall be done by tremie method. The operation of tremie concreting shall be governed by IS 2911 (Part I, Sec. 2). Drilling mud shall be maintained sufficiently above the ground water level.
- 2.9.8.6 Concreting operations shall not proceed if the contaminated drilling mud at the bottom of the pile bore possess density more than 1.12T/ cum. or sand content more than 7%. The drilling mud sample shall be collected from the bottom of pile bore. This shall be checked at regular intervals, as decided by the Employer thereafter.
- 2.9.8.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stabilised as well as to prevent concrete getting mixed up with the thicker suspension of the mud.
- 2.9.8.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.
- 2.9.8.9 The temporary guide casing shall be entirely withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.
- 2.9.8.10 Tests on concrete cubes shall be carried out as specified in this section of the Specifications.
- 2.9.9 **Cut-off-level (COL)**
- 2.9.9.1 Cut-off-level of piles shall be as indicated in approved construction drawings or as directed by the Engineer-in-Charge.
- 2.9.9.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment into pile cap.
- 2.9.9.3 When the pile cut off level is less than 1.0 meter below the working level, concrete shall be cast up to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to minimum of one meter above COL.
- 2.9.9.4 In the circumstances where COL is below ground water level, the need to maintain

a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above COL shall be determined by the Contractor with prior approval of Employer.

2.9.10 Sequence of Piling

2.9.10.1 Each pile shall be identified with a reference number and date wise proper record of construction shall be maintained by the Contractor.

2.9.10.2 The convenience of installation may be considered while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

2.9.11 Building up of Piles

If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or the top level of cast pile is less than the specified level or due to any other reason, then the pile shall be built up by using, same grade of concrete, ensuring proper continuity with the existing concrete and to the satisfaction of the Employer. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

2.9.12 Breaking off of Piles

If any pile already cast requires breaking due to lowering in cut off level or for any other reason, then the same shall be carried out, (not before seven days of casting of concrete in the piles) without affecting the quality of existing pile such as loosening, cracking etc. to the satisfaction of the Employer. No extra payment shall be made on this account.

2.9.13 Preparation of Pile head

2.9.13.1 The soil surrounding the piles shall be excavated up to the bottom of the lean concrete below the pile cap with provision for working space sufficient enough to place shuttering, reinforcement, concreting and any other related operations.

2.9.13.2 The exposed part of concrete above the COL, shall be removed/ chipped off and made square at COL not before seven days of casting of pile.

2.9.13.3 The projected reinforcement above COL shall be properly cleaned and bent to the required shape and level to be anchored into the pile cap as shown in the drawing.

2.9.13.4 The pile top shall be embedded into the pile cap by minimum 50mm or clear cover

to reinforcement, whichever is higher.

- 2.9.13.5 All loose material on the top of pile head after chipping to the desired level shall be removed and disposed-off up to a lead of 2 km or as directed by the Employer.

2.9.14 **Rejection and Replacement of Defective Piles**

- 2.9.14.1 The Employer reserve the right to reject any pile which in his opinion is defective with reference to technical specification & construction drawings on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are judged defective shall be pulled out or left in place as decided by the Employer without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Employer at no extra cost to the Employer.

- 2.9.14.2 During execution of pile foundation work, if the bore holes need to be abandoned due to any reason and pile position to be shifted or realigned, other than for any design requirement by the Employer, fresh bore holes are to be executed at a suitable new position, which may vary from 2D to 3D (where, D is diameter of pile) as decided by the Employer, which may demand for resizing of pile cap including possible increase in reinforcement quantity due to resizing of pile cap. In all such cases the abandoned bore holes are to be filled up with plain cement concrete (1:3:6) so that no cavity remains in the bore hole of the abandoned pile. Any extra claim whatsoever from the contractor on account of abandoned bore hole, filling up of abandoned bore hole with concrete and any extra cost due to resizing of pile cap including increase in reinforcement quantity shall not be entertained by the Employer & the same have to be borne by the contractor.

2.9.15 **Criteria for Terminating the Piles**

- 2.9.15.1 The piles can be terminated at a depth based on design developed/ approved by the Employer, where loads on the piles can be transmitted to the soil in a proper manner or the depth where specified 'N' value is achieved, whichever occurs later. However, in no case piles should be terminated at a higher level than that indicated in the construction drawing.
- 2.9.15.2 Standard penetration test (SPT) shall be carried out starting from 1.0 m above the specified pile termination depth and there after @ 1m up to the pile termination depth.
- 2.9.15.3 The Standard Penetration Test (SPT) shall be carried out based on the following test procedures:
 - a) The test shall be conducted by driving a standard split spoon sampler in the borehole by means of a 650 N hammer having a free fall of

0.75 m.

The sampler shall be driven for 450 mm using the hammer and the number of blows shall be recorded for every 150mm penetration. The number of blows for the last 300 mm drive shall be reported as N value. The test shall be discontinued when the blow count is equal to 100 or the penetration is less than 25mm for 50 blows, whichever is earlier.

- b) At the location where the test discontinued, the penetration and the number of blows shall be reported. Sufficient quantity of disturbed sample shall be collected from the split spoon sampler for identification/ classification of soil. The sample shall be visually classified and recorded at the site.
- c) The specification for the equipments and other accessories, procedure for conducting the test and collection of the disturbed soil sample shall conform to IS 2131.

2.9.16 **Recording of Piling Data**

- 2.9.16.1 The Contractor shall record all the information during installation of piles. Typical data sheet for recording pile data as shown in Appendix D of IS 2911 (Part I, Sec. 2) shall be maintained by the contractor. The pile data shall also include all the details as in *Annexure-B*. On completion of each pile installation, pile record in triplicate shall be submitted to Employer within two days of completion of concreting of the pile.

2.9.17 **Check for Pile bore**

- 2.9.17.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Employer, to ensure that it is free from pile bore spoil/ debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Employer.

- 2.9.17.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted.

A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

2.9.18 **Properties of drilling mud**

- 2.9.18.1 Properties of drilling mud shall be checked as per requirements indicated in *Annexure-A* prior to the commencement of piling work and thereafter at least

once in a week or as found necessary by the Employer, one sample consisting of 3 specimens shall be tested.

2.9.18.2 Density and sand content of the drilling mud shall be checked in each pile.

2.10 Erection of Steel Embedded Parts

2.10.1 General

2.10.1.1 This covers the technical requirements for the supply and fabrication and/or erection of all embedded steel parts by the Contractor. The extent and type of embedded steel parts to be erected shall be as per detailed drawings.

2.10.1.2 The supply of embedded steel parts like ladders, steel pieces set in concrete inserts, dowel bars required for construction joints etc. are in the scope of the Contractor. However, supply of anchor bolts/ stubs, as the case may be, will be supplied by tower contractor.

2.10.1.3 Embedded steel parts shall include items such as foundation anchor bolts, stubs, ladders, steel pieces set in concrete inserts, dowel bars for concrete work etc. shown on the drawing or as required by the Employer. Material shall also include setting in forms for connecting in place and grouting as required. The grouting operations, if required, shall be performed as per the direction of Employer.

2.10.1.4 The Contractor shall erect all embedded steel parts in accordance with the drawings and this specification including setting materials in concrete or grouting pieces in place, furnishing all labour, materials, scaffolding, tools and services necessary for and incidental to the work to its transporting, unloading, storing, handling and erection. Contractor shall furnish welding rods and arrange for field welding as required in accordance with IS 816.

2.10.1.5 Exposed surfaces of embedded material are to be painted with one coat of approved anticorrosive and/or bituminous paint without any extra cost to the Employer. The threads of holding down bolts shall be greased and protected with water proof tape.

2.10.2 Installation

2.10.2.1 During erection, the Contractor shall provide necessary temporary bracing or supports to ensure proper installation of the materials. All materials shall be erected in the true locations as shown in the drawings, plumb and level. Extreme care shall be taken to ensure that the threads of holding down bolts and comparable items are protected from damage.

- 2.10.2.2 Groups of holding down bolts shall be set in such a manner that the tolerance of whole group is not more than 3mm from its true position in plan at the top of the bolt and not more than 3mm from the required level. The top ends of all bolt shanks shall be in one plane to the tolerance stated above.

Holding down bolt assemblies shall be set vertically to a tolerance of not more than 1:500.

2.10.3 Protection Against Damage in Transit

- 2.10.3.1 All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever. All protecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surface shall be suitably packed and all bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit. Should there be any distortion of fabricated members, the Contractor shall immediately report the matter to the Employer. Distorted reinforcement bars or plates received from stores or distorted during transport from stores to the fabrication yard shall not be used in fabrication unless the distortions are minor which in the opinion of the Employer can be removed by acceptable methods. The cost of all such straightening shall be borne by the Contractor within his unit rates.
- 2.10.3.2 These distortions shall be rectified by the Contractor by cold bending. If heating is necessary to rectify the defects, the details of the procedure shall be intimated to the Employer whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

2.11 Foundations Bolts/ Stub

- 2.11.1 The foundation bolts/ stubs, as required, for the tower structures shall be supplied by the respective tower contractor. These shall be embedded in concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate and also co-ordinate with the respective tower contractor for its correctness. The final adjustment of these bolts and their grouting are included in the scope of this contract. Grouting of block outs and the gap between the base plate and top of concrete shall be done by the Contractor after finalisation of alignments. The unit rate of concreting/ unit rate of pile foundation (as the case may be) shall include the cost of above adjustments, grouting, and skins etc. required for this purpose.
- 2.11.2 The Contractor shall be responsible for the correct alignment and levelling of all steel work on site to ensure that the towers are in plumb.

- 2.11.3 Before erection of towers, by tower contractor, on the foundations the top surface of base concrete shall be thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose materials and shall be chipped with a chisel to ensure proper bond between the grout and the foundation concrete. The piling Contractor shall also be responsible for bringing down the top of concrete to the desired level by chipping. In case the foundation as cast is lower than the desired level, the Contractor shall make up the difference by providing additional pack plates without extra cost for any such work or material. No steel structures shall be erected on their foundations unless such foundations have been certified fit for erection by the Employer. Adequate number of air release holes and inspection holes shall be provided in the base plate.

2.12 **Stability of Structure**

- 2.12.1 The Contractor shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations. Guying and bracing shall be done for erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interface with the movement or working of other agencies working in the area. For the purpose of guying, the Contractor shall not use other structures in the vicinity which are likely to be damaged by the guy.
- 2.12.2 Such temporary bracings shall neither be included in the measurement nor extra rate shall be payable. Such temporary bracings used shall be the property of the Contractor and may be removed by him at the end of the job from the site of work.

2.13 **Grouting and under Pinning**

2.13.1 **General requirement**

- 2.13.1.1 Furnishing of all labour materials and equipment and performance of all operations necessary to complete the work of grouting of block outs and foundation bolt holes and under pinning of base plates is in the scope of the Contractor. The cost of the above shall be included in the unit concreting rate.
- 2.13.1.2 Grouting shall be adopted for filling the block outs, pockets below foundation bolt holes. The block out and bolt holes which have to be grouted shall be cleaned thoroughly by use of compressed air immediately before taking up the grouting operations.
- 2.13.1.3 Cement and aluminium powder or anti-shrinkage admixture of approved quality shall be first blended thoroughly in the required proportions as per manufacturer's specification. The mix of grouting shall contain one part of cement

2.13.1.4 The quantity of aluminum powder shall usually be of the order of 0.005% by weight of cement. Any grout which has been mixed for a period longer than half an hour shall not be used on the work. Immediately after preparation the grout shall be poured into the block outs, pockets and foundation bolt holes either from the sides or through the holes provided for this purpose in the base plate, by using special equipment for pressure grouting. It shall be ensured by rodding and by tapping of bolts that the block out is completely filled without leaving any voids. The pouring shall cease as soon as each hole is filled and any excess grout found on the surface of the concrete foundation shall be completely removed and the surface dried.

2.13.1.5 Under pinning shall be resorted to for filling the space between the underside of base plate and the top of foundation concrete. After grouting has been completed as specified above, space between the top surface of the foundation concrete and the underside of the base plate shall be filled with mortar or concrete depending upon thickness to be filled as follows: -

Less than 40mm	Dry packed cement mortar
Over 40mm	Dry packed fine concrete

2.13.1.6 Mortar, fine concrete shall be blended with aluminium powder about 0.005% by weight of cement or with anti-shrinkage admixture in a suitable proportion to the cement mortar in accordance with the recommendations of the manufacturer and subject to the approval of the Employer. Mortar shall comprise cement, sand and water in proportion of approx. 1:3:0.4 by weight. Concrete shall comprise cement, sand, 10mm max. sized aggregate and water in proportion of 1:1.25:2:0.4 by weight. In all cases minimum 28 days cube strength should not be less than 25N/mm².

Shims provided for the alignment of bases shall be positioned at the edges of the base to permit subsequent removal which shall take place not less than 7 days after the underpinning has been executed. The resulting cavities shall be made good with the same grade of mortar or concrete as has been used for the underpinning of the rest of the base plate.

2.13.1.7 Cement, sand and aluminium powder or approved anti-shrinkage admixture, shall first be blended thoroughly in the required proportion. The mortar shall then be prepared by mixing with quantity of water which will produce a sufficiently workable mix to enable complete and proper compaction of the mortar.

2.13.1.8 The mortar shall then be placed below the base plate and rammed in a horizontal direction for each edge until the mortar oozes out through the grout holes

provided in the base plate.

- 2.13.1.9 When it is clear that the center of base has been properly filled, the mortar outside the base plate shall be briefly rammed to ensure compaction below the edges. Any mortar which has been mixed for a period longer than half an hour, shall not be used in the work.

2.13.2 **Materials**

- 2.13.2.1 Cement shall conform to the stipulations contained in IS 8112 and shall have a fineness (specific surface of cement) not less than 225 sqm/kg when tested for fineness by Blaine's air permeability method as per IS 4031.
- 2.13.2.2 Sand shall conform to the stipulations contained in IS 383.
- 2.13.2.3 Water shall be clean and fresh and shall be of potable quality.
- 2.13.2.4 Aluminium powder or anti-shrinkage admixture like 'Groutex' CRS-NS grout (by Cement Research Institute of India) or its equivalent shall be of standard brand from reputed manufacturer and shall be approved by the Employer prior to its use for work.

2.13.3 **Curing**

The work shall be cured for a period of 7 days commencing 24 hours after the completion of the grouting and under pinning operations. The curing shall be done by covering the surfaces with wet gunny bags.

2.13.4 **Bar Grips**

- 2.13.4.1 This covers the technical requirement for furnishing and installation of bar grips complete including all labour materials, equipments, staging, etc.
- 2.13.4.2 The Contractor shall furnish and install the bar grips for various dia of deformed bars as indicated in drawings and as required by these specifications. The bar grip splicing system shall be of approved manufacturer and of the best quality available subject to approval of the Employer.

2.13.5 **Splicing**

- 2.13.5.1
 - a) The reinforcement bars are to be joined without any gap and the sleeve placed in position.
 - b) Pressure is applied by means of a hydraulic press which swages the sleeve down on the bar ends in a series of bites which are applied at high pressure.

- c) The job can also be done in two stages. The 1st stage is to press the half sleeve on the loose bar at the reinforcement yard. The 2nd stage work is to be done at the actual site after the loose bar is inserted through the un-presented end of the sleeve and pressed in-situ.
- 2.13.5.2 The joints shall be staggered as far as possible. Necessary staging arrangements are to be made by the Contractor.
- 2.13.5.3 It may be necessary to fix the sleeve to the reinforcement bars at one end in the open yard for the facility of working. All these working details are to be furnished earlier subject to the approval of the Employer.
- 2.13.5.4 The length of the sleeve should be adequate, that it is safe under the pull-out loading conditions.
- 2.13.5.5 One percent representative samples of each diameter, bars shall be sent for laboratory testing at the cost of the Contractor to check the efficiency of the joints under ideal condition. These samples of sleeves will be sent in the Laboratory for pull out tests.
- 2.13.5.6 All bar grips installation shall be subject to inspection and approval by the Employer before concreting operation are performed. In case of any defect or joint being not up to mark, the same shall be replaced by the Contractor at no extra cost.

2.14 MS Liner

MS liner shall be provided wherever included in the construction drawings approved by the employer and/ or otherwise required by the employer. Detailed technical requirements of MS liner are stipulated in **Clause 5.0** shall apply.

3.0 Rates and Measurement

3.1 Rates and Measurement Applicable When Design of Pile foundation is in Contractor's Scope

The Rate quoted by bidder includes Design & Installation of 750 mm/ 1000 mm/ 1200 mm/ 1500 mm diameter pile of suitable length, which inter-alia includes the design & vetting of pile foundation, excavation, boring, form work for placement of concrete, supply & placement of reinforcement steel & MS liner, concreting and PCC, back filling and conducting Standard Penetration Test & Integrity test etc. as specified in relevant clause of this section.

The details of items for completeness of pile foundation works include the

following items:

3.1.1 Design of Pile foundation

The design of pile foundation shall be carried out as per, design criteria for pile foundation specified in clause 1.2.4 of this section, the soil parameters provided by employer, other hydrological report/ data collected from CWC/ Local authority. After completion of design works, each pile design along with design calculations & drawings shall be vetted from reputed institutions like IITs/NITs and submitted for employer's approval.

3.1.2 Excavation

3.1.2.1 The unit of measurement for excavation shall be in cum. The design excavation volume shall be calculated considering dimension of pile cap plus 150mm on all sides of the pile cap and depth as shown in the drawing approved by employer below the lean concrete level. The excavation covers all types of soil including sheet piling, sheeting, shoring, bracing, draining, dewatering, cofferdams etc. as required for successful completion of job. The excavation shall be carried out in accordance with the stipulations in *clause 2.0* of this Specification.

3.1.2.2 The Contractor shall arrange to transport the excavated soil to a distance as directed by Employer and the rates quoted in Price schedule shall include all lead, lift, carriage etc.

3.1.3 Cement Concrete

3.1.3.1 Actual volume of work as executed or as per drawing, measured in cubic meter corrected up to second place of decimal shall be considered for measurement purpose. Deductions for openings, conduits, pipes, ducts, pockets etc. shall only be made provided they are larger than 0.1 sqm. in area (for each opening).

3.1.3.2 No deduction shall be made for embedded fixtures including reinforcement, sleeves, anchor bolts and similar items.

3.1.3.3 The volume for structural concrete and lean concrete shall be measured separately.

3.1.4 Form Work

3.1.4.1 Formworks of different types/ shapes shall be measured with reference to actual surface area in contact with the concrete. The unit of measurement will be in sqm. corrected upto second place of decimal.

3.1.4.2 Opening up to 0.1 sqm of boxing left for inserts etc. shall not be considered as if

non-existent for the purpose of formwork measurement of surface in which the opening occurs. If the cross-sectional area of any openings exceeds 0.1 sqm., area of such openings shall be measured and deducted from the area payable for the total form work.

3.1.4.3 The total formwork should be water proof and includes the supports, scaffolding, centering, approaches, and fillets for rounding of chamfering junctions, corners etc.

3.1.5 **Back filling**

3.1.5.1 The actual volume of backfilling shall be measured in cubic meter rounded off up to 2nd place of decimal shall include all the necessary operations required to complete the work as per drawing & **Clause 2.0** of this section. The rate quoted by bidder includes the backfilling works also.

3.1.6 **Reinforcement Steel**

3.1.6.1 The bidder shall supply and place reinforcement steel of specific grade, stirrups, annealed wire for binding the reinforcement, chairs, hangers, spacers, welding, tack welding etc. as required to complete the RCC work in pile, pile cap, pedestal/ chimney, tie beam (if required) including cleaning, straightening, cutting, bending, binding etc. Contractor shall also place of reinforcement cage in pile shaft/bore and all other cost for tools, plants, materials, labour, transportation to site are to be borne by the bidder. Wastage, overlaps, spacer bars, chairs, stays, hangers, annealed steel wire shall not be measured and cost of these items shall be deemed to be included in the quoted price of pile foundation.

3.1.6.2 Standard hooks, cranks, bends, authorized laps, etc. shall be measured.

3.1.6.3 Separator pieces between two or more layers of steel shall not be measured.

3.1.6.4 For supporting horizontal reinforcement at heights, drawings for supports, spacers, chairs, hangers, etc. larger than 300mm, shall be prepared by the Contractor and got it approved from Employer.

3.1.6.5 No extra payment shall be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.

3.1.6.6 Dowels as required for completion of the work shall be provided by the contractor which will not be separately calculated for payment.

3.1.7 **Piling work**

3.1.7.1 The items of works are briefly described in the BPS. The various items in the BPS

shall be read in conjunction with the corresponding sections in the Technical Specifications, including amendments, and additions, if any. The rate quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

- 3.1.7.2 The rate shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.
- 3.1.7.3 rate shall also include for all safety measures as required by Codal provisions, local regulations, acts, bye-laws, etc. and mobilization of all plant, equipment, scaffolding, materials, skilled and unskilled labour, demobilisation after completion of work, supervision, establishing level and coordinates at each location by carrying levels from one established bench mark and distances from one set of grid lines furnished by the Employer.
- 3.1.7.4 The rate quoted by bidder shall include the pile boring through all kind of soil, including weathered rocks, laterite, shell, hard rock and shall be inclusive of cost of boring by approved method, bailing out all the pile bore spoils from the pile bore, keeping the bore hole free from bored material/debris etc. and disposing same along with the drilling mud up to a distance of 2 km, flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of pile bore, transporting to laboratory, testing and reporting of results including necessary materials, equipment and manpower.
- 3.1.7.5 The rate quoted shall also include the pile boring through soil including weathered rocks, laterite, shell, hard rock shall include shifting of plant and equipment from one pile location to another location, providing temporary casing as required and removal of the same after completing concreting. The quoted rate shall also include the boring/ installation of pile and is inclusive of the empty boring and extra concreting required above the pile cut off level.
- 3.1.7.6 The rate quoted shall include the pile boring through soil including weathered rock/ laterite shall also include chiseling, if any required, the chiseling through rock in the pile below socketing horizon up to the specified level shall be inclusive of bailing out the pile bore debris/ spoils from the pile bore and disposing off the chiseled materials/debris along with the sludge/ mud up to 2 km, flushing the pile bore by fresh betonies before concreting, collection of samples from bottom of the pile bore, transporting to laboratory, testing and reporting of results.
- 3.1.7.7 The rate shall also include concreting in piles by tremie method only, cost of preparation of pile head and disposal of debris etc., resulting from breaking off of pile up to cut off level (COL), up to a distance of 2 km.

- 3.1.7.8 The rate shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.
- 3.1.7.9 The rate quoted shall be inclusive of performing point load test on the rock samples obtained from bore spoils during the chiseling operations, and shall be inclusive of transportation to laboratory, testing and reporting of the results.
- 3.1.7.10 Measurement for the item of boring through soil including weathered rock shall be done by linear measurement for the length bored from the pile cut off level or ground level whichever is lower through soil/ weathered rock up to termination/ founding level as per drawing or actual length achieved of the pile in meters, up to second place of decimal.

3.1.8 **Standard Penetration Test (SPT)**

The actual quantity of SPT done shall be calculated in nos. and the rate quoted shall include all the necessary equipment, labour, materials, operations etc. required to complete the work as per **Clause 2.0** of this section.

3.1.9 **MS Liner**

- 3.1.9.1 The measurement shall be made in Metric Ton (MT) corrected upto third place of decimal based on the calculated weight of the MS liner as per construction drawing and with reference to the sectional weights of respective thickness of MS plate as per Indian Standards or MS liner actually provided, whichever is less. The rate quoted shall be inclusive of all wastage.
- 3.1.9.2 The rates shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

3.1.10 **Pile Integrity Test**

The actual quantity of pile integrity test done shall be calculated in numbers and the rate quoted by the bidder shall include all necessary equipments, manpower, labour, materials, operations etc. required to complete the work as **per Clause 4.0** of this section. The work shall be deemed to be complete only after submission of complete report of pile integrity test on all piles. Minimum one integrity test per pile installed/casted has to be carried out by the bidder.

3.2 **Rates and Measurement Applicable When Design of Pile foundation is not in Contractor's Scope and Employer shall provide construction drawings to Contractor.**

3.2.1 **Excavation**

- 3.2.1.1 The unit rate for excavation shall be quoted by the Bidder in the respective

schedule of BPS. The unit rate quoted shall hold good for excavation (other than boring) for all depth and size in all types of soil including sheet piling, sheeting, shoring, bracing, draining, dewatering, cofferdams etc. as required for successful completion of job. The excavation shall be carried out in accordance with stipulations in Clause 2.0 of this section.

3.2.1.2 The unit of measurement shall be in cum. The design excavation volume shall be calculated considering dimension of pile cap plus 150mm on all sides of the pile cap and depth as shown in the drawing below the lean concrete level. The payment shall be made based on unit rate quoted, for excavation actually carried out or as per the design excavation volume as calculated above, whichever is less. No extra payment shall be admissible for excavations if required to be carried out in slope to maintain stability of pit.

3.2.1.3 The Contractor shall arrange to transport the excavated soil to a distance as directed by Employer and the rates quoted for excavation in Price schedule shall include all lead, lift, carriage etc.

3.2.2 **Cement Concrete**

3.2.2.1 Actual volume of work as executed or as per drawing issued, whichever is less, measured in cubic meter corrected up to second place of decimal shall be considered for payment as per unit rate quoted in BPS. Deductions for openings, conduits, pipes, ducts, pockets etc. shall only be made provided they are larger than 0.1 sq. in area (for each opening).

3.2.2.2 No deduction shall be made for embedded fixtures including reinforcement, sleeves, anchor bolts and similar items.

3.2.2.3 The volume for structural concrete and lean concrete shall be measured separately.

3.2.3 **Form Work**

3.2.3.1 Formworks of different types/ shapes shall be measured with reference to actual surface area in contact with the concrete and paid on area basis. The unit of measurement will be in sqm corrected up-to second place of decimal.

3.2.3.2 No payments for formwork for construction joints shall be made.

3.2.3.3 Opening up to 0.1 sqm. of boxing left for inserts etc. shall not be considered as if non-existent for the purpose of formwork measurement of surface in which the opening occurs. If the cross-sectional area of any openings exceeds 0.1 sqm., area of such openings shall be measured and deducted from the area payable for the form work.

3.2.3.4 No payment shall be made for making the formwork water proof or for supports, scaffolding, centering, approaches, etc.

- 3.2.3.5 No separate payment shall be made for using fillets for rounding of chamfering junctions, corners, etc.

3.2.4 **Back filling**

The actual volume of backfilling shall be measured in cubic meter rounded off up to 2nd place of decimal and the unit rate shall include all the necessary operations required to complete the work as per drawing & *clause no. 2* of this section.

3.2.5 **Reinforcement Steel**

- 3.2.5.1 The unit rate for reinforcement steel shall include supply and placement of reinforcement steel of specific grade, stirrups, annealed wire for binding the reinforcement, chairs, hangers, spacers, welding, tack welding etc. as required to complete the RCC work in pile, pile cap, pedestal/ chimney, tie beam (if required) including cleaning, straightening, cutting, bending, binding etc. The unit rate shall also include placement of reinforcement cage in pile shaft/ bore and all other cost for tools, plants, materials, labour, and transportation to site by appropriate means as required. The measurement for payments shall be made in Metric Ton (MT) corrected up to third place of decimal based on the calculated weight of reinforcement steel as per construction drawing and with reference to the sectional weights of respective size of reinforcement bars as per Indian Standards or reinforcement bars actually provided, whichever is less. The unit rate quoted shall be inclusive of all wastage.
- 3.2.5.2 Standard hooks, cranks, bends, authorised laps, etc. shall be measured.
- 3.2.5.3 Separator pieces between two or more layers of steel shall not be measured.
- 3.2.5.4 No payment shall be made for supports, spacers, chairs, hangers, etc. of height/ length of 300 mm and less, required for keeping the steel in position. For supporting horizontal reinforcement at heights, drawings for supports, spacers, chairs, hangers, etc. larger than 300 mm, shall be prepared by the Contractor and got it approved from Employer. Payment shall be made for these supports as approved by the Employer, or as actually provided, whichever is less, as per the unit rate quoted for reinforcement.
- 3.2.5.5 No extra payment shall be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.
- 3.2.5.6 Dowels as required for completion of the work shall be provided by the contractor which will not be separately calculated for payment.
- 3.2.6 **Piling work**
- 3.2.6.1 The items of works are briefly described in the BPS. The various items in the BPS shall be read in conjunction with the corresponding clause in this section including amendments, and additions, if any. The unit rate quoted

for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

- 3.2.6.2 The unit rates shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.
- 3.2.6.3 Unit rates shall also include for all safety measures as required by Codal provisions, local regulations, acts, bye-laws, etc. and mobilization of all plant, equipment, scaffolding, materials, skilled and unskilled labour, demobilisation after completion of work, supervision, establishing level and coordinates at each location by carrying levels from one established bench mark and distances from one set of grid lines furnished by the Employer.
- 3.2.6.4 Unit rate on per meter length basis for a particular diameter of pile shall remain unchanged irrespective of the actual length/depth of individual piles executed at any location
- 3.2.6.5 Unit rate for pile boring through all kind of soil, including weathered rocks, laterite, shell, hard rock shall be inclusive of cost of boring by approved method, bailing out all the pile bore spoils from the pile bore, keeping the bore hole free from bored material/debris etc. and disposing same along with the drilling mud up to a distance of 2 km., flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of pile bore, transporting to laboratory, testing and reporting of results including necessary materials, equipment and manpower.
- 3.2.6.6 Unit rate quoted for pile boring through soil including weathered rocks, laterite, shell, hard rock shall include shifting of plant and equipment from one pile location to another location, providing temporary casing as required and removal of the same after completing concreting. The quoted unit rate for boring/installation of pile shall also be inclusive of the empty boring and extra concreting required above the pile cut off level.
- 3.2.6.7 Unit rate for pile boring through soil including weathered rock/ laterite shall also include chiseling, if any required, the chiseling through rock in the pile below socketing horizon up to the specified level shall be inclusive of bailing out the pile bore debris/ spoils from the pile bore and disposing off the chiseled materials/debris along with the sludge/ mud up to 2 km., flushing the pile bore by fresh betonies before concreting, collection of samples from bottom of the pile bore, transporting to laboratory, testing and reporting of results.
- 3.2.6.8 Unit rate of pile boring shall include concreting in piles by tremie method only, cost of preparation of pile head and disposal of debris etc., resulting from breaking off of pile up to COL, up to a distance of 2 km.

- 3.2.6.9 Unit rates shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.
- 3.2.6.10 The rate quoted for boring and installation shall be inclusive of performing point load test on the rock samples obtained from bore spoils during the chiseling operations, and shall be inclusive of transportation to laboratory, testing and reporting of the results.
- 3.2.6.11 Measurement for the item of boring through soil including weathered rock shall be done by linear measurement for the length bored from the pile cut off level or ground level whichever is lower through soil/ weathered rock up to termination/ founding level as per drawing or actual length achieved of the pile in meters, up to second place of decimal.

3.2.7 **Standard Penetration Test (SPT)**

The actual quantity of SPT done shall be calculated in nos. and the unit rate quoted shall include all the necessary equipments, labour, materials, operations etc. required to complete the work as per **clause 2.0** of this section.

3.2.8 **MS Liner**

- 3.2.8.1 The items of works are briefly described in the BPS. The various items in the BPS shall be read in conjunction with the clause 5.0 of this section. The unit rate quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.
- 3.2.8.2 The unit rates shall also include all minor activities which are obviously and fairly intended though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.
- 3.2.8.3 The measurement for payments shall be made in Metric Ton (MT) corrected upto third place of decimal based on the calculated weight of the M.S. liner as per construction drawing and with reference to the sectional weights of respective thickness of MS plate as per Indian Standards or MS liner actually provided, whichever is less. The unit rate quoted shall be inclusive of all wastage.

3.2.9 **Pile Integrity Test**

The actual quantity of pile integrity test done shall be calculated in nos. and the unit rate quoted shall include all necessary equipments, manpower, labour, materials, operations etc. required to complete the work as per **clause 4.0** of this section. The payment shall only be made after successful completion of the job and submission of complete report of pile integrity test on all piles.

4.0 **Testing and Acceptance Criteria**

4.1 Construction Materials

- 4.1.1 Any material considered to be sub-standard or not meeting the requirement of *clause 2.0* of this section and as declared/ certified accordingly by the Employer shall not be used by the Contractor and shall be removed from the site immediately at no extra cost to the Employer.

4.2 Cement Concrete

4.2.1 Testing

- 4.2.1.1 The Contractor shall carry all sampling and testing in accordance with the *Standard Field Quality Plan (SFQP) which is available on the POWERGRID Website 7 (seven) days prior to the actual date of bid opening*, relevant Indian Standards and this Specification at his own cost in field and in a laboratory approved by the Employer. For the tests carried in the laboratory, Contractor shall submit the test results to the Employer in triplicate within 7 (seven) days after completion of the test.
- 4.2.1.2 Facilities required for sampling and testing materials, concrete, etc. in field and in laboratory shall be provided by the Contractor. Where no specific testing procedure is mentioned the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Employer. In field Tests shall be done in the presence of the Employer or his authorized representative. For the tests to be performed in the laboratory other than field, shall be done in the independent certified lab approved by Employer. In case the Employer requires additional test, the Contractor shall arrange to get these tests done and submit to the Employer the test results in triplicate within three days after completion of any test.
- 4.2.1.3 The Contractor shall maintain records of all inspection and testing, which shall be made available to the Employer, whenever required.
- 4.2.1.4 The testing apparatus/ equipment installed in the field laboratory shall be calibrated/ corrected by the qualified person as frequently as possible to give accurate testing results.
- 4.2.1.5 Frequency of sampling and testing, etc. and Acceptance Criteria should be as per SFQP. However, Employer shall have the full authority to call for tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the Specifications. The materials shall be tested to meet all the specified requirements before acceptance at manufacturers' premises or at independent government approved laboratory. Tests indicated in the tables of Standard Field Quality Plan are for cross checking at site to ascertain the conformity of the materials to the Specifications.
- 4.2.1.6 One sample consisting of six test cubes shall be made from the concrete used in each pile, three to be tested after 7 days and three after 28 days.

4.2.1.7 In preparation of test cubes/ specimens, vibrators shall not be used.

4.2.1.8 Concrete shall be tested for slump at every 1-hour interval.

4.2.2 **Acceptance Criteria for Concrete**

- a) The acceptance criteria of concrete shall be in accordance with Standard Field Quality Plan (SFQP) and as per **clause 2.0** of this Specification.
- b) Concrete work found unsuitable for acceptances shall have to be dismantled and replacement is to be done as per specification by the Contractor. No payment for the dismantled concrete, the relevant form work and reinforcement, embedded fixtures, etc. wasted in the dismantling shall be made to the Contractor. If any damage is done to the embedded items of adjacent structures, the same shall be made good free of charge by the Contractor, to the satisfaction of Employer.
- c) The dimensions of concrete as cast, when compared with the drawing, shall be within the tolerances given below. Steps in surface alignment shall not exceed 2mm. No reduction will be permitted in the cover to reinforcement because of a specified negative tolerance in a concrete section.

Structural Element Detail	Permissible Deviation in mm	
Faces of concrete in foundations and structural members against which backfill is placed	+25	-5
Exposed concrete foundations	+10	-5
Top surfaces of Pedestal/chimney and for concrete to receive grouted plant or structural steel work	+5	-5
Alignment of tie beams, Pedestal/chimney, pile cap	+5	0
Cross sectional dimensions of tie beams, Pedestal/chimney, cap	+5	-5
Level and alignment of holding down bolts	+5	-5
Level of holding down bolt assemblies	+10	-5
Alignment of holding down bolt assemblies	+5	-5
Centers of pockets or holes with greatest lateral dimensions not exceeding 150mm	+5	-5
Centers of pockets or holes with greatest lateral dimension exceeding 150mm	+10	-5

4.2.3 **Acceptance criteria of Finished Concrete**

- 4.2.3.1 Finished concrete shall be true to shape, lines, levels plumb and dimensions as shown on drawings.
- 4.2.3.2 All embedded fixtures shall be of correct type and in correct position as shown in drawings.
- 4.2.3.3 Finished concrete surface shall be free from blemishes like honey-combs, air bubbles, fins, etc.
- 4.2.3.4 Exposed concrete surface shall be free from rust stains, grease and mould oil stains etc. and shall have uniform pleasing appearance to the satisfaction of the Employer.
- 4.2.3.5 The finished concrete shall be of a standard quality and equal to the accepted sample.

4.3 **Reinforcement Steel**

Reinforcement shall be checked for cleanliness, proper bending, binding, placing and securing in position with provision for proper cover. The reinforcement should conform to the requirement of under *clause 2.0* of this section.

4.4 **Testing for position and alignment**

- 4.4.1 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.
- 4.4.2 Permissible limits for deviation shall be as specified under *clause 2.0* of this section.

4.5 **Properties of drilling mud**

- 4.5.1 Properties of drilling mud shall be checked as per requirements indicated in *Annexure A*. Prior to the commencement of piling work and thereafter at least once in a week or as found necessary by the Employer, one sample consisting of 3 specimens shall be tested.
- 4.5.2 Density and sand content of the drilling mud shall be checked in each pile.

4.6 **Check for Pile bore**

- 4.6.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Employer, to ensure that it is free from pile bore spoil/ debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Employer.
- 4.6.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted.

A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

4.7 Pile Integrity Test

4.7.1 Pile Integrity test is used to assess the as-installed pile characteristics as well quality achieved during the construction of pile. The parameters to be evaluated through the Pile Integrity Test (also known as low-strain dynamic test/ sonic echo test/ low-strain integrity test) should generally cover pile continuity, defects such as cracks, necking, soil incursions, changes in cross section and approximate pile lengths changes in cross-section if any etc.

4.7.2 The equipment consists of an electronic control unit, a hand-held instrumented hammer and an accelerometer and computer. The test shall be conducted as per IS 14893:2001.

4.7.3 The results to be stored in a compact control unit and transferred to computer and detail analysis to be carried out.

4.7.4 The contractor is to submit a detailed report for the data specified in ***clause 4.7.1*** above and as required by the Employer.

5.0 Structural steel MS liner for RCC Vertical bored piles

5.1 General Requirements

This specification covers general requirements for supply, fabrication, shop painting (if required), and delivery at site mild steel liners of specified diameters and lengths for piles.

MS liner shall be provided to piles at locations, as directed by the Employer and design guidelines mentioned in the Design & Drawings clause of this section. The extent up to which the MS liners for piles required to be provided shall be as shown in the approved drawings and as per direction and written approval of the Employer.

5.2 Drawings

5.2.1 Contractor shall submit calculations and fabrication details for connection/ splice/ joint for fabrication of liners and get these approved by the Employer before starting any fabrication works. The approval of fabrication drawings prepared by the Contractor shall not relieve the Contractor of the responsibility for the liners in place.

Fabrication drawing (drawn to large enough scale) to convey all information clearly shall include the following:

- i) Reference of the design drawings based on which fabrication had been prepared. The reference should include and indicate the latest revision of design drawing.
- ii) layout, elevations and sections with erection marking of all members.
- iii) Quality of Structural Steel, Welding electrodes, and standards to which these conform to. Detailing of structural joints and shop/field splices.
- iv) Details of shop and field joints/connections.
- v) Bill of material indicating size and weight of members/ component.
- vi) Erection assemblies and sub-assemblies identifying all transportable parts.
- vii) Method of erection, special erection instructions, and special precautions to be taken during erection, as required.

5.2.2 Employer reserves the right to make changes in the fabrication drawings. Revisions to drawings may be made to reflect more updated requirements. Revisions to drawings and any new drawings made to include additional work by Contractor shall be considered as a part of this specification and the Employer shall entertain no extra claim on this account. All revisions in the drawings should be highlighted in the drawing distinctly.

5.2.3 Unless otherwise specified, the drawings and specifications are intended to include everything obviously requisite and necessary for the proper and entire completion of the work and the job shall be carried out accordingly for the completeness as required.

5.2.4 In the case of variations in drawings and specifications, the decision of the Employer shall be final. In case Contractor in the execution of his work, find discrepancies in the information furnished by Employer, he shall refer such discrepancies to the Employer before proceeding with such work.

5.3 **Fabrication**

5.3.1 **General**

The fabrication work shall be carried out generally in accordance with IS 800 as well as the stipulation contained in these specifications. All materials shall be completely shop fabricated and finished with proper connection materials for ready assembly in the field. All the workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined true and square where so specified. All edges shall be free of burrs, shearing and chipping shall be neatly and accurately done. Material at the shop shall be kept clean and protected from weather, Checklist format, inspection certificate for fabrication and protocol for handing over of structural steel shall be submitted by the Contractor in the form as agreed to by the Employer.

5.3.2 Straightening

All material shall be straight and free from bends or twists. If necessary, before being worked, the materials shall be straightened, unless otherwise required/ specified. In case plates are distorted or twisted, straightening or flattening shall be done by methods that will not injure the plates. Long plates shall be straightened by passing through mangle or leveling rolls. Heating or forging shall not be resorted to without the prior approval of Employer in writing.

5.3.3 Welding

5.3.3.1 Welding shall be in accordance with IS 816, IS 819, IS 1024, IS 1261, IS 1323, IS 4353 and IS 9595, as appropriate.

5.3.3.2 For welding of any particular type of joint, Contractor shall give evidence acceptable to the Employer of having satisfactorily completed appropriate tests as described in any of the Indian Standards IS 817, IS 1393, IS 7307 (Part J), as relevant and as per the checklists given in the *Annexure* to this section of the specification.

5.3.3.3 The works shall be done as per approved fabrication drawings which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld. Symbols for welding on shop drawings shall be according to IS 813. Efforts shall be made to reduce site welding so as to avoid improper welding due to constructional difficulties.

5.3.3.4 Welding of Structural Steel shall be done by an electric arc process. The procedure to be followed, materials, plant and equipment to be applied shall be subject to the approval of the Employer and shall conform generally to relevant acceptable standards viz. IS 816, IS 9595, IS 814, and Indian Standard Hand Book for metal arc welding, and other standard codes of practice internationally accepted.

5.3.3.5 "Open-Arc-Welding" process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.

5.3.3.6 Wherever welding is done for assembling the components of liner, the job shall be so positioned that down hand welding is possible. In cases where such positioning of job is not possible other manual welding positions could be resorted to.

5.3.3.7 Any structural joints shall be welded only by those welders who are qualified for all welding procedures and positions required in such joint that is welded. The entire weld of any liner joint shall be made by one welder.

5.3.3.8 All welds shall be free from defects like blow holes, slag inclusions, lack of penetration, undercutting, cracks and show uniform Sections, smoothness of Weld metal, feather edge without overlap and freedom from porosity.

- 5.3.3.9 Proper edge preparation shall be made for jointing of materials before welding. Suitable edge preparation shall be done for all processes of welding except for square butt welds. Type of edge preparation shall depend on the thickness of parent materials that are to be joined. The edge forms shall be chosen to suit the design, technology and production conditions and shall be subject to the approval of the Employer. The edge form of weld elements shall be prepared either by machines or by automatic gas cutting with surface rougher of the welding area not exceeding 50 sq.mm. All edge cut by flame shall be ground before they are welded.
- 5.3.3.10 Electrodes used for welding shall be of suitable type and size depending upon specifications of the parent material, the method of welding, the position of welding and quality of welds desired e.g. normal penetration welds or deep penetration welds.
- 5.3.3.11 Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux wire combination for submerged arc welding shall conform to the requirements of F-60 class of AWSA-5-17-69 and IS 3613 (Latest). The electrodes shall be sorted properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.
- 5.3.3.12 Specific approval of the Employer shall be taken by the Contractor for the various electrodes proposed to be used on the work before any welding is started.
- 5.3.3.13 Electrodes larger than 5mm diameter shall not be used for root-runs in butt- welds.
- 5.3.3.14 Welding plant and accessories shall have capacity adequate for the welding procedure laid down and shall satisfy appropriate standards and be of approved make and quality. All the electrical plant in connection with the welding operation shall be properly and adequately earthed and adequate means of measuring the current shall be provided.
- 5.3.3.15 Voltage and current (and polarity if direct current is used) shall be set according to the recommendations of the manufacturer of the electrode being used and suitability to thickness of material, joint form etc.
- 5.3.3.16 Pre-qualified welding procedures recommended by appropriate welding standards and known to provide satisfactory welds shall be followed. For non- standard procedures, qualification tests as prescribed in IS 9595 (latest) shall be made to verify the adequacy of the procedures. A welding procedure shall be prepared by Contractor and submitted to the Employer for approval before start of welding. This shall include all details of welding procedures with references to provisions of IS 9595 and IS 4353. Approval of the welding procedure by Employer shall not relieve Contractor of his responsibility for correct and sound welding

without undue distortion in the finished structure.

5.3.3.17 No welding shall be done, when the surface of the members is wet, during periods of high wind, unless the welding operator and the work are properly protected.

5.3.3.18 In joints connected by fillet welds, the minimum sizes of single run fillet welds for first run and minimum full sizes of fillet welds shall conform to requirements of IS 816.

5.3.3.19 **Sequence of Welding**

i) The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect of by counter distortion. The direction of welding should be away from the point of restraint and towards the point of maximum freedom.

ii) Each case shall be carefully studied before finally following a particular sequence of welding.

5.3.3.20 Approval of welding sequence and procedure shall not relieve the Contractor of the responsibility for the correct welding and for minimising the distortion in the finished structure which in no case shall exceed that laid down in Indian Standards.

5.3.3.21 All welds shall be finished full and made with correct number of runs, the welds being kept free from slag and other inclusions, all adhering slag being removed from exposed faces immediately after such run.

5.3.3.22 Current shall be appropriate for the type of electrode used. To ensure complete fusion, the weaving procedure should go proper and rate of arc advancement should not be so rapid so as to leave the edges un-melted.

5.3.3.23 Pudding shall be sufficient to enable the gases to escape from the molten metal before it solidifies.

5.3.3.24 Non-uniform heating and cooling should be avoided to ensure the excessive stresses are not locked up resulting ultimately in cracks.

5.3.3.25 The fusion faces shall be carefully aligned. Angle shrinkage shall be controlled by presenting. Correct gap and alignment shall be maintained during the welding operation.

5.3.3.26 All main butt welds shall have complete penetration and except where it is

impracticable they shall be welded from both sides, back surface of the weld being gouged out clean before first run of the weld is given from the back.

5.3.3.27 Intermittent welds shall not be permitted without the approval of the Employer. These shall be permitted only when specifically approved in the fabrication drawings.

5.3.3.28 Inspection of Welds: All Welds shall be inspected for flaws by any of the methods described under Clause "Inspection". The choice of the method adopted shall be determined by Employer.

5.3.3.29 The Contractor shall carry out tests which establish soundness of welds. In case the tests uncover defective work, the Contractor shall correct such defects at his own cost and prove the soundness of rectified work at his own cost.

5.3.3.30 The correction of defective welds shall be carried out as directed by Employer without damaging the parent metal. When a crack in the weld is removed, magnetic particles inspection or any other equally positive means as prescribed by Employer shall be used to ensure that the hole of the crack and material up to 25 mm beyond each end of the crack has been removed. Cost of all such test and operations incidental to correction shall be to Contractor's account.

5.3.3.31 Inspection and Rectification

5.3.3.31.1 Visual Inspection

100 percent of the welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The length and size of weld shall be as per approved fabrication drawing. It may be slightly over sized but should not be under sized. The profile of weld is affected by the position of the joint but it should be uniform. In case of butt and corner welds the profile shall be convey and in case of submerged are fillet weld, it shall be slightly concave. The welds should have regular height and width of beads. The height and spacing or ripples shall be uniform. The joints in the weld run where welding has been recommended shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from the unfilled craters on the surface under cuts slag on the surface visible cracks. Such inspection shall be done after clearing the welds surface with steel wire brushes and chisel to remove the sputter metal, scales, slag, etc. If external defects mentioned above are noticed the work shall be dismantled and redone duly replacing the defective materials including the base members.

5.3.3.31.2 Rectification of Defective Welding Work

Wherever defects like improper penetration, extensive presence of blow holes,

undercuts cracking, slag inclusion etc. are noticed by visual inspection/other tests, the welds at such locations shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary and re-welded. The gouging as far as possible be done using gouging electrodes. Flame gouging shall be resorted to only in special cases with specific permission of the Employer.

5.3.3.31.3 Acceptance of the Welded Structures

The acceptance of the welded work shall depend upon correct dimensions and alignment, absence of distortion in the structure, satisfactory results from the examination and testing of the joints and the test specimens as per IS soundness of the welds and upon general workmanship being good.

Random die penetration tests shall be conducted after welding of MS liner plates.

5.4 Erection Marks

5.4.1 Before any steel work leaves the Contractor's fabrication shop, it shall be suitably marked in accordance with the approved fabrication drawing and according to an approved marking plan. Copies of all drawing showing such erection marks on the various steel works to be furnished to the Employer well in advance of the erection.

5.4.2 The erection marks assigned to various components of the structural steel work shall also contain an erection sequence number indicating the sequence in which the various components are to be erected.

5.4.3 Erection marks shall be clearly painted on the work, each piece being marked in at least two places. Each piece shall also have its weight marked thereon. In order to help identification, each piece shall bear the erection marks and erection sequence number. Erection marks shall be painted on the structures, during the process of fabrication to facilitate their identification during inspection. Where a number of components are identical and bear the same erection marks, these components shall be further identified by assigning numerals in addition to the common erection mark.

5.5 Errors

Any error in shop work which prevents proper assembling and fitting of parts in the field, moderate use of drift pins or moderate amount of reaming will be classified by Employer as defective workmanship. All charges incurred by Employer either directly or indirectly because of workmanship will be deducted from the amount due to Contractor, before payment is made. The amount of such deduction will consist of the sum total of the costs of labour direct or indirect,

material, plants, transportation, equipment, rental and overhead expense. In case Employer chooses to reject the material because of poor workmanship the cost of all handling and returning the material to Contractor, if he so desires, shall entirely be to Contractor's account and in such cases, the cost of handling, transport and delivery to site shall be borne by Contractor.

5.6 Protection against Damage in Transit

All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever to prevent damage or distortion during transit. Should there be any distortion of fabricated members the Contractor shall immediately report the matter to the Employer. Distorted steel shall not be used in fabrication unless the distortion is minor which in the opinion of the Employer can be removed by acceptable methods. These distortions shall be rectified by the Contractor by cold-bending. If heating is necessary to rectify the defects the details of the procedure shall be intimated to the Employer whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

5.7 Anti-Corrosive Treatment for Mild Steel Liners

5.7.1 After inspection and issue of test and acceptance certificate, all steel surfaces shall be coated with a coat of direct to rust primer i.e. Densotrol or equivalent and thereafter these shall be provided with a final coat of minimum 250 microns of high built epoxy coal tar, as specified below. The fabricated mild steel liners to be used for the piling work shall be cleaned from grease or any other contaminant, by mechanical/ manual cleaning. The primer shall be applied with a brush or spray to develop a dry film thickness of minimum 25 microns. The primer surface shall be left for curing for at least 24 hours before it is coated with the final coat. The final coat shall consist of high built epoxy coal tar with a thickness of minimum 250 microns. The physical properties of primer and top coat shall be as given below.

5.7.2 Technical data of priming material

1	Binder content	45%
2	Total Solids	45%
3	Solvent	55%
4	Viscosity	16 (Ford Cup No.4)
5	Density	0.88
6	Flash point	+40° C
7	Anti-porosity	80/99 in one and two layers, respectively

8	Heat-resistance	170/220 continuously & short period strain
9	Contact angle	5° (Lorentzon & Weststress)
10	Covering Capacity	12-20 sqm. /litre
11	Layer thickness	12/25 on glossy/coarse surface
12	Homogeneity	No sediment
13	Thinning	Normally, no thinner shall be used
14	Drying time	Dust-free in 2 hours, Solid in 4/5 hours. Between layers from wet-in-wet 2 hours for continuous penetration between layers
15	Lustre	Semi-glossy
16	Colour	Lightly yellowish
17	YSAM group	2
18	Injurious to health	No
19	Physiological condition	No dangerous gas generation when welding
20	Application	Airless spray equipment or conventional painting with roll/brush
21	Cleaning of equipment	White spirit

5.7.3 Technical particulars of final coat

1	System	Two Components Component A: Base Part Component B: Accelerator Part
2	Colour	Black
3	Mixing Ratio	1:1 by Weight
4	% Solid by Weight	More than 95%
5	Pot Lift (Temp.27°C, Relative humidity 65%)	2 hours
6	Setting Time (At 22°C, Relative humidity 65%)	4-5 hours
7	Fully cured	7 days
8	Density of cured mass	1.35
9	Flash Pt. of blended product	40°C (104°F)
10	Hardness	75 Shore D
11	Finish	Semi glossy
12	Water absorption after 6 months	Negligible
13	Covering Capacity	1.5 sqm/kg (400 Microns thickness)

14	Storage Life	1 year in sealed condition

5.8 Shop Connections

- 5.8.1 Surfaces to be permanently in contact shall receive a priming coat immediately at the works except where jointed by welding.

6.0 List of Indian Standards

The construction work of pile foundation shall conform to the following Indian Standards, which shall mean latest revisions, amendments/ changes adopted and published, unless otherwise specified hereinbefore. Some of the important relevant applicable codes for this section are as follows:

1	IS 432	Specification for mild steel and high tensile steel bars and hard drawn steel wire for concrete reinforcement
2	IS 456	Code of practice for plain and reinforcement concrete
3	IS 516	Methods of test for strength of concrete
4	IS 800	Code of Practice for General Construction in Steel
5	IS 813	Scheme of symbols for Welding
6	IS 814	Specification for Covered Electrodes for Metal Arc Welding of Structural Steels
7	IS 816	Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel
8	IS 817	Code of Practice for Liquid Penetrant Flaw Detection
9	IS 1199	Methods of sampling and analysis of concrete
10	IS 1200 (Part-I)	Method of measurement of Building and civil Engineering work-earthwork
11	IS 1200 (Part-23)	Method of measurement of Building and civil Engineering Work-Piling
12	IS 1786	Cold worked steel high strength deformed bars for concrete reinforcement
13	IS 1838	Performed fillers for expansion joints in concrete non- extruding and resilient type (bitumen impregnated filler).
14	IS 2062	Weld able structural steel
15	IS 2074	Ready Mixed Paint, air drying, Red Oxide Zinc Chrome, Priming
16	IS 2386	Specific gravity, density, voids absorption and bulking

	(Part-III)	
17	IS 2502	Code of Practice for bending and fixing of bars for concrete reinforcement
16	IS 2505	General requirements for concrete vibrators immersion type
19	IS 2506	Screed board concrete vibrators
20	IS 2514	Concrete vibrating tables
21	IS 2911 (Part 1/ Section 2)	Code of practice for design and construction of pile foundation-Bored cast-in-situ concrete piles
22	IS 3025	Methods of sampling and test (Physical and chemical) for water used in Industry
23	IS 3350	Methods of tests for routine control for water used in Industry
24	IS 3370	Code of Practice for concrete structure for the storage of liquids
25	IS 3613	Acceptance Tests for Wire Flux Combinations for submerged Arc welding of structural steels
26	IS 3658	Recommended Practice for Radiographic Examination of Fusion Welded Butt Joints in Steel Plates
27	IS 3764	Safety codes for Excavation work
28	IS 4353	Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steels
29	IS 4656	Form vibrators for concrete
30	IS 4701	Code of practice for earth work on canals
31	IS 8500	Specification for weldable structural steel (medium and high strength qualities)
32	IS 9103	Admixtures for concrete
33	IS 10262	Recommended guidelines for concrete mix design

Specification of Drilling Mud (Bentonite Slurry)

- 1.0 Bentonite suspension used for piling work shall satisfy the following requirements:
- a) Liquid limit of bentonite when tested in accordance with IS 2720 (Part V) shall be more than 300 percent and less than 450 percent.
 - b) Sand content of the bentonite powder shall not be greater than 7 percent.
 - c) Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared bentonite suspension shall be between 1.024 and 1.10 gm/ml depending upon the pile dimensions and type of soil in which the pile is to be met. However, the density of bentonite suspension after mixing with deleterious materials in the pile bore may be up to a maximum of 1.25 gm/ml.
 - d) The Marsh viscosity when tested by a Marsh cone shall be between 30 to 60 seconds.
 - e) The differential free swell shall be more than 540 percent.
 - f) The pH value of the bentonite suspension shall be between 9 and 11.5.

Pile Data Sheet

1	Reference No. Location (Co-ordinates)	
2	Sequence of Piling	
3	Pile diameter & Type	
4	Working level (Platform level)	
5	Cut off level (COL)	
6	Actual length below COL	
7	Pile termination level	
8	Top of finished concrete level	
9	Date and time of start and completion of boring	
10	Depth of Ground water table in the vicinity	
11	Type of strata at pile tip	
12	Method of boring operation	
13	Details of drilling mud as used:	
	i) Freshly supplied mud:	
	a) liquid limit	
	b) sand content	
	c) density	
	d) marsh viscosity	
	e) Swelling index	
	f) pH value	
	ii) Contaminated mud:	
	a) Density	
	b) sand content	
14(a)	SPT, N values in soil (from the nearest bore hole) / UCS value in rock (from the nearest bore hole)	
15	Chiseling if any,	from....m to..... m
16(a)	Date and time of start of concreting	
16(b)	Date and time of completion of concreting	
17	Method of placing concrete	
18	Concrete quantity:	
	a) Actual	
	b) Theoretical	
19	Ref. Number of test cubes	
20	Grade and slump of concrete	

21	Results of test cubes	
22	Reinforcement details:	
	i) Main Reinforcement	
	a) Type	
	b) No.	
	c) Dia	
	d) Depth	
	ii) Stirrups:	
	a) Type	
	b) No.	
	c) Dia	
	d) spacing	
23	Any other information regarding constructions, delay and other interruption to the sequence of work.	

Note: The above details are required to be furnished by the Contractor before starting the installation work.

Inspection & Testing for Structural Steel Works

1.0 General

Contractor shall carry out a comprehensive inspections and testing programme during fabrication and erection. An indicative programme of inspection/testing envisaged by Employer is given below. This is however not intended to form a comprehensive programme as it is the Contractor's responsibility to draw up and carry out such a programme duly approved by the Employer. Such approval shall not relieve the Contractor of the responsibility about the correctness and adequacy of workmanship, materials etc.

1.1 Raw Materials Inspection

1.1.1 Steel

i) Specifications

Check the specification of steel and availability of the relevant Test Certificates.

ii) Physical Conditions

- a) Steel shall not be pitted and should be free from scales and rust.
- b) If the plates are bent or distorted, bent to distortion shall normally be removed by the cold treatment etc.
- c) Straightening under hot stage shall be resorted to only under specific permission from the Employer.
- d) If any rolling defect viz, laminations, cracks etc. are found in the steel during processing it shall be rejected.

iii) Storage

- a) Steel plates of different specifications shall be stacked separately.
- b) Steel of IS 2062 quality shall be given a distinctive identification mark.
- c) Steel sections shall be stacked over spacers supported on posts of about 50 cm height above ground. Passage and space between the stacks shall be sufficient for rigging operations.

1.1.2 Electrodes

- i) Electrodes for manual metal arc welding shall be procured envisaged in the welding procedure sheet predetermined before actual welding operation starts.
- ii) Electrodes shall be properly stored dry as required by the IS Code or by the manufacturer.
- iii) Electrodes shall bear the I.S.I or equivalent Certification mark.
- iv) The approval for all the consumables for welding shall be specifically obtained beforehand.

1.1.3 Paints/ Primers

- i) The relevant IS or equivalent mark on sealed tins shall be checked.
- ii) A few tins shall be opened at random to check the condition of the paints. Paint from old stock and showing signs of solidification shall not be accepted.

1.2 Welding Procedure Qualification

As per ASME section (ix) or equivalent Indian Standards, Welding procedures, Specification shall be submitted by the Contractor for review and approval of Employer.

1.3 Welders Qualification Test

As per ASME section (ix) or equivalent Indian Standard.

1.4 Inspection for Tack Assembly set up for:

- i) Level
- ii) Gap
- iii) Offsetting
- iv) Shrinkage allowance
- v) Fitment sequence
- vi) Principal overall size.

1.5 Inspection of Main welds

- a) Fillet welds for
 - i) Size
 - ii) Dye Check
 - iii) Visual examination
 - iv) Dye penetration test/MPI shall be carried out.

- b) Butt welds for
 - i) Dye check for root after back gauging shall be carried out.
 - ii) Mechanical testing of welds (Destructive Tests)
Minimum on joint per liner length/piece.
 - iii) Non-destructive-as per FCL:SS:4-100% visual examination.

B. FABRICATION CHECK LIST (STANDARD)

Title: **Welding Tests on welds and Weld Defects**

Mechanical testing of welds (Destructive test) Butt welds having one or more of the following defects are not acceptable.

- i) Bend test: No crack on root/ face on being bent through 180 deg. with mandrel of 4t where t is the thickness of plate.
- ii) Tensile test: Weld strength not to be less than part metal's strength.

VISUAL EXAMINATION

Following defects are not allowed:

- 1) Unsatisfactory appearance
- 2) Incomplete weld
- 3) Molten metal flow
- 4) Pits
- 5) Surface crack, lack of penetration
- 6) Insufficient length
- 7) Surface defects exceeding 5% of weld seam area

DYE PENETRATION TEST

All surfaces to be examined shall be free from:

- a) Relevant linear indications
- b) Four or more rounded defects in a line separated by 1/16" or less (edge to edge) except where the specification for the material establishes requirements for acceptance so far as defects are concerned.

C. TYPICAL WELDING PROCEDURE DATA SHEET

Contractor.....Address.....

..

Quality of weld metal.....Specification.....
Inspection and Test Schedule Specification.....
Material Specification.....Thickness.....Batch/Cast No.....
Joint Preparation (Fig.).....Gap.....
Location of Specimens.....
Weather Conditions.....Time of day.....Wind brake used.....
Electrode Group No..... Make.....Specimen.....
Pre and Post Heating.....
Welding position.....
Size of Reinforcement.....Whether removed.....
Welding Sequence.....
Backing Strip use.....Type.....
Welding Process.....
Current Conditions-Polarity.....
Size of Electrode.....
Amperage and Voltage.....
Number of Electrodes used per run.....
Cleaning method.....
Remarks.....

Signature

Engineer-in-Charge

Employer

(Inspecting Authority)

For and on behalf of
Contractor

Date:

D. **FABRICATION CHECK LIST: ACCEPTANCE PROFORMA**

No.: _____

Dt.: _____

Project: _____

Work: _____

Sub-Assy

Sl. No.	Characteristic	As per	Actual	Accept/ reject	Remarks
		DRG/FCL			

Engineer-in-Charge

Employer

(Inspecting Authority)

Signature

For and on behalf of
Contractor

Date:

**Section-1
(OPGW)**

Introduction, General Information and General Requirement

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1.2	General Requirements	2
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1.4	References	6

(Strikeout/Delete whichever is not applicable)

Section 1 (X)

Introduction, General Information and General Requirement

This part of the Tender Documents describes the technical specifications of OPGW and associated hardware & fittings including joint box etc. This specification describes the functional and performance requirements of the system.

This part of specification describes the functional and performance requirement of the Fibre Optic cable and its associated hardware & fittings.

1.1 Scope and General Requirements

The scope of OPGW requirement is described as follows:

The scope shall include planning, design, engineering, manufacturing, supply & testing of OPGW cable & associated items and documentation of:

- (i.) 24F OPGW cable/ 48F OPGW Cable
- (ii.) All associated hardware, fittings and accessories (Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps etc.) required for installation of OPGW cable.
- (iii.) Joint box for above OPGW cable
- (iv.) Fibre Optic approach cable including associated installation material (as required if specified in BoQ).
- (v.) Fibre Optic Distribution Panels (FODP) (as required if specified in BoQ).

The various Sections of this specification define the design, performance, test and implementation requirements for OPGW Cable system.

1.2 General Requirements

The Contractor must conform to the requirements and provide any special equipment necessary to meet the requirements stated herein.

The Contractor shall offer the product meeting the design accordingly.

The Bidder's proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation in order to determine compliance with this specification without further necessity for inquiries.

The Bidder's proposal shall clearly identify all features described in the specifications or in any supporting reference material that will not be implemented; otherwise, those features shall

Become binding as part of the final contract.

The offered items shall be designed to operate in varying environments. Adequate measures shall be taken to provide protection against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration and electro-magnetic interference etc.

The Contractor shall demonstrate a specified level of performance of the offered items during well-structured factory tests and field testing wherever required.

Provision to be complied as per latest guidelines of GOI/ MOP/DPIIT/DOT.

The Contractor shall ensure following things and at their own cost,:-

- (i) *Any imported equipment/material/item/parts/component to be supplied under the contract shall be tested in the certified laboratories to check for any kind of embedded malware/trojans/cyber threats and for adherence to Indian Standards as per the directions issued by Ministry of Power/Govt. of India from time to time. In case of such import from specified "prior reference" countries, the requirement of prior permission from the Govt. of India including protocol for testing in certified and designated laboratories by Ministry of Power/Govt. of India shall also be complied with by the contractor.*
- (ii) *The equipment offered by the contractor shall at least conform to the requirements specified under relevant IS standard. In case of discrepancy between IS and other international standard, provisions of IS shall prevail. The Contractor shall also note that the list of standards presented in this specification is not complete. Whenever necessary, the list of standards shall be considered in conjunction with specific IS. If the IS standard is not available for an equipment/material, then other applicable International standard (IEC/Equivalent), as per the specification, shall be accepted."*
- (iii) *The bidder/contractor shall list out the products and components producing Toxic e-waste under the contract and shall furnish to the Employer the procedure of safe disposal at the time of closing of the contract.*
- (iv) *The Bidder shall have to furnish a certificate regarding cyber security/safety of the equipment/ process to be supplied/services to be rendered as safe to connect.*

1.3 Organization of the Technical Specification Document

Section 3 through 4 and Appendices provide the project requirements of the fibre optic cabling system to be provided.

<u>Section 2</u>	contains specifications for OPGW cabling & associated hardware & fittings
<u>Section 3</u>	contains the requirement for Inspection & Testing requirement
<u>Chapter 4</u>	contains the Support Services & documentation

The following is a list of the Appendices:

<u>Appendix A</u>	-	Data Requirement Sheets (DRS)
<u>Appendix B</u>	-	Guidelines for Off Line Installation
<u>Appendix C</u>	-	Splicing Guide Lines
<u>Appendix D</u>	-	Type Test Procedure
<u>Appendix E</u>	-	FAT Procedure
<u>Appendix F</u>	-	SAT Procedure
<u>Appendix G</u>	-	Guidelines for Approach Cable Installation

1.4 Applicable Standards

The following standards and codes shall be generally applicable to the equipment and works supplied under this Contract:

(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, 2009 IEEE Standard for Testing and Performance for 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

<i>EIA/TIA-455-41</i>	Compressive Loading Resistance of Fibre Optic Cables
<i>EIA/TIA-455-59</i>	Measurement of Fibre Point Defects Using an OTDR
<i>EIA/TIA-455-62</i>	Measurement of Optical Fibre Macrobend Attenuation
<i>EIA/TIA-455-78</i>	Spectral Attenuation Cutback Measurement for Single- Mode Optical Fibres
<i>EIA/TIA-455-80</i>	Measurement of Cut-Off Wavelength of Single-Mode Fibre by Transmitted Power
<i>EIA/TIA-455-81</i>	Compound Flow (Drip) Test for Filled Fibre Optic Cable
<i>EIA/TIA-455-82</i>	Fluid Penetration Test for Fluid-Blocked Fibre optic Cable
<i>EIA/TIA-455-91</i>	Fibre Optic Cable Twist-Bend Test
<i>EIA/TIA-455-164</i>	Single-Mode Fibre, Measurement of Mode Field Diameter by Far-Field Scanning
<i>EIA/TIA-455-167</i>	Mode Field Diameter Measurement, Variable Aperture Method in the Far-Field
<i>EIA/TIA-455-168</i>	Chromatic Dispersion Measurement of Multimode Graded Index and Single-Mode Optical Fibres by Spectral Group Delay Measurement in the Time Domain
<i>EIA/TIA-455-169</i>	Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Phase-Shift Method
<i>EIA/TIA-455-170</i>	Cable Cut-off Wavelength of Single-Mode Fibre by Transmitted Power
<i>EIA/TIA-455-174</i>	Mode Field Diameter Measurement
<i>EIA/TIA-455-175</i>	Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Differential Phase-Shift Method
<i>EIA/TIA-455-176</i>	Method of Measuring Optical Fibre Cross-Sectional Geometry by Automated Grey-Scale Analysis
<i>EIA/TIA-598</i>	Optical Fibre Cable Colour Coding

(6) International Electrotechnical Commission IEC standards

<i>IEC-60793-1 series</i>	Optical fibres - Generic & product specifications, measurement methods & test procedures specification
<i>IEC-60794-1-1</i>	Optical fibre cables - Generic specification
<i>IEC-60794-1-2</i>	Optical fibre cables - Basic optical cable test procedure
<i>IEC-60794-3</i>	Optical fibre cables - Duct, buried and aerial cables - sectional specification
<i>IEC-60794-4</i>	Optical fibre cables - Overhead cables
<i>IEC-61089</i>	Round wire concentric lay overhead electrical stranded conductors
<i>IEC-61232</i>	Aluminium-clad steel wires for electrical purposes
<i>IEC-61284</i>	Overhead lines-Requirements and tests for fittings
<i>IEC-61395</i>	Overhead electrical conductors - Creep test procedures for stranded conductors

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.

1.5 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

.....**End of this section.**.....

Section-02 (X)
Specification for Fibre Optic cabling & associated items

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Section-02

Specification for OPGW cabling and associated hardware & fittings

This section of the technical specification describes the functional and technical specifications of Fibre Optic cabling and associated items.

2.1. Fibre Optic Cabling

In this section of the technical specification, the functional & technical specifications of OPGW cable, Fibre Optic Approach Cable, Joint Box and associated hardware & fittings for the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade optical fibre is specified. 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.

2.1.1. Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristics :

2.1.1.1. 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 2-1(a).

2.1.1.2. 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 2-1 (a) shall be "guaranteed" fibre attenuation of any & every fibre reel.

Table 2-1(a)
DWSM Optical Fibre Characteristics

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

2.1.2. Fibre Optic Cable Construction

The OPGW (Optical Ground Wire) cable is to be installed on the transmission lines in place of Earth wire for 765/400/220/132kV lines. 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 meeting the design parameters specified in Technical Specifications.

2.1.2.1. Optical Fibre Cable Lengths

The estimated optical fibre cable length for F.O. link(s) are provided in BOQ considering 5% for plain and 7% for hilly areas over and above route length of the transmission line to take care of sag, splicing length, loop length, tower height/down lead length, wastages, etc.

The Contractor shall supply the OPGW cable in standard drum length mostly in 5 km (with $\pm 5\%$ tolerance) for plain terrain & 3 km (with $\pm 5\%$ tolerance) for hilly terrain.

2.1.2.2. Optical Fibre Identification

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.

2.1.2.3. Optical Fibre Strain& Sag-Tension chart

The OPGW cable the optical fibres shall experience no strain under all loading conditions defined in IS 802. 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 Tensile Strength (UTS/ 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 0.45 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 under various conditions mentioned below:

1. 53° C , no wind and no ice
2. 32° C, no wind and no ice
3. 0°C, no wind and no ice
4. 32° C, full wind and no ice
5. 32° C, 75% full wind and no ice
6. 0° C, 2/3rd / 36% of full wind (IS 802:1977 / 1995)

The above cases shall be considered for the spans from 100 m to 600 m or higher span length in the range of 50 m spans. Max. Vertical sag, max. tension and max sag at 0° C & no wind shall be considered in line with the design parameter of transmission line. The full wind load shall be considered as the design wind load for all the specified transmission lines as per relevant IS 802 version and the sag-tension chart shall be submitted considering the transmission lines.

2.1.2.4. Cable Materials

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

2.1.2.4.1. 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, nonhygroscopic, 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.

2.1.2.4.2. Metallic Members

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

2.1.2.5. 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 and Packing: The OPGW shall be supplied in returnable steel drums for main supply & non-returnable steel drums for spare supply. These painted steel drums shall be corrosion free, shall be of adequate strength, and constructed to protect the OPGW against all damage and displacement during transit, storage, subsequent handling & stringing operations in the field. The supplier shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. The ownership of the empty OPGW drums shall lie with the OPGW supplier who shall ultimately take back the empty OPGW drums. 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.

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 standard drum length.

2.1.3. Optical Ground Wire (OPGW) construction

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.

2.1.3.1. OPGW design

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. The individually coated optical fibre(s) shall be provided directly in stainless steel tube in case stainless steel tube design.

(a) Central Aluminium tube type

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.

(b) Central Stainless Steel tube type

The composite fibre optic overhead ground wire shall consist of a central fibre optic unit made up of stainless steel with aluminium coating/tube surrounded by concentric-lay stranded metallic wires in single or multiple layers. 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

Central Fibre Optic Unit

(a) Central Aluminium tube type

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.

(b) Central Stainless Steel tube type

The central fibre optic unit shall be designed to house and protect optical fibres provided in single buffered tube of stainless steel tube 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 shall be of stainless steel tube with aluminium protective coating or stainless steel tube with Al protecting outer tube. In case of aluminium protective coating, the coating must completely cover the tubes leaving 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.

2.1.3.2 OPGW Parameters to be considered for different line voltage and wind zones

Transmission Line Voltage and wind zone	OPGW Cable Parameters						
	UTS (Kg)	Area (sqmm)	Wt. (Kg/m)	Dia. (mm)	Modulus of Elasticity (Kg/sqmm)	Coeff. Of linear Expansion (per deg C)	Central Fibre optic unit design
765 kV D/C WZ 1-4 400kV M/C WZ 1-4 400kV D/C WZ 1-5	9350±150	56.5±2.5	0.45±0.01	12 ±0.2	14290±110	0.0000138±0.0000003	Al tube
765 kV WZ 5	9098±150	57.5±2.5	0.49 ±0.01	11.5 ±0.2	14114 ±110	0.0000136 ±0.0000003	Stainless Steel Tube
220 kV D/C WZ 1-4 132kV D/C WZ 1-5	7376±50	51±2	0.355±0.01	11.4±0.02	12344±100	0.0000149±0.0000003	Al Tube
River Crossing Section	20059±100	118±5	0.884±0.01	14.7±0.2	16355±100	0.0000127±0.0000003	Stainless Steel Tube

For Al tube & Stainless steel tube design details refer clause 2.1.3.1 above.

2.1.3.2. 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 2.2(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.

2.1.3.3. Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as 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.

2.1.3.4. Electrical and Mechanical Requirements

Table 2-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics.

Table 2.2(a)

OPGW Electrical and Mechanical Requirements

(1)	Everyday Tension	$\leq 20\%$ of UTS of OPGW
(2)	D.C. Resistance at 20°C:	< 1.0 ohm/Km
(3)	Short Circuit Current	≥ 6.32 kA for 1.0 second (for 220 kV & above lines) ≥ 5.6 kA for 1.0 second (for 132 KV & 66KV lines) Short Circuit shall be applicable as per the Voltage level of the lines

2.1.4. Installation Hardware

Installation Hardware includes all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The estimated quantity for hardware fittings are provided in Percentage BOQ. Initially 70% of total hardware shall be supplied based on quantities in BOQ or as directed by Project Manager and balance 30% shall be supplied as directed by Project Manager.

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. For river crossing and special transmission lines (where heavier earthwire used e.g. 7/4.5) OPGW installation hardware design slippage shall occur between 9% and 14% of UTS of OPGW.

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 performed 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 Ultimate 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) Tension Fitting for Suspension Tower: The OPGW cable sections shall also be terminated & spliced on suspension towers as per requirement. For this, a special fitting namely Yoke plate alongwith tension fittings shall be provided for termination/jointing of OPGW on Suspension tower. Typical drawing of suspension fitting where cable may be terminated on suspension tower is given in Appendices.
- (f) 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.

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 as per manufacturer recommendation and damper placement chart.

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/stain less 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:

Sl. No.	Description	Technical Particulars
1	Span Length in meters (i) Ruling design span: (ii) Maximum span: (iii) Minimum Span:	400 meters 1100 meters 100 meters
2	Configuration:	As per Specifications
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 sample calculations and manufacturer recommendation.

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.)

2.1.5. 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

2.1.5.1. 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.

2.1.6 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 BoQ. Actual supply to be done as per directives of Project Manager of PGCIL.

2.1.6.1 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.

2.1.6.2 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.

2.1.6.3 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.

2.1.6.4 Fibre Optic Approach cable Installation hardware

At all locations, approach cable shall be laid within PLB HDPE duct along with necessary accessories such as pushfit coupler, end cap, cable bends etc.

2.1.7 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 preconnectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.
- (b) 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. No more than 12 fibres shall be terminated in a single splice tray.
- (c) FODPs shall be supplied in suitable cabinets/racks with locking arrangement. The dimension of FODP cabinet shall be minimum 2200mm x 600mm x 600mm (HxWxD) and shall meet or exceed ingress protection class IP55 specifications.
- (d) 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.
- (e) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

2.1.8 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.

Section - 03 (X) Inspection & Testing

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	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. 23	
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Section 03 (X)

INSPECTION & TESTING

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 & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted overall price, 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.

All security related features shall be demonstrated during FAT/SAT as required by the Employer.

3.1 Inspection

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre optic

Communication network shall be available to the Employer/ PGCIL. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment? To facilitate this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

- (a) Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification shall be provided by the Contractor to the Employer/ PGCIL.
- (b) Inspections to be performed by the Employer/ PGCIL will include visual examination of hardware, cable dressings and labeling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.
- (c) Access to inspect the Contractor's standards, procedures, and records that are applicable to the supplied equipment shall be provided to the Employer/ PGCIL. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.
- (d) The inspection rights described above shall also apply to sub Contractors who are responsible for supplying major components described in this Specification. These items shall be inspected and tested at the sub Contractor's factory by the Employer's/ PGCIL representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.
- (e) The above inspection rights shall also apply to sub Contractors supplying assemblies, subassemblies and components. However, such items will normally be inspected and tested by the Employer's / PGCIL representatives at the Contractor's site before acceptance.

3.2 Test Plans and Procedures

Test plans for both factory and site acceptance tests shall be provided by the Contractor. Test plans shall be modular to allow individual test segments to be repeated upon request.

Procedures for type test, factory acceptance test, and site acceptance test for OPGW (including hardware accessories) and communication equipment (wherever applicable) have been provided in Appendix D, E & F respectively.

The Contractor shall submit a Test Schedule for the Employer's approval within one (1) week after the award of contract for Type Tests and three (3) months after the award of contract for all other tests. The test schedule shall list the tests to be carried out, and the approximate test duration. The test periods shall also be indicated in the PERT chart or equivalent for the Work.

The Contractor shall give the Employer twenty one (21) days written notice of any material being ready for testing. Fifteen days prior to the scheduled testing, the Employer/ PGCIL shall provide written notice to the Contractor of any drawings, equipment, material, or workmanship which, in the Employer's/ PGCIL opinion, are not compliant to the specification. The Contractor shall give due consideration to such objections, if valid, effecting the corrections as necessary or shall prove, in writing, that said modifications are unnecessary for contract compliance.

3.2.1 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for approval, at least four (4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results, and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in Table 3-1.

**Table 3-1
Factory & field Test Plan Requirements**

Item:	Description:
1.	Test schedule
2.	Record-keeping assignments, procedures and forms
3.	Procedures for monitoring, correcting and retesting variances
4.	Procedures for controlling and documenting all changes made to the communications equipment after the start of testing

3.2.2 Test Procedures

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/ jig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

3.2.3 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer/ PGCIL by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test

records are described in Table 3-2.

Table 3-2
Test Record Requirements

Item:	Description:
1.	Test Title and Revision Level, if applicable; contract references
2.	Date and time for test start and test completed
3.	Test title and reference to the appropriate section of the test procedures
4.	Description of any special test conditions or special actions taken (Includes test- case data).
5.	Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.
6.	Test procedure modifications made during testing.
7.	Variance Report(s) tracking information and copies (if variance(s) was detected).
8.	Contractor's test engineer(s) identification, signature and remarks
9.	Employer's test witness identification, signature and remarks
10.	List of all attachments
11.	Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.)

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test. These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer/ PGCIL within the specified duration after the completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer, and shall also bear the Contractor's reference and heading.

3.2.4 Rejection of Elements

Any item or component which fails to comply with the requirements of this Specification in any respect, at any stage of manufacture, test, and erection or on completion at site may be rejected by the Employer either in whole or part as considered necessary.

Material or components with defects of such a nature that do not meet the requirements of the Specification by adjustment or modification shall be replaced by the Contractor at his own expense. After adjustment or modification, the Contractor shall submit the items to the Employer/ PGCIL for further inspection and/or tests.

3.2.5 Test Periods Defined

The terminology used in Volume I, General Conditions of Contract and their correlation with the tests requirements described within this section is as follows:

Pre-Commissioning & Commissioning Period - The Site Acceptance Test (SAT)
Operational Acceptance - Successful completion of SAT

3.3 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) Validity period of type tests conducted on the equipment i.e. the period for which Type Test Reports shall remain valid and acceptable to employer provided no major change has been introduced in the basic design/technology/material/mechanical construction/functionalities of the equipment/ performance characteristic/manufacturing process of the equipment, is as mentioned below:

S.No.	Name of Equipment	Periodicity (in years)
1	OPGW and its Hardware fittings & accessories / Fibre Optic Cable (Approach cable)	5
2	Telecom Equipment and all other items.	5
3	DCPS / Battery & Battery Chargers	7

In case of OPGW, the type tests conducted on OPGW design with 48fibers can be accepted for same OPGW design with 24fibers in line with IEEE 1138-2009 clause 6.2.

In case of Change in make of fibres in approved OPGW/ Approach Cable design, fibre specific type tests of OPGW/Approach cable shall be repeated provided all other OPGW/Approach cable design parameters remain same and the original design is type tested.

Further, the validity of Type Test reports shall be considered from Completion date of type testing up to the date of bid opening. The type tests of the equipment shall be repeated during its validity period, if there is change in technology, basic design, construction, electrical/thermal/mechanical stress, performance characteristics or materials employed or changes in manufacturing process, setup or combination of any of above.

In case the type Test reports are not valid as per the conditions stipulated in this specification, the Contractor shall repeat the type tests at no extra cost to the employer/purchaser.

- (c) The Contractor shall submit, within 30 days of Contract Award, copies of previous test reports for Type Tests specified in the Technical Specifications. These reports may be accepted by the Employer only if they apply to materials and equipment that are due to be delivered under the Contract and are similar in design only if test procedures and parameter values are identical to those specified in these specifications carried out at accredited labs and witnessed by third party / customer's representatives.

The type test reports of hardware fittings and vibration dampers approved with a particular make of OPGW Cable, shall be accepted with OPGW designs of other manufacturers also (where both are Standard OPGW designs having similar parameters such as diameter , UTS, etc.).

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.

- (d) Contractor shall submit the details of laboratory(s) for the type tests.
 - (i) Type Tests on indigenous equipment, for which testing facility is available in India, should have been conducted in any independent laboratories approved by Government or accredited by National Accreditation Body of the Country, like Central power Research Institute(CPRI), Electrical Research and development Association(ERDA) etc.
 - (ii) Type Tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National Accreditation Body of that country.
 - (iii) Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National Accreditation Body of respective country.
 - (iv) Type tests conducted in-house by manufacturers shall also be acceptable provided the laboratory is accredited by national Accreditation Body of the country and the tests have been witnessed by a representative of NABL accredited laboratory/Power Utility.

All the type tests shall be certified or performed by reputed laboratories using material and equipment data sheets as per procedures provided in under this technical specification.

- (e) The Contractor shall provide a detailed schedule for performing all specified type tests at least 30 days prior to planned commencement of each type test.

These tests shall be performed in the presence of a representative of the Employer / PGCIL.

- (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.

In case of failure in any particular type test(s) or type testing not done during the visit of employer representative PGCIL, then all the expenses for re-deputation of Inspector/ Employer representative for type testing shall be borne by Contractor.

3.3.1 Type Test Samples

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

3.3.2 List of Type Tests

The type testing shall be conducted on the following equipment/items

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

3.3.2.1 Type Tests for Optical Fibres

The type tests listed below in table 3-3 shall be conducted on DWDM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

Table 3-3
Type Tests for Optical Fibres

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Section-02 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
2	Attenuation Variation with Wavelength	As per Section-02 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak	As per Section-02 of TS	IEC 60793-1-40 Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles
5	Attenuation With Bending (Bend Performance)		IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field dia.		IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174
7	Chromatic Dispersion		IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter		IEC 60793-1-20 Or EIA/TIA 455-176
9	Point Discontinuities of attenuation		IEC 60793-1-40 Or EIA/TIA 455-59
10	Core -Clad concentricity error		IEC 60793-1-20 Or EIA/TIA 455-176
11	Fibre Tensile Proof Testing		IEC 60793-1-30 Or EIA/TIA 455-31B

3.3.2.2 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 3-4 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 3-4
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure
	Water Ingress	IEEE 1138-	IEEE 1138-2009

Table 3-4
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure
1	Test	2009	Method 6.4.3.5
2	Seepage of filling compound	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.3.6
3	Short Circuit Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.3.3
4	Aeolian Vibration Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.3.1
5	Galloping test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.3.2
6	Cable Bend Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.2.3
7	Sheave Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.2.1
8	Crush Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.2.2
9	Twist Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.2.4
10	Creep Test	IEEE 1138-	IEEE 1138-2009

Table 3-4
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure
		2009	Method 6.4.1.1
11	Strain Margin Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.1.3
12	Stress Strain Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.1.2
13	Temperature Cycling Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.3.7
14	Corrosion (Salt Spray) Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.3.8
15	Ultimate Tensile Strength Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.1.4
16	Lightning Arc Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.3.4
17	DC Resistance Test	IEEE 1138-2009	IEEE 1138-2009 Method 6.4.1.5
-End Of Table-			

3.3.2.3 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

Applicable Standards: IEC 61284, 1997.

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 a 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 UTS 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.

3.3.2.4 Type Test on Vibration Damper

(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. for OPGW - $0.060 f$ to $0.357 f$ 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 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 UTS 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 UTS 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 $\pm 25/f$ mm where f is the frequency in Hz.

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

The clamp slip test as mentioned 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 $\pm 20\%$
- (2) The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than $\pm 20\%$

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

SI No.	Test Name	Test Procedure
1	Visual examination & Dimensional and material verification	IEC 61897 Clause 7.1 & 7.2
2	Clamp Slip test	IEC 61897 Clause 7.5
3	Clamp bolt tightening test	IEC 61897 Clause 7.7
4	Attachments of weights to messenger cable	IEC 61897 Clause 7.8
5	Attachment of clamps to messenger cable	IEC 61897 Clause 7.8
6	Damper effectiveness evaluation	IEC 61897 Clause 7.11.3.2

3.3.2.5 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 $\pm 0.05\text{dB}$. 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 $+55^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 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 $\pm 0.05\text{dB}$, and the internal humidity rate measured, less than 2%.

(iii) Water Immersion test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be immersed in water for 24 hours. 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 $\pm 0.05\text{dB}$.

(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 $\pm 0.05\text{dB}$. 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 $\pm 180^\circ$ shall be exercised on the cable. Each cycle shall be less than one minute.
- b) 3 flexure cycles of the cable, of $\pm 180^\circ$ with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than $\pm 0.05\text{dB}$. 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.

3.3.2.6 Type Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in table 3-5: 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 3-5:
Type Tests Fibre Optic Approach Cable**

S.NO.	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours
2	Seepage of filling compound	(EIA 455-81A) Preconditioning : 72 hours,

**Table 3-5:
Type Tests Fibre Optic Approach Cable**

S.NO.	Test Name	Test Procedure
		Test duration : 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength Test	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) - 2 cycles
-End Of Table-		

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 $\pm 10\%$. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

3.4 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 and associated hardware fitting , 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 CIP Clearance/Interim Inspection Report. 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 test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. List of factory acceptance tests for Fibre Optic Transmission system, Termination Equipment Sub-system

NMS are given in specified Tables in this section. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance tests for the other 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, alarms and diagnostics etc.

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

3.4.1 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. In case a number of equipments are required for demonstration of the performance of any equipment during FAT, the sample size shall be taken as that number of equipments which are necessary to demonstrate the performance, irrespective of the percentage.

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.

3.4.2 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), alongwith 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.

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

The factory acceptance tests listed in table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138, 1994 section 4.2.2.1 and section 5.2.2.1. 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 3-6
Factory Acceptance Tests for Optical Fibres: Optical Tests

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation Coefficient	TS Vol II ,Table 2-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS Vol II, Section 2.1.1.2	EIA/TIA 455-59
3	Attenuation at Water Peak	TS Vol II ,Table 2-1(a)	EIA/TIA 455- 78A
4	Chromatic Dispersion		EIA/TIA 455-168A/169A/175A
5	Core - Clad Concentricity Error		EIA/TIA 455-/176
6	Cladding diameter		EIA/TIA 455-176
7	Fibre Tensile Proof Testing		EIA/TIA 455-31B
-End of 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.

3.4.4 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 3-7
Factory Acceptance Tests on OPGW
Applicable standard: IEEE 1138 / IEC
60794

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

3.4.5 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 3-8. The sampling plan shall be as per relevant standard:

Table 3-8
Factory Acceptance Tests On OPGW Fittings

S. No.	Factory Acceptance Test
Suspension Assembly	
1	UTS/Mechanical Strength of the assembly
2	Clamp Slip Test
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Mechanical strength of each component

Table 3-8
Factory Acceptance Tests On OPGW Fittings

S. No.	Factory Acceptance Test
5	Galvanising test
Tension Assembly	
6	Clamp Slip Strength test
7	Visual Material verification and dimensional checks as per approved DRS/Drawings
8	Mechanical strength of each component
9	Galvanising Test
Vibration Damper	
10	Galvanising test on damper, masses and messenger wires
11	Damper response (resonant frequencies)
12	Clamp Slip test
13	Strength of messenger wires
14	Attachments of weights to messenger cable
15	Attachments of clamps to messenger cable
16	Clamp bolt tightening test
17	Clamp bolt torque test
18	Dynamic characteristic test.
19	Visual Material verification and dimensional checks as per approved DRS/Drawings
Structure Mounting Clamp	
20	Clamp fit test
21	Clamp Strength test
22	Visual Material verification and dimensional checks as per approved DRS/Drawings
End of Table	

3.4.6 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 3-9:

**Table 3-9
Factory Acceptance Tests On Approach Cable**

S. No.	Factory Acceptance Test
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings

3.4.7 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

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

**Table 3-10
Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP**

S. No.	Factory Acceptance Test
1	Visual check of Quantities and Specific Component Number for each component of Splice Enclosure/FODP and dimensional checks against the approved drawings.

3.4.8 Factory Acceptance Test on Test Equipment , Pigtail & other items

As per technical specification and approved DRS/Documents.

3.5 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment & 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, Telecom equipment, NMS 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 & Telecom equipment installation. The tests to be conducted during SAT of PLCC Equipment are specified in respective section.

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.

3.5.1 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.

3.5.1.1 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 3- 11(a) through 3-11(c) below:

Table 3-11(a)
Fibre Optic Cable Pre-Installation Testing

Item:	Description:
1.	Physical Inspection of the cable assembly for damage
2.	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm

Table 3-11(a)
Fibre Optic Cable Pre-Installation Testing

3.	Fibre Optic Cable length measurement using OTDR

Table 3-11(b)
Fibre Optic Cable Splicing Testing

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

Table 3-11(c)
Fibre Optic Cable Commissioning Testing

Item:	Description:
1.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
2.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.
3.	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4.	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.
-End of Table-	

QUALITY ASSURANCE PROGRAMME :

- 1) To ensure that the equipment and services under the scope of this Contract, whether manufactured or performed within the Contractor's Works or at his Sub- Contractor's premises or at the Employer's site or at any other place of Work as applicable, are in accordance with the specifications, the Contractor shall ensure suitable quality assurance programme to control such activities at all points necessary. A quality assurance programme of the Contractor shall be in line with ISO requirements & shall generally cover the following :

- a) The organisation structure for the management and implementation of the proposed quality assurance programme.
- b) System for Document and Data Control.
- c) Qualification and Experience data of Bidder's key personnel.
- d) The procedure for purchases of materials, parts, components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
- e) System for shop manufacturing and site erection controls including process controls, fabrication and assembly control.
- f) System for Control of non-conforming products including deviation dispositioning, if any and system for corrective and preventive actions based on the feed back received from the Customers and also internally documented system for Customer complaints.
- g) Inspection and test procedure both for manufacture and field activities.
- h) System for Control of calibration of testing and measuring equipment and the indication of calibration status on the instruments.
- i) System for indication and appraisal of inspection status.
- j) System of Internal Quality Audits, Management review and initiation of corrective and Preventive actions based on the above.
- k) System for authorising release of manufactured product to the Employer.
- l) System for maintenance of records.
- m) System for handling, storage and delivery.
- n) A quality plan detailing out the specific quality control measures and procedure adopted for controlling the quality characteristics relevant to each item of equipment furnished and /or service rendered.
- o) System for various field activities i.e. unloading, receipt at site, proper storage, erection, testing and commissioning of various equipment and maintenance of records. In this regard, the Employer has already prepared Standard Field Quality Plan for transmission line/substation equipments as applicable, Civil/erection

Works which is required to be followed for associated works.

The Employer or his duly authorised representative reserves the right to carry out quality audit and quality surveillance of the system and procedure of the Contractor/his vendor's quality management and control activities.

➔ **Quality Assurance Documents**

The Contractor shall ensure availability of the following Quality Assurance Documents:

- i) All Non-Destructive Examination procedures, stress relief and weld repair procedure actually used during fabrication, and reports including radiography interpretation reports.
- ii) Welder and welding operator qualification certificates.
- iii) Welder's identification list, welding operator's qualification procedure and welding identification symbols.
- iv) Raw Material test reports on components as specified by the specification and in the quality plan.
- v) The Manufacturing Quality Plan(MQP) indicating Customer Inspection Points (CIPs) at various stages of manufacturing and methods used to verify that the inspection and testing points in the quality plan were performed satisfactorily.
- vi) Factory test results for testing required as per applicable quality plan/technical specifications/GTP/Drawings etc.
- vii) Stress relief time temperature charts/oil impregnation time temperature charts, wherever applicable.

INSPECTION, TESTING & INSPECTION CERTIFICATE :

- 1) Contractor shall procure bought out items from sub-vendors as per the list in "Compendium of Vendors" available on POWERGRID web-site www.powergridindia.com after ensuring compliance to the requirements/conditions mentioned therein. Contractor shall explore first the possibilities of procuring the bought out items from POWERGRID approved existing vendors. In case of their unavailability / non-response, Contractor may approach POWERGRID for additional sub-vendor approval. In that case, the assessment report of proposed sub vendor by Contractor along with the enclosures as per Annexure-I shall be submitted within 60 days of the award. The proposal shall be reviewed and approval will accorded

based on the verification of the document submitted and/or after the physical assessment of the works as the case may be

If proposal for sub-vendor is submitted after 60 days, the Contractor's proposal normally will not be considered for current LOA. However, POWERGRID may process the case for developing more vendors for referred items, if found relevant. In all cases, It is the responsibility of the Contractor that Project activities do not suffer on account of delay in approval/non approval of a new sub- vendor.

For TL packages, the makes/model of items shall be finalized during approval of DRS by PGCIL.

The responsibility and the basis of inspection for various items & equipment is placed at **Annexure-II** along with the requirement of MQP (Manufacturing Quality Plan), ITP(Inspection & Test Plan), FAT(Factory Acceptance Test) which should be valid & POWERGRID approved and Level of inspection envisaged against each item.

Contractor shall ensure that order for items where MQP/ITP/FAT is required will be placed only on vendors having valid MQP/ITP/FAT and where the supplier's MQP/ITP/FAT is either not valid or has not been approved by POWERGRID, MQP shall be generally submitted as per POWERGRID format before placing order. A Copy of MQP format is placed at **Annexure - III**.

Items not covered under MQP/ITP/FAT shall be offered for inspection as per POWERGRID LOA/technical Specifications/ POWERGRID approved data sheets/ POWERGRID approved drawings and relevant Indian / International standards.

Inspection Levels: For implementation of projects in a time bound manner and to avoid any delay in deputation of POWERGRID or its authorized representative, involvement of POWERGRID for inspection of various items / equipment will be based on the level below: the contractor to intimate NHIDCL also.

Level -I: Contractor to raise all inspection calls and review the report of tests carried out by the manufacturer, on his own, as per applicable standards/ POWERGRID specification, and submit to concerned POWERGRID inspection office/Inspection Engineer. CIP/MICC will be issued by POWERGRID based on review of test reports/certificates of manufacturers.

Level - II: Contractor to raise all inspection calls and carry out the inspection on behalf of POWERGRID on the proposed date of inspection as per applicable standards/specification. However, in case POWERGRID wishes to associate itself

during inspection, the same would be intimated to Contractor and CIP/MICC will be issued by POWERGRID. Else, Contractor would submit their test reports/certificates to POWERGRID. CIP/MICC will be issued by POWERGRID based on review of test reports / certificates.

Level - III: Contractor to raise inspection calls for both, stage (as applicable) & final inspection and carry out the stage inspections(if applicable) on behalf of POWERGRID on the proposed date of inspection as per applicable standards/specification. However, in case POWERGRID wishes to associate itself during stage inspection, the same would be intimated to Contractor and CIP will be issued by POWERGRID. Else, Contractor would submit the test reports / certificates of stage inspection after their own review and CIP will be issued by POWERGRID based on review of test reports / certificates. Final inspection will be carried out by POWERGRID and CIP/MICC will be issued by POWERGRID.

Level - IV: Contractor to raise inspection calls for both, stage (as applicable) & final inspections. POWERGRID will carry out the inspection for both stage & final inspection as per applicable standards/specification and CIP/MICC will be issued by POWERGRID.

- 2) Contractor shall ensure that to implement the above inspection levels, particularly for the quality control and inspection at sub-vendor's works, they would depute sufficient qualified & experienced manpower in their Quality Control and Inspection department. Further, to assure quality of construction, Contractor shall have a separate workforce having appropriate qualification & experience and deploy suitable tools and plant for maintaining quality requirement during construction in line with applicable Field Quality Plan (FQP).
- 3) The Employer, his duly authorised representative of PGCIL and/or outside inspection agency acting on behalf of the Employer shall have at all reasonable times access to the Contractor's premises or Works and shall have the power at all reasonable times to ensure that proper Quality Management practices / norms are adhered to, inspect and examine the materials & workmanship of the Works, to carry out Quality/Surveillance Audit during manufacture or erection and if part of the Works is being manufactured or assembled at other premises or works. The Contractor shall obtain for the Employer and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works. The item/equipment, if found unsatisfactory with respect to workmanship or material is liable to be rejected. The observations for improvements during product/ process inspection by POWERGRID shall be recorded in Quality Improvement Register (available & maintained at works) for review & timely compliance of observations.

- 4) Contractor shall submit inspection calls over internet -POWERGRID Engineer I/C through Email or through letter with an intimation to NHIDCL. After raising the inspection calls, Contractor shall then proceed as per the message received from PGCIL.
- 5) The Employer/ PGCIL reserves the right to witness any or all type, acceptance and routine tests specified for which the Contractor shall give the Employer/Inspector of PGCIL Twenty one (21) days written notice of any material being ready for testing for each stage of testing as identified in the approved quality plan as customer inspection point(CIP) for indigenous inspections. All inspection calls for overseas material shall be given at least forty five (45) days in advance. Such tests shall be to the Contractor's account. The Employer/inspector, unless witnessing of the tests is waived by Employer/ PGCIL, will attend such tests within Twenty one (21) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector three copies of tests, duly certified. Contractor shall ensure, before giving notice for type test, that all drawings and quality plans have been got approved. The equipment shall be dispatched to site only after approval of Routine and Acceptance test results and Issuance of Dispatch Clearance in writing by the Employer. CIP/Material Inspection clearance certificate (MICC) shall be issued by the Employer after inspection of the equipment or review of test reports as applicable. Employer/ PGCIL may waive off the presence of Employer's inspecting engineer. In that case test will be carried out as per approved QP and test certificate will be furnished by the supplier for approval. CIP/MICC will be issued only after review and approval of the test reports.
- 6) Contractor shall generally offer material for inspection as per supply bar chart approved by POWERGRID and not before 30 days from schedule indicated in the bar chart. In case Contractor offers material(s) for inspection prior to 30 days from the scheduled date with necessary approval of POWERGRID, POWERGRID shall inspect the material and issue CIP only. However, in such an exceptional case, MICC shall be issued only as per provision of original / revised approved supply schedule.
- 7) Contractor shall minimize the number of inspection calls by offering optimum quantities in each inspection call at the respective manufacturer's works.
- 8) Contractor shall inspect the material themselves and only after they are fully convinced about the Quality, they shall offer the material for POWERGRID inspection and shall also ensure that relevant portion of LOA approved

drawing and data sheets along with applicable Quality Plans are available at the works of Contractor or their Sub-vendor before the material is offered for inspection.

- 9) Contractor shall ensure that material which has been cleared for dispatch after inspection will be dispatched within 30 days in case of domestic supplies and within 60 days in case of Off-shore supplies from the date of issuance of CIP. Material which is not dispatched within stipulated time as above will be reoffered for POWERGRID inspection or specific approval of POWERGRID QA&I shall be obtained for delayed dispatch.
- 10) The Employer or IE of PGCIL shall give notice in writing to the Contractor, of any objection either to conformance to any drawings or to any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Employer/Inspection Engineer of PGCIL giving reasons therein, that no modifications are necessary to comply with the Contract.
- 11) All Test Reports and documents to be submitted in English during final inspection of equipment by POWERGRID or as and when required for submission.
- 12) When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Employer/Inspection Engineer (IE) of PGCIL shall issue a certificate to this effect within fifteen (15) days after completion of tests & submission of documents by Contractor/manufacturer but if the tests are not witnessed by the Employer/IE, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Employer/IE. Contractor shall, on completion of all tests, submit test reports within Ten (10) days to POWERGRID IE. Failure of the Employer/IE to issue such a certificate shall not prevent the Contractor from proceeding with the Works. The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract.
- 13) In all cases, where the Contract provides for tests whether at the premises or works of the Contractor or of any Sub- Contractor, the Contractor, except where otherwise specified, shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer/Inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Employer/Inspection Engineer or to his authorised representative to accomplish testing.
- 14) The inspection and acceptance by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of

the Contractor in respect of the agreed quality assurance programme forming a part of the Contract, or if such equipment is found to be defective at a later stage.

- 15) The Employer will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material comply with the specification.
- 16) The Employer reserves the right for getting any additional field tests conducted on the completely assembled equipment at site to satisfy that material complies with specifications.
- 17) Rework/ Re-engineering, if any, on any item/equipment shall be carried out only after mutual discussions and in accordance with mutually agreed procedure. Contractor shall submit Joint Inspection Report of equipments under Re-Work/Re-Engineering alongwith procedure for the same to POWERGRID for approval, before taking up the Re-Work/Re-Engineering, failing which POWERGRID reserves the right to reject the equipment.
- 18) Contractor may establish a field test Laboratory to execute Civil Construction testing requirements at site with the condition that all testing equipment shall be calibrated from POWERGRID approved accredited Testing laboratories, with calibration certificates kept available at site and all testing personnel employed in the Field Testing Laboratories to be qualified and experienced Engineers or testing to be carried out at POWERGRID approved Third Party Laboratories.
- 19) Contractor shall ensure that all possible steps are taken to avoid damages to the equipment during transport, storage and erection.
- 20) The Employer reserves the right to increase or decrease their involvement in inspections at Contractor's Works or at his Sub-Contractor's premises or at the Employer's site or at any other place of Work based on performance of Contractor/sub Contractor.

Assessment report from Contractor for proposed sub-vendor along with following enclosures (to the extent available):

1. Registration / License of the works
2. Organization chart with name and qualification of key persons
3. List of Plant and Machinery.
4. List of testing equipment with their calibration status.
5. List of Raw material, bought out items with sourcing details
6. List of out-sourced services with sourcing details.
7. List of supply in last three years.
8. Third party approval, if any (viz. ISO, BIS),
9. Pollution clearance wherever applicable
10. Energy Conservation & Efficiency report
(Applicable to industries having contract load more than 100 KVA)
11. Formats for RM, in process and acceptance testing
12. Type test approvals conducted in last 5 years, if applicable
13. Performance Certificates from customers
14. Photographs of factory, plant and machinery & testing facilities

Annexure-II

MQP & INSPECTION LEVEL REQUIREMENT

Sl. No.	Item / Equipment	Requirement of MQP/ITP/FAT	Inspection Level
1	Battery	No	II
2	Battery Charger	Yes	III
3	Test Equipment	No	I *
4	FO Cable	Yes	III
5	OPGW & H/W	Yes	III
6	FODP including pigtail	No	II
7	Hardware Fittings for Fibre Optic approach cable	Yes	III
8	SDH Equipments (ADM), PDH, Primary Multiplexer	Yes	IV
9	Drop & Insert Multiplexer	Yes	IV
10	DACS	Yes	IV
11	Main Distribution Frame	No	I
12	HDPE Pipe	No	II
13	NMS, TMN	Yes	IV
14	Synchronization Equipment	No	Level-I
15	48V DCPS	Yes	III
16	Furniture	No	I

Note:

* MICC for test and measuring equipment shall be issued only after actual verification/demonstration of satisfactory performance at site.

** Though level-2 items, CIP can be issued also on review of TCs and visual inspection of these items.

MANUFACTURING QUALITY PLAN

Page 2 of 2

		Customer POWERGRID / NHIDCL	Vendor's Code:	Item:	Q.P. No. Rev. No. Date:	Valid From: Valid Upto:

Code 1 Indicates place where testing is planned to be performed i.e. Inspection location A At Equipment Manufacturer's works B At Component Manufacturer's works C At Authorised Distributor's place D At Independent Lab E At Turn Key Contractor's location F Not specified	Code 2 Indicates who has to perform the tests i.e. Testing J Agency The Equipment Manufacturer K The Component Manufacturer L The Third Party M The Turnkey Contractor
Code 3 Indicates who shall witness the tests i.e. Witnessing P Agency Component Manufacturer itself Q Component Manufacturer and Equipment Manufacturer R Component Manufacturer, Equipment Manufacturer and Contractor S Equipment Manufacturer itself T Equipment Manufacturer and Contractor U Equipment Manufacturer, Contractor and POWERGRID V Third Party itself	Code 4 Review of Test Reports/Certificates W By Equipment manufacturer during raw material/bought out component inspection. X By Contractor during product/process inspection Y By POWERGRID during product/process inspection Z By Contractor and/or POWERGRID during product/process inspection
Code 5 Whether specific approval of sub-vendor / Component make is envisaged? E Envisaged Not Envisaged	Code 6 Whether test records required to be submitted after final inspection for issuance of CIP/MICC Y Yes N No

Appendix-A

Data Requirement Sheets

Appendix-A

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.

DRS Form 1(a)

DATA REQUIREMENTS SHEETS for
OVERHEAD FIBRE OPTIC CABLE

OPTICAL GROUND WIRE (OPGW) - 24/48 Fibre:

Manufacturer: _____

Part #: _____

Configuration: _____

CABLE CONSTRUCTION			
Seq	Parameter:	As per Technical Specification	As per Bidder Offering
1.	No. of Fibres Dual Window Single-Mode:	24/48	
2.	Buffer Type:	As applicable	
3.	Buffer Tube material	As applicable	
4.	No. of Buffer Tubes:	As applicable	
5.	No. of Fibers per bufferTube:	As applicable	
6.	Expected Cable Life:	25 Year	
7.	Parameters of OPGW		
(i)	UTS	In Kgf	
(ii)	Effective area	In mm ²	
(iii)	Weight	In kg/m	
(iv)	Diameter	In mm	
(v)	Modulus of elasticity	In kg/ mm ²	
(vi)	Coeff. Of linear expansion	In /C	
(vii)	Central tube design	Al or Steel	

DRS Form 2
DATA REQUIREMENTS SHEETS for OPTICAL FIBRE
DUAL-WINDOW SINGLE MODE (DW-SM)

OPTICAL PARAMETERS			
Seq	Parameter:	As per Technical Specification	As per Bidder offering
1.	Fiber manufacturer(s)/Type:		
2.	Attenuation Coefficient@ 1310 nm: @ 1550 nm:	≤ 0.35 dB/km ≤ 0.21 dB/km	
3.	Point discontinuity @ 1310nm: @ 1550nm:	≤ 0.05 dB ≤ 0.05 dB	
4.	Nominal Mode Field Diameter @ 1310 nm:	8.6 to 9.5 μm (± 0.6 μm)	
5.	Chromatic Dispersion Coefficient @ 1310 (1288-1339) nm: @ 1310 (1271-1360) nm: @ 1550 nm:	3.5 ps/(nmxkm) 5.3 ps/(nmxkm) 18 ps/(nmxkm)	
6.	Zero dispersion wavelength:	1300 to 1324 nm	
7.	Cutoff wavelength:	≤ 1260 nm	
Physical and Mechanical Properties			
8.	Bend Performance: (37.5 mm radius, 100 turns) @1310 nm (30 mm radius, 100 turn) @1550 nm (16mm radius, 1 turn) @ 1550nm	≤ 0.05 dB ≤ 0.05 dB ≤ 0.50 dB	
9.	Cladding Diameter (nominal $\pm$ deviation):	125.0 $\mu\text{m} \pm 1$ μm	
10.	Polarisation mode dispersion coefficient	≤ 0.2 ps/km ^{1/2}	
11.	Proof test level	≥ 0.69 Gpa	

Appendix-B.1

GUIDELINES FOR OPGW CABLE OFF-LINE INSTALLATION

1. General

Installation procedure for OPGW is basically similar to that for conventional overhead ground wires in overhead transmission line construction, however particular care required to be taken for protection of optical fibers in OPGW cable from damage by handling the same properly during transportation , unloading and installation at site. Off line installation to be carried out using power operated winch machines and pulley blocks on each tower using experienced installation team comprising of minimum 25 persons. The installation team shall have one team leader/crew in- charge along with 15 skilled and 10 unskilled persons minimum in one installation crew.

List of Tools and Plants to be used are as per enclosed Annexure.

Following aspects are to be kept in mind before taking up live-line installation:

- a) Tools and Plant suitability
- b) Working conditions, specially following:
 - Strong winds more than 7 m/sec
 - Rain or snow
 - Foggy
 - Lightening

2. Safety measures

All site workers must follow the Electricity Rules and Employer specified safety procedures. They must use safety belts, safety shoe, safety helmet and other safety items required.

Assign foremen/Crew In-charge for each erection crew for enforcing installation guidelines. It may be ensured that only authorized person is climbing the tower during live-line installation of OPGW. Fix the warning red flag on the tower, in order to keep the workers from encroaching into unsafe zones.

2.1 Permission to Work (PTW) :

Permit to work to be obtained by the representative of installation agency from concerned sub-station staff in coordination with employer project manager prior to commencement of installation in case of power line crossings and the same is to be returned after completion of the work in all respect within the specified time duly following the PTW conditions.

2.2 Preparedness to tackle untoward incidents:

- a) Safety Engineer has to make sure the availability of First Aid Box with each team.
- b) Maintain a record of the details of list of all nearby hospitals/clinics in each area, with contact details and Emergency contact nos. of Ambulances.
- c) In case of any untoward situation, Safety engineer/crew incharge must act fast and provide the necessary first aid to the affected person(s). Ambulance to be arranged immediately from the nearby area and coordinate with hospital for immediate medical assistance as required.

3. Off-line Installation Process

3.1 Installation plan:

Following measures are to be taken in advance for smooth completion of the installation.

- Coordination with employer project manager of PGCIL,
- Erection crew mobilization along with T&Ps
- Safety aspects
- Field quality aspects
- Transportation arrangement

3.2 Materials handling:

Check the material with respect to the approved documentation. All materials shall be visually examined for any physical damage. Any material, which is not as per documentation or is damaged, shall not be used.

OPGW Drums checks:

- Packing condition
- Packing list (Object, Type, Length, OPGW Weight, Drum No. etc)
- Attenuation results of OPGW

Hardware Fittings Checks:

- Bolts, Nuts Pitch
- Type & Quantity

Handling of OPGW:

OPGW contains optical fibers which are very delicate and to be handled with due

care. For the safety of optical fibers, it is very important to avoid the bending at sharp angle. Manufacturer guidelines are to be followed strictly while handling the same.

In order to avoid undue tension on OPGW, it is not recommended to pay off OPGW together with phase conductors or other wires tied in parallel. The tension during stringing works should be well managed within permissible limits.

Adequate length of OPGW shall be ensured as loop at each joint location after stringing so that it is possible to bring OPGW up to the ground level for carrying out jointing work.

4. OPGW Stringing

- Hang the pulley blocks on one of the earth wire peaks for the whole section (Section is a consecutive group of towers needed to support the installation of scheduled length of OPGW Drum)
- Carry out paying of pilot wire for entire section and connect the same with OPGW on drum side and winch machine on other side suitably.
 - Pull the Pilot Wire with the use of winch machine to pay out the OPGW.
 - Maintain proper tension while pulling OPGW so as to avoid damage to fibers inside the OPGW. In no case pulling tension should exceed 15 % of UTS of OPGW.
- **Set the Come-along and Lever Block to the OPGW.** With this OPGW paying for a section gets completed.

5. OPGW sagging

- Use the pre-calculated Sag & Tension Table as sag reference.
- Avoid fixing the sag if the wind is strong.

5.1 Sagging:

1) Methods and procedures for sagging of OPGW are the same as those of normal overhead ground wire.

After stringing the OPGW shall be sagged using information furnished on the sag and tension chart. The sag of the OPGW should not exceed the existing ground-wire sag.

3) Sagging thermometers shall be used to determine accurate temperature and OPGW sag of each sag section. Sagging thermometer shall be used sufficiently

prior to the actual sagging operation to represent the temperature of the OPGW.

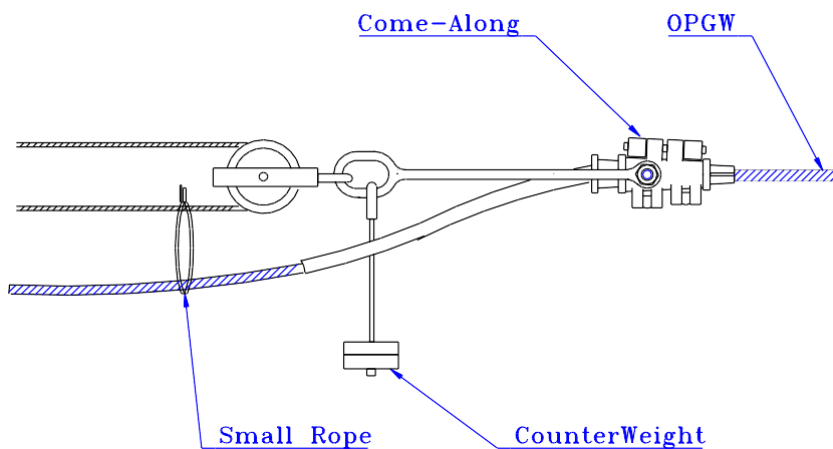
5) At the time of sagging OPGW, the sag should be within 6 inches of the theoretical value for existing temperature condition.

7) OPGW tension between each sag section shall be equalized and this shall be determined by the vertical position of the suspension clamps on the last clipped structure of the preceding sag section.

8) For pulling the OPGW with tension, the device of come-along is to be recommended.

9) Personnel should be specifically deployed for keeping watch on sag at a different section of the line during stringing.

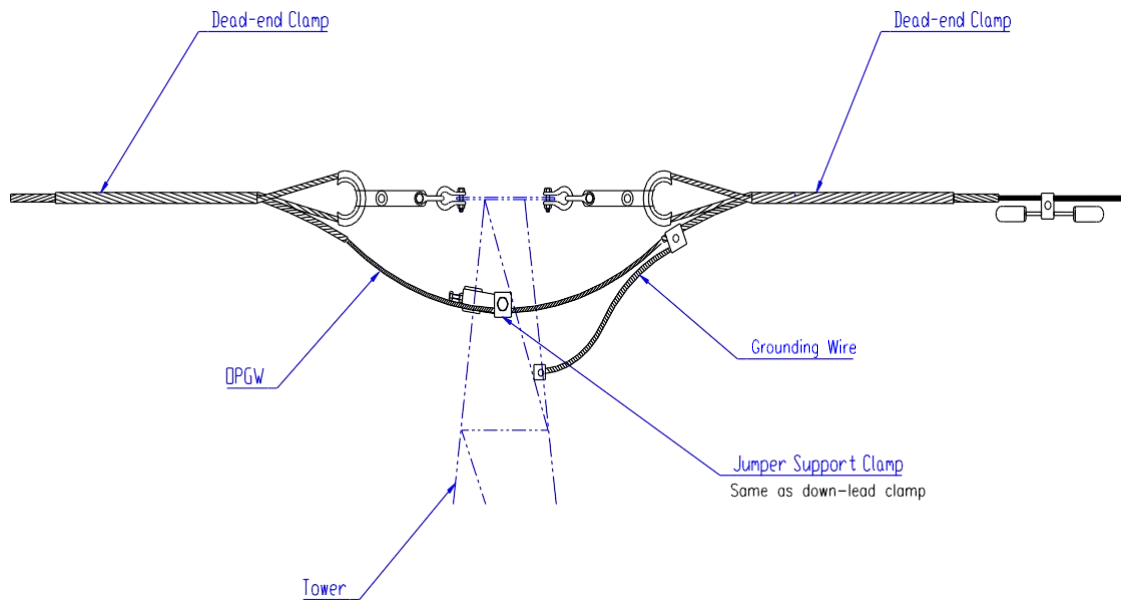
10) Waterproof caps shall be fixed at both ends of the OPGW cable after installation.



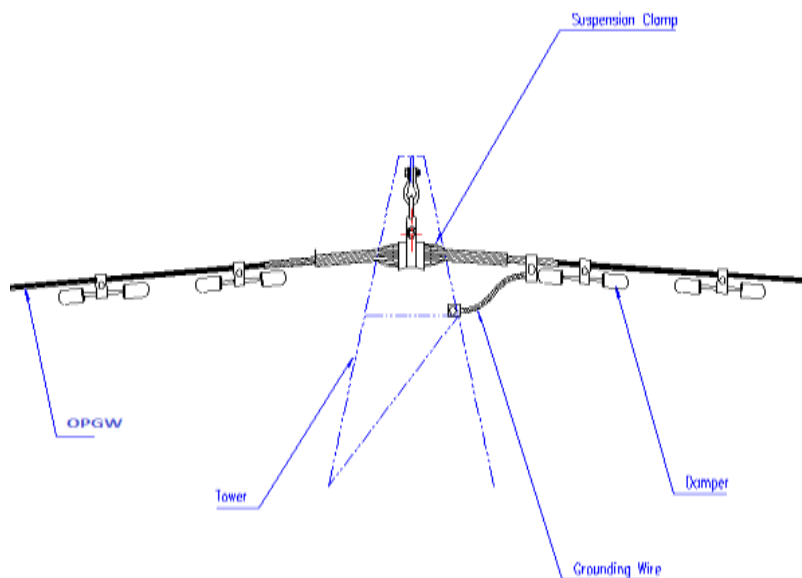
6. OPGW Clamping

- 6.1 Make sure to install and tighten the bolt of clamp properly.
- 6.2 Tightening must be made sequentially from the support point.

TENSION TOWER



SUSPENSION TOWER

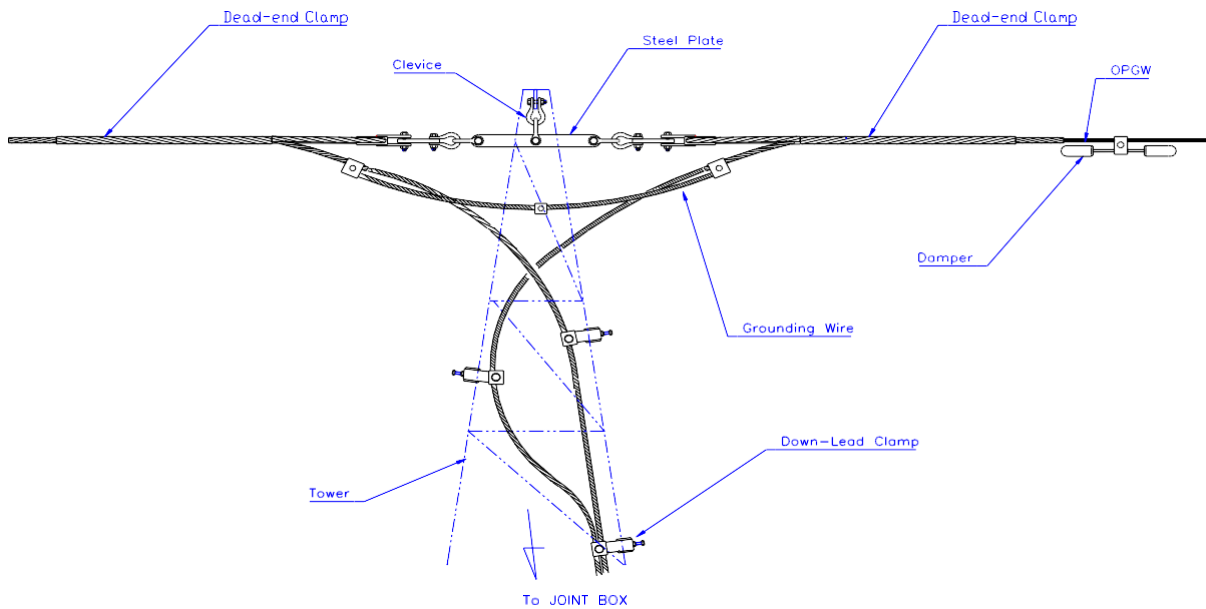


7. OPGW down Leading

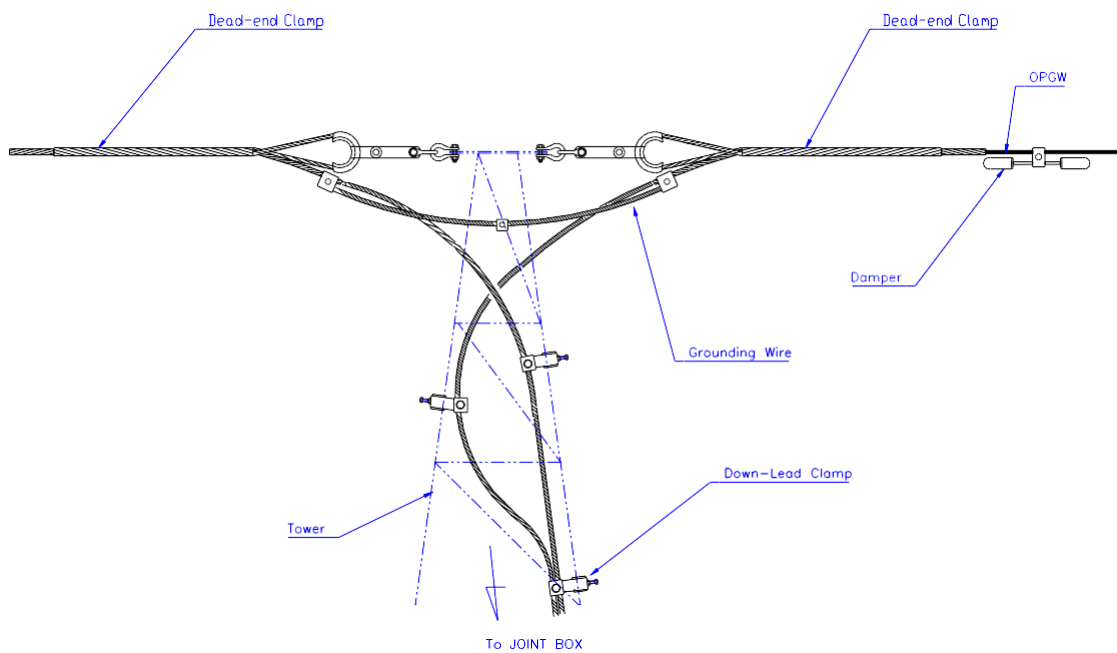
- 7.1 Make sure to clip the OPGW with down lead clamp to the tower in a careful manner.
- 7.2 Make sure to tighten the bolt of down-lead clamp properly.

7.3 Install the down-lead clamp at appropriate interval .

SUSPENSION TOWER FOR JOINTING TOWER



TENSION TOWER OF JOINTING TOWER



Annexure-1**List of Tools:**

S. No	Description	Specifications
01	Pulley block(Aluminum roller) 300 mm	20 Nos
02	Pulley block(Aluminum roller) 450 mm	20 Nos
03	Pulley block(Aluminum roller) 600 mm	6 Nos
04	Pilot Wire (14 mm)	1000 M
05	Pilot Wire (16 mm)	7000 M
06	Pilot Rope 12 mm Nylon Rope	600 M
07	Earthing roller	3-way roller
08	Winch machine (3 Tons)	2 Nos
09	Drum stand	2 sets
10	Reel winder	6 Nos
11	Come along clamp	8 Nos
12	Torque Wrench (1 Ton)	2 Nos
13	Running Board (20 Kg)	4 Nos
14	D-shackle	30 Nos
15	Snatch Block (1 way 2 ton)	8 Nos
16	Snatch Block (2 way 2 ton)	4 Nos
17	Chain Block (3 Ton)	4 Nos
18	Wire Connector	20 Nos
19	Braid Clamp	6 Nos
20	Wire Clamp	20 Nos
21	Swivel (3 ton)	10 Nos

Appendix – B.2

GUIDELINES FOR OPGW CABLE LIVE-LINE INSTALLATION

1. General

Installation procedure for OPGW is basically similar to that for conventional overhead ground wires in overhead transmission line construction, however particular care required to be taken for protection of optical fibers in OPGW cable from damage by handling the same properly during transportation, unloading and installation at site. Live line installation to be carried out using traction machines and support rollers (hanging pully blocks) using experienced installation team comprising of minimum 30-35 persons. The installation team shall have one team leader/crew in-charge along with 15 skilled and 14 unskilled persons minimum in one installation crew.

List of Tools and Plants to be used are as per enclosed Annexure.

Following aspects are to be kept in mind before taking up live-line installation:

- a) Condition of existing ground wire for its suitability for live-line OPGW installation
- b) Tools and Plant suitability
- c) Working conditions, specially following:
 - Strong winds more than 7 m/sec
 - Rain or snow
 - Foggy
 - Lightening

2. Safety measures

All site workers must follow the Electricity Rules and Employer specified safety procedures. They must use safety belts, safety shoe, safety helmet and other safety items required.

Assign foremen/Crew In-charge for each erection crew for enforcing installation guidelines. It may be ensured that only authorized person is climbing the tower during live-line installation of OPGW. Fix the warning red flag on the tower, in order to keep the workers from encroaching into unsafe zones.

Frequent verification of healthiness of T&P and ropes shall be carried out before start of work.

2.1 Permission to Work (PTW) :

Permit to work to be obtained by the representative of installation agency from concerned sub-station staff in coordination with employer/ project manager of PGCIL prior to

commencement of installation and the same is to be returned after completion of the work in all respect within the specified time duly following the PTW conditions.

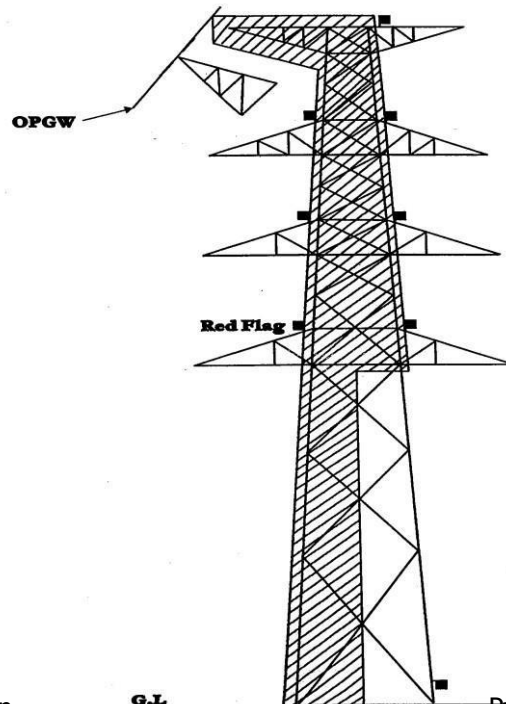
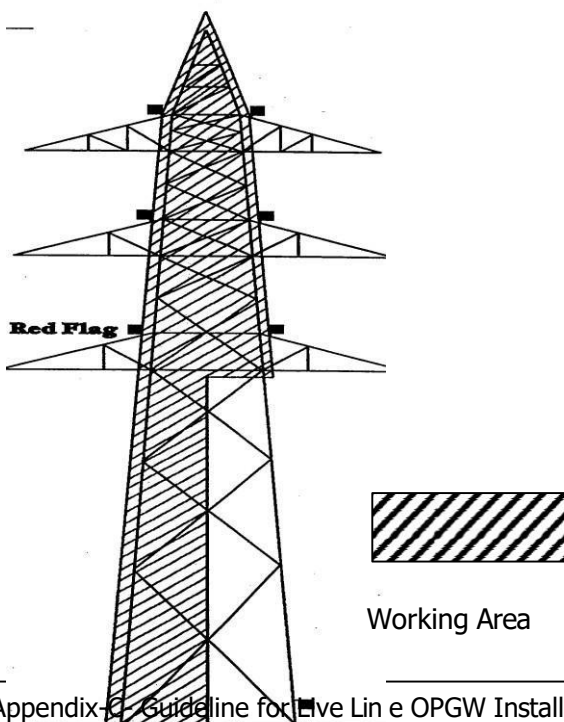
2.2 Preparedness to tackle untoward incidents:

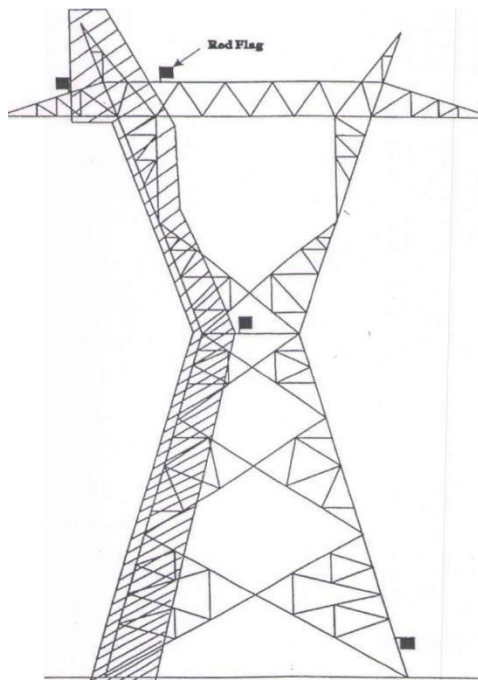
- a) Safety Engineer has to make sure the availability of First Aid Box with each team.
- b) Maintain a record of the details of list of all nearby hospitals/clinics in each area, with contact details and Emergency contact nos. of Ambulances.
- c) In case of any untoward situation, Safety engineer/crew incharge must act fast and provide the necessary first aid to the affected person(s). Ambulance to be arranged immediately from the nearby area and coordinate with hospital for immediate medical assistance as required.

2.3 Marking of Zones during OPGW Stringing:

It is very essential for the installation agency to be aware of safe zones of the Tower while carrying out live-line installation. Generally crew members identified for preparation work on the ground, will not work on the tower and will remain within hazard-free zone.

The pictorial view of the working zone and limitation of the restricted zone are shown below for your convenience.





Working Area

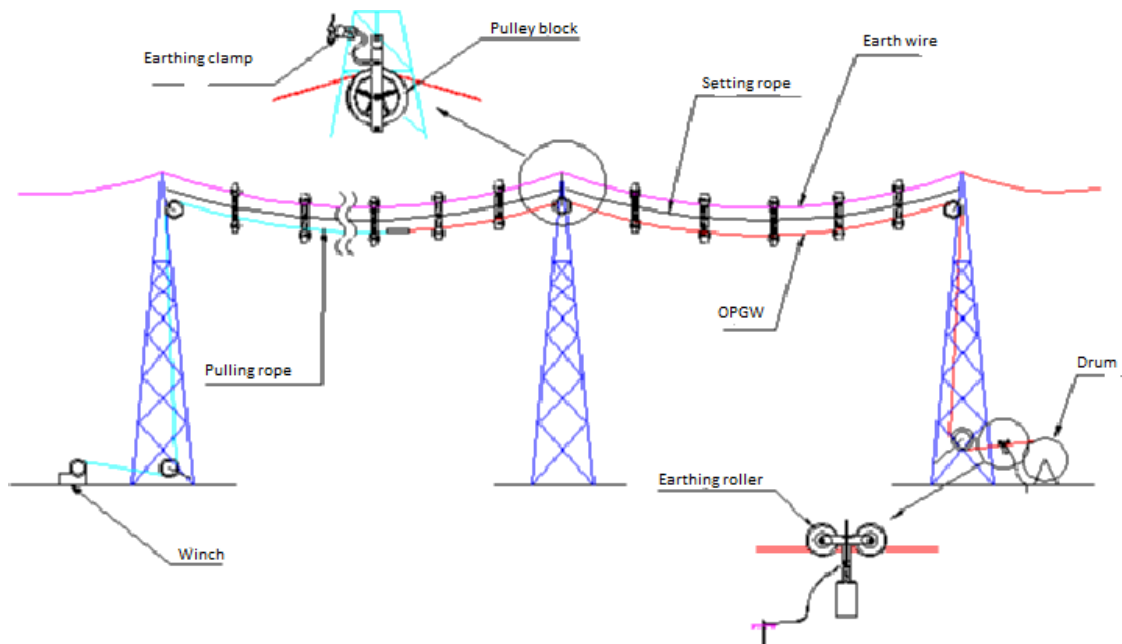
3. Grounding

Grounding of the following before starting work at site is required to be ensured. Grounding devices include the following:

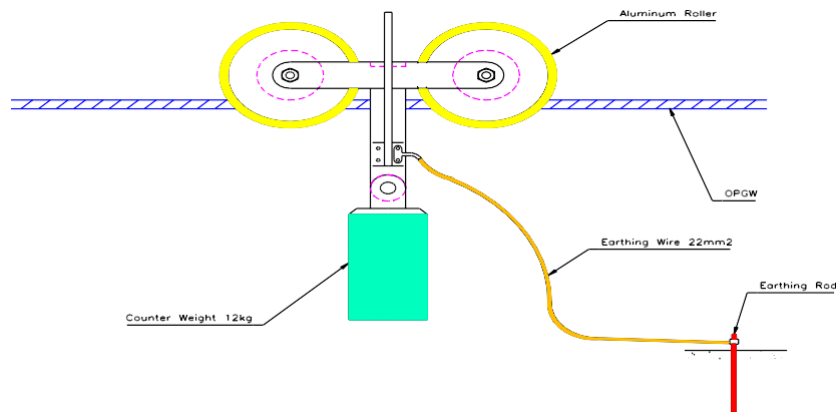
3.1 Equipment Grounding:

Equipment like OPGW and Existing Ground wire (GW), aerial rollers(pulley blocks) are connected with individual copper cable attached to the tower (with copper rod installed on the ground) or to the main grid if grounding system exists. Grounding clamp shall be cleaned well and ensure proper contact.

3.2 Running Ground:

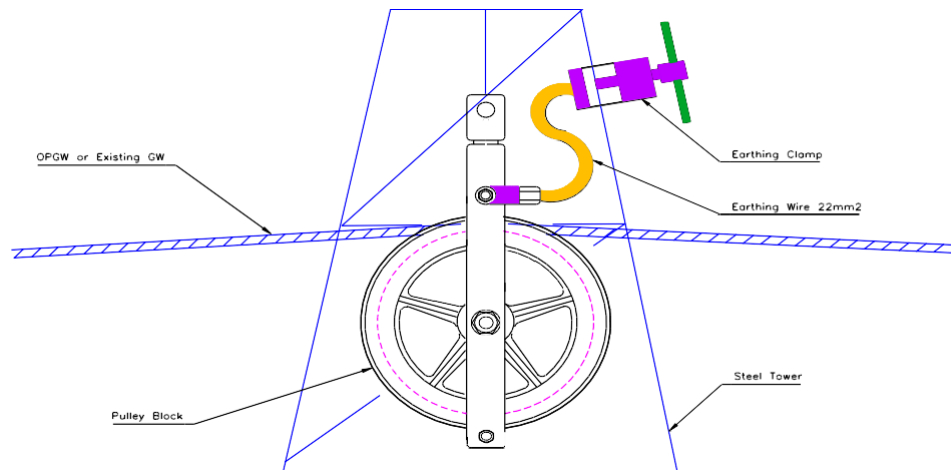


Running ground shall be installed on the OPGW at drum side during OPGW stringing time and at the Winch side on the existing GW during dismantling time for the whole stringing operation to avoid any electrical charges of induction from the line.



3.3 Pulley Block Grounding:

For each tower grounding type pulley block must be used.



Grounding cable must be connected to the ground source first then to the object that needed to be grounded.

When removing grounds, the ground must be removed from the grounded objects first and then remove the grounding clamp from the ground source.

In case of any problems during the installation work, the person in charge of the section will immediately contact sub-station in charge of the line and employer Project Manager immediately for required support.

Further , in order to have proper earthing, one aluminum roller (hanging pulley block) shall be used for additional safety after every ten rollers (neoprene) used in the span/section.

4. Live-line Installation Process

4.1 Installation plan:

Following measures are to be taken in advance for smooth completion of the installation.
PTW availability and coordination with employer project manager

- Erection crew mobilization along with T&Ps
- Safety aspects
- Field quality aspects
- Transportation arrangement

4.2 Materials handling:

Check the material with respect to the approved documentation. All materials shall be visually examined for any physical damage. Any material, which is not as per documentation or is damaged, shall not be used.

OPGW Drums checks:

- Packing condition
- Packing list (Object, Type, Length, OPGW Weight, Drum No. etc)
- Attenuation results of OPGW

Hardware Fittings Checks:

- Bolts, Nuts Pitch
- Type & Quantity

Handling of OPGW:

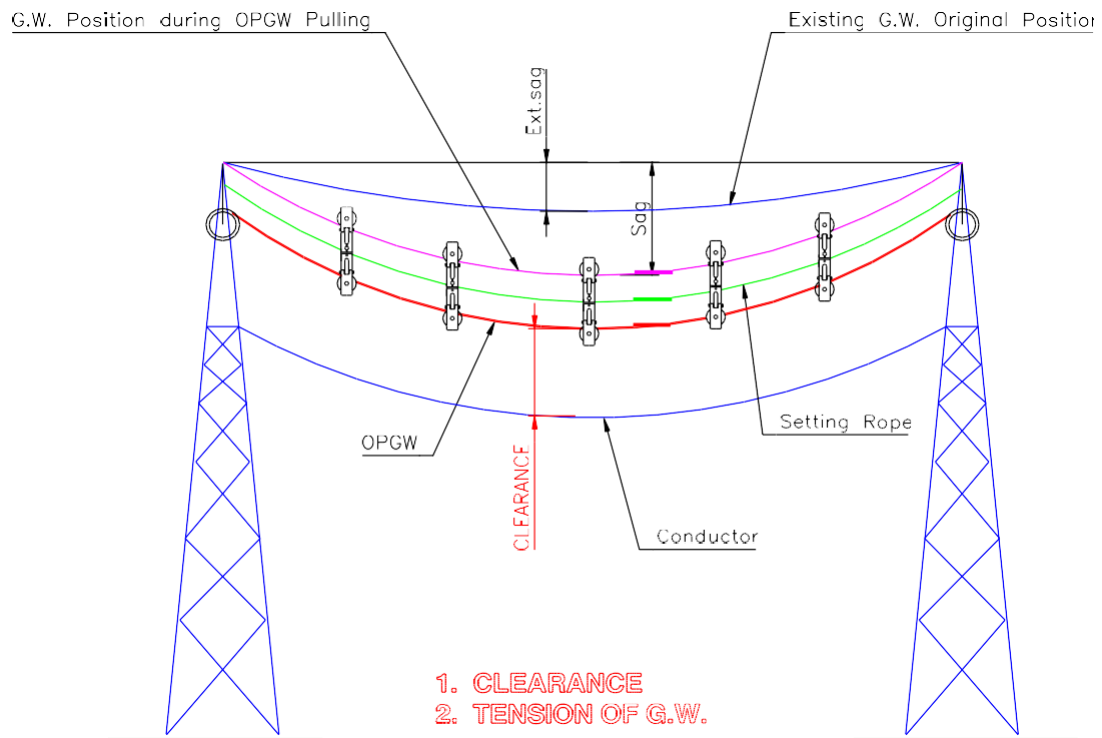
OPGW contains optical fibers which are very delicate and to be handled with due care. For the safety of optical fibers, it is very important to avoid the bending at sharp angle. Manufacturer guidelines are to be followed strictly while handling the same.

In order to avoid undue tension on OPGW, it is not recommended to pay off OPGW together with phase conductors or other wires tied in parallel. The tension during stringing works should be well managed within permissible limits.

Adequate length of OPGW shall be ensured as loop at each joint location after stringing so that it is possible to bring OPGW up to the ground level for carrying out jointing work.

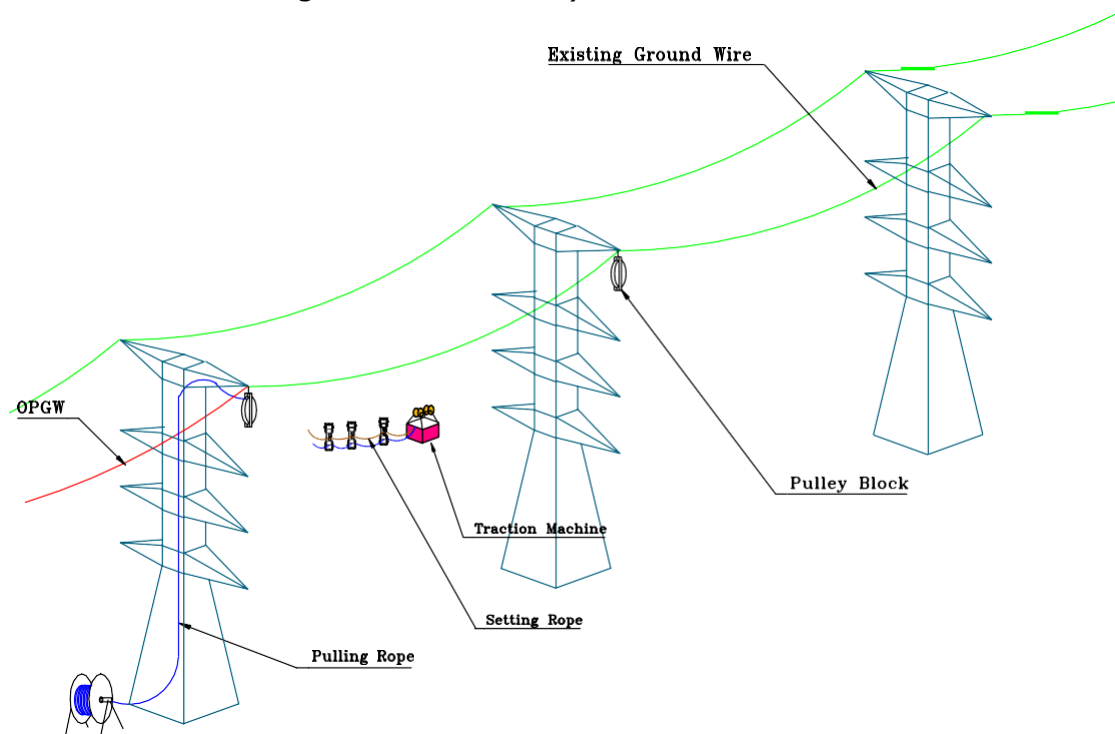
5. Clearance Checking

- 5.1 Check the clearance between existing ground-wire and live conductor before Stringing. Check the clearance between OPGW and live conductor.



6. OPGW Stringing

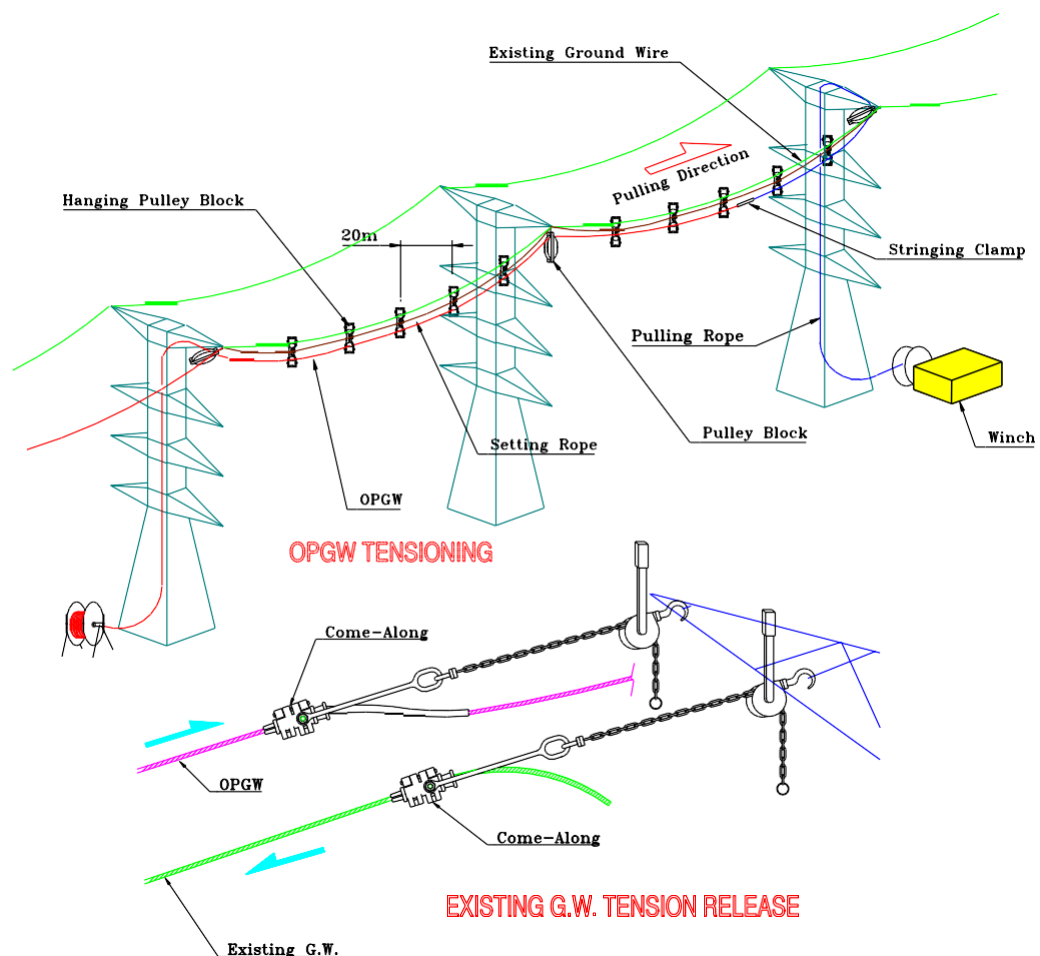
- Removal of Aviation globules in the spans (wherever applicable) by taking proper shutdown.
- Hang the pulley blocks on one of the earth wire peaks for the whole section (Section is a consecutive group of towers needed to support the installation of scheduled length of OPGW Drum)



- Set the Traction machine on the existing ground wire.
- Set the support rollers (hanging pulley blocks) on the existing ground wire where the OPGW is to be installed.
- Connect the Setting Rope and Pulling Rope to the Traction Machine.
- Pull the support rollers(hanging pulley blocks), Setting Rope and Pulling Rope with the use of Traction Machine. Support rollers (Hanging Pulley blocks) should be hanged at an interval depending on voltage level, which is mentioned below. (A mark with these specified interval shall be marked on setting rope)

Sl.no	Voltage level	Spacing
1	220kV	18-22m
2	400kV	15-18m
3	765kV	10-12m

- For every ten support rollers (hanging pulley blocks) of neoprene used in the span/section, one aluminum roller (hanging pulley block) shall be used.
- Securing the pulling & setting rope at end towers of the stringing section.
- Connect the OPGW to the Pulling Rope with Stringing Clamp.
- Pull the Pulling Rope with the use of winch machine to pay out the OPGW.
- Set the Come-along and Lever Block to the existing ground wire.
- Release the tension of existing ground wire. At the same time, with a fixed come-along and Lever Block, give more tension to the OPGW.

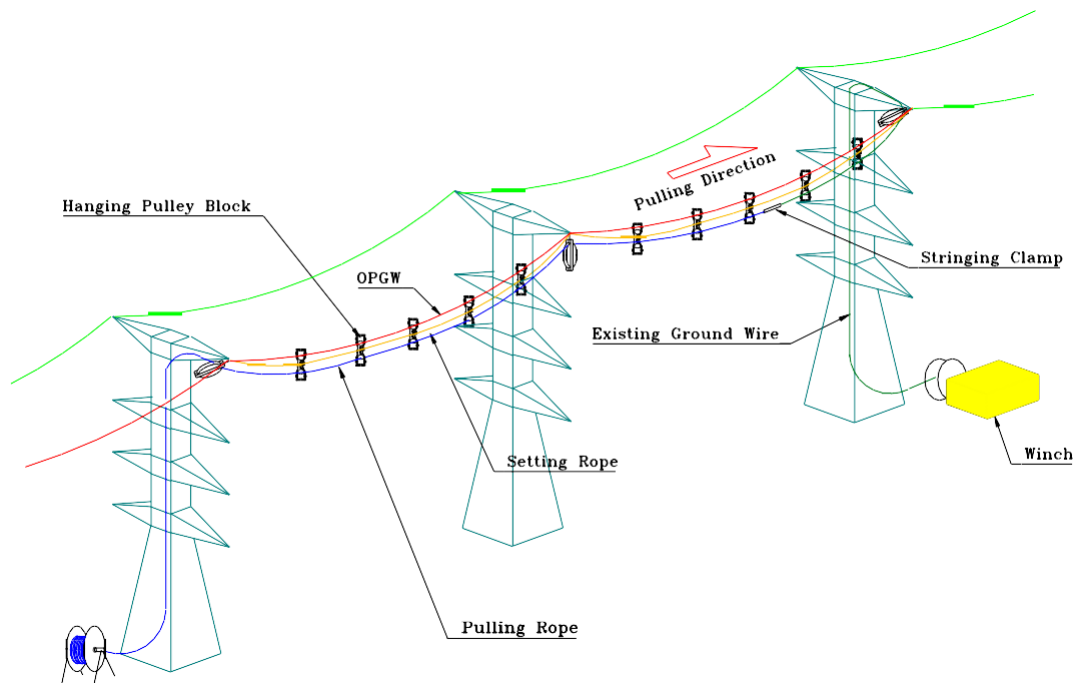


- Position of OPGW and existing ground wire will interchange with above action. The OPGW will be in upper position and existing ground wire in lower position in support rollers (hanging pulley blocks).
- With this OPGW paying for a section gets completed.
- Finally after successful stringing of OPGW and dismantling of Earthwire alongwith all ropes, support rollers etc., proper shutdown may be taken to install aviation globules back in the respective spans. The installing agency to ensure healthiness of all ropes and T&Ps used for the stringing work.

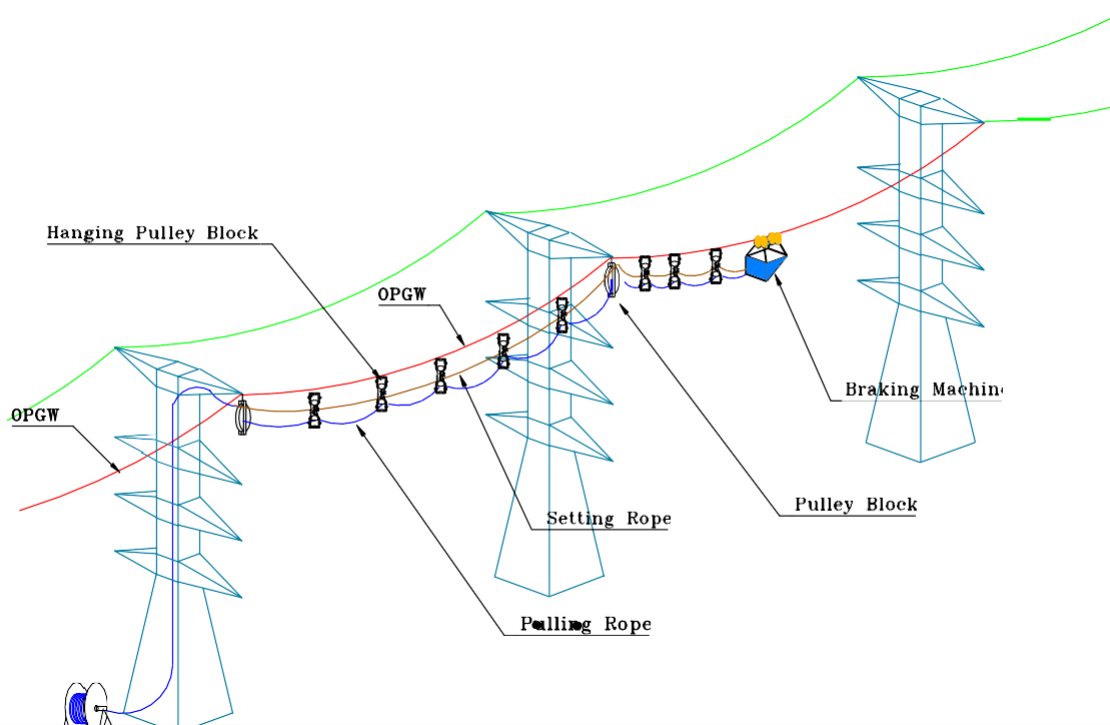
7. Dismantling process

7.1 Existing ground wire:

- Connect the existing ground wire with the Pulling Rope.
- Pull the Pulling Rope with winch to dismantle the ground wire.



7.2 Hanging Pulley Block, Setting Rope and Pulling Rope:



- Set the Breaking Machine on the OPGW of the span required for dismantling.
- Connect the Pulling Rope and Setting Rope to the Braking Machine.
- Pull the Setting Rope and Pulling Rope to dismantle.

Collect and dismantle the support rollers (hanging pulley blocks) upon reaching the succeeding tower.

8. OPGW sagging

- Use the pre-calculated Sag & Tension Table as sag reference.
- Avoid fixing the sag if the wind is strong.

8.1 Sagging:

1) Methods and procedures for sagging of OPGW are the same as those of normal overhead ground wire.

2) After stringing the OPGW shall be sagged using information furnished on the sag and tension chart. The sag of the OPGW should not exceed the existing ground-wire sag.

3) Sagging thermometers shall be used to determine accurate temperature and OPGW sag of each sag section. Sagging thermometer shall be used sufficiently prior to the actual sagging operation to represent the temperature of the OPGW.

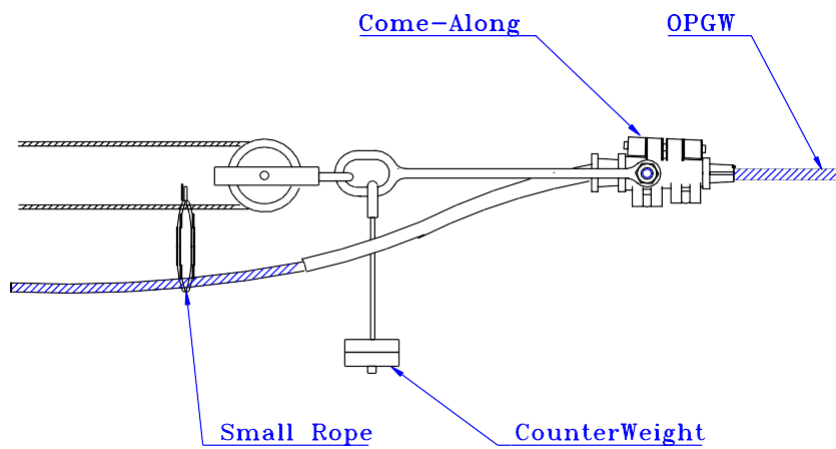
5) At the time of sagging OPGW, the sag should be within 6 inches of the theoretical value for existing temperature condition.

7) OPGW tension between each sag section shall be equalized and this shall be determined by the vertical position of the suspension clamps on the last clipped structure of the preceding sag section.

8) For pulling the OPGW with tension, the device of come-along is to be recommended.

9) Personnel should be specifically deployed for keeping watch on sag at a different section of the line during live line stringing.

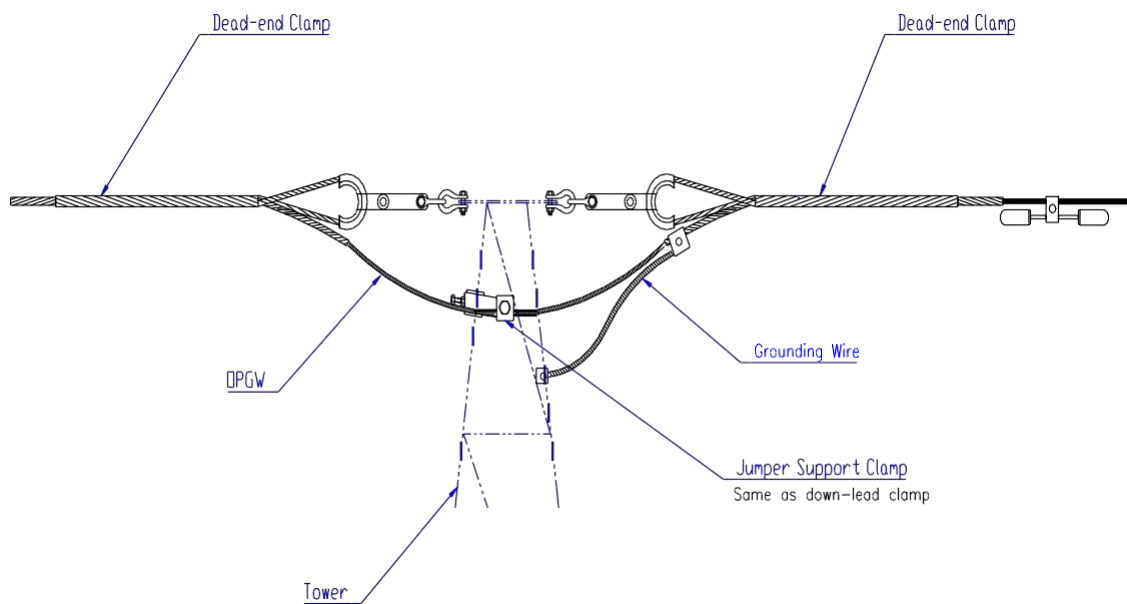
10) Waterproof caps shall be fixed at both ends of the OPGW cable after installation.



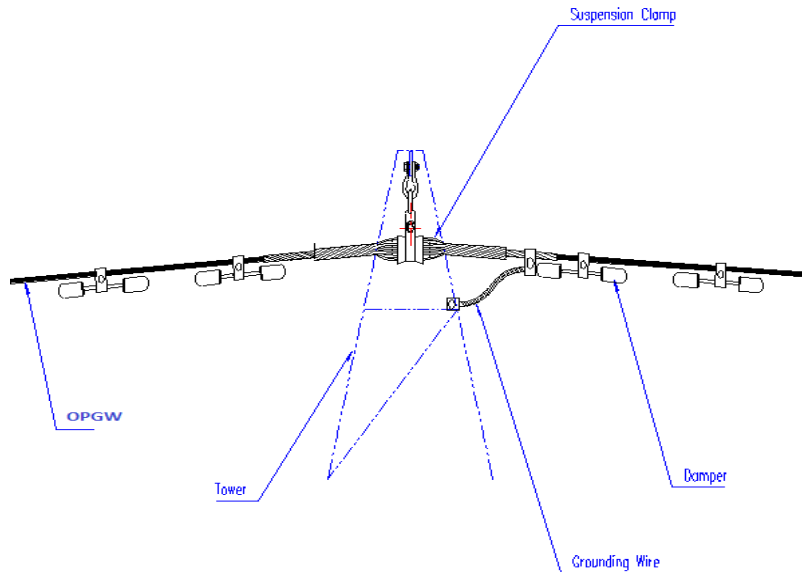
9. OPGW Clamping.

- 9.1 Make sure to install and tighten the bolt of clamp properly.
- 9.2 Tightening must be made sequentially from the support point.

TENSION TOWER



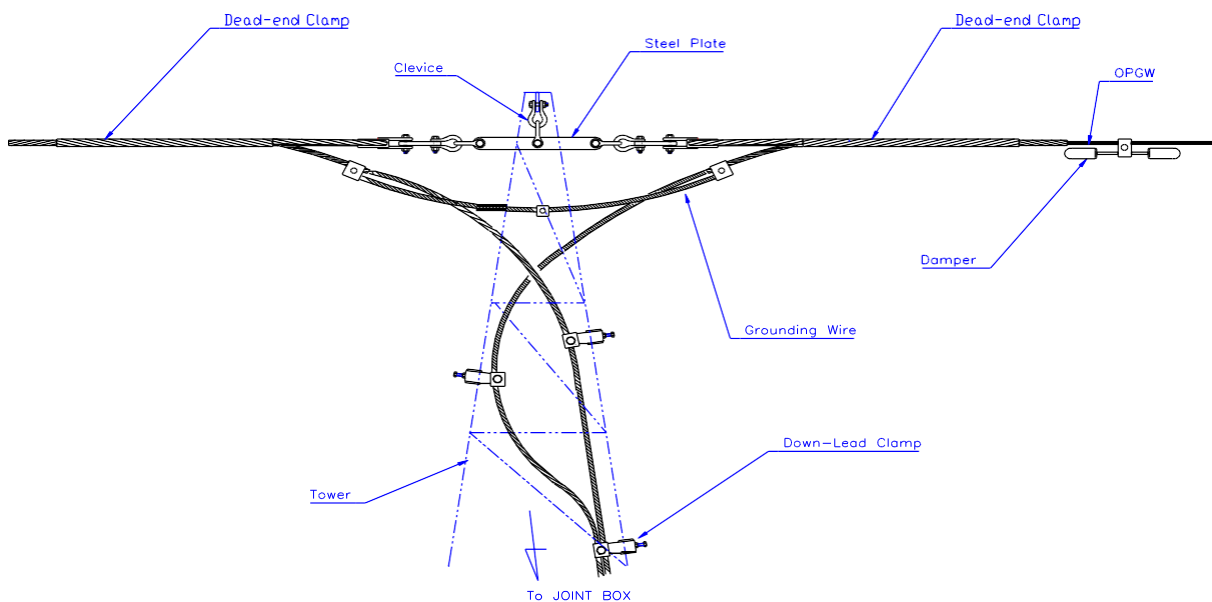
SUSPENSION TOWER



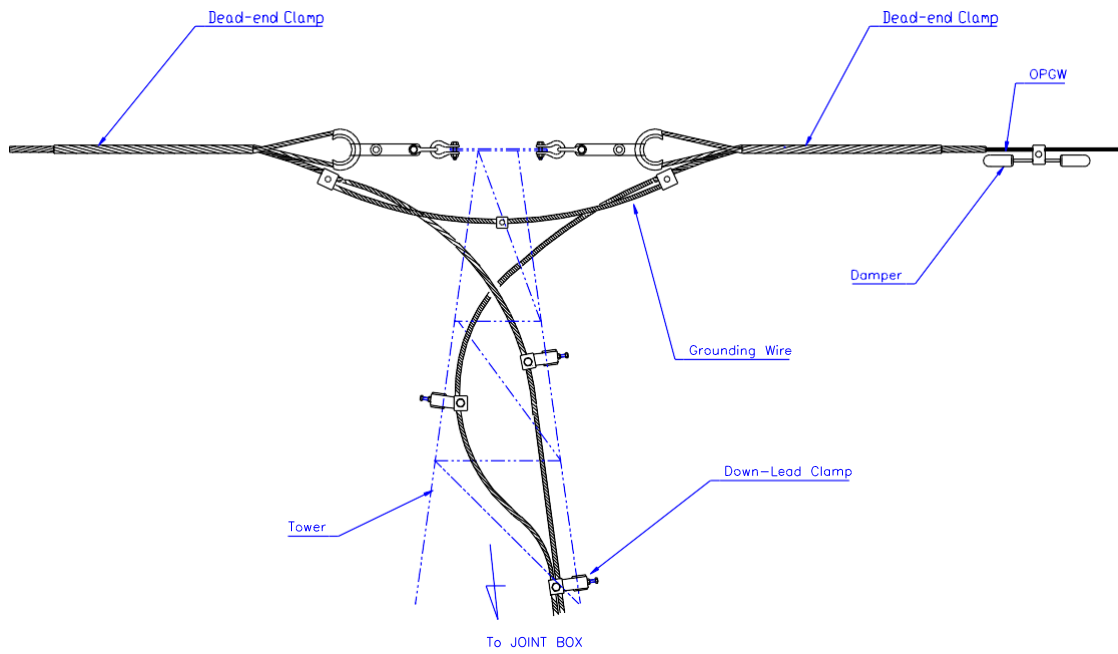
10. OPGW down Leading

- 10.1 Make sure to clip the OPGW with down lead clamp to the tower in a careful manner.
- 10.2 Make sure to tighten the bolt of down-lead clamp properly.
- 10.3 Install the down-lead clamp at appropriate interval .

SUSPENSION TOWER FOR JOINTING TOWER



TENSION TOWER OF JOINTING TOWER



Annexure-1

List of Tools:

S. No	Description	Specifications
01	Aerial Roller/Pulley Block (Aluminum)	300 mm
02	Aerial Roller/Pulley Block (Aluminum)	450 mm
03	Aerial Roller/Pulley Block (Aluminum)	600 mm
04	Setting rope	12 mm PP rope Rope
05	Pulling Rope	(i) For Preparation: a) 12mm PP Rope Rope (for 400kv and above); b) 12mm Nylon rope(for 220kv & below) (ii) For OPGW Pulling: 14mm Nylon rope
06	Lifting/Supporting Rope	12mm PP rope
07	Earthing roller	3-way roller
08	Traction machine	35 kgf
09	Winch machine	3 tons
10	Drum stand	
11	Wheel winder	
12	Come along clamp	
13	Kitto clamp	
14	D-shackle	
15	Sag-scope	
16	Support Rollers (Hanging Pulley block)	
17	Aluminium Roller (Aluminium Hanging Pulley Block)	
18	Earthing Lead	
19	Braking Machine	

Appendix - C

Guidelines for Splicing of Fibre Optic Cable

CONTENTS

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2. Jointing of Optical Fibre	3
3. Flowchart of jointing procedure	4
4. Jointing works	
a) Preparing of materials, tools and equipment	5
b) Cutting and treatment of OPGW ends	5
c) Fixing OPGW in the pass cable	6
d) Application of thermo-shrinkable tube	7
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g) Taking out of optical units	8
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6. Measurement of splicing loss	14
7. Fixing the joint box lid	16
8. Installation of a joint box	18

1. General

OPGW based Fibre Optic network being established by Power Utilities for catering data & voice communication requirements. OPGW is being supplied in number of drums for a link and required splicing for completing of a fibre optic link. Generally fusion method is being used for splicing of fibres in cable. For carrying out splicing work, experienced personnel is essential for handling splicing kit and necessary instruments such as OTDR etc.

- a) Jointing of OPGW is usually carried out on the ground. For ease of jointing with accuracy, adequate space (with tent) to be ensured on the ground for jointer and equipment. This floor space should be protected against the heavy wind, strong sunshine, high temperature, rain and dusty atmosphere.
- b) Attention must be paid so as not to damage OPGW including its optical components during handling, cutting, un- stranding of component wires and jointing.
- c) Attenuation of optical fibers to be measured just before splicing and after splicing.
- d) Typical organization chart for jointing work is given below:

A. Jointing In charge -1

A.1 For Testing :

- (i) Lineman - 1
- (ii) Jointer & Tester - 1
- (iii) Unskilled labor -1

A.2 For Jointing :

- (i) Lineman- 1
- (ii) Jointer & Tester - 1
- (iii) Unskilled labor -1

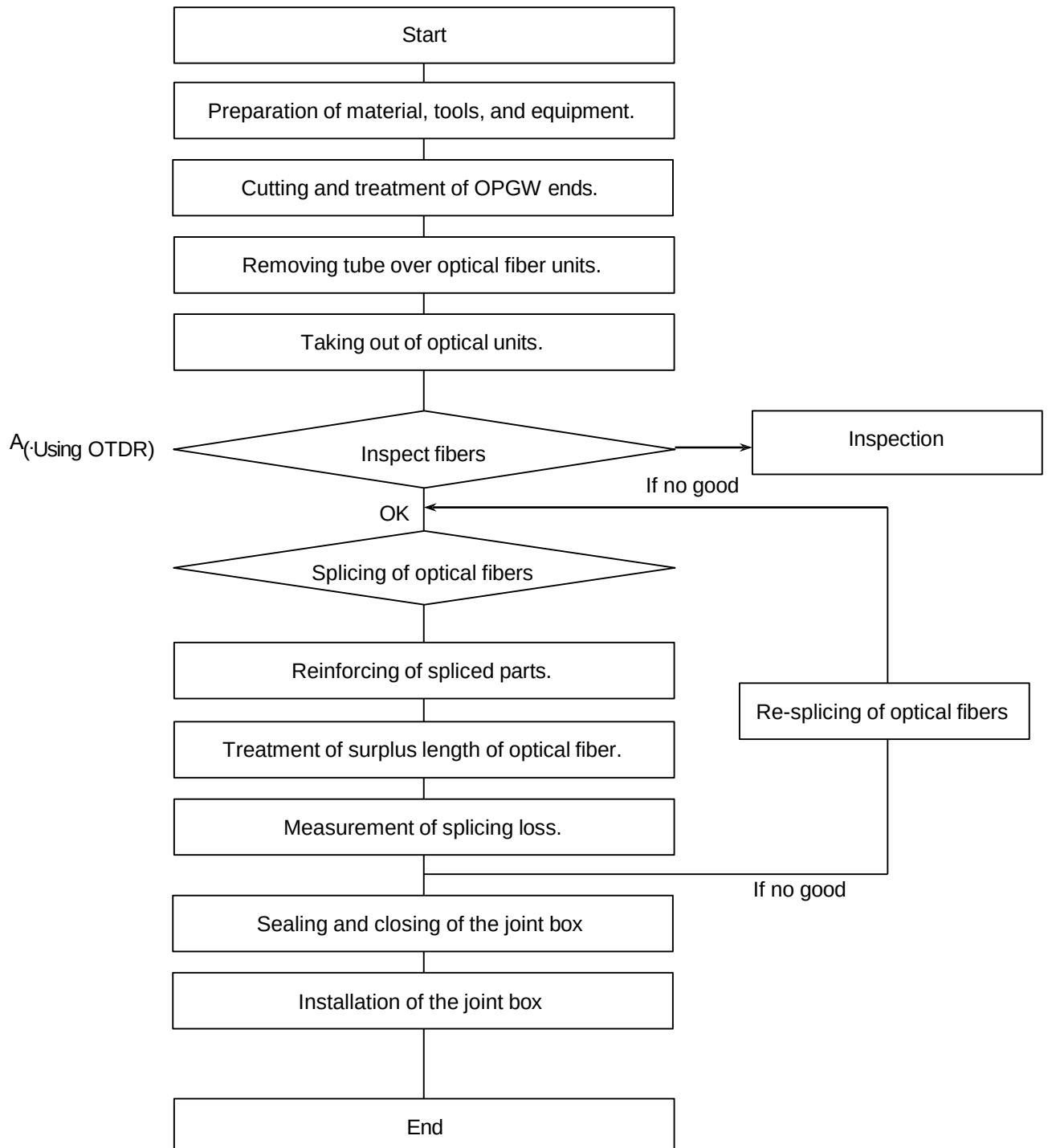
2. Jointing of optical fibre

Optical fibre are joined by using Fusion splicing. It is the process of fusing or welding two fibers together usually by an electric arc. Fusion splicing is the most widely used method of splicing as it provides for the lowest loss and least reflectance, as well as providing the strongest and most reliable joint between two



3. Flowchart of jointing procedure.

Process flow chart of OPGW jointing works is summarized briefly, as below:



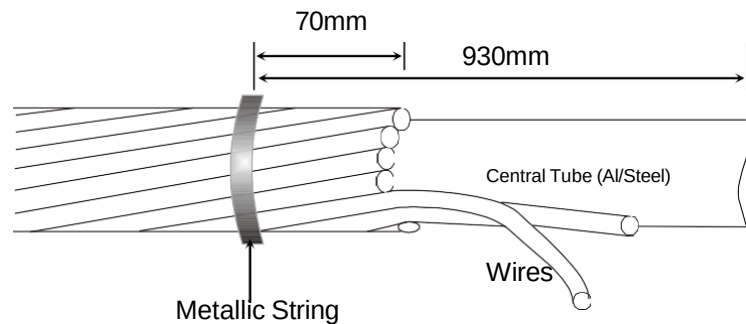
4. Jointing works

a) Preparation of materials, tools and equipment

It may be ensured that all the materials, tools and equipment listed in the Table-1 are available. The Table-1 shows tentative list of required tools & material.

b) Cutting and treatment of OPGW ends

- Coiled OPGW to be brought down and cut-off unnecessary lengths of the OPGW with a cable cutter.
- Put marks on OPGW at positions where OPGW is to be fixed to the glands of the joint box. Carryout mounting of OPGW at a position about 70mm below the cutting mark with a metallic string to prevent the stranded wires from becoming loose after cutting off the OPGW.



- Notch the Strand wires of the OPGW with a hacksaw to the depth of 1/3 or 1/2 of the Strand wire diameter. In this case, take care not to damage the inside Central Tube (AL/Steel) of the OPGW.
- Loose the Strand wires from the OPGW ends one by one and snap them off at the notched position.
- Cut the Central Tube (AL/Steel).

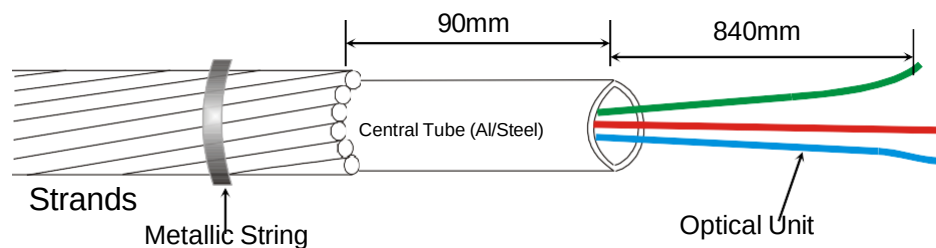


Table-1: Tools & Material

Description	Qt'y	Purpose
Stabilized light source	1	Measure loss
Optical power meter	1	Measure loss
Dummy fiber	1	Measure loss
Fusion splicer	1	Splicing fiber
Fiber cutter	2	Cutting fiber
Jacket stripper	2	Remove fiber jacket
Washing agent	2	Cleaning fiber
Ethyl alcohol	2	Cleaning fiber
Gauze	1 Set	Cleaning fiber
Dust remove	1	Cleaning splicer
Cable cutter	1	Cutting OPGW
Hacksaw	1	Cutting AW wire
Pipe cutter	1	Cutting al tube
Knife	1	
Screw driver set(+, -)	1	
Pliers	2	
Light stand	1	Lighting
Hexagon wrench	1	
Portable telephone set	2	
Engine generator(If need)	1	Power supply
OTDR	1	
Electric reel	1	
Optical telephone set	2	
Electric cord	1	

c) Fixing OPGW in the Passcable (see the Figure 4. for main assembling particulars)

- Insert OPGW in the passcable until OPGW touch the internal clamping or until the Central Tube (AL/Steel) is outside from the passcable of about 90 mm.

- Lock the moving clamping with torque force of 12 NM, like a Figure 5.

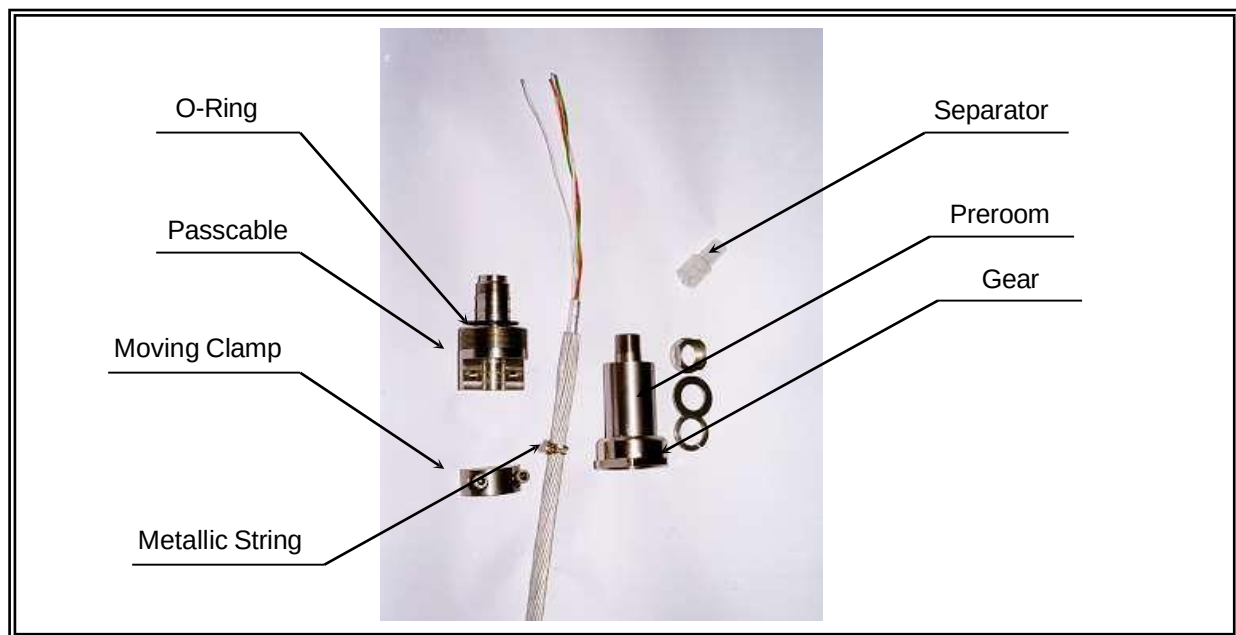


Fig. 4

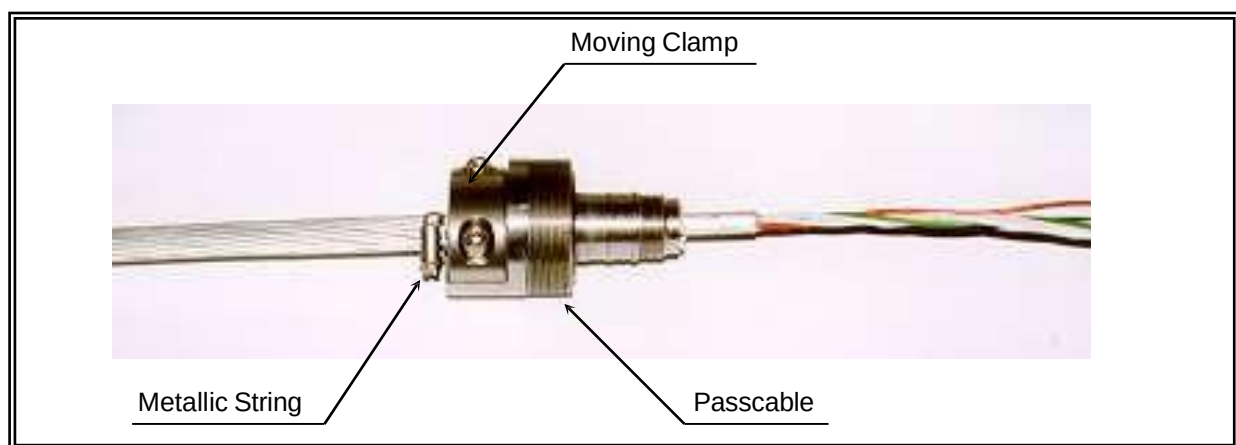


Fig. 5

d) Application of thermo-shrinkable tube

- Cover the Central Tube (AL/Steel) with aluminium sheet and put the thermo-shrinkable tube with heating gun or lamp, like a Figure 6.

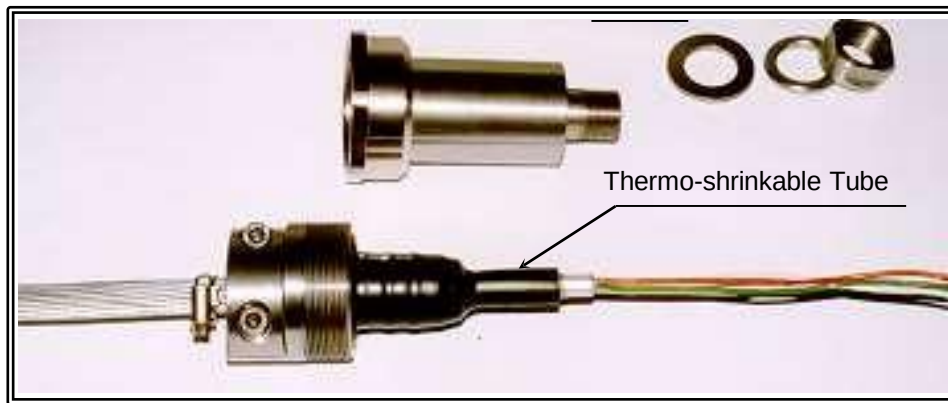


Fig. 6

e) Application of the preroom

- Lock the passcable to the preroom.
- Screw down the preroom to the passcable.

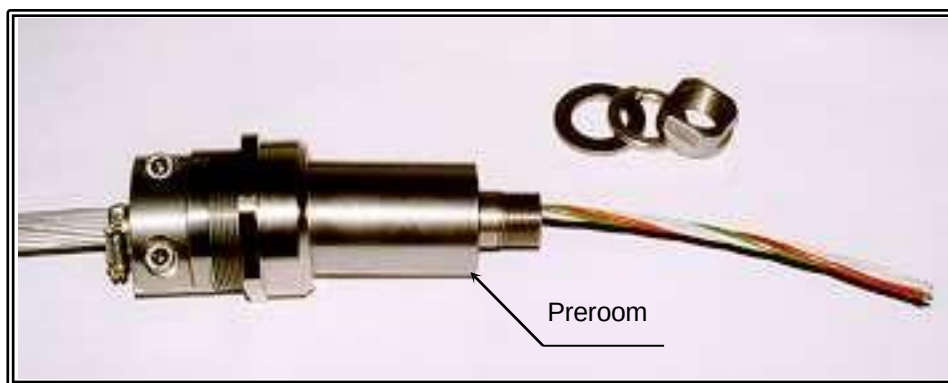


Fig. 7

f) Fixing of the preroom

- Put the preroom in the hole of the splice enclosure base.
- Give attention that the O-ring is in the right position and fix with the torque force of 50 NM

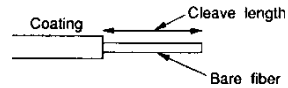
g) Taking out of optical units

- Remove the PBT tube of optical units leaving a suitable distance (around 1m) from the edge of the AL tube.
- Make each optical unit into loops of about 5 to 10 cm diameter, and stick these optical unit loops at a suitable position on the joint box with plastic adhesive tape in order to ensure that the optical unit is not damaged during splicing work.

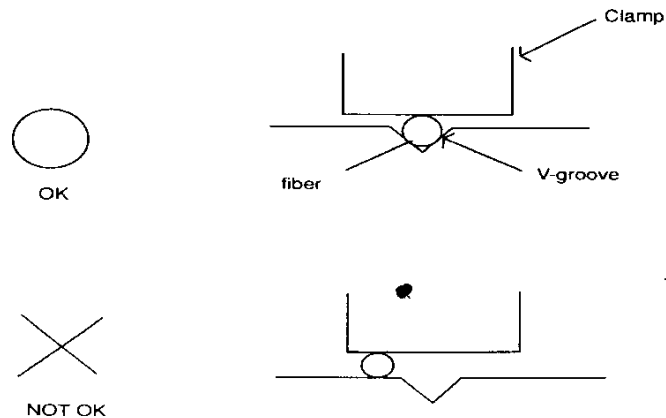
h) Splicing of optical fibers.

- Cleave length

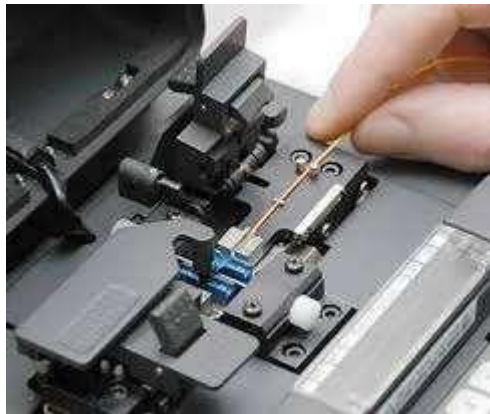
Bare fiber length should be $16\text{mm} \pm 5$ after cleaving.



- Remove the fiber coating. Clean the fiber and then cleave the bare fiber to the predetermined length. Slip a protection sleeve over one of the two fibers for reinforcement after splicing. Set the prepared fiber in the v grooves as shown in the figure below.



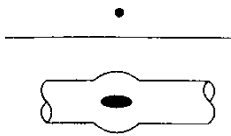
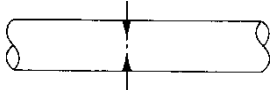
- Clamp the prepared fiber exactly by pushing the clamp lever. After clamping the right and left fibers, close the hood. Make sure that the prepared fiber is not trapped by the hood, and not caught by any other part of the machine.



- Evaluate the splice.

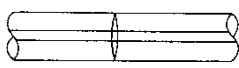
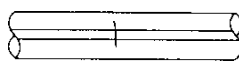
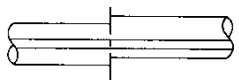
The evaluation of the splicing should be done by the splicing loss and the external appearance at the splice point.

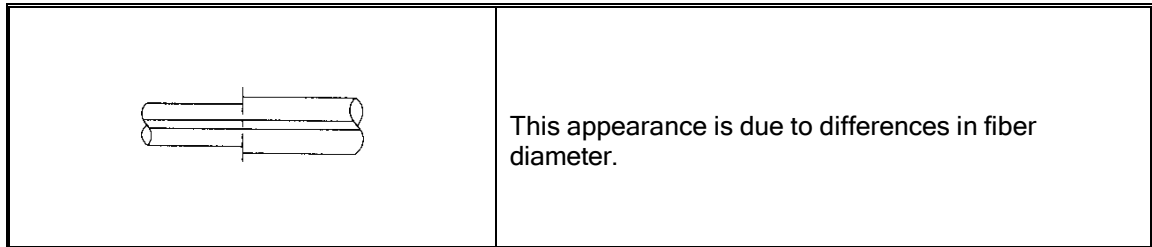
- (1) Splicing having the following appearance shall be rejected.

Bubble 	Be sure to remove this type of splice, because the splice loss can be extremely high. Caused by 1. Dust on fiber end 2. Condensing 3. Bad cleaving 4. Pre-fusion time is too short. 5. Arc power is too strong.
Thick black line 	In this case, make re-fusion by ARC Switch, and check it again.(*)
Black shadow 	

(*) In the case where fluorine doped fiber is splicer, a black line will always appear at the splicing point, but does not cause any damage to the characteristics of the optical transmission.

- (2) The following splices are acceptable, even if the external appearance at the splice point does not look good.

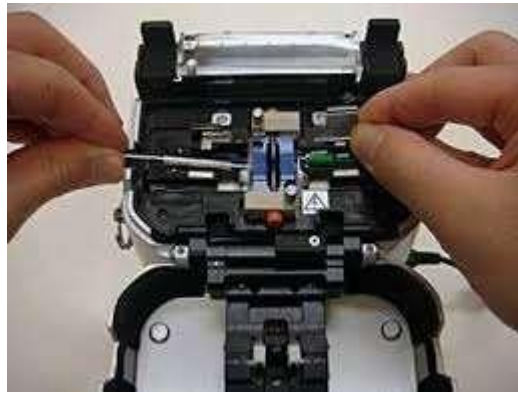
White line 	It is all right if the estimated splice loss is within the specified value. This is due to optical causes upon observation, and there is no effect on the splice characteristics.
Blurred thin line 	Same as above
	Because of core alignment, this is possible for fiber with large core eccentricity.



When the spliced portion is required to be observed in detail, “FIELD CHANGE” and “FOCUS UP” and “FOCUS DOWN” SW on top mounted console panel are useful.

i) Reinforcing of spliced parts.

- (I) Open the heater cover, the left fiber clamp and right fiber clamp
- (II) Open the hood, take out the spliced portion, close the hood, and press the “RESET” SW.



- (III) Slide fiber protection sleeve over the spliced portion.

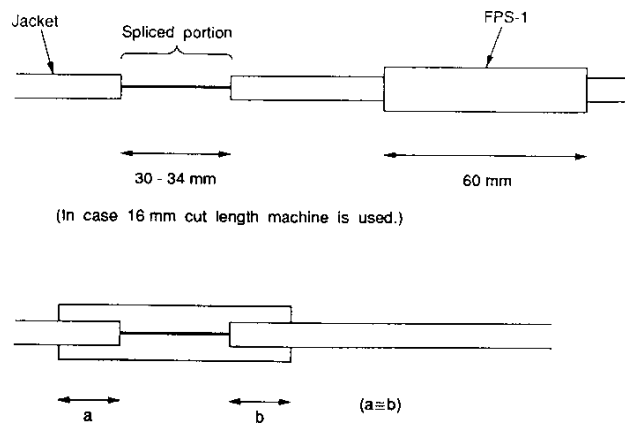


Fig. 5

Note

- Make sure fiber coating is clean.
- Put the sleeve over the splice as shown in Fig. 5.
- Don't twist the fiber.

- Protection sleeve should be straight.
- (IV) Apply a slight tension and place the splice in the heater, close the right hand heater clamp by pressing down with the right hand fiber.
- (V) Next, close the left hand heater clamp while pulling the fiber slightly, and close the heater cover.

Note

- Fiber should be straight.
 - Make sure that there is no dust, or jelly in the protection sleeve.
- (VI) Press the “HEATER SET” SW, and the “working” indicator will light up.



Fig. 5

- (VII) After the tensile proof test (a few seconds), it will take a few minutes until the fiber protection sleeve is shrunk. A buzzer will indicate the finishing of shrinking the sleeve.
- If the fiber breaks, or the fiber is loosely clamped or slips during the tensile proof test, the buzzer will beep intermittently. Correct the condition before proceeding.

Note 1

- Both the splicer and heater can be operated simultaneously.

Note 2

- The tensile proof strength can be set from 50 to 500 grams. This value is set to 200 grams normally.

- (VIII) Open the heater cover and clamps.

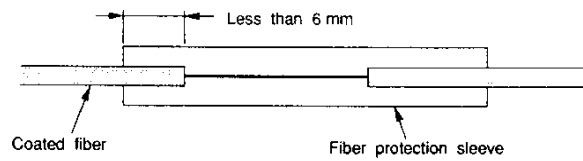
Take out the protected splice carefully while pulling the fiber slightly.

Cool the protection sleeve for a few minutes, as it is very hot just after reinforcement.

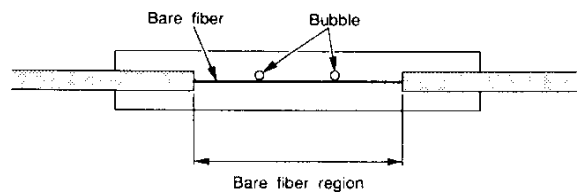
- (IX) Check the appearance of the reinforced portion.

Bad protection examples

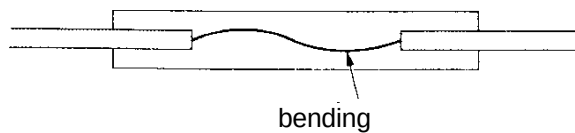
- Short coverage of coated fiber.



- Bubble on bare fiber.

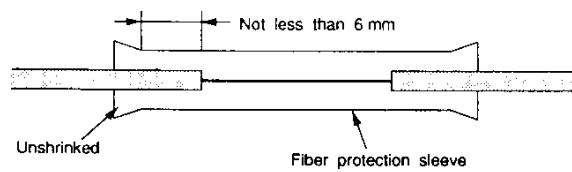


- Bending bare fiber

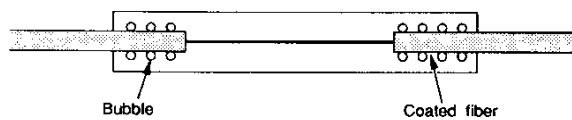


Good protection examples

- Unshrink sleeve end



- Bubble on coated fiber



5. Treatment of surplus length optical fibers.

- Arrangement of loose tube

The loose tube should be dressed up while closing joint box so that it is protected against impact, corrosion and bend. The loop diameter of loose tube is more than 50mm.

- Arrangement of optical fiber

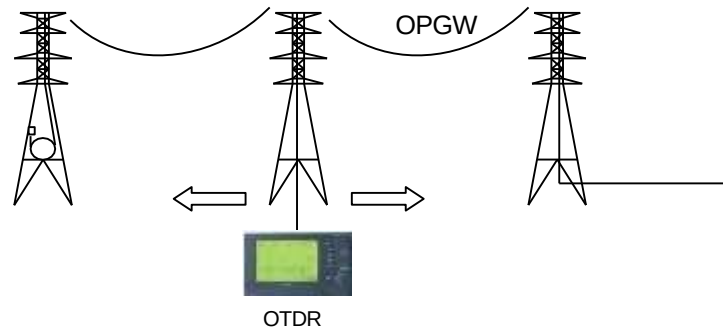
The spliced portion of optical fiber should be put in regular order in the fusion splice protector, and the extra length of optical fiber should be put on the splice tray.

The loop diameter of optical fiber is more than 50mm.

6. Measurement of splice loss: Splice loss shall be measured by using OTDR.

A. Test (Before splicing)

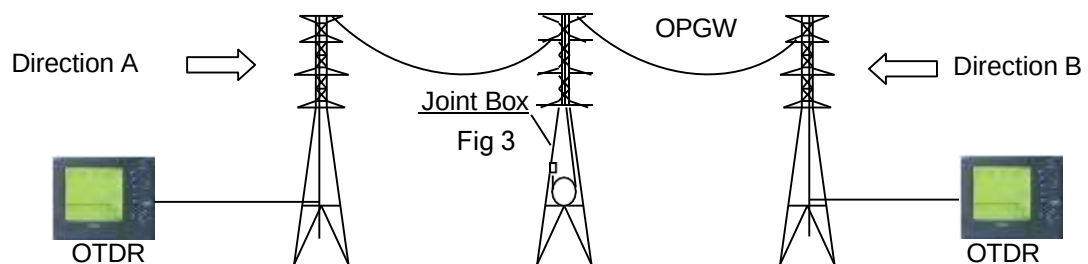
- After successfully completion of the installation, check for optical attenuation and discontinuity at every splicing points (Joint Box Locations).



- The attenuation of the fibres shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.1dB. The overall optical fibres attenuation should be less than 0.21dB/km at 1550nm and 0.35dB/km at 1310nm.

B. Splicing Test (After splicing)

- Before closing the splice enclosure, splice loss shall be measured for checking the splicing condition.



- Before closing the in-line splice enclosure, the splice test shall be executed at both sides (direction A & direction B) of jointing point.
- The average of bi-directional attenuation of fusion splices shall not be more than 0.05 dB and no single splice loss shall exceed 0.1 dB at 1550 nm.
- Appearance of splice enclosure shall have no defect,
- Splice enclosure shall have good sealing condition to prevent moisture and dust free environment, and render it waterproof.

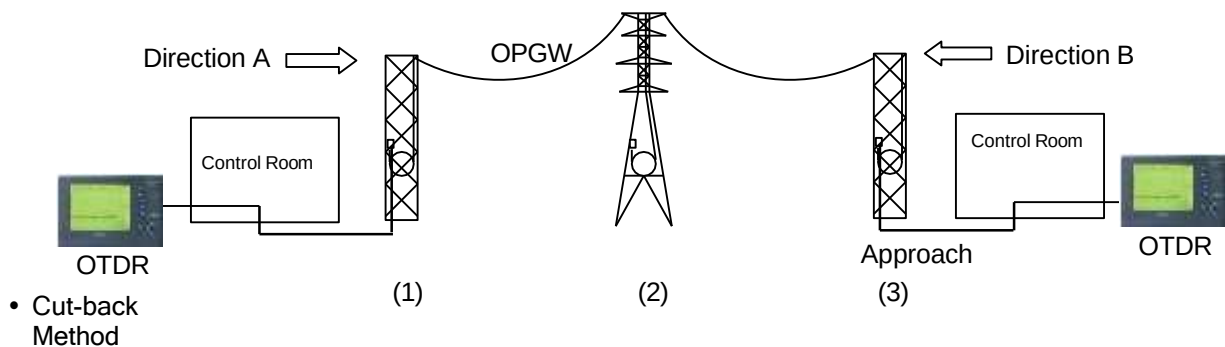
*No point discontinuities in excess of 0.1dB

- Every effort shall be taken to minimize the splice loss during splicing so that every splice loss in the link shall lie within 0.05 dB. Maximum splice loss at any splice joint may be permitted up to 0.1 dB.

However, such events shall be avoided to minimize the splice loss and total loss in the link.

C. Measurement of splicing loss.

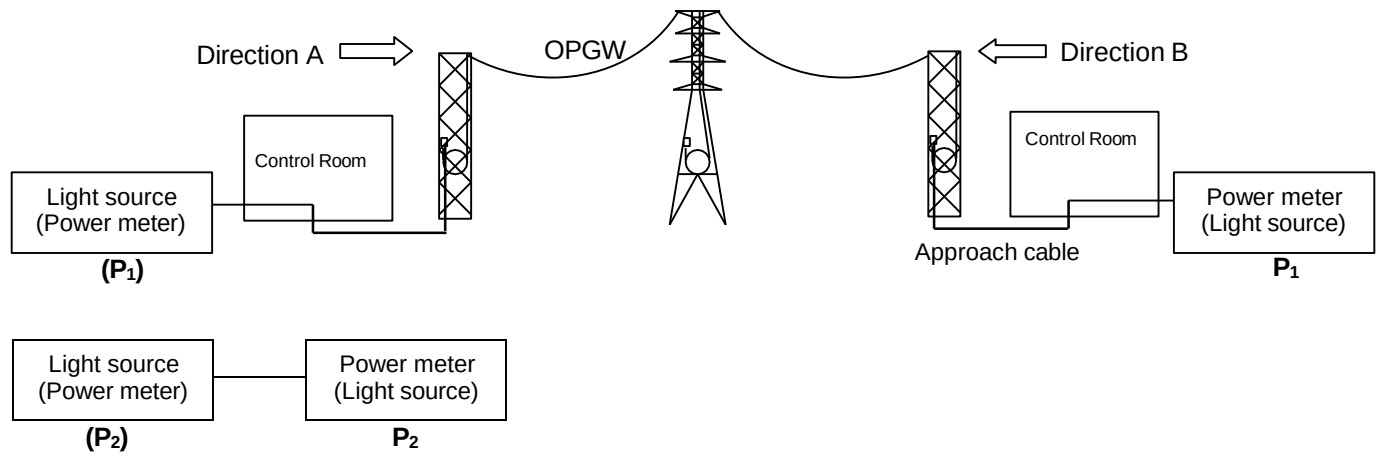
Measure the of splice loss by OTDR



$$\text{Transmission Loss (dB)} = P_2 - P_1$$

P_1 : Power measured when light source is connected to power meter with the OPGW fibre in between.

P_2 : Power measured when light source and power meter are connected to one another with reference fibre in between.



7. Fixing the joint box lid

- Fix the cover to the joint box after having confirmed that nothing is left in the joint box such as tools and dusts.
- Lock the lid with the torque force of 10 NM.

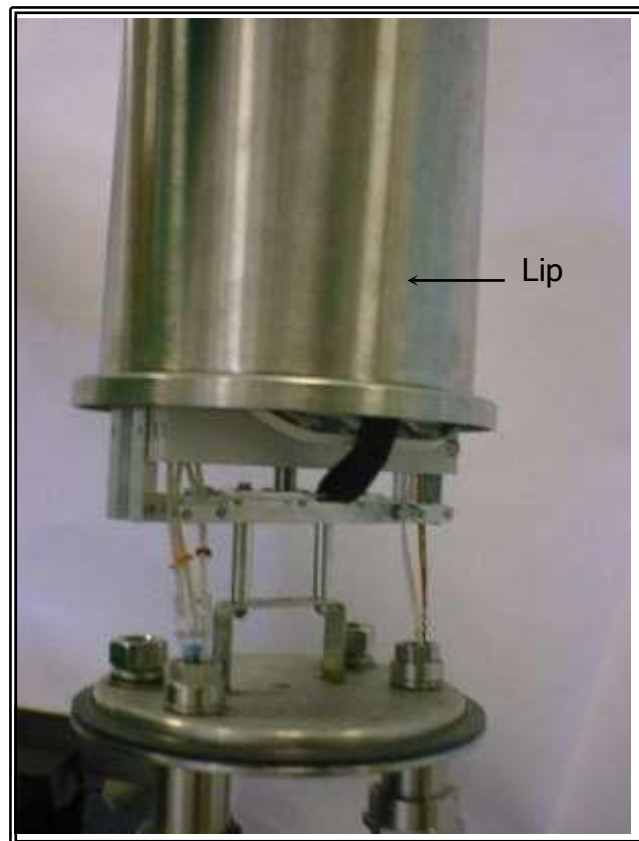
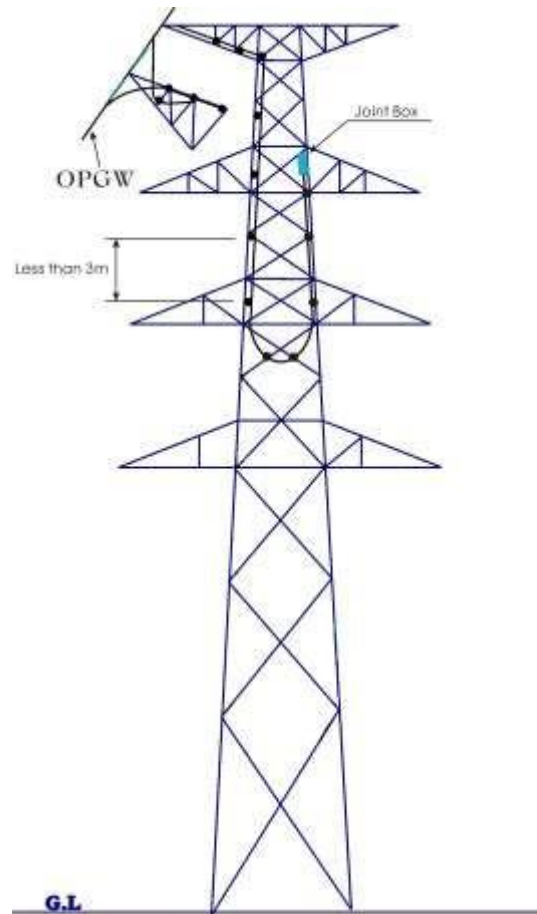


Fig. 6

8. Installation of a joint box.

SPLICING TOWER

The balanced length of OPGW should be coiled around a circle having a diameter of more than 1.5 meters after completion of jointing and firmly fixed to the tower as shown in figure.



The position of the joint box should be near the top cross-arm of the tower as shown in the figure.

Check Point

- Check the status of water proof.
- Fusion splice working is protection it against dirt, grit and moisture.
- Lift the joint box using the eye bolt of lid.
- Fixing condition of joint box on the tower.
- Coiling condition of sur-plus(balanced) length of OPGW

Type Test procedures on optical fibre are listed in the below table:

No	Item	Acceptance Criteria	Test procedure	Test result (pass/fail)
1	Attenuation	Max.: $\leq 0.35\text{dB/km}$ at 1310nm	IEC 60793-1-40 EIA/TIA 455-78A	
		Max.: $\leq 0.21\text{dB/km}$ at 1550nm		
2	Attenuation Variation with Wavelength	0.05dB/km (1525nm to 1575nm) 0.05dB/km (1285nm to 1330nm)	IEC 60793-1-40 EIA/TIA 455-78A	
3	Attenuation at water peak	Max.: $\leq 0.35\text{dB/km}$ at 1383nm	IEC 60793-1-40 EIA/TIA 455-78A	
4	Temperature Cycling (Temperature Dependence of Attenuation)	$\leq 0.05\text{ dB}$ (-60°C to $+85^\circ\text{C}$), 2 Cycles	IEC 60793-1-52 EIA/TIA 455-3A	
5	Attenuation with Bending (Bend Performance) a) 75mm dia $\pm$ 2mm., 100 turns @ 1310nm b) 60mm dia $\pm$ 2mm., 100 turns @ 1550nm c) 32mm dia $\pm$ 2mm., 1turn @ 1550	$\leq 0.05\text{dB}$ $\leq 0.05\text{dB}$ $\leq 0.5\text{dB}$	IEC 60793-1-47 EIA/TIA 455-62A	
6	Point Discontinuities of Attenuation	$\leq 0.1\text{dB}$	IEC 60793-1-40 EIA/TIA 455-59	
7	Mode Field Diameter	$9.2 \pm 0.4\mu\text{m}$ at 1310nm	IEC 60793-1-45 EIA/TIA 455-164A/167A/174A	
8	Core-Clad Concentricity Error	$\leq 0.5\mu\text{m}$	IEC 60793-1-20 EIA/TIA 455-176	
9	Cladding Diameter	$125 \pm 1.0\mu\text{m}$	IEC 60793-1-20 EIA/TIA 455-176	
10	Chromatic Dispersion	$\leq 3.5\text{ ps}/(\text{nm}\cdot\text{km})$ from 1280nm to 1339nm	IEC60793-1-42 EIA/TIA 455 168A/169A/175A	
		$\leq 5.3\text{ ps}/(\text{nm}\cdot\text{km})$ from 1271nm to 1360nm		
		$\leq 18\text{ ps}/(\text{nm}\cdot\text{km})$ at 1550nm		
	Zero Dispersion wavelength Zero Dispersion slope:	1312 nm $\pm$ 12nm $\leq 0.092\text{ ps}/\text{nm}^2\cdot\text{km}$		

11	Fiber Tensile Proof Testing	≥ 0.69 Gpa	IEC 60793-1-31 EIA/TIA 455-31B	
-End of Table-				

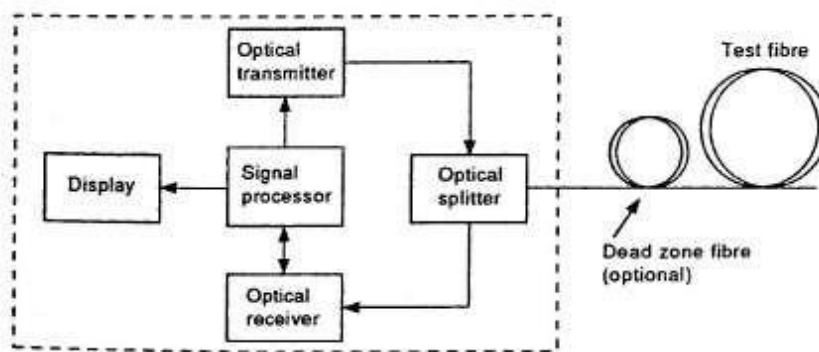
TYPE TEST PROCEDURE FOR OPTICAL FIBER

Attenuation

Test Name : Attenuation.
Final Custome PGCIL/NHIDCL
Project Name : NHIDCL Silchar - Variantge Pkg 1.
Optical fiber Manufacturer:
Fibre Type :
Standard : IEC 60793-1- 40, EIA/TIA 455-78A.

Test Set-up

An optical time-domain reflectometer (OTDR) is prepared and used for Transmission performance testing, which consists of the following minimum list of components and block diagram is show below.



Test Procedure

Used an OTDR for indirect measurement of attenuation or fiber attenuation coefficient of the optical fiber by performing this measurement at multiple wave lengths; connected the specimen either to the instrument or to one end of the dead-zone fiber. Connected the other end of the dead-zone fiber to the instrument. The attenuation coefficient and accurate distance were recorded with the effective group-delay index of the specimen determined in advance.

Acceptance Criteria

- A) Any permanent increases in optical attenuation greater than 0.35 dB/km at nominally 1310nm shall constitute failure.
- B) Any permanent increases in optical attenuation greater than 0.21 dB/km at nominally 1550nm shall constitute failure.

Conclusion

The fiber meets the acceptance criteria of fiber attenuation test.

Tested by:

Witnessed by:

(Sign with date)

(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER

Attenuation Variation with wave length Test

Test Name : Attenuation Variation with wave length
Test : Final Customer :
Power Grid Corporation of India Limited Project Name/ NHIDCL :
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1-40,EIA/TIA 455-78A.

Test Set-up

The cut-back technique is the only method directly derived from the definition of fibre attenuation, in which the power levels, $P_1(\lambda)$ and $P_2(\lambda)$, are measured at two points of the fibre without change of input conditions. $P_2(\lambda)$ is the power emerging from the end of the fibre, and $P_1(\lambda)$ is the power emerging from a point nears the input after cutting the fibre.

Test Procedure

First cleared the optical fiber and cut the end of the optical fiber smoothly, then put the processed optical fiber to V notch. It must be ensured that processed optical fiber connect the end of preset pigtail.

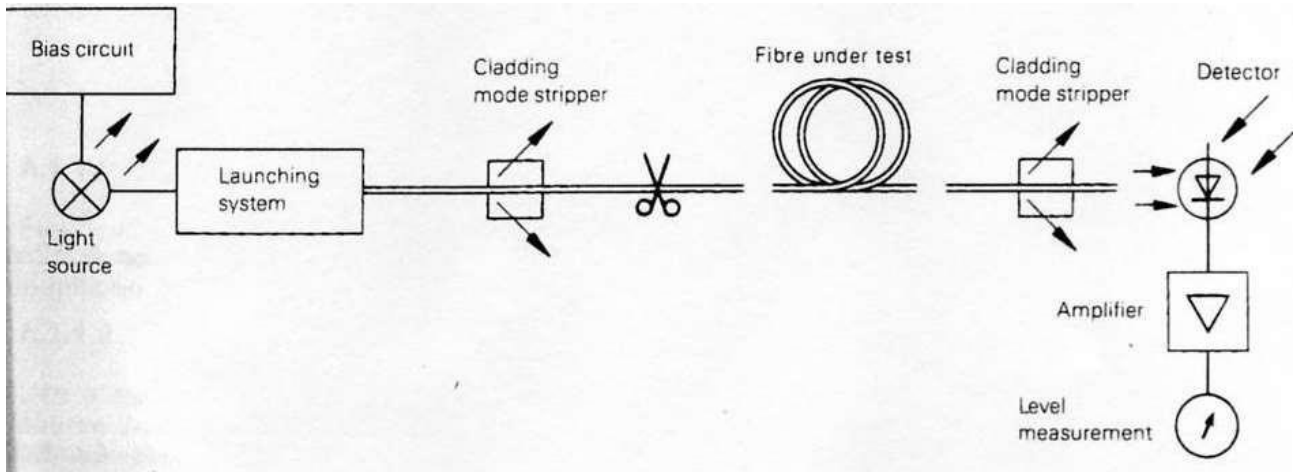
Second choose the attenuation test key and checked the display on computer. The spectrum value should be recorded with different wavelength.

Acceptance Test

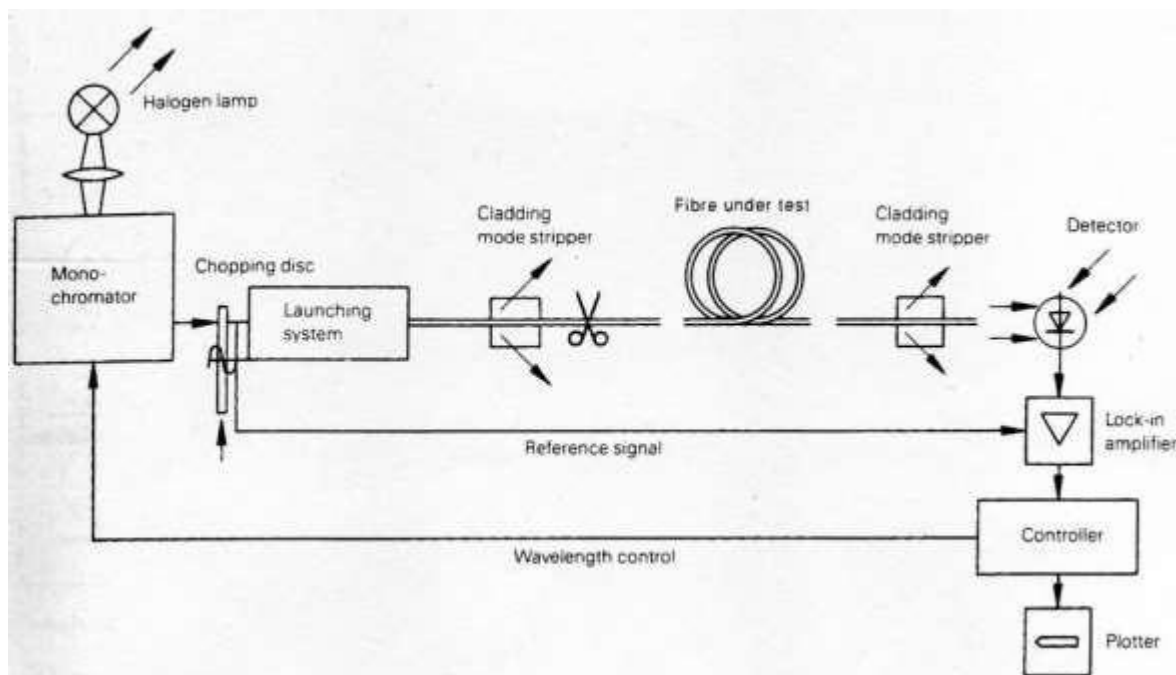
- A) Any permanent increases in optical attenuation greater than 0.05 dB at nominally 1525nm to 1575nm shall constitute failure.
- B) Any permanent increases in optical attenuation greater than 0.05 dB at nominally 1285nm to 1330nm shall constitute failure.

Conclusion

The fiber meets the acceptance criteria of fiber attenuation variation with wavelength test.



A.1- Arrangement of equipment to make loss measurement at one specified wavelength.



A.2- Arrangement of equipment used to obtain loss spectrum

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER
Attenuation at Water Peak

Test Name : Attenuation at Water Peak.
Final Customer : Power Grid Corporation /NHIDCL
Project Name :
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1- 40, EIA/TIA 455-78A.

Test Set-up

Any optical fiber multi-parameter analysis is to be prepared and used for attenuation at water peaking testing

Test Procedure

- A) First cleared the optical fiber and cut the end of the optical fiber smoothly, then put the processed optical fiber to V notch. It must be ensured that processed optical fiber connect the end of preset pigtail.
- B) Second choose the attenuation test key and checked the display on computer. The attenuation value recorded at 1383nm.

Acceptance criteria

- A) Any optical attenuation greater than 0.35dB/km at nominally 1383nm shall constitute failure.

Conclusion

The fiber meets the acceptance criteria of fiber attenuation at water peak test.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBRE Temperature Cycling

Test Name : Temperature cycling .
Final Customer : PGCIL/NHIDCL
Project Name :
Optical fiber Manufacturer:
Fibre Type : 24B1-55(58.7:40.3), 48B1-55 (58.7:40.3)
Standard : IEC 60793-1-52,EIA/TIA 455-3A.

Test Set-up

An optical time-domain reflectometer (OTDR) is prepared and used for Transmission performance testing, which consists of the following minimum list of components and block diagram is show below.

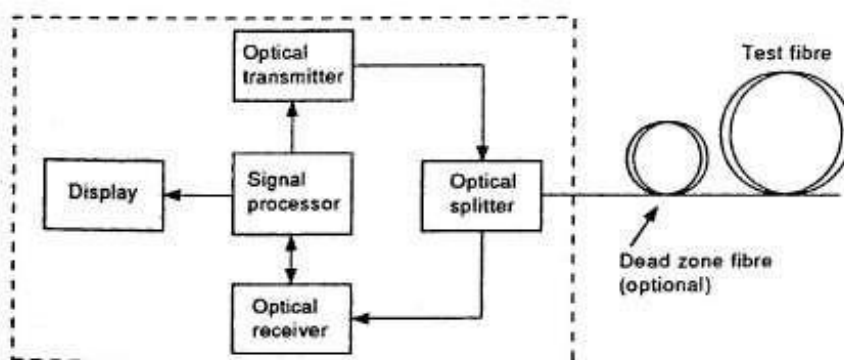


Figure.1 - Block diagram of an OTDR

Test Procedure

Use an OTDR for indirect measurement of attenuation or fiber attenuation coefficient of the optical fiber by performing these measurements at multiple wave lengths; connect the specimen either to the instrument or to one end of the dead-zone fiber. Connect the other end of the dead-zone fiber to the instrument. The attenuation coefficient and accurate distances are recorded with the effective group-delay index of the specimen determined in advance.

For Temperature Cycling (Temperature Dependence of Attenuation) test, the specimen under test i.e. optical fiber of length $\geq 2,000$ meters is placed in a chamber and subjected to changes in temperature for duration & specifications as below and the attenuation is measured using OTDR.

Minimum temperature : -60°C
Maximum temperature : +85°C

Minimum dwell time at each temperature :2hr.

Maximum rate of change of temperature

:1°C/mi

n Number of consecutive cycle :2.

The length of fibre outside the chamber shall not be more than 10% of the total sample lengths.

Acceptance criteria

A) Any optical attenuation greater than 0.05dB at nominally 1310nm shall constitute failure.

B) Any optical attenuation greater than 0.05dB at nominally 1550nm shall constitute failure.

Conclusion

The fiber meets the acceptance criteria of fiber temperature cycling test.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER
Attenuation with Bending (Bend Performance)

Test Name : Attenuation with Bending (Bend
Performance). Final Customer : PGCIL/NHIDCL
Project Name :
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1-47, EIA/TIA 455-62A.

Test Setup

Mandrel each with a diameter of 75mm, 60mm & 32mm for single-mode fibers and a loss measurement instrument is prepared. Determine the macro bending loss at 1550nm & 1310nm with optical power meter.

Test Procedure

Loosely wind the fiber on the mandrel, avoiding excessive fiber twist for 100 turns with mandrel diameter 60mm & 75mm and 1 turn with mandrel diameter 32mm to test at wavelength 1550nm & 1310nm for the fiber. In order to determine the induced attenuation due to macro bending, the value is corrected for the intrinsic attenuation of the fiber. The fiber length outside the mandrel and the reference cut-back length are free of bend. The optical power meter are monitored for test.

Acceptance criteria

- A) Any permanent increase optical attenuation greater than 0.05dB at nominally 1310nm for 75mm $\pm$ 2mm dia. 100 turns shall constitute failure.
- B) Any permanent increase optical attenuation greater than 0.05dB at nominally 1550nm for 60mm $\pm$ 2mm dia. 100 turns shall constitute failure.
- C) Any permanent increase optical attenuation greater than 0.5dB at nominally 1550nm for 32mm $\pm$ 0.5mm dia. 1 turn shall constitute failure.

Conclusion

The fiber meets the acceptance criteria of fiber attenuation with bending test.

Tested by:
(Sign with date)

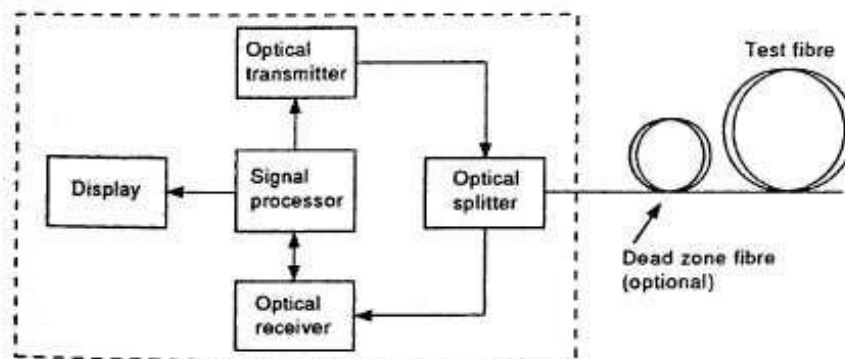
Witnessed by:
(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER Point Discontinuities of Attenuation

Test Name : Point Discontinuities of Attenuation.
Final Customer PGCIL/NHIDCL
Project Name :
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1-40, EIA/TIA 455-59.

Test Set-up

An optical time-domain reflectometer (OTDR) is prepared and used for Transmission performance testing, which consists of the following minimum list of components and block diagram is show below.



Test Procedure

1. Connect the test sample either to the instrument or to one end of end dead-zone fiber (if used). Connect the other end of the dead-zone fiber (if used) to the instrument.
2. If the accurate locations of point defects are to be recorded, the effective group delay index of the test sample is required. If this value is not known, use **FOTP-60** to determine it.
3. Enter OTDR parameters such as source wavelength, pulse duration, length range, and signal averaging into the instrument, along with the test sample effective group index. The values of some of these parameters may be present in the instrument.
4. Adjust the instrument to display a backscatter signal from the test sample. It may be advantageous to begin with coarse vertical and horizontal scaling to maximize the length displayed. An example is given in Figure 1.
5. Examine the OTDR signal along the test sample for point defects. If increased resolution is need, adjust the graphical display, if possible, to expand the section of interest to large scale (exercising care to assure that proper reading of the true signal can still be distinguished from the noise

points); an example is given in

Figure.2.

6. To determine that a point defect (rather than an attenuation non-uniformity situation) exist observe the area in question using two different pulse durations. The shape of the loss or gain changes with the pulse duration, the anomaly is a point defect. If the shape does not change, the anomaly shall be considered to be attenuation non-uniformity to be measured by **FOTP-61**.

7. Report any point defect deviations which exceed the value specified in the detail specification. Describe the nature of these faults (e.g. apparent loss or gain, reflection, duration, etc) as required by the Detail Specification.

7.1. Determine the defect location, if required, by placing a cursor at the beginning (or at another point specified by the OTDR manufacturer) of a power rise or drop, this may be difficult to do at a drop. Obtained the distance coordinate via the alphanumeric display.

7.2. Obtain the apparent loss or gain of the defect, if required, by the method described by the OTDR manufacturer. Some instruments required placement of a pair of cursors on each side of the defect. The two best-fit straight lines (from a two-point or least-squares fit for each) are extrapolated to the defect location. If available, the linear fit method should be chosen. The vertical separations of the lines give the apparent loss or gain. Note any reflection peak.

7.3. When possible, repeat the test for single launched into the test sample in the opposite direction. A more accurate loss estimate (and the elimination of apparent gain) is made by averaging readings taken directionally at the same wavelength. This eliminates the effect of any backscatter different for the fiber sections on both side of the defect.

7.4. If required by the Detail specification, repeat the test at another wavelength.

Acceptance Criteria

A) Any permanent increases in optical attenuation greater than 0.1 dB/km at nominally 1310nm shall constitute failure.

B) Any permanent increases in optical attenuation greater than 0.1 dB/km at nominally 1550nm shall constitute failure.

Conclusion

The fiber met the acceptance criteria of fiber point discontinuities of attenuation test.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

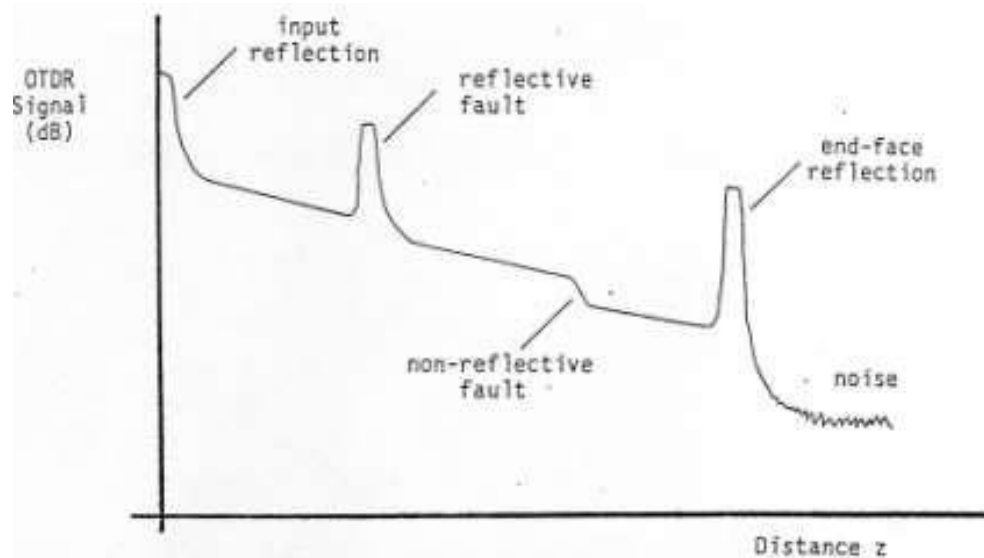


Figure 1. Schematic of an OTDR Trace. Point defects with apparent loss are shown, one reflective and one non-reflective.

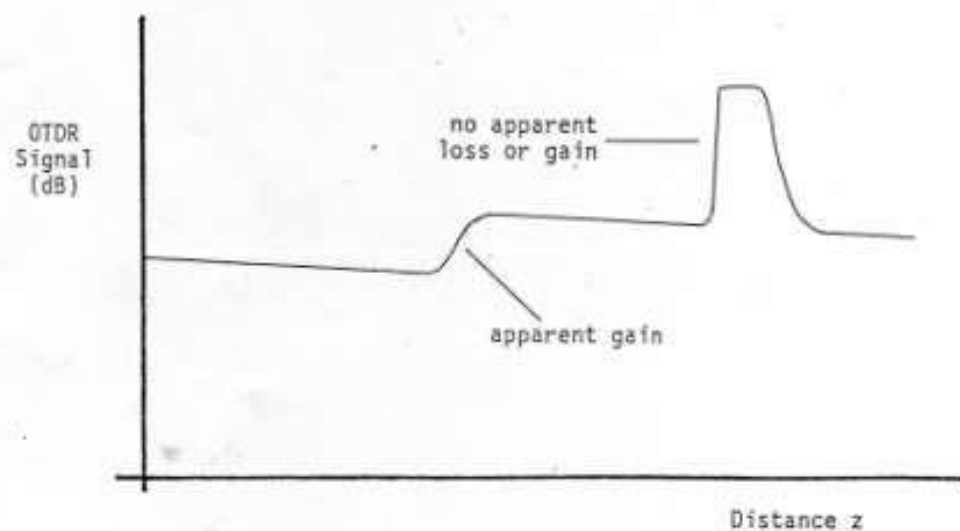


Figure 2. Schematic of an expanded OTDR trace. Two point defects are shown, one with apparent gain, and another with no apparent loss or gain.

TYPE TEST PROCEDURE FOR OPTICAL FIBER

Mode Field Diameter

Test Name : Mode field Diameter.
Final Customer : Power Grid Corporation of India Limited,
India. Project Name :
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1-45, EIA/TIA455-164A/167A/174A.

Test Set-up (Geometric Parameters)

An optical fiber multi-parameters analysis system is prepared and used for attenuation at mode field diameter testing.

Test Procedure

First cleared optical fiber and cut the end of optical fiber smoothly, then put the processed optical fiber to V notch. It must be ensured that processed optical fiber connect the end of preset pigtail.

Second choose the attenuation test key and checked the display on computer. The mode field diameter was recorded.

Acceptance Criteria

The mode field diameter greater than $9.2 \pm 0.4 \mu\text{m}$ at nominally 1310nm shall constitute failure.

Conclusion

The fiber met the acceptance criteria of fiber mode field diameter test.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER
Core-Clad Concentricity Error

Test Name : Core-clad Concentricity Error.
Final Customer : Power Grid Corporation of India Limited,
India. Project Name :
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1- 20, EIA/TIA 455-176.

Test Set-up

Suitable incoherent light sources was used for the illumination of the core and the cladding. Adjustable in intensity and stable in intensity over a time period sufficient to perform the measurement.

For the grey-scale method a CCD video camera was used to detect the magnified output near-field Image and transmit it to a video monitor. The video digitizer performance the digitization of the image for further computer analysis. This video system was sufficiently linear such that, after calibration, the measurement uncertainty was not greater than required.

For single near-field scan method a means was provided to scan the focused image of the fiber near-field pattern which provides knowledge of the distance scanned. An example was a single detector (such as a PIN-hole) placed on a stepper-motor driven translator with position feedback device, or a video array detector of known element size and spacing. The detector was linear over the range of intensities encountered.

Test Procedure

First cleaved optical fiber and cut the end of optical fiber smoothly, then put the processed optical fiber to V notch. It must be ensured that processed optical fiber connect the end of preset pigtail.

Second choose the attenuation test key and checked the display on computer. The mode field diameter was recorded.

Acceptance Criteria

The core-clad concentricity error greater than $0.5\mu\text{m}$ shall constitute failure.

Conclusion

The fiber meet the acceptance criteria of fiber core-clad concentricity error test.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

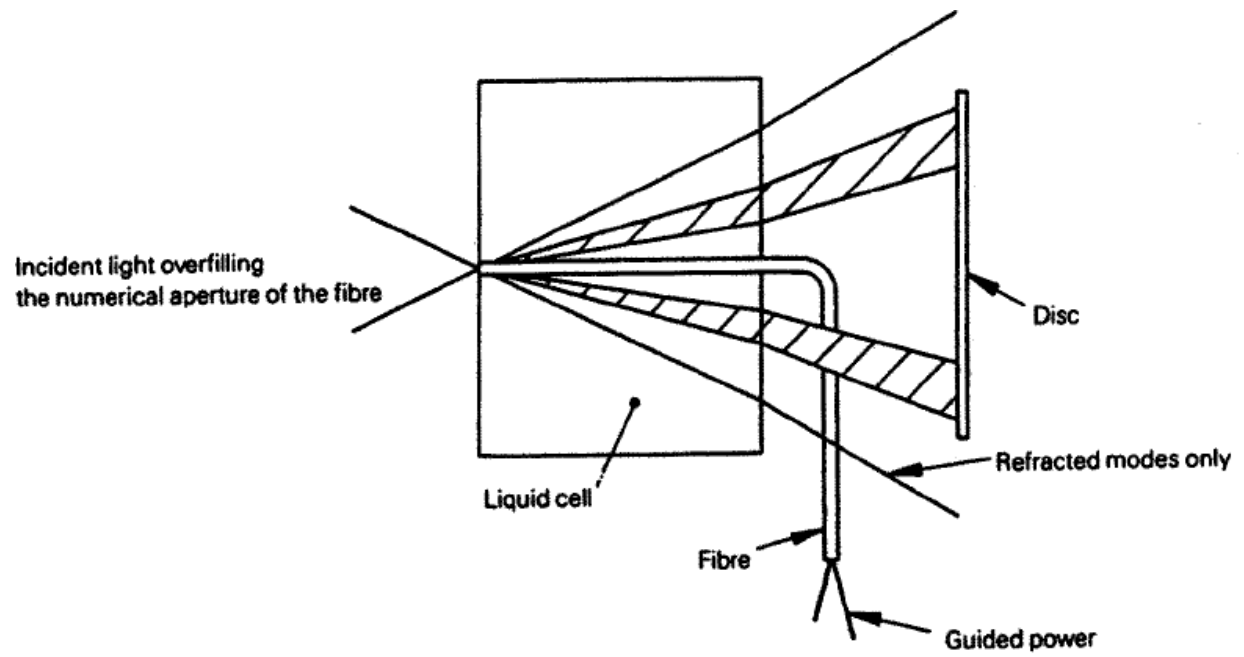
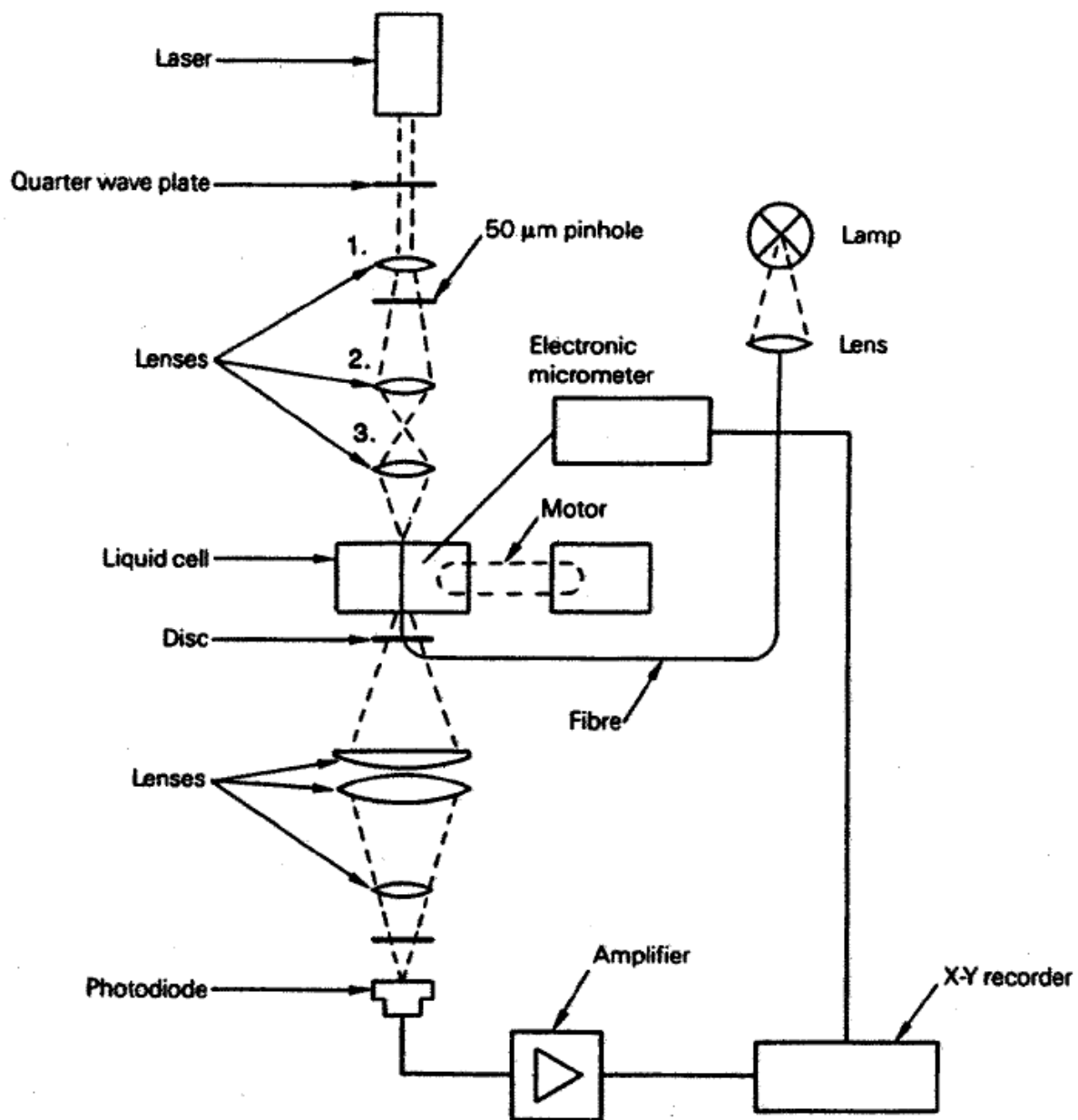


Figure2: Refracted near-field method-Schematic diagram



IEC 574/01

Figure3: Typical arrangement of the refracted near-field test set

TYPE TEST PROCEDURE FOR OPTICAL FIBER

Cladding Diameter

Test Name : Cladding Diameter.
Final Customer : Power Grid Corporation of India Limited,
India. Project Name :
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1-20, EIA/TIA 455-176.

Test Set-up

Suitable incoherent light sources was used for the illumination of the core and the cladding. Adjustable in intensity and stable n intensity over a time period sufficient to perform the measurment.

For the grey-scale method a CCD video camera was used to detect the magnified output near-field Image and transmit it to a video monitor. The video digitizer performance the digitization of the image for the futher computer analysis. This video system was sufficiently linear such that,after calibration,the measurement uncertainty was not great than required.

For single near-field scan method a means was provided to scan the focused image of the fiber near-field pattenen which provides knowledge of the distance scanned. An example was a single detector (such as a oin-hole) placed on a stepper-motor driven translator with position feedback device,or a video array detector of know element size and spacing.The detector was linear over the range of intensities encountered.

Test Procedure

First cleared optical fiber and cut the end of optical fiber smoothly, then put the processed optical fiber to V notch. It must be ensured that processed optical fiber connect the end of preset pigtail.

Second choose the attenuation test key and checked the display on computer. The mode field diameter was recorded.

Acceptance Criteria

The cladding diameter shall be less than 124.0 μ m or greater than 126.0 μ m shall constitute failure.

Conclusion

The fiber meet the acceptance criteria of fiber Cladding diamter test.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

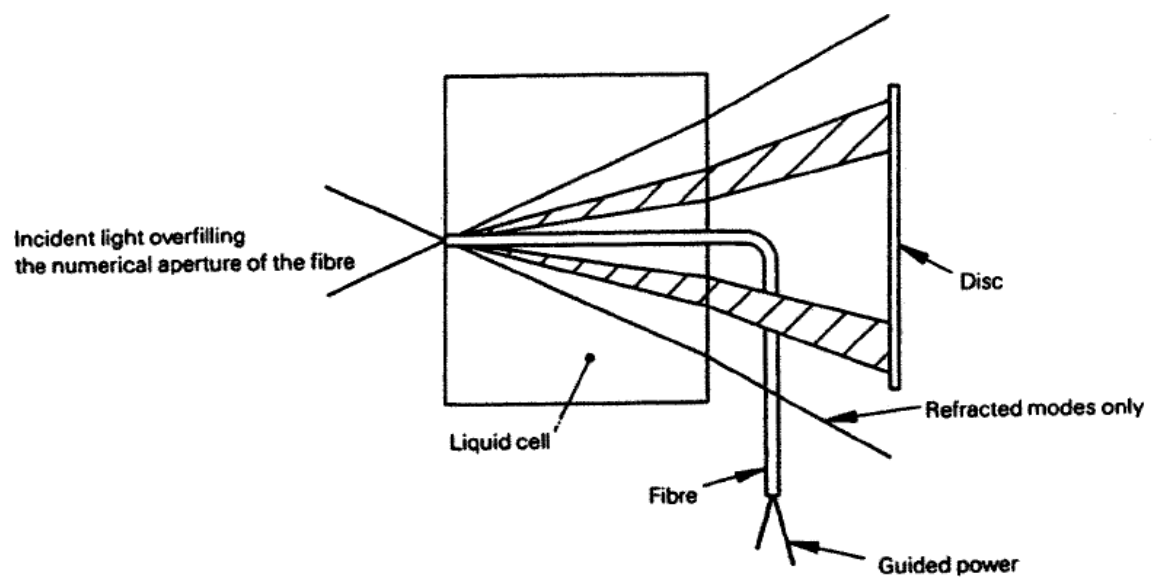


Figure2: Refracted near-field method-Schematic diagram

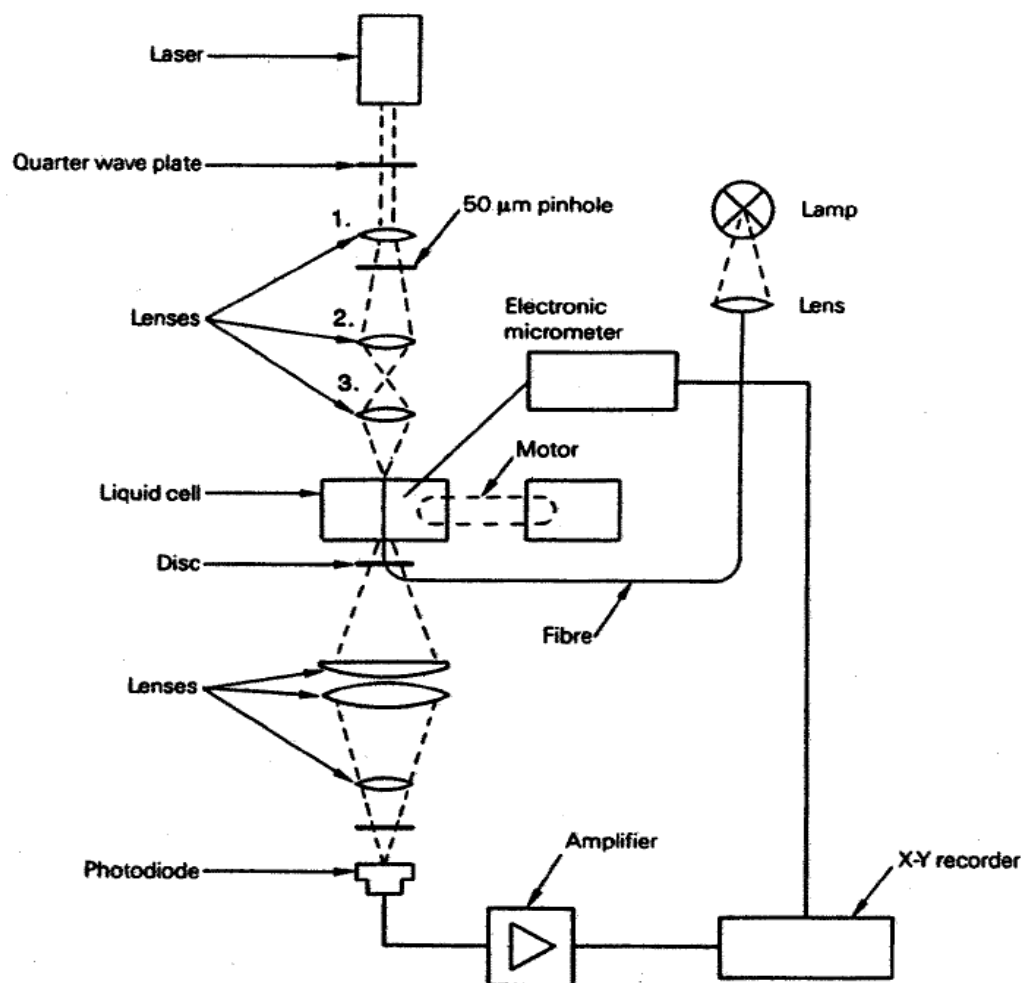


Figure3: Typical arrangement of the refracted near-field test set

TYPE TEST PROCEDURE FOR OPTICAL FIBER Chromatic Dispersion Test

Test Name : Chromatic Dispersion Test.
Final Customer : Power Grid Corporation of India Limited,
India. Project Name :
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1-42, EIA/TIA 455 168A/169A/175A.

Test Set-up (Chromatic Dispersion)

The test sample shall be on fiber or cable as specified in the detail specification, of know length greater than 1 km long to produce adequate phase measurement accuracy. For a 3-wavelength system, the minimum length can be estimated from equation.

A phase calibration fiber of the same fiber class as the test sample shall be used to facilitate input phase measurement or input phase equalization. The length of this fiber shall be less than or equal to 0.2% of the test fiber length.

Test Procedure

The phase calibration fiber shall be connected to the measurement apparatus; a reference signal shall also be established. The phase, for each signal source shall be measured and recorded.

Alternately to above, if the signal sources are phase adjustable, then with the phase calibration fiber in place, the phases of all signal sources shall be equalized. Test sample measurements shall then be performed as describe in below.

The test fiber shall be connected to the measurement apparatus; a reference signal shall be also be established.

Acceptance Criteria:

- a) The Chromatic dispersion greater than 3.5 ps/(nm.km) at nominally 1280nm to 1339nm shall constitute failure.
- b) The Chromatic dispersion greater than 5.3 ps/(nm.km) at nominally 1271nm to 1360nm shall constitute failure.
- c) The Chromatic dispersion greater than 18 ps/(nm.km) at nominally 1550nm shall constitute failure.
- d) The Zero dispersion wavelength less than 1300nm or greater than 1324nm shall constitute failure
- e) The Zero dispersion slope greater than 0.092 ps/nm².km shall constitute failure.

Conclusion:

The fiber meets the acceptance criteria of fiber attenuation with bending test .

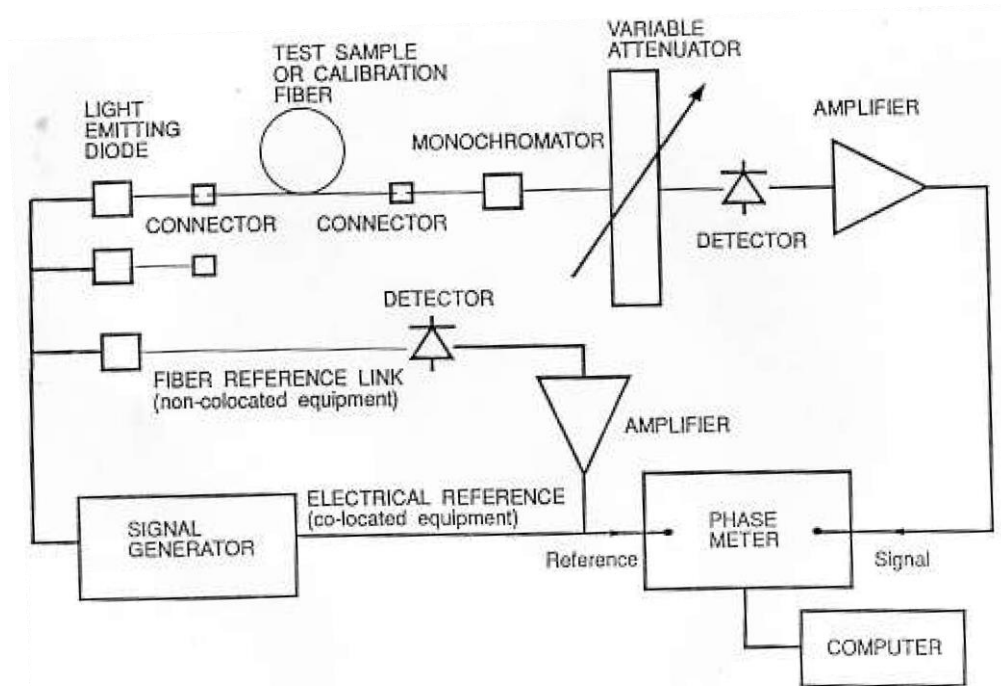


Figure : Chromatic Dispersion Test set-LED System

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER

Fiber Tensile Proof Test

Test Name : Fiber Tensile Proof Test.
Final Customer : Power Grid Corporation of India Limited,
India. Project Name :
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1-31, EIA/TIA 455-31B.

Test Set-up (Fiber Tensile Proof)

To measure fiber proof with the indicated general operating requirements, the braked capstan type machine is used. Care should be used in the design so as to prevent coating damage.

Test Procedure

The test specimen is fed into the machine according to the operating instructions for the machine. Set the tension load on the machine according to the provision in the sub procedure given in the following form. The procedure allows easy detection by the operator of any failure in the fiber, if or when it occurs. The test specimen is run through the proof test machine with 1sec.

The tension value shall be recorded by Newton.

Acceptance Criteria:

- a) Fibre breakage during the test shall constitute failure
- b) The stress σ on the test fiber was 0.69 GPa
- c) The strain ϵ on fibre was greater than 1.0%

Conclusion:

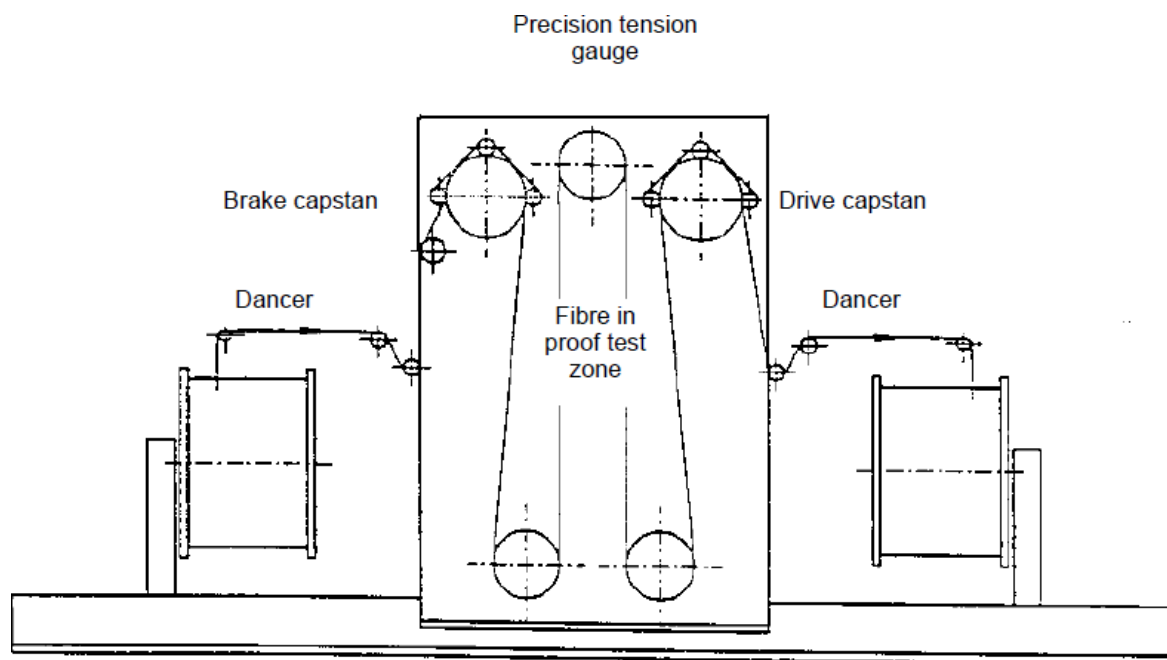
The fiber met the acceptance criteria of fibre tensile proof test.

Tested by:

(Sign with date)

Witnessed by:

(Sign with date)



Fibre pay-off region
Stage 1 : constant pay-off

Proof testing region
Stage 2 : Proof testing with
 master braking capstan and
 precision tension gauge

Fibre take-up region
Stage 3 : Constant
 tension take-up
 spooling

Figure 5 - Braked capstan machine

Type Test Procedure For OPGW Cable

The type test procedures to be conducted on the OPGW cable are as follows:

S.No.	TEST NAME	APPLICABLE STANDARD	TEST RESULT (PASS / FAIL)
1	Water Ingress Test	IEEE 1138-2009 Method 6.4.3.5	
2	Seepage of Filling Compound Test	IEEE 1138-2009 Method 6.4.3.6	
3	Short Circuit Test	IEEE 1138-2009 Method 6.4.3.3	
4	Aeolian Vibration Test	IEEE 1138-2009 Method 6.4.3.1	
5	Galloping Test	IEEE 1138-2009 Method 6.4.3.2	
6	Cable Bend Test	IEEE 1138-2009 Method 6.4.2.3	
7	Sheave Test	IEEE 1138-2009 Method 6.4.2.1	
8	Crush Test	IEEE 1138-2009 Method 6.4.2.2	
9	Twist Test	IEEE 1138-2009 Method 6.4.2.4	
10	Creep Test	IEEE 1138-2009 Method 6.4.1.1	
11	Strain Margin Test	IEEE 1138-2009 Method 6.4.1.3	
12	Stress Strain Test	IEEE 1138-2009 Method 6.4.1.2	
13	Temperature Cycling Test	IEEE 1138-2009 Method 6.4.3.7	
14	Corrosion (Salt Spray Test)	IEEE 1138-2009 Method 6.4.3.8	
15	Ultimate Tensile Strength Test	IEEE 1138-2009 Method 6.4.1.4	
16	Lightning Arc Test	IEEE 1138-2009 Method 6.4.3.4	
17	DC Resistance Test	IEEE 1138-2009 Method 6.4.1.5	

Note: All Hardware fittings to be used during type test shall be as per approved DRS/ drawings applicable for offered OPGW cable to be type tested.

Reference docs:

1. Approved DRS / Drawings of OPGW
2. Approved DRS / Drawings of OPGW fittings
3. Applicable standard. (IEEE 1138-2009)
4. Section -03 - Technical specifications

TYPE TEST PROCEDURE FOR OPGW CABLE

(1) Test Name: Water Ingress Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.3.5

CLASSIFICATION: Operation/environmental/conditional

INTENT

The intent of the Water Ingress Test is to determine if the quantity of fluid blocking compound in the OPGW cable is sufficient and uniformly distributed to inhibit water from migrating through the optical unit. This test is only applicable for those cable designs that utilize a water-blocking compound inside the optical unit. Water ingress into the optical unit can degrade the performance of the optical fibers.

OBJECTIVE

To expose a length of fluid blocked optical unit to a head of water to verify that water does not pass through the unit.

The optical performance of the OPGW cable is not monitored during this test.

SET-UP

Water ingress test for OPGW cable that use water-blocking compound is based on the most recent revision of EIA/TIA-455-82-B, except that the retest length, if used, shall be 1 m rather than 3 m.

A 1 m section of OPGW cable shall be prepared for this test. All components of the cable shall be removed from the fluid-blocked optical unit that contains the optical fibers.

The fluid-blocked optical unit shall be positioned horizontally with one end attached to the bottom of a suitable tube containing a column of water that is at least 1 m in height using a watertight fitting. A clear, plastic tube is commonly used for this purpose. No part of the fluid-blocked component shall be above horizontal. The fitting shall not restrict water from entering the optical unit. A collection dish, or equivalent means of detecting water, shall be placed under the open end of the optical unit to collect any water that may pass through it.

Optical measurements are not required for this test.

The optical unit and collection dish shall be visually checked for water. The start and completion times shall be recorded. No electronic measurements are required for this test.

PROCEDURE

The reservoir, or tube, shall be filled with water such that the head above the optical unit is least 1.0 m. The water shall be maintained at this level for at least 1 h. During, and at the conclusion of, the 1 h period, the open end of the optical unit shall be visually checked for water.

Acceptance criteria

No water shall leak through the open end of the 1 m sample. If the first sample fails, one additional 1 m sample, taken from a section of OPGW cable immediately adjacent to the first sample, may be tested for acceptance.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Water Ingress test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(2) Test Name: Seepage of Filling Compound Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer)

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.3.6

Classification : In-service/environmental/conditional

Intent

The intent of the Seepage of Flooding Compound Test is to determine if the fluid-blocking compound in the OPGW cable is vulnerable to flowing at elevated temperatures. This test is only applicable for those cable designs that utilize a fluid-blocking compound. The negative impact of the flooding compound seeping is that the compound could accumulate inside the splice box.

Objective

- a) To subject the OPGW cable to an elevated temperature that may cause the fluid-blocking compound to drip or otherwise leak from the optical fiber unit.
- b) The optical performance of the OPGW cable is not monitored during this test.

Set-up

The test shall be performed in accordance with TIA/EIA-455-81-B, except that an optional preconditioning cycle as described in 5.1.1.2.1 in IEEE Std 1138-1994 [B39] may be used. Five OPGW cable samples, each $30.0 \text{ cm} \pm 0.5 \text{ cm}$ in total length shall be prepared. All metallic strands are cut back $13.0 \text{ cm} \pm 0.25 \text{ cm}$ from one end to expose the fluid-blocked optical unit(s). The sample ends shall not be blocked or sealed. The samples are suspended vertically from a support frame. Small, lightweight collection dishes are placed directly under each sample to collect any fluid- blocking compound that may drip from the optical unit. The samples shall be shielded from any air circulation in the chamber. The temperature in the chamber shall be measured using a thermocouple placed near the support frame close to the samples.

Optical measurements are not required for this test.

Procedure

The temperature chamber shall be preheated to at least $65 \text{ }^{\circ}\text{C}$.

The five collection dishes shall be weighed and recorded using a scale having an accuracy of at least $\pm 0.001 \text{ g}$. The support frame, with the covered samples, shall be placed in the chamber. After a 1 h preconditioning period, the samples are removed from the chamber and the dishes weighed and recorded. The dishes are placed under the samples and returned to the chamber. After 23 additional

hours (24 h total), the samples are again removed from the chamber and the dishes weighed and recorded. Changes in weight of ± 0.001 g are not considered due to leakage of flooding compound.

Acceptance criteria

The filling and flooding compound shall not flow (drip or leak) at 65 °C.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Seepage of Filling Compound test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(3) Test Name: Short Circuit Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type :

Standard: IEEE 1138-2009 Method 6.4.3.3

Classification : In-service/electrical/mandatory

Intent

The intent of the Short-circuit Test is to subject the OPGW cable to short-circuit conditions that represent field conditions. Damage can be inflicted to the cable strands through birdcaging, loss of tensile strength, or melting or softening of non-metallic components because of excessively high temperatures. The optical signals may also be adversely affected by short-circuit conditions.

NOTE—Due to the potential loss of tensile strength of the cable when temperatures exceed 220 °C, a tensile strength test following the Short-circuit Test is recommended on the test sample to verify it meets the vendor's specification for UTS.

Objective

- a) To verify the mechanical performance of the OPGW cable when subjected to the specified short circuit conditions.
- b) To verify the optical performance of the OPGW cable when subjected to the specified short- circuit conditions.

Set-up

The set-up for the Short-circuit Test is shown in Figure 1.

Apparatus

Two OPGW cable samples shall be used for this test. One sample is used to monitor the performance of the optical fibers and to observe any physical damage that might occur during the test. The second sample is used to measure the temperature at several points in the cross-section of the cable. If placed outdoors, the samples shall be positioned such that effects due to wind, solar radiation, etc., are the same on the samples.

The cables shall be electrically connected in series so that they are subjected to the same short-circuit current. Suitable means, such as low level circulating ac current, shall be used to maintain the temperature of the cables as measured by the temperature sample to the manufacturers specified reference temperature for short-circuit capacity of the cable.

Optical sample

For optical attenuation measurements, the optical cable sample shall be prepared according to Table 4. The length of cable between the current injection points shall be at least 10 m. The optical fibers shall be terminated beyond each dead-end clamp. A suitable means shall be used to tension the cable from 15% to 20% of the UTS of the OPGW cable when the cable is at the manufacturers specified reference temperature. A suitable device such as a dynamometer or load cell shall be used to measure the tension in this sample.

Temperature sample

The temperature in this sample shall be measured at three locations or more. This is normally achieved using fast-responding thermocouples. However, other techniques that provide reliable and accurate data may be used if available. If thermocouples are used, they shall be spaced approximately 1 m apart, at the midpoint of the sample. They shall be installed in the cable to provide the temperature at the following points in the sample:

- a) Located where the maximum temperature rise is expected. Depending on the design of the OPGW cable, this would normally be aluminum component(s) such as the wires, an aluminum tube, or the slotted central core, if applicable.
- b) Located where the second highest temperature rise is expected. This may involve an aluminum component and a steel component or two steel components.
- c) Located inside the optical unit with the intent of measuring the temperature of the optical fibers.

Thermocouples may be “pinched” between two adjacent components. It is recognized that the thermocouple will be influenced by any components making contact with the junction. The thermocouples shall be isolated from other instrumentation to prevent electrical interference. A suitable means (e.g., turnbuckles, hydraulic cylinder) shall be used to tension this cable but it is not necessary to measure the tension.

Instrumentation and data acquisition

For each short-circuit application, or “pulse,” a suitable data acquisition system shall record the short circuit current, the optical power readings from the optical sample and the thermocouple readings from the temperature sample.

The aluminum, steel, and non-metallic components of the cable will reach their respective maximum temperatures at different times. Typically, the optical unit will take the longest time. For this reason, the data shall be acquired for sufficient time after each pulse in order to record the maximum temperatures of all components. The temperatures in the metallic components may reach their respective maximums in less than 1 s. For this reason, the data sampling rate shall be fast enough to capture these maximums.

Procedure

The cables shall be heated to the manufacturers specified reference temperature as indicated by the highest reading thermocouple in the temperature sample. All thermocouples shall be maintained at a constant temperature. The optical signals shall be stable for at least 15 min before proceeding.

If required, “preliminary” pulses, not to exceed about 50% of the supplier’s specified short current value, may be applied in order for the test lab to establish the proper electrical parameters. Preliminary pulses are not considered part of the “official” test. If necessary, the optical signals shall be allowed to stabilize after the preliminary pulses before proceeding with the official test. Once stable, the difference between the power meters shall be zeroed 5 min before the first official pulse and shall be considered the start of the official test.

The cable shall then be subjected to five official pulses. For the official pulses, the minimum and maximum values for the electrical parameters are shown in Table 1:

Table 1 —Electrical parameters

Parameter	Target value
Fault I ² t	As per approved DRS of OPGW
Fault duration	Same as primary protection breaker operation, if known. Otherwise, maximum 0.5sec (50 Hz)

The cable shall be allowed to cool to the specified reference temperature after each pulse as measured by the highest reading thermocouple. The cable will be held at the reference temperature for at least 5 min between pulses.

For each pulse, the fault current and duration may vary slightly from the target values. The objective is to achieve the I²t level for each pulse. To recognize the practical issues of performing this test, the following allowances are made. The average of the five pulses shall exceed the minimum I²t level specified by the supplier. However, no single pulse shall be less than 95% of the minimum I²t level.

The optical sample shall be visually inspected for bird caging or other damage periodically throughout the test. Because the cable components can be disturbed when the thermocouples are installed, observations made on the temperature sample are not considered official.

After the final pulse, the optical and temperature data shall continue to be acquired for at least 15 min after the thermocouple with the highest reading has returned to the reference temperature. Final optical and temperature readings and observations of the cable shall be taken at this time. This designates the official end of the short-circuit test.

The optical cable sample shall be dissected after the test. Attention shall be paid in particular to the sections of cable closest to the terminating hardware, and at the midpoint of the span. Each separable

component of the cable shall be separated and inspected for excessive wear, discoloration, deformation, or other signs of breakdown.

Acceptance criteria

- a) Any cracking or breaking of any component of the optical sample shall constitute failure. This assessment is made with the naked eye.
- b) There shall be no bird-caging of any of the strands of the optical sample. Bird-caging is defined as one or more cable strands that permanently protrude greater than one strand diameter from the normal cable geometry. A strand will be considered to have bird-caged if light can be seen between the protruding strand and the cable. This observation will be made after the cable has cooled to the reference temperature after the last pulse. Temporary bird-caging during the pulses shall not constitute failure.
- c) There shall be no permanent increase in optical attenuation greater than 0.05 dB/fiber at nominally 1550 nm $\pm$ 20 nm for single-mode fibers.
- d) If specified, the maximum temperature of any metallic component shall not exceed the manufacturers' value at any time during the test. Additionally, the temperature of the optical core shall not exceed 180 C at any time during the test. Higher temperatures may be allowed if agreed upon between manufacturer and end user.
- e) Any excessive wear, discoloration of fibers, deformation, or other signs of breakdown shall constitute failure.

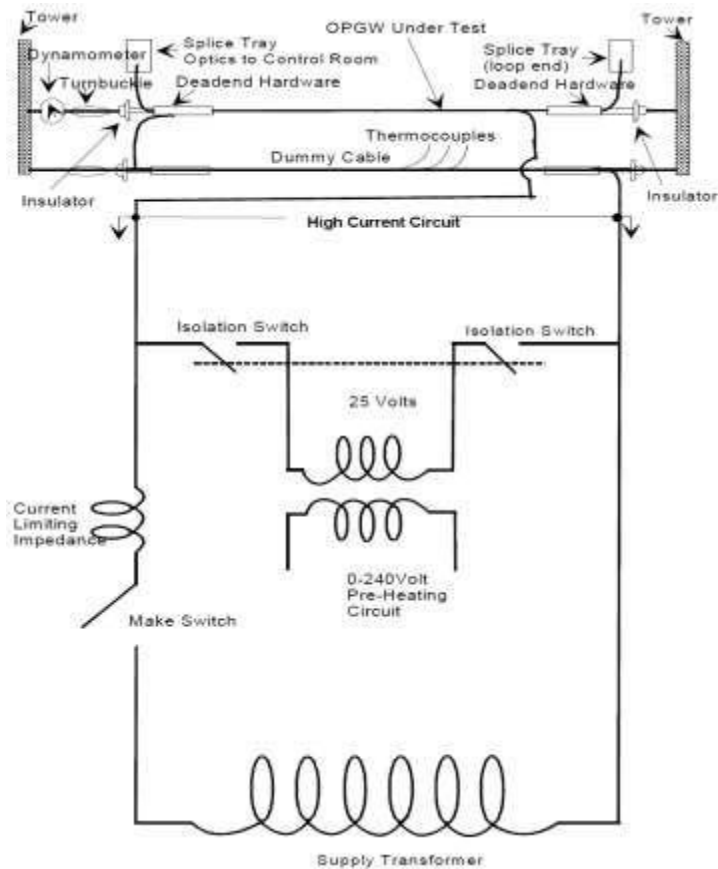


**Figure 1: Test Setup For Short
Circuit Test OBSERVATIONS, IF
ANY:**

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Short Circuit test.

(TESTED BY)

D BY)

Sign & Date
Date

(WITNESSE

Sign &

TYPE TEST PROCEDURE FOR OPGW CABLE

(4) Test Name: Aeolian Vibration Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.3.1

Classification : In-service/mechanical/mandatory

Intent

The intent of the Aeolian Vibration Test is to subject the OPGW cable and support hardware to damped aeolian vibrations. This type of conductor vibration is caused by laminar wind as it passes over bare cable and is a common occurrence in the field. Fatigue damage can occur on the metal components of the cable or hardware at attachment locations. The optical signals may also be adversely affected by Aeolian vibration.

Objective

- a) To verify the mechanical integrity of the OPGW cable and the supporting hardware when subjected to simulated vibration conditions.
- b) To verify the optical performance of the OPGW cable when subjected to the specified vibration conditions.

Set-up

The set-up for the Aeolian Vibration Test is shown in Figure 2.

Test Apparatus

The OPGW cable shall be contained between two intermediate abutments. The active span cable

length shall be at least 20 m. The passive span cable length shall be approximately half the active span length. Fixed-end abutments shall be used to load and maintain tension in the fiber optic cable.

The dead-end assemblies shall be installed between intermediate abutments. The suspension assembly shall be supported at a height such that the static sag angle of the cable to horizontal shall be $1.5^{\circ} \pm 0.5^{\circ}$ in the active span.

An electronically controlled shaker shall be used to excite the cable in the vertical plane. The shaker armature shall be securely fastened to the cable so that it shall be perpendicular to the cable in the vertical plane. The shaker shall be located in the span to allow a minimum of five vibration loops between the suspension assembly and the shaker.

The cable shall be prepared for attenuation measurements as described in 6.2.

A laser micrometer or other suitable means shall be used to measure the free loop antinode amplitude. The free loop antinode amplitude of the cable shall be measured at the second free loop from the suspension assembly towards the shaker.

A load cell or dynamometer shall be used to measure the cable tension. A thermocouple shall be used to measure the air temperature.

The optical power signals, peak-to-peak free loop amplitude, vibration frequency, number of cycles, cable tension, and air temperature shall be recorded at periodic intervals by a suitable data logging system.

Procedure

The OPGW shall be tensioned to $25\% \pm 2\%$ of the cable UTS and the exit angles of the cable from the suspension clamp measured. This tension shall be applied using a cantilever weight arm on one of the end abutments or other suitable means.

This tension shall be applied using a cantilever weight arm on one of the end abutments or other suitable means.

The free loop conductor velocity (i.e., $f_{y\max} = \text{vibration frequency} \times \text{peak-to-peak free loop amplitude}$) shall be maintained at an average value of at least 275 mm/s peak for the duration of the test. The vibration frequency shall be approximately equivalent to that produced by a 4.5 m/s wind (i.e., $\text{frequency} = 830 \text{ divided by the diameter of the OPGW in mm}$). The actual vibration frequency shall produce standing waves and good system stability. The target free loop peak-to-peak antinode amplitude will be approximately onethird the diameter of the cable. This amplitude shall be maintained at this level in the second free loop from the suspension assembly towards the shaker. The frequency and amplitude may vary slightly during the test; however, the average free loop conductor velocity ($f_{y\max}$) shall be maintained throughout the test.

The amplitude of the span from the dead end to the shaker and the passive span shall not exceed the amplitude of the span between the shaker and the suspension.

The number of vibration loops shall be counted, and their average loop lengths calculated for each of the three sections of the OPGW. The three sections are (1) between the dead end and shaker, (2) between the shaker and suspension, and (3) in the passive span between the suspension and dead end.

The OPGW shall be subjected to 100 million vibration cycles.

Optical measurements shall be taken for 15 min after the completion of the vibration cycles.

Acceptance criteria

a) Any cracking or breaking of any component of the OPGW cable or the supporting hardware shall constitute failure. This assessment is made with the naked eye.

b) A permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at nominally 1550 nm for single-mode fibers shall constitute failure.

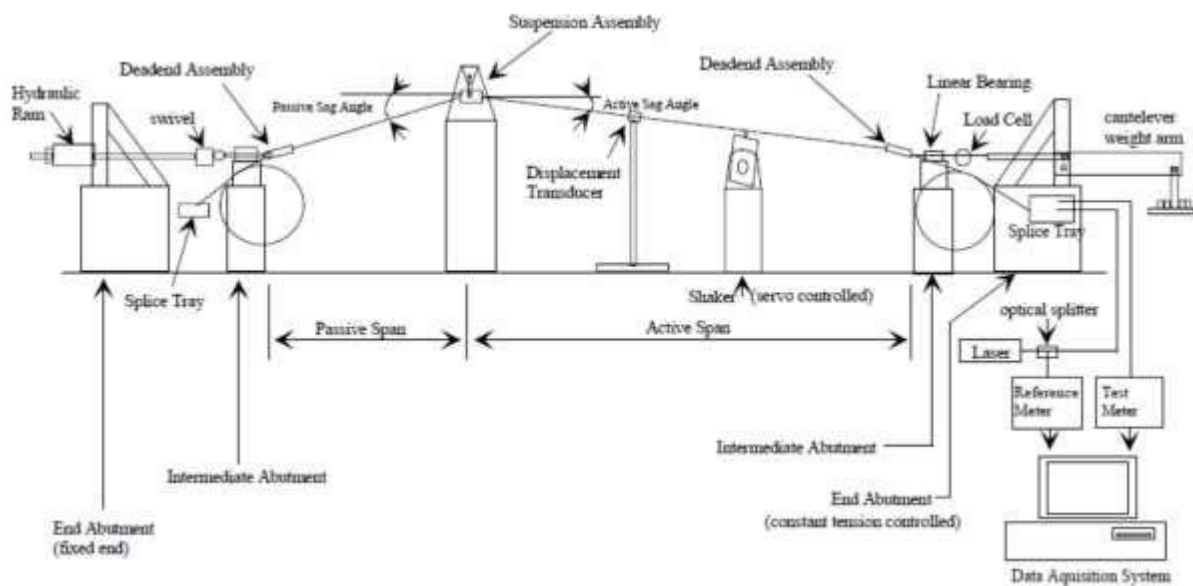


Figure 2 –General arrangement for Aeolian Vibration Test

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Aeolian Vibration test.

(TESTED BY)

(WITNESSED BY)

Sign & Date

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(5) Test Name: Galloping Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type

Standard: IEEE 1138-2009 Method 6.4.3.2

Classification : In-service/mechanical/conditional

Intent

The intent of the Galloping Test is to subject the OPGW cable and support hardware to galloping motions. This type of conductor motion is caused by the wind as it passes over iced cables. This phenomenon can occur in areas that experience icing or wet snow. Fatigue or other damage can occur on the components of the cable, hardware, and/or to the structure. The optical signals may also be adversely affected by galloping.

Objective

- a) To verify the mechanical integrity of the OPGW cable and the supporting hardware when subjected to simulated galloping conditions.
- b) To verify the optical performance of the OPGW cable when subjected to the specified galloping conditions.

Set-up

The set-up for the Galloping Test is shown in Figure 3.

Test apparatus

The test section shall be contained between two intermediate abutments. The active span cable length shall be approximately 20 m and the passive span cable length shall also be approximately 20 m. Fixed-end abutments are used to load and maintain tension in the cable. The initial tension shall be approximately 2% of the cable's UTS. This shall be applied using a cantilever weight arm or other suitable means.

The dead-end assemblies shall be installed between the intermediate abutments. The suspension assembly shall be supported at a height such that the static sag angle of the cable to horizontal shall

be approximately than 1.5° in the active span. A calibrated load cell or dynamometer shall be used to measure the cable tension.

A suitable mechanism (e.g., hydraulically driven, motor-drive) shall be used to oscillate the cable in the vertical plane. The mechanism shall be located in the span and attached to the cable to oscillate the cable in a steady, single-loop gallop motion between the suspension assembly and the shaker.

The free loop antinode amplitude shall be measured in the active span at a point midway between the suspension assembly and the dead end. This shall be achieved by manually observing a graduated scale supported next to the cable.

The cable shall be prepared for attenuation measurements as described in 6.2.

The free loop peak-to-peak antinode amplitude, galloping frequency, optical power signals, tension, and number of cycles shall be recorded at periodic intervals. They may be recorded manually or with a data logging system.

Procedure

Reference optical measurements shall be taken while the cable is at tension and prior to starting the test. The difference between the reference and test signals for the initial measurement provides an initial base reading.

The change in this difference during the test indicates the change in the attenuation of the test fiber.

The cable shall be subjected to 100 000 galloping cycles in the single-loop mode. The frequency shall be adjusted such that the cable exhibits steady, single-loop galloping motions in the active span. The free loop peak-to-peak antinode amplitude shall be maintained at one twenty-fifth of the active span length for the duration of the test. Reasonable movements at both dead end and at the suspension are permitted in order to promote steady galloping motions in the active span. The galloping amplitude in the passive span shall not exceed the amplitude in the active span.

Acceptance criteria

a) Any cracking or breaking of any component of the OPGW cable or the supporting hardware shall constitute failure. This assessment is made with the naked eye.

b) A permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at nominally 1550 nm for single-mode fibers shall constitute failure.

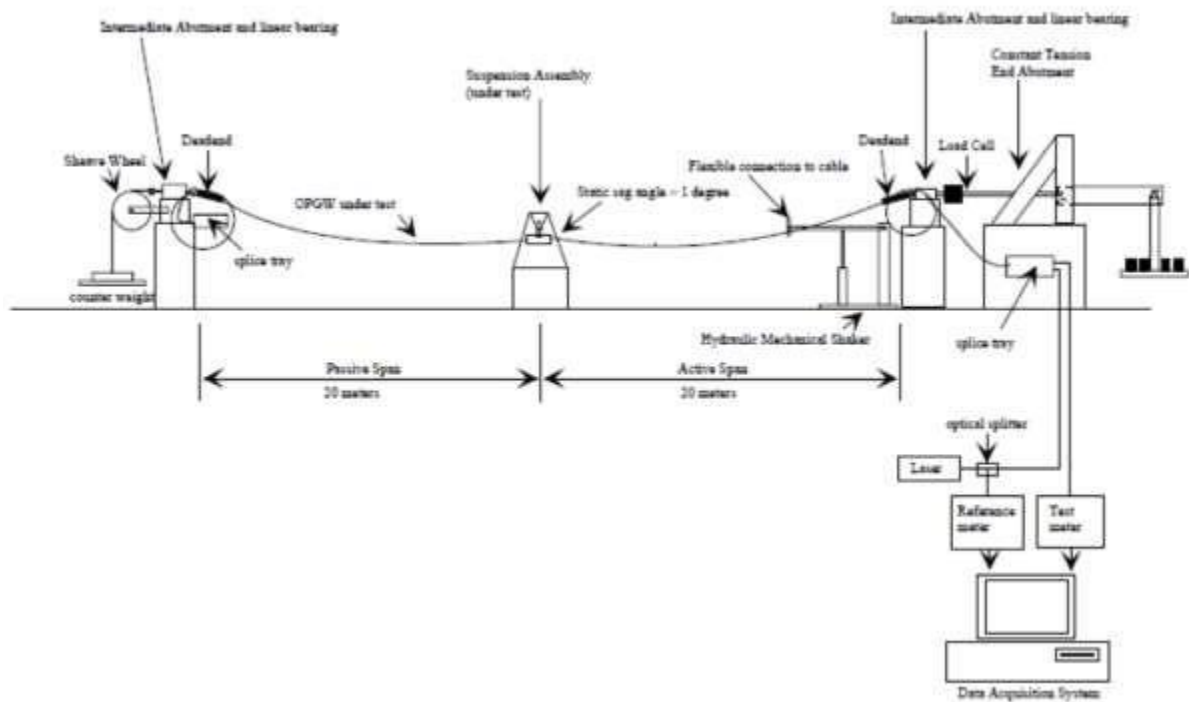


Figure 3: General Arrangement For Galloping Test

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Galloping test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(6) Test Name: Cable Bend Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard : IEEE1138-2009 Method 6.4.2.3

Classification : Installation/mechanical/mandatory

Intent

The intent of the Bend Test is to subject the OPGW cable to a bending action similar to what might be experienced during installation. The cable and/or the optical unit(s) could be damaged and the optical performance could be adversely affected.

Objective

- a) To verify the mechanical integrity of the OPGW cable when subjected to the specified installation conditions.
- b) To verify the optical performance of the OPGW cable when subjected to the specified installation conditions.

Set-up

The preparation of the fibers and number of fibers to be spliced shall be according to 6.2.

Procedure

The minimum bend radius specified by the manufacturer shall be used for the maximum bend radius of the test set-up unless a larger value is agreed to between supplier and purchaser.

The cable sample shall be wrapped two complete times in a close helix around a mandrel with a radius no larger than the minimum bend radius specified by the manufacturer. Sufficient tension shall be applied to ensure that the sample is kept in close contact to the mandrel. The cable shall be held in this position for 1 min.

A reference optical measurement shall be taken prior to bending. Another measurement shall be made after the cable is bent around the mandrel and held stationary. The difference between the two signals for the initial optical measurement provides the test result. The change in this difference during the test would indicate any changes of attenuation in the test fiber. The signals shall be recorded using a digital data logging system.

Acceptance criteria

- a) There shall be no cracking or breaking of any component of the OPGW cable constitutes failure. This assessment is made with the naked eye.
- b) There shall be no permanent increase in optical attenuation greater than 0.05 dB/fiber at 1550 nm $\pm$ 20 nm for single-mode fibers.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Cable Bend test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(7) Test Name: Sheave Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.2.1

Classification : Installation/mechanical/mandatory

Intent

The intent of the Sheave Test is to subject the OPGW cable to a simulated action of being pulled over a number of sheaves during installation. Installation includes stringing and sagging operations. During installation, it is possible the OPGW cable could become excessively deformed. The optical unit(s) could also be damaged and the optic fibers adversely affected.

Objective

- a) To verify the mechanical integrity of the OPGW cable when subjected to the specified installation conditions.
- b) To verify the optical performance of the OPGW cable when subjected to the specified installation conditions.

Set-up

The general arrangement for the Sheave Test is shown in Figure 4. For optical attenuation measurements, the cable shall be prepared according to 6.2. The length of OPGW cable between loading points of the dead-end assemblies shall be a minimum of 8 m. The sheave shall be rigidly supported such that it can not swing. The diameter of the sheave shall be no greater than 38 to 42 times the OPGW cable diameter unless otherwise specified. The sheave may be grooved or ungrooved and shall be lined. The cable shall be initially tensioned to $15\% \pm 1\%$ of the cable UTS at a total deflection angle of $30^\circ \pm 2^\circ$ over the sheave. The method of attachment, while not required to be rigid, shall limit the twisting of the cable occurring near the dead ends. A suitable instrument, such as a dynamometer or load cell, shall be installed to measure the tension in the OPGW cable during the test.

Procedure

At least 2.5 m of the cable sample shall be pulled 15 cycles (i.e., 15 times in each direction) over the sheave. Before the first pull, the midpoint and both ends of the 2.5 m length shall be located and marked. A suitable instrument (e.g., caliper, micrometer) shall be used to measure the maximum and minimum diameters at the three locations after tensioning before the first cycle and after the fifteenth cycle. If necessary, the cable tension may be adjusted between cycles to maintain the level at 15%

± 1% UTS before each cycle.

The cable tension and the optical power meter signals shall be recorded at least two times every cycle using a suitable data logging system.

After the test, the cable section passing over the sheave shall be dissected and all cable components visually

examined for any damage. The maximum and minimum diameters (d_{max} and d_{min} , respectively) of the unit(s) containing the fibers shall be measured at the same locations as the cable diameters were measured.

The ovality of the cable and of the optical unit(s) shall be calculated after the test using the following calculation:

$$\text{Ovality} = ((d_{max} - d_{min}) / (d_{max} + d_{min})) * 100\%$$

Acceptance criteria

a) The ovality of the cable or optical units at the measured locations shall not exceed 10%.

b) Cracking or breaking of any component of the OPGW cable caused by the test shall constitute failure.

This assessment is made with the naked eye.

c) A permanent increase in optical attenuation greater than 0.1 dB/test fiber km at 1550 nm ± 20 nm for single-mode fibers shall constitute failure.

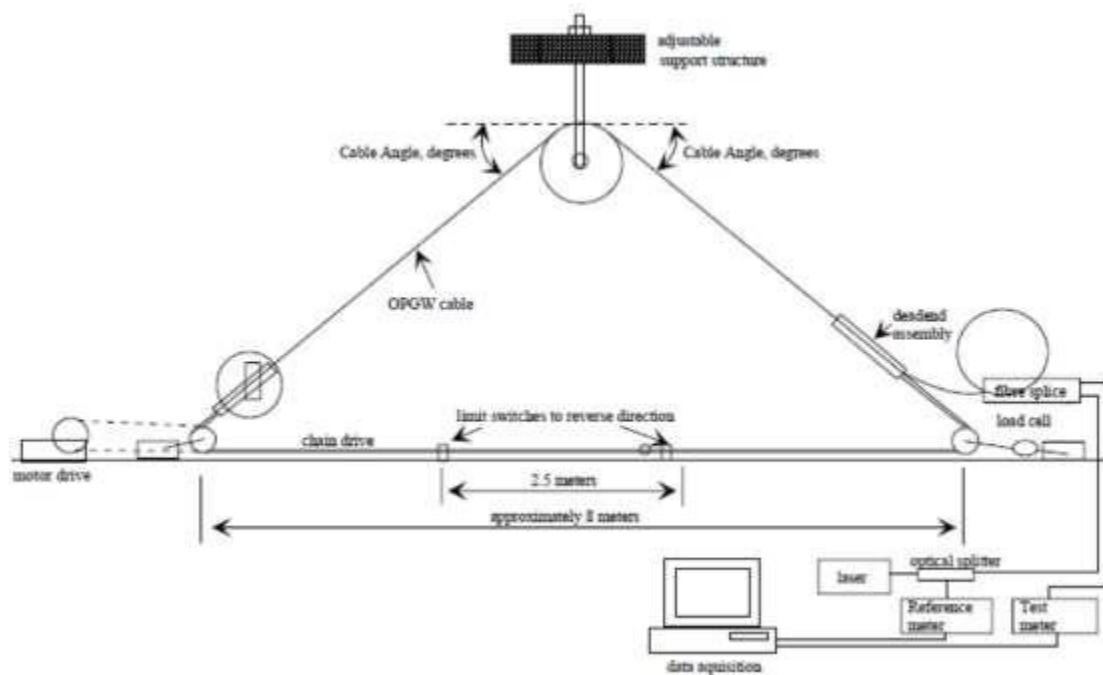


Figure 4: General Arrangement For Sheave Test

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Sheave test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(8) Test Name: Crush Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.2.2

Classification :Installation/mechanical/conditional

Intent

The intent of the Crush Test is to subject the OPGW cable to simulated crushing or clamping forces that could occur during installation or maintenance. The cable could be crushed to the extent of adversely affecting the optical signals or reducing the tensile strength.

Objective

- a) To verify the mechanical integrity of the OPGW cable and the supporting hardware when subjected to crush forces.
- b) To verify the optical performance of the OPGW cable when subjected to crush forces.

Set-up

The set-up for the Crush Test is shown in Figure 5. An untested cable section from the test sample prepared for the Sheave Test may be used for the Crush Test.

The number of fibers to be spliced shall be according to 6.2.

The cable shall be supported between two steel plates that transfer a compressive load uniformly over a 100 mm length of the sample. The edges of the plates shall be slightly rounded. The cable and plates shall be positioned in a suitable test machine. The test shall be carried out in a temperature- controlled laboratory at $22\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$.

The crush load and the optical power meters shall be monitored and recorded every second by a digital data logging system.

Procedure

The test shall be performed in accordance with EIA/TIA-455-41-A.

The cable shall be mounted between the plates with minimal load such that the cable is firmly positioned along the length of the steel plates. The load shall be then gradually increased to the value specified by the supplier within 1 min and 2 min and held for 10 min. The test shall be performed at three locations approximately 1 m apart.

The ovality of the cable and of the optical unit(s) shall be calculated after the test using the following calculation:

$$\text{Ovality} = ((d_{\text{max}} - d_{\text{min}}) / (d_{\text{max}} + d_{\text{min}})) * 100\%$$

Acceptance criteria

- a) Any ovality of the cable or optical fiber units at the measured locations that exceed 10% shall constitute failure.
- b) Any cracking or breaking of any component of the OPGW cable shall constitute failure. This assessment is made with the naked eye.
- c) A permanent increase in optical attenuation greater than 0.05 dB/fiber at 1550 nm $\pm$ 20 nm for single-mode fibers shall constitute failure.

The above criteria shall apply to all three test locations.

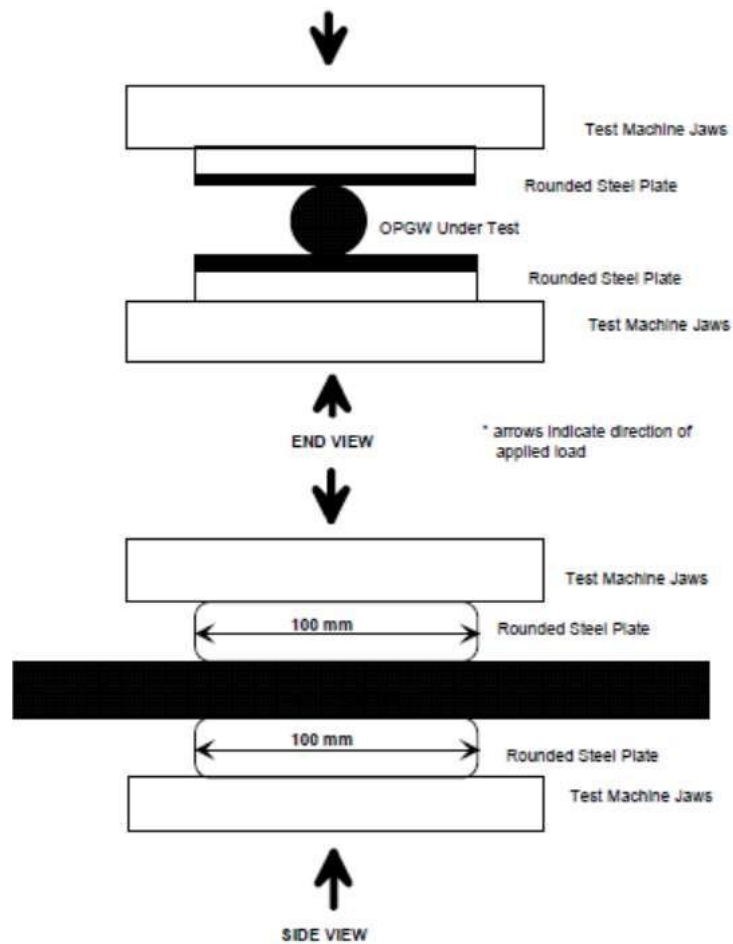


Figure 5: General Arrangement For Crush Test

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Crush test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(9) Test Name: Twist Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.2.4

Classification : Installation/mechanical/mandatory

Intent

The intent of the Twist Test is to subject the OPGW cable to a simulated action of being pulled during installation (i.e., stringing and sagging). During installation, the OPGW cable could become excessively deformed. The optical unit(s) could also be damaged and the optical performance could be adversely affected.

Objective

- a) To verify the mechanical integrity of the OPGW cable when subjected to the specified installation conditions.
- b) To verify the optical performance of the OPGW cable when subjected to the specified installation conditions.

Set-up

An OPGW cable sample shall be installed in a suitable tension test machine. The length of the cable between the dead-end assemblies shall be at least 10 m. One dead-end assembly shall be attached to the tensioning device through a load cell. The other dead-end assembly shall be attached to the stationery end of the test machine through a swivel. The OPGW cable sample shall be fixed onto itself so as to allow rotational motion without disturbing the optical splice arrangement.

The OPGW cable sample shall be terminated beyond both dead-end assemblies such that the optical fibers could not move relative to the OPGW cable.

The cable and fiber terminations and the method to measure optical attenuation are described in 6.2.

Procedure

The cable shall be tensioned to 20% of the cable UTS. The cable sample shall be rotated in the direction of the lay of the strands for two and one-half turns. This number of turns shall be calculated from the test cable length to produce a total twist in the cable of 90° per meter. The cable sample shall be rotated back to the initial position. The cable shall be rotated in the reverse direction to the lay of the strands. The cable sample shall be again reversed in direction to rotate the cable sample to its original position. This constitutes one torsion cycle. This cycle shall be repeated a second time.

The signals from the optical power meters and the cable tension as measured by the load cell shall be monitored continuously and recorded every 10 s using a digital data logging system.

Acceptance criteria

- a) Any cracking or breaking of any component of the OPGW cable shall constitute failure. This assessment is made with the naked eye.
- b) A permanent increase in optical attenuation greater than 0.10 dB/test fiber km at 1550 nm $\pm$ 20 nm for single-mode fibers shall constitute failure.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Twist test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(10) Test Name: Creep Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.1.1

Classification : Cable characteristic/mechanical/conditional

Intent

The intent of the Creep Test is to determine the long-term tensile creep characteristics of the OPGW cable.

This information is used in the sag-tension calculations during the design layout of a fiber optic cable system.

Objective

a) To produce the long-term, room temperature tensile creep curve and equation for the OPGW cable.

b) The optical performance of the OPGW cable is not required to be monitored during this test unless specified

by the cable purchaser.

Set-up

The test shall be set-up in accordance with IEC 61395 unless otherwise specified by the cable purchaser and where noted in this standard.

The OPGW cable sample shall be terminated such that all the load carrying components of the cable are prevented from moving relative to each other at the loading points. A suggested method is to use epoxyresin grips to encapsulate all components of the cable at the loading points.

The OPGW cable sample shall be installed in a test facility suitable for creep testing. The length of the cable between the loading points of the dead-end assemblies shall be a minimum of 10 m. The cable shall be preloaded to a maximum of 2% of the UTS of the cable. The cable shall not remain at the preload value for more than 5 min. A suitable transducer shall be used to measure the longitudinal cable elongation over a gauge length of at least 8 m. A suitable transducer such as a load cell or dynamometer shall be used to measure the tension in the cable. The cable temperature shall be measured at both ends of the gauge section. The test shall be carried out in a temperature-controlled environment at $22\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$.

Procedure

The test shall be performed in accordance with IEC 61395 unless otherwise specified by the cable purchaser or noted in this standard.

The test tension shall be 25% of the UTS of the cable unless otherwise specified by the cable purchaser.

The cable shall be tensioned at a rate such that the time to reach the test tension $\pm 2\%$ of this tension is $5 \text{ min} \pm 10 \text{ s}$. Final adjustments may be made to achieve the test tension within 10 min of the start of loading. However, the load shall remain within $\pm 2\%$ of the test tension at all times while any final adjustments are made. Sudden loading or unloading of the cable shall be avoided at all times. The load on the cable shall be maintained at the test tension $\pm 1\%$ for 1000 h.

The elongation of the cable and applied load shall be monitored and recorded during the test as per IEC 61395 using a suitable data logging system.

Acceptance criteria

Unless otherwise specified by the cable purchaser, there are no acceptance criteria for this test.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for creep test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(11) Test Name: Strain Margin Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.1.3

Classification : Cable characteristic/mechanical/mandatory

Intent

The intent of the Strain Margin Test is to determine the cable tension and strain at which the optical fibers start to elongate. This information is of concern when the cable is exposed to heavy wind and ice conditions.

Objective

- a) To determine the cable tension and strain at which the optical fibers begin to elongate.
- b) To verify the optical performance of the OPGW cable during the test.

Set-up

The OPGW cable sample shall be terminated such that all of the load carrying components of the cable are prevented from moving relative to each other at the loading points. For optical attenuation measurements, the cable shall be prepared according to 6.2. The number of fibers to be spliced shall be according to 6.2 less the number used for fiber elongation.

For the fiber elongation measurement, at least four fibers shall be spliced together. Fiber elongation shall be measured using suitable optical equipment. If the optical equipment is able to measure fiber strain directly, then a gauge length is not required. If the equipment used measures absolute fiber elongation, such as a high resolution OTDR, then the gauge length shall be taken to be the length of fiber from dead end to dead end, plus half the length of each set of three loops beyond each dead end.

The OPGW cable sample shall be installed in a suitable tensile test machine. The length of the cable between the loading points of the dead-end assemblies shall be a minimum of 10 m. The cable shall be preloaded to a maximum of 2% of the UTS of the cable. It shall be supported over its length such that the cable will not lift by more than 10 mm at the test tension condition. A suitable transducer shall be used to measure the longitudinal cable elongation over a gauge length of at least 8 m. A

suitable transducer such as a load cell or dynamometer shall be used to measure the tension in the cable.

The test shall be carried out in a temperature-controlled environment at $22\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$.

Procedure

The cable shall be tensioned at a uniform rate to achieve 100% of the cable UTS in 20 min to 30 min. Readings of the optical attenuation, fiber, and cable elongation shall be taken at periodic intervals while loading the cable. The load shall be continuously increased until the fibers begin to elongate. The data from the instruments shall be recorded simultaneously.

The strain margin is defined as the cable load (or cable strain) at which the fibers have elongated. The methodology to determine onset of fiber strain is shown in IEC 60794-1-2, Method E1, tensile performance.

If agreed between the supplier and the purchaser, the cable may be loaded to failure on completion of the Strain Margin Test to obtain the breaking strength of the cable. If this is done, it is not considered part of the Strain Margin Test and therefore cable strain measurements are not required. If a breaking strength test is performed, the load shall be applied at a rate such that the time to reach the UTS of the cable is at least 5 min. Premature failure of the cable during the breaking strength test does not invalidate the data obtained from the Strain Margin Test.

Acceptance criteria

Strain margin of the OPGW cable shall be above 47% of its UTS. The cable shall show no permanent increase in optical attenuation greater than 0.20 dB/test fiber km from preload to the maximum rated design tension (MRDT) of the cable at $1550\text{ nm} \pm 20\text{ nm}$ for single-mode fibers.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Strain Margin test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(12) Test Name: Stress Strain Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.1.2

Classification : Cable characteristic/mechanical/mandatory

Intent

The intent of the Stress-Strain Test is to determine the stress-strain characteristics and the final modulus of elasticity (MOE) of the OPGW cable. This information is used in the sag-tension calculations during the design layout of a fiber optic cable system.

Objective

- a) To produce the stress-strain curve and the final MOE for the OPGW cable.
- b) Monitoring the optical performance of the OPGW cable is not required during this test unless specified by the cable purchaser.

Set-up

The test shall be set-up in accordance with IEC 61089 unless otherwise specified by the cable purchaser and where noted in this standard.

The OPGW cable sample shall be terminated such that all the load carrying components of the cable are prevented from moving relative to each other at the loading points. A suggested method is to use epoxyresin grips to encapsulate all components of the cable.

The OPGW cable sample shall be installed in a suitable tensile test machine. The length of the cable between the loading points of the dead-end fittings shall be a minimum of 10 m. The cable shall be preloaded to a maximum of 2% of the UTS of the cable. It shall be supported over its length such that the cable will not lift by more than 10 mm at the maximum tension condition. A suitable transducer shall be used to measure the longitudinal cable elongation over a gauge length of at least 8 m. A suitable transducer such as a load cell or dynamometer shall be used to measure the tension in the cable.

The test shall be carried out in a temperature-controlled environment at $22\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$.

Procedure

The test shall be performed in accordance with IEC 61089 unless otherwise specified by the cable purchaser or noted in this standard.

The cable shall be tensioned according to the loading schedule in the following table. To reduce creep during loading, all loads shall be applied based on the rate to reach 85% of UTS in 2 min. The elongation of the cable and applied load shall be monitored and recorded at appropriate intervals using a suitable data logging system. Load and elongation data shall be recorded a minimum of every 5 min during each hold period and at all preloads. If possible, more frequent readings are preferred.

See Table 2.

Table 2 –Tension loading schedule

Step	Load % UTS	Hold time (min)
Preload	2	—
1	30	30
Preload	2	< 2
2	50	60
Preload	2	< 2
3	70	60
Preload	2	< 2
4	85	60
Preload	2	—

The slope of the final unloading curve from 85% UTS is the final MOE of the cable.

If agreed between the supplier and the purchaser, the cable may be loaded to failure on completion of the Stress-Strain Test to obtain the breaking strength of the cable. If this is done, it is not considered part of the Stress-Strain Test and therefore cable strain measurements are not required. If a breaking strength test is performed, the load shall be applied at a rate such that the time to reach the UTS of the cable is at least 5 min. Premature failure of the cable during the breaking strength test does not invalidate the data obtained from the Stress-Strain Test.

Acceptance criteria

Unless otherwise specified by the cable purchaser, there are no acceptance criteria for the Stress-Strain Test.

If performed the breaking strength of cable shall meet or exceed 100% of the cable UTS.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met the acceptance criteria for Stress Strain test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(13) Test Name: Temperature Cycling Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.3.7

Classification : In-service/environmental/mandatory

Intent

To subject the OPGW cable to extreme temperatures as may be experienced in the field by the cable.

Objective

To verify the optical performance of the OPGW cable when subjected to the specified temperature conditions.

Set-up

A sample with a minimum of 500 m of fiber (cabled fiber) shall be placed in a suitable thermal chamber.

For optical attenuation measurements, the optical cable sample shall be prepared according to

6.2. Two thermocouples shall be placed in the environmental chamber to measure the temperature.

They shall be placed on a 25 cm cable sample located either side of the cable reel.

Procedure

The test shall be performed in accordance with TIA/EIA-455-3.

The cable shall be subjected to two thermal cycles. A thermal cycle is based on the chamber temperature starting at

22 °C ± 3 °C, lowering to at least -40 °C and holding for a minimum of 16 h. The temperature shall then be increased to at least 85 °C and held for a minimum of 16 h. To complete the cycle, the temperature shall be returned to 20 °C. All temperature transitions shall be conducted at a rate of 20 °C to 40 °C per hour. The chamber temperature is based on the average of the two thermocouples on the 25 cm cable samples.

At a minimum, the thermocouples and optical data shall be recorded at the beginning and end of the test and at the beginning and end of every hold period.

Acceptance criteria

A permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at 1550 nm $\pm$ 20 nm for single-mode fibers shall constitute failure.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Temperature Cycling test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(14) Test Name: Corrosion (Salt Spray Test)

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.3.8

Classification : Storage/in-service, environmental/conditional

Intent

To subject the OPGW cable to salt fog corrosion that may be experienced in the field by the cable.

Objective

The objective of this test is to determine the effects of a controlled salt atmosphere on the OPGW sample.

Set-up

This test is a 1000 h saltbox spray test. Three cable samples of $75\text{ cm} \pm 5\text{ cm}$ shall be cut from the reel of OPGW. Heat shrink tubing or silicone seal shall be placed over both ends of the cable to a distance not to exceed $7.5\text{ cm} \pm 0.5\text{ cm}$ from either end of the cable sample. The purpose of the tubing is to reduce or eliminate the corrosion occurring at the open ends of the test cable.

Procedure

The test cables are placed into a standard salt spray-testing box as defined by ISO 9227:2006 [B40] or ASTM B 117 [B3]. The cable samples are to be placed horizontal in the test chamber to simulate a standard horizontally suspended OPGW cable. The test is to run continuously for 1000 h for salt spray testing.

Acceptance criteria

At the end of the test, the cables are to be removed and dissected for corrosion damage. The cables have passed the test if:

- a) There are no locations where the aluminum-clad steel wires have been pitted so as to expose the underlying steel strength member in any way what so ever.

- b) There are no locations where solid aluminum wires have been point pitted beyond a depth of 10% of the total individual wires diameter at the point of the pit.
- c) There is no damage to the internal fiber containment tubing.
- d) In the case of aluminum coated tubing, there can be no removal of the aluminum coating that exposes the underlying stainless steel tube.
- e) In the case of “other” coated tubing, there can be no removal of the coating that exposes the underlying tubing to the elements.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Corrosion (Salt Spray test).

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(15) Test Name: Ultimate Tensile Strength Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.1.4

Classification : Cable characteristic/mechanical/mandatory

Intent

The intent of the Ultimate Tensile Strength Test is to determine the actual breaking strength of the cable.

Objective

- a) To verify that the actual (ultimate) tensile strength of the OPGW cable meets or exceeds the UTS of the OPGW cable specified by the supplier.
- b) Monitoring the optical performance of the OPGW cable is not required during this test unless specified by the cable purchaser.

Set-up

The OPGW cable sample shall be installed in a suitable tensile test machine. The length of the cable between the loading points of the dead-end assemblies shall be a minimum of 10 m. A suitable transducer such as a load cell or dynamometer shall be used to measure the tension in the cable.

Procedure

The load shall be applied at a uniform rate such that the time to reach the UTS of the cable is at least 5 min. The ultimate tensile strength of the cable shall be defined as the maximum load the cable can withstand before failure. Individual strand failures do not necessarily constitute cable failure. However, no outer layer strands shall fail below 75% of the cable UTS. This is to ensure that the outer strands will not unravel below the maximum design loading conditions.

This test may be performed separately or on the same cable sample as the Stress-Strain Test or the Strain Margin Test. In this case, the Ultimate Tensile Strength Test would be performed immediately following the Stress-Strain Test or the Strain Margin Test.

Acceptance criteria

The ultimate tensile strength of the OPGW cable shall meet or exceed 100% of the UTS of the cable. In addition, any outer layer strand failing below 75% of the cable UTS shall constitute failure. If the maximum load does not meet 100% of the UTS of the cable, the test shall be repeated if the following occurs:

- a) The break occurs beneath or within 50 mm (2 in) of a dead-end fitting.
- b) The OPGW cable slips in a dead-end fitting.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Ultimate Tensile Strength Test .

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(16) Test Name: Lightning Arc Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138- 2009 Method 6.4.3.4

Classification : In-service/electrical/mandatory

Intent

The intent of the Lightning Arc Test is to subject the OPGW cable to lightning conditions that represent field conditions. Damage can be inflicted to the cable strands through loss of tensile strength as a result of melting or softening of strands because of extremely high temperatures. The optical signals may also be adversely affected by lightning conditions.

Objective

- a) To verify the mechanical performance of the OPGW cable when subjected to the specified lightning conditions.
- b) To verify the optical performance of the OPGW cable when subjected to the specified lightning conditions.

Set-up

The test shall be set-up in accordance with IEC 60794-1-2, Method H2, unless otherwise specified by the cable purchaser and where noted in this Standard.

Test apparatus

An OPGW sample shall be installed between two fixed abutments. The length of the cable between the load points of the dead-end assembly shall be greater than 10 m. A load cell or dynamometer shall measure the tension in the cable.

Optical network

For optical attenuation measurements, the sample shall be prepared according to 6.2. The optical attenuation shall be monitored and recorded by a digital data logging system at a suitable sampling rate. The tension may be recorded manually.

Procedure

The test shall be performed in accordance with IEC 60794-1-2, Method H2, unless otherwise specified by the cable purchaser and where noted in this standard.

Five sections of the cable sample shall be tested separately according to Table 3. The class of the OPGW cable shall be agreed between the purchaser and the manufacturer.

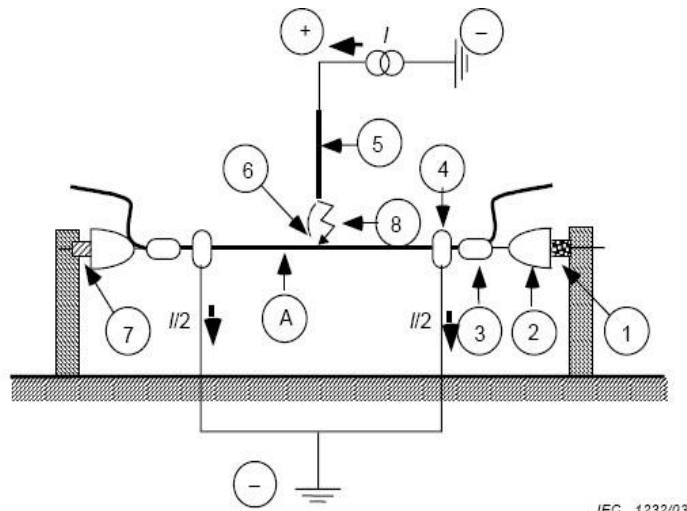
Table 3 - Test parameters	
	Class 1
Current (A)	200
Duration (S)	0.5
Charge transfer (C)	100

Each section shall be tensioned to 15% to 20% of the cable UTS. An arc current with negative polarity on the electrode shall be applied to the cable through a 5 cm $\pm$ 1 cm long thin filament. A thin filament may be used to initiate the arc to the cable. The charge transference to the cable shall be as specified by the supplier. The tolerance on the charge transference is $\pm 10\%$. A charge exceeding 110% of the target value may also be acceptable.

After the Lightning Arc Test, the sections of the cable sample shall be tension tested to determine the remaining strength. If there are broken wires, the numbers and types (aluminum, ACS) of the broken wires shall be reported. For information purposes, the cable and its components shall be inspected and material changes shall be documented.

Acceptance criteria

- There shall be no permanent increase in optical attenuation greater than 0.05 dB/fiber at nominally 1550 nm $\pm$ 20 nm for single-mode fibers.
- The minimum remaining strength of any of the tested cable sections shall be greater than 75% of the cable UTS.



1	Turnbuckle	5	Electrode with plane surface preferring Wolfram – Copper
2	Insulator	6	Metal fuse for ignition
3	Anchoring clamps	7	Tension meter
4	Symmetric earthing connectors	8	Gap between electrode and cable surface $\leq 6\text{cm}$
A	Test sample (inc OPAC messenger wire)		

Figure 6: Test Setup For Lightning Arc Test

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Lightning Arc test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(17) Test Name: DC Resistance Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2009 Method 6.4.1.5

Classification : Cable

characteristic/electrical/mandatory

Intent

The intent of the DC Resistance Test is to determine the actual dc resistance of the cable.

Objective

a) To verify that the actual dc resistance of the OPGW cable does not exceed the dc resistance stated by the supplier.

Set-up and procedure

Copper connectors shall be crimped on each end of a 5 m cable sample. Alligator-type clips shall be used to connect a calibrated current source of 10 A to the cable. A bar with a calibrated length of about 1 m with sharp knife edges shall be used to obtain a precise gauge length.

Optical measurements are not required for this test.

The potential drop between the knife edges shall be measured by a micro-ohmmeter and displayed directly as micro-ohms. Resistance measurements shall be taken five times. The dc resistance per meter of the cable shall be calculated by averaging the five individual measurements and dividing by the gauge length. To minimize error due to heating, the current shall be injected through the cable for only a few seconds to obtain a reading. The temperature at the time of testing shall be recorded. If the temperature of the cable at the time of measurement is lower than that specified by the cable manufacturer, then the resistance measurements shall be corrected to the specified temperature.

Acceptance criteria

The actual dc resistance of the OPGW cable shall not exceed the dc resistance stated by the manufacturer at the specified temperature.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for DC Resistance test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

Space for Observations

IEEE-1138:2009 Clause 6.2

Procedure for optical measurements and fiber preparation:

To increase the sensitivity to changes in attenuation, a number of fibers in each test sample are spliced together, or concatenated, to form one long, continuous optical path. The minimum number of fibers to be spliced and monitored for applicable tests is shown in Table-1. Whenever possible, an equal number of fibers shall be selected from each optical unit.

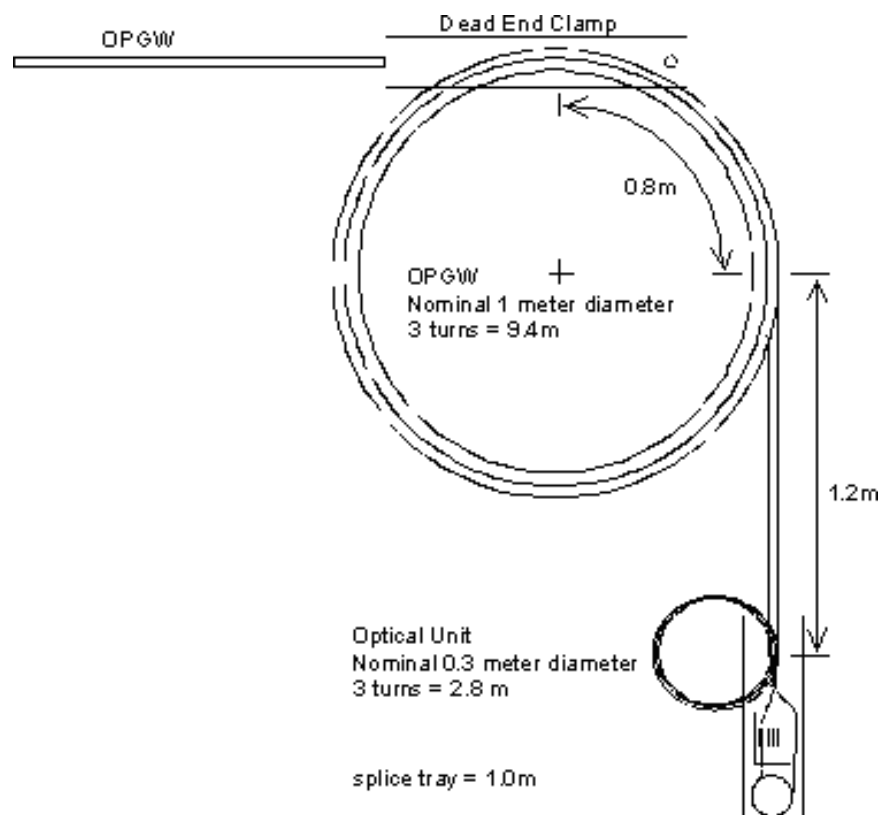
Table-4 Minimum Fibers for Tests

Cable fiber Count	Minimum number of fibers to be spliced and monitored
1 to 24	All
25 to 48	24
49 to 96	36
97 to 192	48
193 to 384	60
385 to 768	72

A laser source with the appropriate wavelength is injected to an optical splitter. The splitter divides the source signal into two signals with nominally equal optical power. During the test, the optical measuring system (source, splitter, and receiver) shall remain stable. One of the split signals is sent directly to an optical power meter and serves as the reference signal. The other split signal is spliced into one of the free ends of the concatenated test fibers. A second power meter is connected to the returning end of the test fibers. This measurement is the test signal. During the tests, the readings from the reference and test optical power meters are monitored and recorded periodically in a suitable manner for future analysis. Any changes from the initial difference between the reference and test signals indicate a change in the attenuation in the fibers due to the test. A net increase in attenuation indicates a loss in the optical signal strength. A net decrease in attenuation indicates a gain in the signal strength.

For tests where the OPGW is subjected to tension, the samples are terminated in a manner such that the optical fibers at both ends of the sample cannot move relative to the OPGW cable. Although other arrangements may be used, an example of an arrangement for preparing loops between the test sample and the fiber splice tray is shown in Figure 1. Three loops of cable with a diameter of 1 m are formed and secured as close as possible to the dead-end tension clamps. Another three loops of the fiber optic unit only are formed just in front of the splice tray. This configuration will ensure that

all metallic, non-metallic and fiber components are prevented from relative movement during the test.



Total length: $9.4 + 0.8 + 1.2 + 2.8 + 1.0 = 15.2\text{m}$

Figure 7 : Test Sample Termination Arrangement

The type test procedures on the OPGW Cable fittings and accessories are listed in below table:

No.	TEST NAME	APPLICABLE STANDARD	TEST RESULT PASS/FAIL
1	Visual examination, dimensional & material verification test	ISO 1461-2009/IEC:61284-1997	
2	Mechanical Strength Test for Suspension assembly	IS 2486/IEC:61284-1997	
3	Mechanical Strength Test for Tension assembly	IS 2486/IEC:61284-1997	
4	Clamp Slip Strength Test for Suspension assembly	IS 2486/IEC:61284-1997	
5	Slip Strength Test for Tension Clamp	IS 2486/IEC:61284-1997	
6	Grounding clamp and structure mounting clamp fit test	IS 2486/IEC:61284-1997	
7	Structure mounting clamp strength test	As per Vol. B Technical specification	

Reference Document:

- 1) Approved DRS & Drawings of OPGW Hardware & Fittings.
- 2) Applicable for OPGW installation hardware & fittings.
- 3) Applicable standard.(ISO 1461 IS 2486/IEC:61284)
- 4) Contract-Technical Specifications

Sampling Procedure: For OPGW installation hardware and fittings, at least ten (10) samples shall be offered for selection.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

1. TYPE TEST PROCEDURE OF VISUAL EXAMINATION, DIMENSIONAL & MATERIAL VERIFICATION TEST

Test Name: Visual Examination, Dimensional & Material Verification

Test Manufacturer:

Standard: ISO 1461-2009 / IEC 61284-1997

Objective: It shall be verified that the samples are in accordance with the relevant drawings, particularly as regards any dimensions to which special tolerance apply and have a sufficient galvanized coating.

Test Procedure:

The following tolerance shall be allowed/on all dimensions to which special tolerance do not apply.

Appearance: To check all and ascertain to be appropriate as per DRS & Drawings.

Dimensions:

(A) Forgings:

- i) Dimensions up to and including 30mm ± 1.5 mm.
- ii) Dimensions greater than 30 mm..... $\pm 5\%$ upto max. of ± 5 mm.

(B) Helical Fittings:

- i) Dimensions up to and including 30mm ± 1.5 mm.
- ii) Dimensions greater than 30 mm..... $\pm 5\%$ upto max. of ± 5 mm.

Galvanizing (Tension assembly fittings, Suspension assembly fittings, Earth lead Assembly Down-lead/fastening Clamps, all nuts & bolts components as per approved DRS & Drawings):

- i) Galvanized coatings shall be tested in accordance with as appropriate.
- ii) All measurements shall be made after galvanizing where galvanizing is the normal finish. Galvanized coatings shall be tested and galvanized coating shall be minimum 85 μ m, except 43 μ m of bolts & nuts.

Acceptance Criteria:

Fittings shall be accordance with their relevant drawings within the tolerance Specified.

Galvanized coatings on general articles shall be minimum thickness of 85 μ m, except 43 μ m of bolts & nuts.

OBSERVATIONS, IF ANY:

TEST RESULT: The Hardware Fittings as tested met/did not meet the requirements as preapproved DRS & Drawings.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

2. TYPE TEST PROCEDURE OF MECHANICAL STRENGTH TEST FOR SUSPENSION ASSEMBLY

Test Name: Mechanical Strength Test for Suspension Assembly

Manufacturer:

Standard: IS 2486 / IEC 61284-1997

Objective: To verify the mechanical strength test for suspension Assembly.

TEST SET-UP

The armour rods /reinforcement rods are assembled onto the approved OPGW by the installation instructions to check the assembly is correctly fitted and is the same that will be carried out during installation.

TEST PROCEDURE

Part 1:

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 stabilize.
2. The load shall then be increased at a steady rate 67% of minimum failure load and held for five (5) minutes. The angle between the cable, the suspension assembly and the horizontal shall not exceed 16° .
3. This load shall then be removed in a controlled manner and the protection splice shall be disassembled.
4. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:

1. 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 stabilize.
2. 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 shall occur during this period.
3. The applied load shall then be increased until the failing load is reached and value shall be documented.

ACCEPTANCE CRITERIA

1. No evidence of binding of the nuts or deformation of components at end of Part 1 of test.
2. No evidence of fracture at the end of one minute at the minimum failure load during Part 2 of the test.
3. Any results outside the above parameters shall constitute a failure.

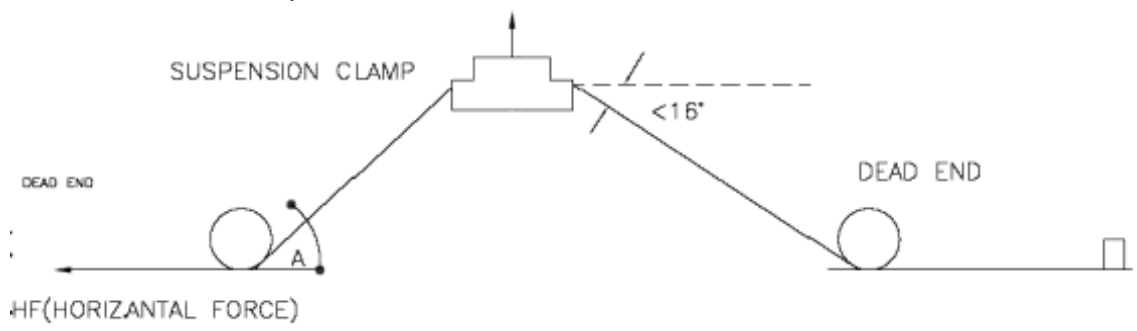


Figure 1: Test set up for mechanical strength test for suspension assembly

OBSERVATIONS, IF ANY:

TEST RESULT: The Hardware Fittings of OPGW cable met/not met the acceptance criteria for the Mechanical Strength Test for suspension assembly.

(Tested by)

Sign & date

(Witnessed by)

Sign & date

3. TYPE TEST PROCEDURE OF MECHANICAL STRENGTH TEST FOR TENSION ASSEMBLY

Test Name: Mechanical strength for Tension assembly

Manufacturer:

Standard: IS 2486 / IEC 61284-1997

Objective: To verify the mechanical strength test for the tension assembly.

TEST SET-UP

The Tension assembly is correctly fitted and is the same that will be carried out during installation.

TEST PROCEDURE

Part 1:

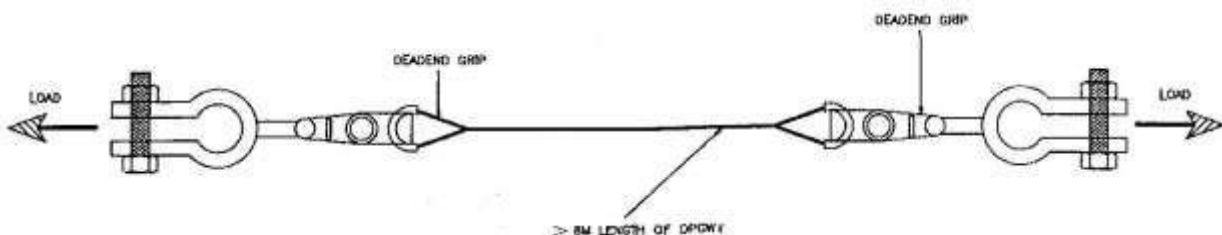
1. The tension assembly (excluding tension clamp) of cable section shall be increased at a constant rate up to a load equal to 50% of the specified minimum failure load increased at a constant rate and held for one (1) minute for the test rig to stabilize.
2. The load shall then be increased at a steady rate to 67% of the minimum failure load and held for five minutes.
3. This load shall then be removed in a controlled manner and the tension assembly shall be disassembled, Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:

1. The Tension Dead-End and associated components shall then be reassembled and bolts tightened as before.
2. The tensile load 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 stabilize and the load shall be further increased at a steady rate until the specified minimum failure load is reached and held for one minute.
3. The applied load shall then be increased until the failing load is reached and the value shall be documented.

ACCEPTANCE CRITERIA

1. No evidence of binding of the nuts or deformation of components at end of part 1 of test.
2. No evidence of fracture at the end of one minute at the minimum failure load during part 2 of the test.
3. Any results outside the parameters shall constitute a failure.
4. Failure load shall meet or exceed value as per approved DRS.



OBSERVATIONS, IF ANY:

TEST RESULT: The Hardware Fittings of OPGW cable met/not met the acceptance criteria for the Mechanical Strength Test for Tension assembly.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

4. TYPE TEST PROCEDURE OF SLIP STRENGTH TEST FOR SUSPENSION ASSEMBLY

Test Name: Clamp slip strength test of suspension

assembly Manufacturer:

Standard: IS 2486 / IEC 61284-1997

Objective: To verify the clamp slip strength test for suspension assembly proposed for the OPGW cable.

Test Set-up: The below figure shows the schematic of the test configuration. The OPGW used for this test shall be type approved by Power Grid.

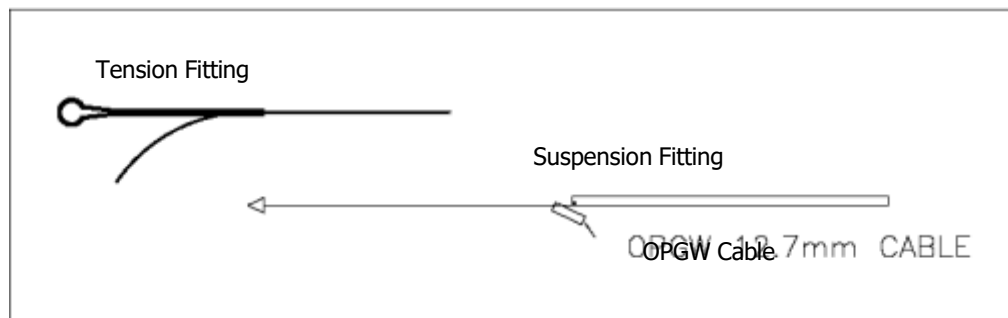


Figure 3: Test set up for slip strength test for suspension assembly

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.

Test procedure:

1. After 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 were marked by 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 2mm relative position between clamp body and the armour rods shall be marked on one side.
2. 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, the relative displacement between clamp body and the armour rods will be observed. If the slippage is 2mm or above, the test shall be terminated. Otherwise at the end of one minute the position of the clamp body and 2mm relative position between clamp body and armour rods shall be marked on the other side.
3. 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 2mm 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:

1. No slippage* shall occur at or below the specified minimum slip load of 12 KN.
2. Slippage shall occur between the specified minimum and maximum slip load of 12-17 KN.
3. There shall be no slippage of the reinforcing rods over the cable, and no slippage of the armour rods over the reinforcing rods.
4. The relative movement (i.e. more than 2 mm between armour rods and clamp body) between minimum 12 KN and maximum slip 17 KN shall be considered as slip.
5. The armour rods shall not be displaced from their original lay or damaged **.
6. Any result outside the above parameters is a failure.

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

** 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 shall constitute a failure.

For each sample tested there shall be Graphical records of Slip Load against Position Displacement

OBSERVATIONS, IF ANY:

Test Results: The hardware fittings, as tested, met/ not met the acceptance criteria for the Clamp Slip strength Test for suspension assembly.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

5. TYPE TEST PROCEDURE OF SLIP STRENGTH TEST FOR TENSION CLAMP

Test Name: Slip strength test of tension clamp

Manufacturer:

Standard: IS 2486 / IEC 61284-1997

Objective: To verify the slip strength test for tension clamp proposed for the OPGW cable.

TEST SET-UP

The set-up for the slip strength for tension clamp is shown in Figure-4.

The tension clamps shall be fitted on both ends of a 8 m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile machine and anchored in a manner similar to the arrangement to be used in service.

TEST PROCEDURE

1. A tensile load shall gradually be applied up to 20% of the Rated Tensile Strength of the OPGW.
2. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the reinforcing rods and Tension Dead-End relative to the reinforcing rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip.
3. The load shall be gradually increased at a constant rate until it reaches 50% of the specified UTS and the Position scale of the recorder is 'zeroed'.
4. The load shall then gradually be increased at a constant rate until it reaches 95% of the specified UTS and maintained for one minute.
5. After 1 minute pause, the load is slowly released to zero and the markings examined and measured for any relative movement.
6. On completion of the test a graph of load against position is produces for each of the two measurements.

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 Clamp, Reinforcing Rods or OPGW.

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

Any results outside these parameters shall constitute a failure.

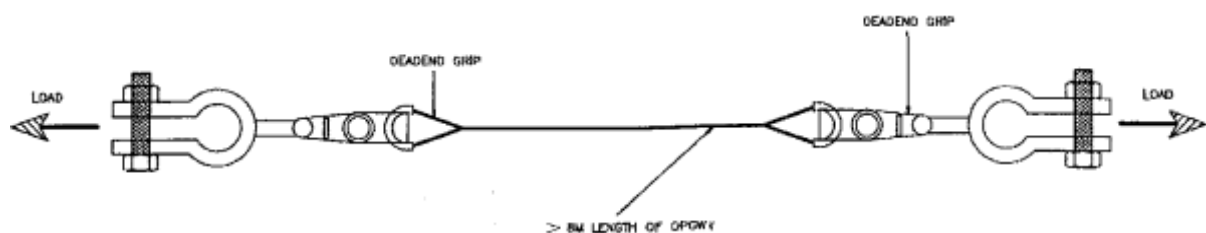


Figure 4: Test set up for slip strength test of tension clamp

OBSERVATIONS, IF ANY:

TEST RESULT: The Hardware Fittings of OPGW cable met/not met the acceptance criteria for the Slip strength Test for Tension clamp.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

**6. TYPE TEST PROCEDURE FOR
GROUNDING AND STRUCTURE MOUNTING CLAMP FIT TEST FOR SUSPENSION SET AND
TENSION SET**

Test Item: Fit Test of Grounding Clamp

Manufacturer:

Standard: IEC 61284-1997

Objective: To determine the Fit test for Grounding clamp and structure mounting (downlead clamp) clamp fit test proposed for the OPGW cable.

TEST PROCEDURE

For structural 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.

For grounding clamp, one series of tests shall be conducted with one fibre optic cable with structural reinforcing rods installed in one side, the grounding wire into other side, for both Suspension and Tension assemblies, separately.

The clamp shall be installed including clamping compound as required on the fibre optic cable and the grounding wire. The nut shall be tightened on to the bolt by using torque wrench with supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the completion of the test, the fibre optic cable and the grounding wire components shall be examined for distortion, crushing or breaking. Also the fibre optic cable shall be checked to ensure free movement within the core using dial calipers to measure the diameter of the core tube.

ACCEPTANCE CRITERIA

There shall be no visible distortion, crushing, cracking or breaking of the core tube and the fibre optic cable within the core tube shall be free to move. The diameter of the core tube as measured at any location in the clamped area shall be not more than 0.5 mm larger or smaller of the core diameter of the core tube as measured outside the clamped area.

There shall be no visible distortion crushing or cracking of the grounding wire. Any result outside these parameters is a failure.

OBSERVATIONS, IF ANY:

TEST RESULTS:

Fitting No.	Torque applied for 10 mins (Nm)	Free Movement of core (Yes/No)	Visual distortion, crushing, cracking or breaking	Average core diameter in clamped area (mm)	Average core diameter in unclamped area (mm)	Difference (mm)
1						
2						
3						

The Hardware Fittings of OPGW cable met/not met the acceptance criteria for the Fit Test for Grounding clamp.

(Tested by)

(Witnessed by)

Sign & date

Sign & date

7. TYPE TEST PROCEDURE OF STRUCTURE MOUNTING CLAMP STRENGTH TEST

Test Name: Structure Mounting Clamp Strength Test

Manufacturer:

Standard: Technical Specification

Objective: To demonstrate the ability of the down lead bracket assembly to withstand a specified load.

Test Set-up:

The clamp and mounting assembly shall be assembled on a vertical 200mm x 200mm angle and a short length of fiber optic cable installed as shown in Figure 2

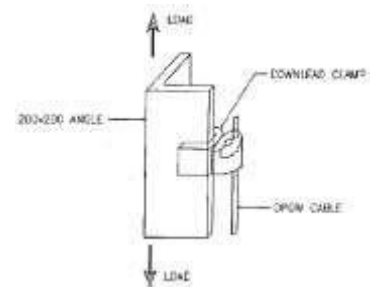


Figure 2: Schematic of structure mounting clamp strength test

Test Procedure:

1. A vertical load of 200 kg is applied at the end of the mounting clamp and held for 5 minutes.
2. The markings on the structure Down Lead Clamp and OPGW are examined for any signs of visible distortion, slipping or breaking of any components.
3. The load is increased to 400 kg and held for 30 seconds.
4. The load is then removed and the markings on the structure, Down Lead Clamp and OPGW are examined for any signs of visible distortion, slipping or breaking of any components.

Acceptance Criteria:

Any visible distortion, slipping or breaking of any component of the mounting clamp shall constitute failure.

Test Results:

The Structure mounting Clamps tested, met the requirement specified in technical specification, and results are shown as follows.

S/N	Load (kg)	Description	Comment
1	400		
2	400		
3	400		
4	400		
5	400		

The Hardware Fittings of OPGW cable met/not met the acceptance criteria for the Structure Mounting Clamp Strength Test.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

Type test items on vibration damper are listed in below table:

No.	TEST NAME	APPLICABLE STANDARD	TEST RESULT PASS/FAIL
1	Visual examination, dimensional & material verification test	IEC 61284-1997	
2	Dynamic characteristic test (Damper response test)	As per Vol. B Technical specification	
3	Vibration analysis test (Damping efficiency test)		
4	Clamp slip test	IEC:61897-1998	
5	Fatigue test	As per Vol. B Technical specification	
6	Attachment Of Weights To Messenger Cable Test	IEC:61897-1998	
7	Attachments of clamp to messenger cable test	IEC:61897-1998	
8	Clamp bolt tightening test	IEC:61897-1998	
9	Damper effectiveness evaluation test	IEC:61897-1998	

Reference Document:

- 1) Approved DRS & Drawings of OPGW Hardware & Fittings.
- 2) Applicable for OPGW installation hardware & fittings.
- 3) Vol B Contract Technical specification.

Sampling Procedure: For vibration damper, at least ten (10) samples shall be offered for selection.

1 TYPE TEST PROCEDURE OF VISUAL EXAMINATION, DIMENSIONAL & MATERIAL VERIFICATION TEST

Test Name: Visual Examination, Dimensional & Material Verification Test

Customer: Power Grid Corporation of India Limited, India

Manufacturer:

Standard: ISO 1461-2009 / IEC 61284-1997

Objective: It shall be verified that the samples are in accordance with the relevant drawings, particularly as regards any dimensions to which special tolerance apply and have a sufficient galvanized coating.

Test Procedure:

The following tolerance shall be allowed/on all dimensions to which special tolerance do not apply.

Appearance: To check all and ascertain to be appropriate as per DRS & Drawings.

Dimensions:

(A) Forgings:

- i) Dimensions up to and including 30mm ± 1.5 mm.
- ii) Dimensions greater than 30 mm $\pm 5\%$ upto max. of ± 5 mm.

(B) Helical Fittings:

- i) Dimensions up to and including 30mm ± 1.5 mm.
- ii) Dimensions greater than 30 mm $\pm 5\%$ upto max. of ± 5 mm.

Galvanizing (as per approved DRS & Drawings):

- i) Galvanized coatings shall be tested in accordance with as appropriate.
 - ii) All measurements shall be made after galvanizing where galvanizing is the normal finish.
- Galvanized coatings shall be tested and galvanized coating shall be minimum 85 μ m, except 43 μ m of bolts & nuts.

Acceptance Criteria:

Fittings shall be accordance with their relevant drawings within the tolerance Specified. Galvanized coatings on general articles shall be minimum thickness of 85 μ m, except 43 μ m of bolts & nuts.

OBSERVATIONS, IF ANY:

TEST RESULT: The Hardware Fittings as tested met/did not meet the requirements as preapproved DRS & Drawings.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

2 TYPE TEST PROCEDURE OF VIBRATION DAMPER DYNAMIC CHARACTERISTIC TEST (DAMPER RESPONSE TEST)

Test Name: Dynamic Characteristic Test of Vibration Damper (Damper response test)
Customer: Power Grid Corporation of India Limited, India
Manufacturer:
Standard: As per Vol. B Technical specification

Test Procedure:

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 ± 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 were 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. The above dynamic characteristics test on five dampers shall be conducted. The variation below the samples tested shall confirm to the sample test limits. The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.

Acceptance criteria:

- (i) The Force Vs frequency curve showing steep peaks at resonance frequencies and deep troughs between the resonance frequencies shall constitute failure.
- (ii) The above mean reactance response curve should lie within following limits:
V.D. for OPGW- $0.060 f$ to $0.357 f$ kgf/mm*
Where f is frequency in Hz.
- (iii) The above mean phase angle response curve shall be between 25° to 130° within the frequency range of interest.
- (iv) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

OBSERVATIONS, IF ANY:

TEST RESULTS:

The Hardware Fittings of OPGW cable met/not met the acceptance criteria for Dynamic Characteristic Test of Vibration Damper.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

3 TYPE TEST PROCEDURE OF VIBRATION ANALYSIS TEST (DAMPING EFFICIENCY TEST)

Test Name: Vibration Analysis Test (Damping efficiency test) for vibration damper
Customer: Power Grid Corporation of India Limited, India
Manufacturer:
Standard: As per Vol. B Technical specification

TEST PROCEDURE

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 by means of computer programs using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

- (a) The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as max Permissible Every Day Tension (20% of UTS), for a span ranging from 100 m to 1100 m.
- (b) 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.
- (c) The power dissipation curve obtained from Damper Characteristic test shall be used for analysis with damper.
- (d) 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.
- (e) 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.
- (f) 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.

ACCEPTANCE CRITERIA

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.

The dynamic strain levels at damper attachment point is not more than 150 micro-strains (single peak)

OBSERVATIONS, IF ANY:

TEST RESULT:

The Hardware Fittings of OPGW cable met/not met the acceptance criteria for the Damper Analysis test of Vibration Damper.

(Tested by)

(Witnessed by)

Sign & date

Sign & date

4 TYPE TEST PROCEDURE OF VIBRATION DAMPER CLAMP SLIP TEST

Test Name: Clamp slip test of vibration damper

Customer: Power Grid Corporation of India Limited, India

Manufacturer:

Standard: IEC 61897-1998

TEST SET-UP

The Vibration damper clamp slip shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 15 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 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.

TEST PROCEDURE

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

Clamp slip shall be considered as having occurred when a slip distance of 1 mm is measured.

ACCEPTANCE CRITERIA

No movement of the Vibration damper clamp relative to the conductor greater than 1 mm shall occur at or before the end of application of 2.5 kN for 60 s. If both a minimum and a maximum slip load are stated, the slip shall occur between those values. Surface flattening of the outer strands of the conductor is acceptable.

OBSERVATIONS, IF ANY:

TEST RESULT: The Hardware Fittings of OPGW cable met/not met the acceptance criteria for the Clamp Slip test of Vibration Damper.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

5 TYPE TEST PROCEDURES FOR VIBRATION DAMPER FATIGUE TEST

Test Name: Fatigue test of vibration damper

Customer: Power Grid Corporation of India Limited, India

Manufacturer:

Standard: As per Vol. B Technical specification

Objective: To determine the fatigue of vibration damper.

TEST SET-UP

The Vibration damper fatigue test 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% UTS of OPGW 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.

TEST PROCEDURE

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 $\pm 25/f$ mm where f is the frequency in Hz.

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

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

After the above tests, the damper shall be removed from fibre optic cable and subjected to dynamic characteristics test, the Graphs showing results for:

- a) Force Vs Frequency
- b) Phase angle Vs Frequency
- c) Power dissipation Vs Frequency

Shall be recorded as per test procedure of Dynamic characteristic 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.

ACCEPTANCE CRITERIA

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

OBSERVATIONS, IF ANY:

TEST RESULT:

The Hardware Fittings of OPGW cable met/not met the acceptance criteria for the Fatigue test of Vibration Damper.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

6 TYPE TEST PROCEDURE FOR ATTACHMENT OF WEIGHTS TO MESSENGER CABLE TEST

Test Name: Attachment Of Weights To Messenger Cable Test Of Vibration Damper

Customer: Power Grid Corporation of India Limited, India

Manufacturer:

Standard: IEC 61897-1998

Test Procedure:

On an assembled damper a tensile load shall be applied between the weights coaxial with the messenger cable. The load shall be gradually increased (100 N/s maximum) until it reaches 5.0 kN (specified minimum slip load). This load shall be kept constant for 60 s.

The load shall then be increased slowly until one weight has been pulled free of the messenger cable. The maximum load obtained during this process shall be recorded, for information purposes only.

Acceptance Criteria:

No relative movement greater than 1mm between each weight and the messenger cable shall occur at or before the end of the application of 5.0 kN for 60s.

OBSERVATIONS, IF ANY:

Test Results:

The Hardware Fittings of OPGW cable met/not met the acceptance criteria for the Attachment Of Weights To Messenger Cable Of Vibration Damper.

(Tested by)

Sign & date

(Witnessed by)

Sign & date

7 TYPE TEST PROCEDURE FOR ATTACHMENTS OF CLAMP TO MESSENGER CABLE TEST

Test Name: Attachments Of Clamp To Messenger Cable Test Of Vibration

Damper Customer: Power Grid Corporation of India Limited, India

Manufacturer:

Standard: IEC 61897-1998

Test Procedure:

A tensile load shall be applied between the messenger cable and the clamp body, coaxial with the messenger cable. The load shall be gradually increased (100 N/s maximum) until it reaches 1.5 kN (specified minimum slip load). This load shall be kept constant for 60 s.

The load shall then be increased slowly until the clamp has been pulled free of the messenger cable. The maximum load obtained during this process shall be recorded, for information purposes only.

Acceptance criteria:

No movement of the clamp relative to the messenger cable greater than 1mm shall occur at or before the end of the application of 1.5 kN for 60s.

OBSERVATIONS, IF ANY:

Test Results:

The Hardware Fittings of OPGW cable met/not met the acceptance criteria for Attachments Of Clamp To Messenger Cable Test.

(Tested by)

Sign & date

(Witnessed by)

Sign & date

8 TYPE TEST PROCEDURE FOR CLAMP BOLT TIGHTENING TEST OF VIBRATION DAMPER

Test Name: Clamp Bolt Tightening Test Of Vibration Damper

Customer: Power Grid Corporation of India Limited, India

Manufacturer:

Standard: IEC 61897-1998

Test Procedure:

The test shall be performed using the conductor for which the clamp is intended to be used. The bolt(s) or nut(s) shall be tightened to a torque 10 % above the specified installation torque.

Lastly, the torque shall be increased to twice the specified installation torque. This increase shall not result in any breakage of threaded parts or other components.

Acceptance criteria:

Regarding 1.1 times torque, the test is passed if the threaded connection remains serviceable for any number of subsequent installation or removals, and all components comprising the clamp are undamaged.

Regarding 2 times, the test is passed if any breakage either to threaded parts or to the components connected to them does not occur.

OBSERVATIONS, IF ANY:

Test Results:

Damper No.	1.1 times torque Comment on condition of components	2 times torque Comment on condition of components
1		
2		
3		

The Hardware Fittings of OPGW cable met/not met the acceptance criteria for Clamp Bolt Tightening Test of Vibration Damper.

(Tested by)

Sign & date

(Witnessed by)

Sign & date

9 TYPE TEST PROCEDURE FOR DAMPER EFFECTIVENESS EVALUATION TEST OF VIBRATION DAMPER

Test Name: Damper effectiveness Evaluation Test of Vibration

Damper Customer: Power Grid Corporation of India Limited,

India Manufacturer:

Standard: IEC 61897-1998

Test Procedures

The damping efficiency test shall be conducted on a laboratory set up with a minimum free span length of 30m. Install the OPGW on the test span, and the OPGW shall be tensioned at Every Day Stress (20% of UTS).

A rigid clamp shall be installed to support rigidly (but not to tension) the OPGW at both ends of the span and the damper and shaker shall be positioned in figure 1. The shaker shall be installed in such a way that its connection to the OPGW cable is located in the first loop for all frequencies to be employed.

The damper or dampers shall be installed in accordance with manufacturer recommendations, unless specified. OPGW bending strain shall be monitored adjacent to the rigid clamp at the span end with the damper(s) and to both sides of the clamp of each damper. Two strain gauges shall be attached to the OPGW at each of the three positions; one each on the two uppermost strands and as close as practicable to, but not more than 2 mm from the last point of contact of the rigid clamp with strands and 5 mm from the last point of contact of the damper clamp with strands.

The test span shall be excited to achieve stable cable motion at the frequencies for which resonance occurs within the range $0.18/d \sim 1.4/d$, where d is the OPGW diameter in metre. A maximum of 20 tuneable frequency span resonances shall be tested, they shall be reasonably spaced over the frequency range indicated above.

Adjust the input power at each tuneable frequency until the highest of the strain readings corresponds to 150 micro-strain (single peak).

At each of these test frequencies the following shall be recorded:

- Frequency;
- OPGW Bending strain;
- Power Input P_j from the shaker;
- OPGW antinode peak-to-peak amplitude Y_j in one of the loops near the damper.

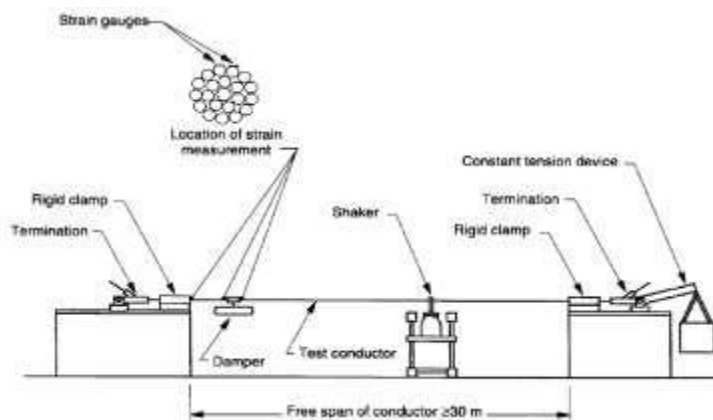


Figure 1-Test for laboratory test of damper effectiveness

Acceptance Criteria

For each test frequency the power input P_j during the test shall exceed the assumed wind power input $P_{w,j}$ which shall be calculated from the equation:

$$P_{w,j} = L \cdot d^4 + f_j^3 \cdot f_n(Y_j/d)$$

Where,

L is the maximum protectable conductor span length for the damper arrangement under test as agreed between purchaser and supplier (m);

d is the OPGW diameter

(m); f_j is the frequency (Hz);

Y_j the conductor antinodes peak-to-peak amplitude

(m); $f_n(Y_j/d)$ is the wind power input function;

OBSERVATIONS, IF ANY:**Test Results:**

The Hardware Fittings of OPGW cable met/not met the acceptance criteria for Attachments of Clamp To Messenger Cable Test.

(Tested by)
Sign & date

(Witnessed by)
Sign & date

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).

List of test items

S.No.	TEST NAME	APPLICABLE STANDARD	TEST RESULT (PASS / FAIL)
1	Temperature cycling Test	EIA 445-20/IEC 60794-1-C 10	
2	Humid Heat Test	IEC 60794-1 or EIA/TLA 455	
3	Water Immersion Test	IEC 60060 or EIA/TLA 455	
4	Vibration Test	IEC 60794-1 or EIA/TLA 455	
5	Bending and Torsion Test	IEC 60794-1 or EIA/TLA 455	
6	Tensile Test	IEC 60794-1 or EIA/TLA 455	
7	Drop Test	IEC 60068-2-32	

Type Test procedure for Temperature Cycling Test

Test Name : **Temperature Cycling Test**
Final Customer : Power Grid Corporation of India Limited,
India. Project Name :
Manufacturer :
Box Type :
Standard : (EIA 455-20/IEC 60794-1-C 10).

TEST SET-UP

Fiber Optical cable is installed in the splice enclosure and optical fiber spliced and looped.

TEST PROCEDURE

The Joint 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 will be recorded in the form of plots/graphs.

ACCEPTANCE CRITERIA

Variation in attenuation shall be less than $\pm 0.05\text{dB}$. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

Conclusion

The joint box meets the acceptance criteria of temperature cycling test

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

Project Name-
LOA No.-

Type Test procedure for Humid Heat Test

Test Name : **Humid Heat Test**
Final Customer : Power Grid Corporation of India Limited,
India. Project Name :
Manufacturer :
Box Type :
Standard : (IEC 60794-1 or EIA/TLA -455).

TEST SET-UP

Fiber Optical cable is installed in the splice enclosure and optical fiber spliced and looped.

TEST PROCEDURE

The sealed Joint box , 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 variation attenuation of the fibres will be recorded through graphs.

ACCEPTANCE CRITERIA

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%.

Conclusion

The joint box meets the acceptance criteria of Humid Heat Test.

(TESTED BY)
Sign & Date

(WITNESSED BY)
Sign & Date

Project Name-
LOA No.-

Type Test procedure for Rain Withstand Test/Water Immersion Test

Test Name : **Water Immersion Test.**

Final Customer : Power Grid Corporation of India Limited,

India. Project Name :

Manufacturer :

Box Type :

Standard : IEC 60060 or EIA/TLA 455

TEST SET-UP

Fiber Optical cable is installed in the splice enclosure and optical fiber spliced and looped.

TEST PROCEDURE

The Joint Box with optical fibres cable installed and fibres spliced fixed, is subjected to 24 hours of Water immersion in accordance with IEC 60060 testing requirements

ACCEPTANCE CRITERIA

1. No water seepage or moisture was detected in the joint box.
2. The attenuation variation of the fibres after the test shall be less than $\pm 0.05\text{dB}$.

Conclusion

The joint box meets the acceptance criteria of Rain withstand Test/Water Immersion Test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

Project Name-
LOA No.-

Type Test procedure for Vibration Test

Test Name : **Vibration Test**

Final Customer : Power Grid Corporation of India Limited,

India. Project Name :

Manufacturer :

Box Type :

Standard : (IEC 60794-1 or EIA/TLA 455).

TEST SET-UP

The Joint box, with fiber united inside, is installed on vibration in the horizontal vertical direction separately with a frequency scanning of 5 to 50HZ.

TEST PROCEDURE

The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the Vibrations direction. Variation in attenuation shall be recorded.

ACCEPTANCE CRITERIA

1. The Variation in attenuation, of the fibres, shall be less than $\pm 0.05\text{dB}$.
2. The joint box shall be examined for any defects or deformation. There shall be no loosening or Visible damage of the OPGW cable at the entry point.

Conclusion

The joint box meets the acceptance criteria of Vibration Test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

Project Name-
LOA No.-

Type Test procedure for Bending and Torsion Test

Test Name : **Bending and Torsion Test**
Final Customer : Power Grid Corporation of India Limited,
India. Project Name :
Manufacturer :
Box Type :
Standard : (IEC 60794-1 or EIA/TLA 455).

TEST SET-UP

OPGW is installed in the joint box and optical fiber are spliced and looped inside.

TEST PROCEDURE

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 $\pm 180^\circ$ shall be exercised on the cable. Each cycle shall be less than one minute.
- b) 3 bending cycles of $\pm 180^\circ$ shall be exercise on the cable. Each cycle shall be less than one minute.

ACCEPTANCE CRITERIA

1. The Variation in attenuation, of the fibres, shall be less than $\pm 0.05\text{dB}$.
2. The cables connection ring shall remain securely fixed to the box with the connection Maintained Firmly.
3. No defects and fissures shall be noted on the joint ring or on the joint box.

Conclusion

The joint box meets the acceptance criteria of Bending And Torsion Test.

(TESTED BY)
Sign & Date

(WITNESSED BY)
Sign & Date

Project Name-

LOA No.-

Type Test Procedure for Tensile Test

Test Name : **Tensile Test.**

Final Customer : Power Grid Corporation of India Limited,

India. Project Name :

Manufacturer :

Box Type :

Standard : (IEC 60794-1 or EIA/TLA 455).

TEST PROCEDURE

The joint box with cable fixed to the boxes is subjected to a minimum tension of 448 N for a period of two minutes.

ACCEPTANCE CRITERIA

No fissure shall be noted in the connections or on the box.

Conclusion

The joint box meets the acceptance criteria of Tensile Test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

Project Name-

LOA No.-

Type Test Procedure For Drop Test

Test Name : **Drop Test**

Final Customer : Power Grid Corporation of India Limited,

India. Project Name :

Manufacturer :

Box Type :

Standard : (IEC 60068-2-32).

TEST PROCEDURE

With 2 lengths of 11 meters of cable fixed to the box, it has to be dropped five times from a height of 10 meters.

ACCEPTANCE CRITERIA

There shall be no fissure, at all, of the box, and the connections shall remain tight.

Conclusion

The joint box meets the acceptance criteria of Drop Test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

FACTORY ACCEPTANCE TEST PROCEDURE FOR OPTICAL FIBRE (ITU-T G.652D)

APPLICABLE STANDARD RELEVANT STANDARDS OF EIA/TIA 455

Sl. No.	Test Name	Test Procedure	Acceptance Criteria
1	Attenuation Coefficient	EIA/TIA 455-78A	$\leq 0.35\text{dB/km}$ (1310nm) $\leq 0.21\text{dB/km}$ (1550nm)
2	Point Discontinuities of Attenuation	EIA/TIA 455-59	$\leq 0.1\text{ dB}$
3	Attenuation at Water Peak	EIA/TIA-455-78A	$\leq 0.34\text{dB/km}$ at 1383nm
4	Chromatic Dispersion	EIA/TIA 455 - 168A/169A /175A	$\leq 18\text{ ps/(nm}\cdot\text{km)}$ at 1550nm
			$\leq 3.5\text{ ps/(nm}\cdot\text{km)}$ from 1288 nm to 1339nm
			$\leq 5.3\text{ ps/(nm}\cdot\text{km)}$ from 1271nm to 1360nm
			Zero Dispersion wavelength: 1300nm - 1324nm; Zero Dispersion slope: $\leq 0.092\text{ ps/nm}^2\cdot\text{km}$
5	Core - Clad Concentricity Error	EIA/TIA 455- 176	$\leq 0.5\text{ }\mu\text{m}$
6	Cladding Diameter	EIA/TIA 455-176	$125 \pm 0.7\text{ }\mu\text{m}$
7	Fibre Tensile Proof Testing	EIA/TIA 455-31B	$\geq 1.0\%$, 1 sec. $\geq 0.69\text{ Gpa}$ (100kpsi)

Note: The test report of the above tests for the fibres are to be carried out by the Fibre Manufacturer and used in the OPGW shall be shown to the inspector during OPGW FAT and shall be submitted along with the OPGW FAT reports.

FACTORY ACCEPTANCE TEST PROCEDURE FOR OPGW CABLES

APPLICABLE STANDARD IEEE 1138 :2009 / IEC 60794

Sl. No	Factory Acceptance Test on Manufactured OPGW Cable	Sampling Plan
1	Attenuation Coefficient (1310nm, 1550nm)	10% of offered OPGW drums/Lot and 100% of fibres in selected OPGW Cable drums(Minimum 2 drums).
2	Point Discontinuities of attenuation	10% of offered OPGW drums/Lot and 100% of fibres in selected OPGW Cable drums(Minimum 2 drums).
3	Visual Material verification and dimensional checks as per approved drawings	Quantity Verification: 100% of offered material.
4	Ultimate Tensile Strength	1 Sample from the selected OPGW drums/Lot.
5	Lay Length Measurements	10% of offered OPGW drums/Lot(Minimum 2 drums).

1. **Attenuation Coefficient (1310nm, 1550nm)**
2. **Point Discontinuities of attenuation**

Test Standard : IEC 60793-1-40, EIA/TIA-455-59 & EIA/T1A-455-61 and ITU-T G.652 D

Test Location :

Test Objective : To measure the optical attenuation at wavelengths 1310 nm and 1550 nm & Point discontinuities at both wavelength of 1310 nm and 1550nm.

Test Set-ups:

Prepare the sample under test as per the figure showing below the test setup. The test bench is connected with Optical Time Domain Reflectometer (OTDR) to measure the value of attenuation coefficient and Point discontinuities

Test Procedure:

1. Connect the test sample either to the instrument or to one end of end dead-zone fiber (if used). Connect the other end of the dead-zone fiber (if used) to the instrument.
2. If the accurate locations of point defects are to be recorded, the effective group delay index of the test sample is required. If this value is not known, use FOTP-60 (Method A) to determine it.
3. Enter OTDR parameters such as source wavelength, pulse duration, length range, and signal averaging into the instrument, along with the test sample effective group index. The values of some of these parameters may be present in the instrument.
4. Adjust the instrument to display a backscatter signal from the test sample. It may be advantageous to begin with coarse vertical and horizontal scaling to maximize the length displayed. An example is given in Figure.
5. Examine the OTDR signal along the test sample for point defects. If increased resolution is needed, adjust the graphical display, if possible, to expand the section of interest to larger scale (exercising care to assure that proper reading of the true signal can still be distinguished from the noise points).
6. To determine that a point defect (rather than an attenuation non-uniformity situation) exist observe the area in question using two different pulse durations. If the shape of the loss or gain changes with the pulse duration, the anomaly is a point defect. If the shape does not change, the anomaly shall be considered to be attenuation non-uniformity to be measured by **FOTP-61**.
7. Report any point defect deviations which exceed the values specified in the Detail Specification. Describe the nature of these faults (e.g. apparent loss or gain, reflection, duration, etc.) as required by the Detail Specification.
 - 7.1 Determine the defect location, if required, by placing a cursor at the beginning (or at another point specified by the OTDR manufacturer) of a power rise or drop, this may be difficult to do at a drop. Obtain the distance coordinate via the alphanumeric display.

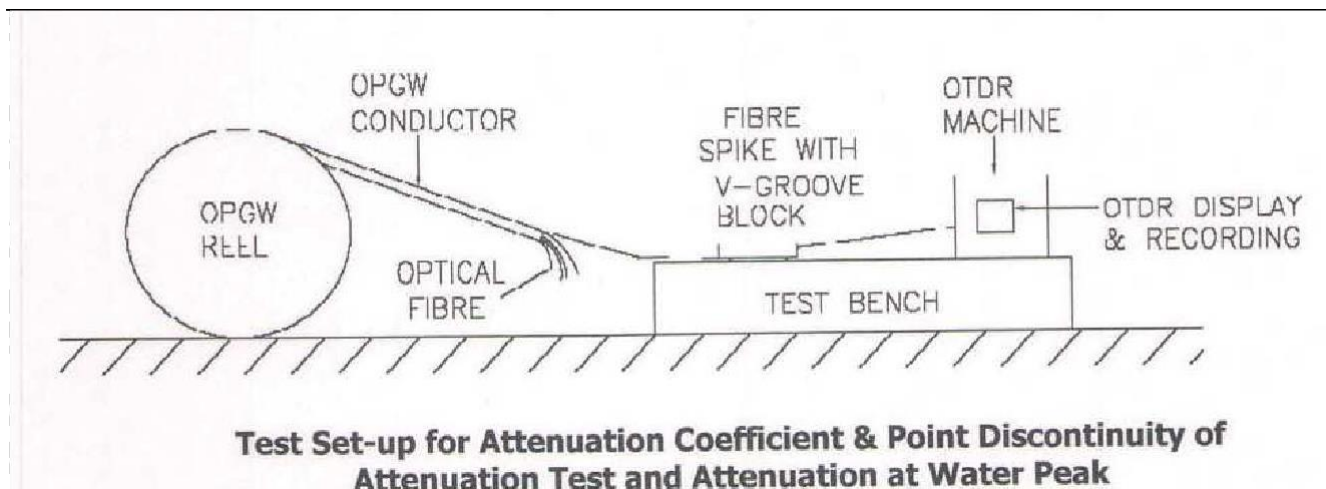
7.2 Obtain the apparent loss or gain of the defect, if required, by the method described by the OTDR manufacturer .Some instruments required placement of a pair of cursors on each

side of the defect. The two best-fit straight lines (from a two-point or least-squares fit for each) are extrapolated to the defect location. If available, the linear fit method should be chosen. The vertical separation of the lines gives the apparent loss or gain. Note any reflection peak.

- 7.3 When possible, repeat the test for a single launched into the test sample in the opposite direction. A more accurate loss estimate (and the elimination of apparent gain) is made by averaging

readings taken directionally at the same wavelength. This eliminates the effect of any backscatter different for the fiber sections on both side of the defect.

- 7.4 Repeat the test at another wavelength.



Acceptance Criteria:

For Attenuation

Wavelength	Attenuation
1310 nm	< 0.35 dB/Km
1550 nm	<0.21 dB/Km

For Point Discontinuity: Attenuation of fiber shall be uniform throughout its length such that there are no point discontinuity in excess of 0.1dB.

ATTENUATION AND POINT DISCONTINUITY

Ring Mark	Fiber id	At 1310 nm				Ring Mark	At 1550 nm			
		Optical Attenuation	Point Discontinuity	Pass or Fail	Remarks		Optical Attenuation	Point Discontinuity	Pass or Fail	Remarks

Observations, if any:

Test Results:

The attenuation and point discontinuity measured have met/not met the acceptance criteria.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

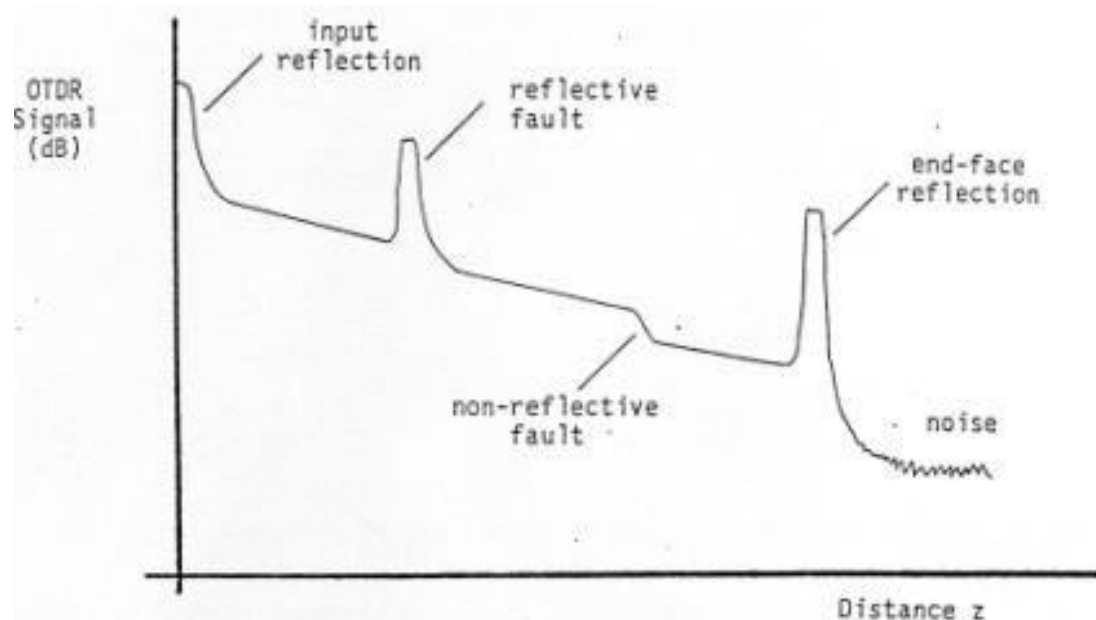


Figure 1. Schematic of an OTDR Trace. Point defects with apparent loss are shown, one reflective and one non-reflective.

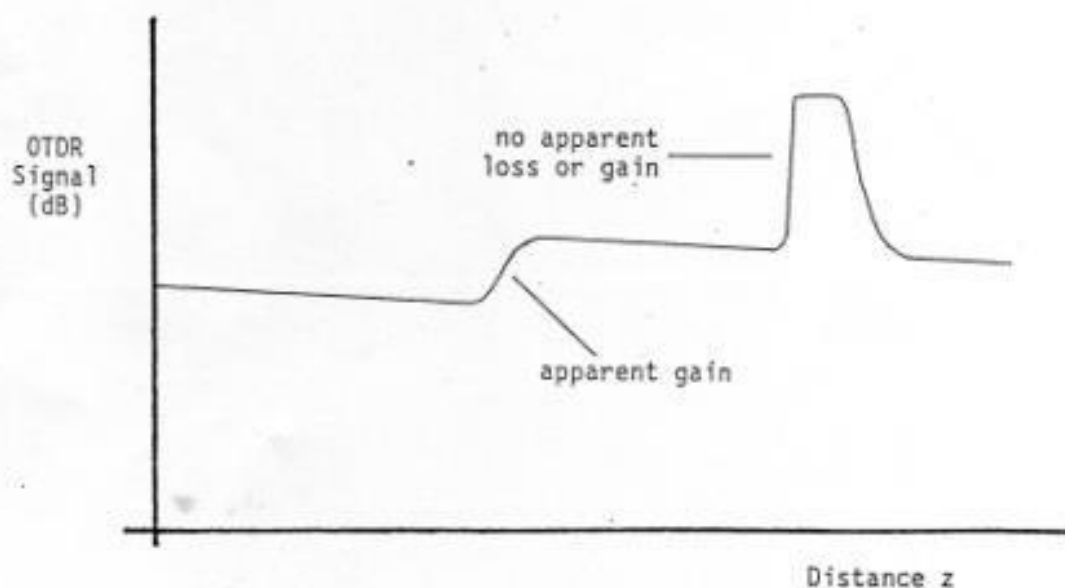


Figure 2. Schematic of an expanded OTDR trace. Two point defects are shown, one with apparent gain, and another with no apparent loss or gain.

3. VISUAL MATERIAL VERIFICATION AND DIMENSION CHECK & GENERAL TESTS

Standard : IEEE-1138:2009, IEC 61089, IEC 61232 & MFR's Technical Specification

Test Location :

Cable Type: OPGW

Reference Document Approved DRS & Drawings of OPGW.

Test Procedure:

1. Physical Verification for the 100% offered quantity of the offered reels/drums shall be carried out.
2. 100% physical verification of sealing of cable ends with end caps, check for provision of spare cable caps for each drum.
3. 100% verification of Sealing/Pasting the drum details over the end cap with transparent tape.
4. Verification of drum details properly printed and pasted on each drum suitably as per approved document.
5. Measure the overall diameter at the outside end of the complete OPGW on 10% of offered reels/drums using Caliper/Micrometer of high accuracy.
6. The diameter recorded is the average of two readings, rounded to two decimals of millimeter, taken at right angles to each other at the same location.
7. The verification of the external aspect is made by checking appearance and finish of the completed OPGW. The sequence of the metallic wires/ACS strands and the Aluminium Tubes shall be in accordance with the approved DRS & Drawings.
8. The metallic wires are removed and the diameter of each wire is measured with a micrometer using the same method as referred at point no. 5.
9. The metallic wires are individually examined by eye. All the wires shall be free from imperfections such as fissures, roughness, grooves and inclusions.
10. The Aluminium Tubes are examined by eye. All Aluminium Tubes shall be free from corroding substances, pinholes, cracks, scratches, indentations and other surface imperfections. The inner & outer diameter of each Aluminium Tube is measured with a micrometer using the same method as referred at point no. 5.

Acceptance Criteria:

Acceptance criteria shall be as per Table Test No.5 for the offered OPGW cable.

Test Results: Visual Verification, Dimensional Checks & other requirements including physical parameters/values of complete OPGW cable, Metallic wires, ACS strands, Aluminium tube and complete optical unit measured/observed have met/not met the acceptance criteria.

Test Summary: The following tests are to be checked and verified under Visual Verification, Dimensional Check Tests and General tests on OPGW Cable.

Table Test-5

Visual Verification, Dimensional & General Tests	Acceptance Criteria
A. Aluminium Clad Steel Strands/Wires:	
1. Appearance	Circular
2. Diameter of each Strand	AS PER APPROVED Cat-1 DRS
3. Elongation at Fracture	AS PER APPROVED Cat-1 DRS
4. No. of ACS Strands	AS PER APPROVED Cat-1 DRS
5. Thickness of Al coating / % IACS	AS PER APPROVED Cat-1 DRS
6. Twist Test (for ACS Strand)	AS PER APPROVED Cat-1 DRS
7. Tensile Strength	AS PER APPROVED Cat-1 DRS
8. Resistance	AS PER APPROVED Cat-1 DRS
B. Complete OPGW Cable:	
1. Appearance	Circular
2. OPGW Cable Construction	AS PER APPROVED Cat-1 DRS
3. Overall cable diameter	AS PER APPROVED Cat-1 DRS
4. Pitch ratio (length (mm)/diameter (mm))	AS PER APPROVED Cat-1 DRS
5. Weight of OPGW Cable	AS PER APPROVED Cat-1 DRS
6. Attenuation Coefficient at 1310nm and 1550nm	AS PER APPROVED Cat-1 DRS
7. Rated Tensile Strength/UTS	AS PER APPROVED Cat-1 DRS
C. General Tests on Optical Unit:	
1. Total no. of fibres, No. of fibres per buffer tube & Color coding of optical fibres in each Tube	AS PER APPROVED Cat-1 DRS
2. No. of Buffer tubes, Color of Buffer tubes, Buffer tube Material	AS PER APPROVED Cat-1 DRS
3. Aluminium tube (Outer and Inner diameter)	AS PER APPROVED Cat-1 DRS
4. Binding Yarn/Tape (Thermal barrier)	AS PER APPROVED Cat-1 DRS
5. Filling Material	AS PER APPROVED Cat-1 DRS
6. Strengthening Member (FRP)	AS PER APPROVED Cat-1 DRS

Note: Elongation at Fracture, Thickness of Al coating; Twist Test will be carried out only once.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

4. ULTIMATE TENSILE STRENGTH TEST

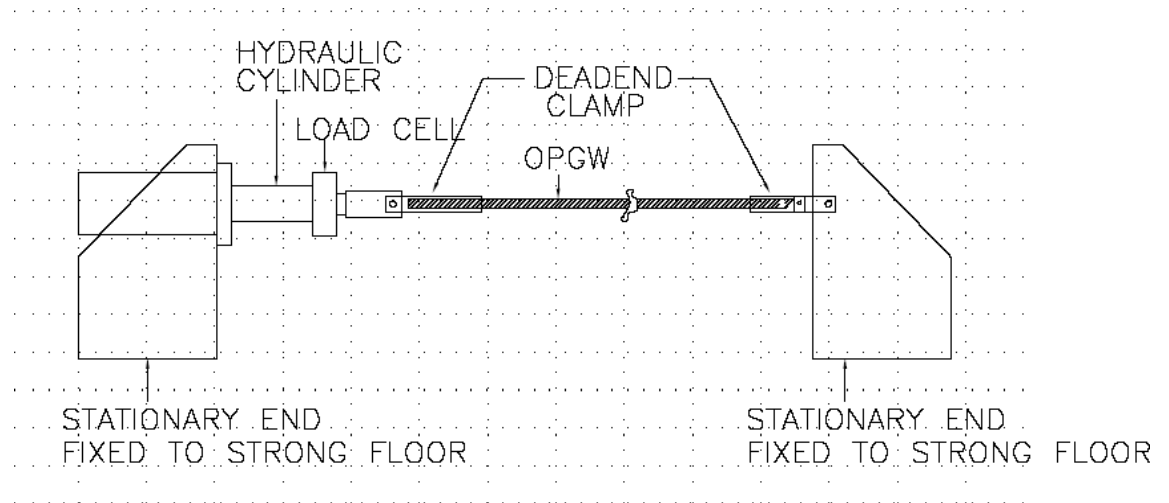
Test Standard	:	IEEE 1138:2009
Test Location	:	
Cable Type	:	OPGW
Objective	:	To verify the actual (ultimate) tensile strength of the OPGW meets or exceeds the UTS of the OPGW.

Test Set-up:

The OPGW sample shall be installed in a suitable tensile test machine. The length of the cable between the loading points of the tensile machine to be minimum 10m. Pre-tension at 2% UTS a suitable transducer such as a load cell or dynamometer shall be used to measure the tension in the cable as per figure.

Test Procedure:

1. A tension is applied to the OPGW conductor until failure of the conductor occurs. The sample cable length is 10 mtrs minimum between the dead end clamps. Pre-tension the sample to 2% UTS of OPGW.
2. The load shall be applied at a uniform rate such that the time to reach UTS of the cable is at least 5 minutes and then hold for one(1) minute at 100% UTS. Record the continue plot/graph for applied force vs elongation/displacement/time. The observations of UTS test should meet or exceed the 100% UTS of the OPGW mentioned in DRS.
3. The ultimate tensile strength of the cable shall be defined as the maximum load the cable can withstand before failure. Individual strand failures do not necessarily constitute cable failure. However, no outer layer strands shall fail below 75% of the cable UTS. This is to ensure that the outer strands will not unravel below the maximum design loading conditions



Acceptance Criteria:

The OPGW should with stand not less than 100% of the UTS without failure of any outer strands or any component of OPGW for a period of at least one minute holdup at 100% UTS.

Observations, if any:

Test Results:

The OPGW withstood/did not with stand not less than 100% of the ultimate tensile strength without failure of any outer strands or any components of OPGW for a period of at least one minute holdup at 100% UTS.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

5. LAY LENGTH MEASUREMENT

Test Standard : IEEE 1138: 2009

Test Location :

Cable Type : OPGW

Test Set-up: See figure- 3.

Lay length measurement shall be made on a Straight length of OPGW cable while under tension load.

Test Procedure:

1. Measurements are taken at stranding operations between the closing die and capstan reel.
2. Take a piece of paper (onion skin quality) which is a length greater than three times the maximum lay length specified for the OPGW under measurement.
3. Lay the paper over the OPGW and run a lead pencil over the length of the paper to obtain strand marks on the tracing paper.
4. The lay length is determined by measuring the strand marks for N strands of the OPGW cable (N number of strands in layer).
5. Repeat for total of three measurements and average the measurements to determine lay length.

Acceptance Criteria:

Cable Type	Lay Length
OPGW	10 to 16 * OPGW outside Diameter

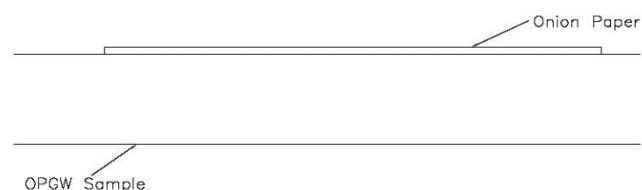


Figure 3 – TEST SET-UP for Lay Length Measurement Test

Test Results:

The lay length measurement for OPGW cable shall be between 10 to 16 times OPGW outside diameter.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

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4. Mechanical Strength Test on Each Component
5. Galvanizing Test

II. Tension Assembly- for Dead End; for Pass Through; for Splicing location and Tension Assembly for Suspension Tower(Yoke Plate type)

1. Visual Material verification and dimensional checks as per approved DRS/Drawings
2. Clamp Slip Strength Test
3. Mechanical strength Test on Each Component
4. Galvanizing Test

III. Structure Mounting Clamp (Down Lead Clamp) & (Earth Lead Assembly)

1. Clamp Fit Test
2. Clamp Strength Test
3. Visual Material verification and dimensional checks as per approved DRS & Drawings
4. Galvanizing Test

VI. In Line Splice Enclosures (Joint Box) & FODP

1. Visual Material verification and Specific component number & dimensional checks

- Reference Documents:**
- 1) Approved DRS & Drawings in Category-I
 - 2) Applicable Standards - IEC 61284, 1997

SAMPLE SIZE AND CRITERIA FOR CONFORMITY as per IS:2486

1. SAMPLING

1.1 LOT

All fittings of same type and design manufactured under similar conditions of production, offered for acceptance. A Lot may consist of the whole or part of the quantity offered for FAT.

1.2

The number of fittings to be selected at random from the lot shall be in accordance with column I and col II of Table 1. If required {Point no. 2 Conformity) additional fittings as given in col III of Table 1 shall also be selected at random. In order to ensure the randomness of selection, random number tables shall be used (see IS 4905 : 1968).

2. CONFORMITY

Each of the fittings selected in the first stage in accordance with column I and column II of Table 1 shall be subjected to all acceptance tests. A fitting shall be declared defective if it fails in any of these tests. The lot shall be, considered as conforming to the requirements of acceptance tests if the number of defectives, in the sample is less than or equal to corresponding acceptance number (see column IV). The lot shall be rejected if the number of defectives is equal to or greater than first rejection, 'R1' (see column V). If the number of defective fittings are in between 'A' and 'R1', a second sample of same size (see column III) shall be selected from the lot at random and subjected to the tests. If the number of defectives in the two samples combined is less than 'R2' (see column VI), the lot shall be considered as conforming to the requirements of acceptance tests, otherwise the lot shall be rejected.

Table 1: Sampling Procedure (IS 2486)

S.No.	Lot Size	Sample Size		A	R1	R2
		I - Stage	II - Stage			
	(I)	(II)	(III)	(IV)	(V)	(VI)
1.	101 to 500	5	5	0	2	2
2.	501 to 1000	8	8	0	2	2
3.	1001 to 3000	13	13	0	2	2
4.	3001 to 10000	20	20	0	3	4
5.	10001 to 35000	32	32	1	4	5
6.	35001 and above	50	50	2	5	7

**VISUAL MATERIAL VERIFICATION AND DIMENSIONAL CHECKS FOR
HARDWARE FITTINGS OF OPGW CABLE
(Suspension Assembly, All types of Tension Assemblies & Downlead Assembly)**

Document : IEC 61284:1997, Approved DRS & Drawings

Manufacturer :

Test Location :

Test Sample : 100% of Quantity

- Suspension Assembly
- All types of Tension Assemblies- Dead End; Pass through; Splicing Location & Tension Assembly for Suspension Tower
- Parallel Groove clamp & Earth Lead Assembly/Grounding wire
- Vibration Dampers
- Downlead clamp Assembly

Objective : This test determines the factory acceptance of the batch quantity of fittings that they confirm to the relevant drawings and where appropriate/ have a sufficient galvanized coating.

Test Procedure:

1. Physical/Visual Verification for the part no. of all the materials as per approved DRS& drawings.
2. It shall be verified that the sample are in accordance with their relevant drawings, particularly as regards any dimensions to which special tolerance apply and indicated in the corresponding approved DRS/Drawings.
3. The following tolerance shall be allowed/on all dimensions to which special tolerance do not apply.

Appearance: To check all and ascertain to be appropriate as per DRS & Drawings.

Dimensions: (A) Forgings:

- i) Dimensions up to and including 30mm ± 1.5 mm.
- ii) Dimensions greater than 30 mm..... $\pm 5\%$ upto max. of ± 5 mm.

(B) Helical Fittings:

- i) Dimensions up to and including 30mm ± 1.5 mm.
- ii) Dimensions greater than 30 mm..... $\pm 5\%$ upto max. of ± 5 mm.

Galvanizing: i) Galvanized coatings shall be tested in accordance with as appropriate.

ii) All measurements shall be made after galvanizing where galvanizing is the normal finish. Galvanized coatings shall be tested and galvanized coating shall be minimum 85µm.

Acceptance Criteria:

Fittings shall be accordance with their relevant drawings within the tolerance Specified.
Galvanized coatings on general articles shall be minimum thickness of 85µm.

Observation, if any;

Test Results: The Hardware fittings, as tested met / did not meet the requirement as per approved DRS & Drawings.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

CLAMP SLIP STRENGTH TEST FOR SUSPENSION ASSEMBLY

Test location :

Manufacturer :

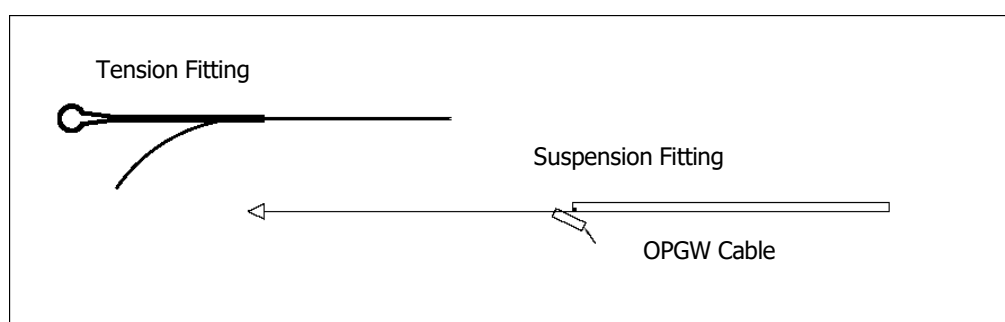
Test Standard : Overhead lines. Requirements and Test for fittings, IEC 61284 11.4.2 (method A) Slip Test on standard dampers with a specified minimum and maximum slip load and Manufacturer's Technical Specification.

Test Sample : OPGW Cable
Suspension Assembly

} As per approved DRS/Drawings

Objective: To simulate a differential load on the Suspension clamp assembly and prove that the load at which the cable slips through, is within the specified minimum and maximum slip load.

Test Set-up: The below figure shows the schematic of the test configuration. The OPGW used for this test shall be type approved by Power Grid.



Paint/Red marking should be applied to the assembly to assist in the visual inspection of relative movement.

The OPGW is assembled between the extremities of the hydraulic ram and subject to a tension load of 20% of the Ultimate Tensile Strength.

All Suspension Clamp and their associated components shall be identified against the relevant drawing and be uniquely marked for any future identification.

All results shall be automatically recorded on a plotter using 200mm horizontal Position scale and a 20kN vertical Load scale.

The following dimensions shall be recorded before the start of each test using a diameter tape or other suitable means:

- Cable diameter at the center position of initial Clamp placement.
- Protection Splice diameter at the center position of initial Clamp placement.

Assemble the Suspension Clamp on the OPGW using the Installation Instructions as a strict guide to ensure that the assembly is correctly fitted and is the same that will be carried out during actual installation.

Reduce the load applied to the OPGW to zero and detach the OPGW from the fixed end of the tension machine. Attach the Clamp to the fixed extremity mounting and secure with the approved bolt and nut, which must run down finger tight only to clear the split pin hole.

Test procedure:

1. A graph of Load (kN) and position(mm) shall be plotted.
2. The OPGW is loaded 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 Reinforcement rods, Armour rods and Suspension clamp were marked. The relative positions of the helical armour rods and associated reinforcing rods at each end were marked and also 2mm relative position between clamp body and armour rods was marked on one side.
3. The load is increased to the minimum slip window of 12 kN(Check for Minimum Slip Strength value for fitting in DRS) at a rate of 3 kN per minute and held constant for 60 seconds. At the end of this one minute, the relative displacement between clamp body and the armour rods will be observed. If the slippage is 2mm or above, the test shall be terminated. Otherwise at the end of the position of the clamp body and 2mm relative position between clamp body and armour rods are marked on the other side.
4. After 1 minute, pause, the load is further increased at a rate of 3 kN per minute until either the relative position between clamp body and armour rods reaches more than 2mm or the load reaches the maximum slip load of 17 kN(Check for Maximum Slip Strength value for fitting in DRS). Visual examination of all paint marks is recorded, and a measurement of any displacement recorded in the table of results.

On completion of the test, a graph of 'Load' (kN) against 'Position' (mm) shall be produced. This graph shall form the test record and will be examined to ascertain the point that slip has occurred.

Acceptance Criteria:

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

1. No slippage* shall occur at or below the specified slip load of 12 kN(check Minimum Slip Strength value for fitting in DRS).
2. Slippage shall occur between the specified min. and maximum slip load of 12-17 kN (or as per Minimum & Maximum Slip strength value in DRS).
3. There shall be no slippage of the reinforcing rods over the cable, and no slippage of the armour rods over the reinforcing rods.

4. The relative movement (i.e. more than 2 mm between armour rods and clamp body) between minimum slip strength (as per DRS), 12 KN and maximum slip strength (as per DRS), 17 KN shall be considered as slip.

5. The armour rods shall not be displaced from their original lay or damaged **.

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

** 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 shall constitute a failure.

For each sample tested there shall be Graphical records of Slip Load against Position Displacement Identification List of all components against relevant drawings Measurement of OPGW diameter.

Observation, if any;

Test Results: The Suspension Assembly, as tested, met / did not meet the requirement specified in technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

Mechanical Strength Test for Suspension Assembly

Manufacturer :

Test Location :

Test Standard : MFR's Technical Specification, IEC61284:1997

Test Sample : OPGW Cable
Suspension Assembly } As per approved DRS/Drawings

Objective: To determine the mechanical strength performance of the suspension assembly fitting for the OPGW.

Test Set-up:

The Items to be tested are installed into the hydraulic test machine and secured. The components being tested will be labeled to be exactly the same as the corresponding drawing in order to make identification clear.

The general arrangement for the Test Set-up is shown in Figure 1.

The Armour Rods and Protection Splice are assembled on to the approved OPGW using the Installation instructions as a strict guide to ensure that the assembly is correctly fitted and is the same that will be carried out during actual installation. The assembly shall be mounted in the hydraulic tensile test machine, with the Suspension Assembly suspended by the associated Clevis Eye in their normal working position. Suitable facilities to avoid bird-caging (twist) of the OPGW when tensioned shall also be provided.

Note: Care shall be taken to ensure that during the installation of the test fitting that the OPGW strands remain tight.

Test Procedure:

Part 1:

1. The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified Minimum Failure Load as per DRS (MFL) increased and held for one minute for the test rig to stabilize.
2. The load shall then be increased at a steady rate 67% of minimum failure load and held for 5 minutes. The angle between the cable, the suspension assembly and the horizontal shall not exceed 16°.
3. This load shall then be removed in a controlled manner and the protection splice disassembled.

-
4. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:

1. 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 stabilize.
2. The load shall be further increased at a steady rate until the specified minimum failure load is reached and held for one minute.
3. The applied load shall then be increased until the failing load is reached and value shall be documented.

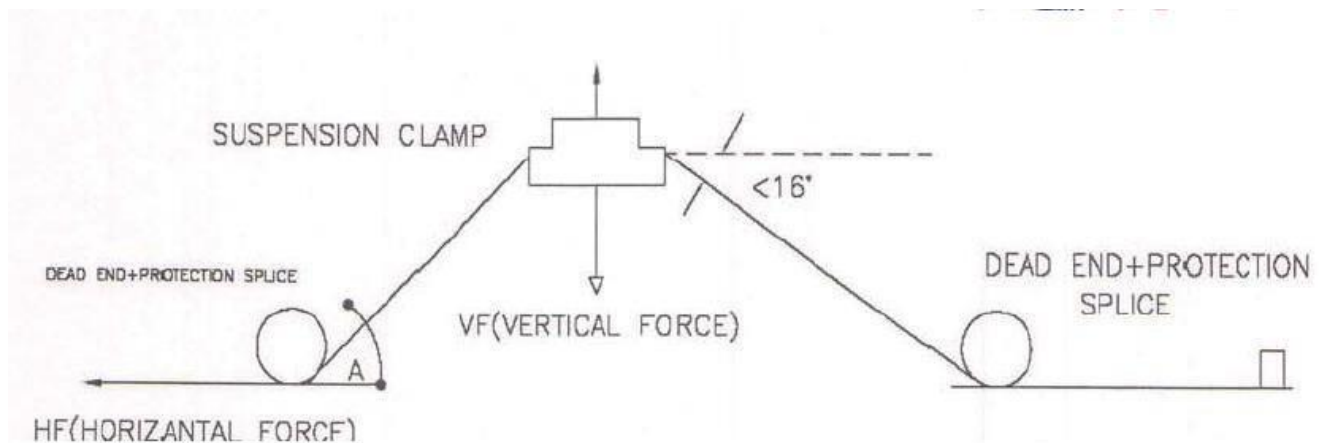


Figure 1: Test set up for mechanical strength test for suspension assembly

Acceptance Criteria:

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

- i) No evidence of Binding of the Nuts or Deformation of components at the end of Part 1 of test.
- ii) No evidence of Fracture up to 1 minute at Minimum Failure Load during Part 2 of the Test.
- iii) Any result outside these parameters shall constitute a failure.

Suspension clamp Shackle: Ultimate Strength (minimum) of fitting: as per approved DRS.

For each sample tested there shall be:-

Part 1:

Identification list of all components against relevant drawings and confirmation that the components meet the declared dimensions. Record of physical examination, specifically commenting on evidence of Binding of the Nuts, and deformation of the Suspension assembly components.

Part 2:

Confirmation record that the Clamp sustained a MFL load for one minute without fracture.
Recorded value of breaking load.

Identification of components against relevant drawing numbers:

Drawing Number	Issue	Description

Table of Suspension Assembly examination:

Sample Number	Part 1		Part 2	
	Possible to disassemble Assbly (Yes/No)	Comment on condition of components	Ass. sustained MFL for 1 minute (Yes/No)	Breaking Load (KN)
1				
2				
3				
4				
5				

Observations, if any:

Test Results: The Suspension Assembly, as tested, met/did not meet the requirement specified in the technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

**MECHANICAL STRENGTH TEST ON EACH COMPONENT OF SUSPENSION ASSEMBLY
&
MECHANICAL STRENGTH TEST ON ALL TYPES OF TENSION ASSEMBLIES
i.e. Dead End or Pass through or Splicing Location or Tension fitting for Suspension
Tower (Yoke plate)**

Manufacturer :

Test Location :

Test Standard : IEC 61284: 1997

Test Sample : OPGW

Tension Assembly
or each component of Suspension
Assembly



As per approved
DRS & Drawings

Objective: To assess the Mechanical strength (Failing Load) test on each component of All types of Tension Assemblies.

TEST SET-UP

The Tension assembly is correctly fitted and is the same that will be carried out during installation.

TEST PROCEDURE

Each component of the Tension/Suspension assembly shall be fixed with suitable fixing arrangement with the test machine. The load shall be increased steadily up to their specified tensile strength and held for one minute. The load shall then be increased up to the breaking of the component.

Acceptance Criteria:

1. No evidence of the fracture after one minute at nominated rated load.
2. The Mechanical strength (failing load) shall not be less than the specified rated requirement of load for all components.
3. Any result outside these parameters shall constitute a failure.

In case of Tension fitting on Suspension Tower(Yoke Plate Type), the mechanical strength test is performed upto Failure Load/ breaking strength of Yoke Plate (as per value mentioned in DRS for Yoke Plate) during this Test. Additionally, the breaking strength of Yoke Plate should be more than the UTS of OPGW. Any evidence of fracture or deformation at the end of one minute at the minimum failure load/ breaking strength of

Yoke Plate shall be considered as failure. Any result outside these parameters shall also constitute a failure.

Observation, if any;

Test Results: Each component of tension assembly, as tested, met/did not meet the requirement specified in technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

CLAMP SLIP STRENGTH TEST ON ALL TYPES OF TENSION ASSEMBLIES

i.e. Dead End or Pass through or Splicing Location or
Tension fitting for Suspension Tower (Yoke plate)

Manufacturer :

Test location :

Test Standard : IEC 61284-
1997

Test Sample OPGW

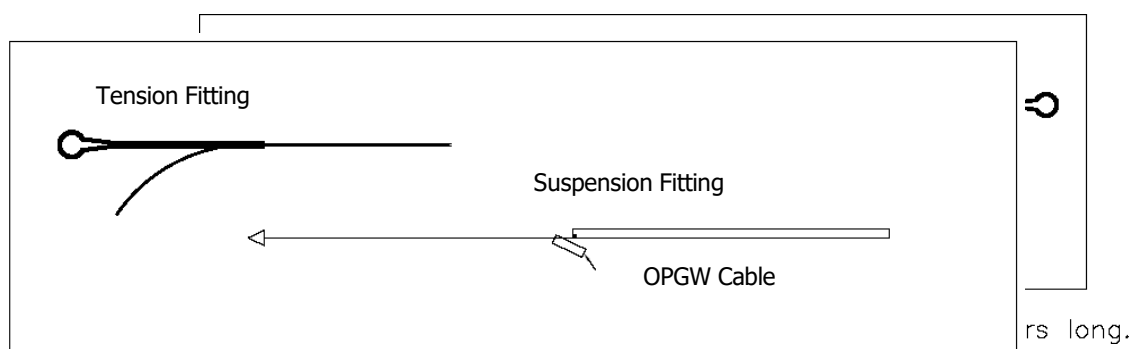
Cable Tension

Assembly

} As per approved DRS/Drawings

Objective : To determine the clamp slip strength for the various types of tension assemblies proposed for the OPGW cable.

Test Set-up: The general arrangement for the Slip Strength Test of the Tension Assemblies is shown below



The Tension Assembly and associated components shall be identified against the relevant drawing and be uniquely marked for any future identification

The set-up for the slip strength for tension clamp is shown in Figure-2.

The tension assembly shall be fitted on a more than 8 m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile machine and anchored in a manner similar to the arrangement to be used in service.

The Reinforcing Rods and Tension Assembly fitting is assembled on the OPGW using the Installation Instruction as a strict guide to ensure that the assembly is correctly fitted and is the same that will be carried out during actual installation. The assembly shall be mounted in the hydraulic tensile test machine, with suitable facilities to avoid bird caging (twist) of the OPGW when tensioned.

Note: Care shall be taken to ensure that during the installation of the test fittings the OPGW strands remain tight.

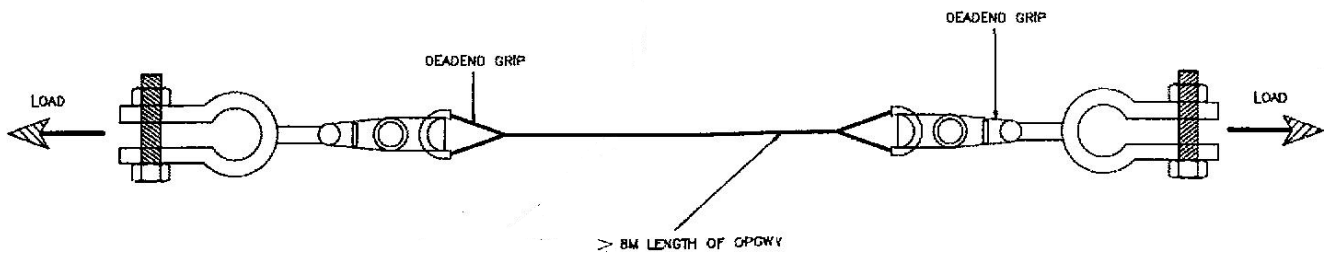


Figure 2: Schematic of slip strength test for tension assembly

Test Procedure:

A tension load shall gradually be applied up to 20% of the Ultimate Tensile Strength of the OPGW Cable.

1. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the reinforcing rods and the tension Dead-End relative to the reinforcing rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip.
2. The load shall gradually be increased at a rate of 6 kN per minute until it reaches 50% of the specified UTS and the Position scale of the recorder is 'zeroed'.
3. The load shall gradually be increased at a rate of 6 kN per minute until it reaches 95% of the specified UTS and maintained for one minute.
4. After 1 minute pause, the load shall slowly be released to zero and the markings examined and measured for any relative movement.
5. On completion of the test a graph of Load (kN) against Position' (mm) shall be produced for each of the two measurements. This graph shall form the test record and will be examined to ascertain the degree of any movement.

Acceptance Criteria:

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

No movement* shall, occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Tension assembly.

No failure or damage or disturbance to the lay of the Tension Clamp, 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 OPGW as a result of the test itself are not regarded as slippage.

Any result outside these parameters shall constitute a failure.

Test Results:

The Tension Assembly, as-tested, met / did not meet the requirement specified in technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

STRUCTURE MOUNTING CLAMP STRENGTH TEST
(For Downlead Assembly)

Lab Location :
Manufacturer :
Test Standard : Technical Specification
Test Sample: OPGW Cable } As per approved DRS & Drawings
Down lead clamp }

Objective: To demonstrate the ability of the down lead bracket assembly to withstand a specified load.

Test Set-up:

The clamp and mounting assembly shall be assembled on a vertical 200mm x 200mm angle and a short length of fiber optic cable installed as shown in Figure 3.

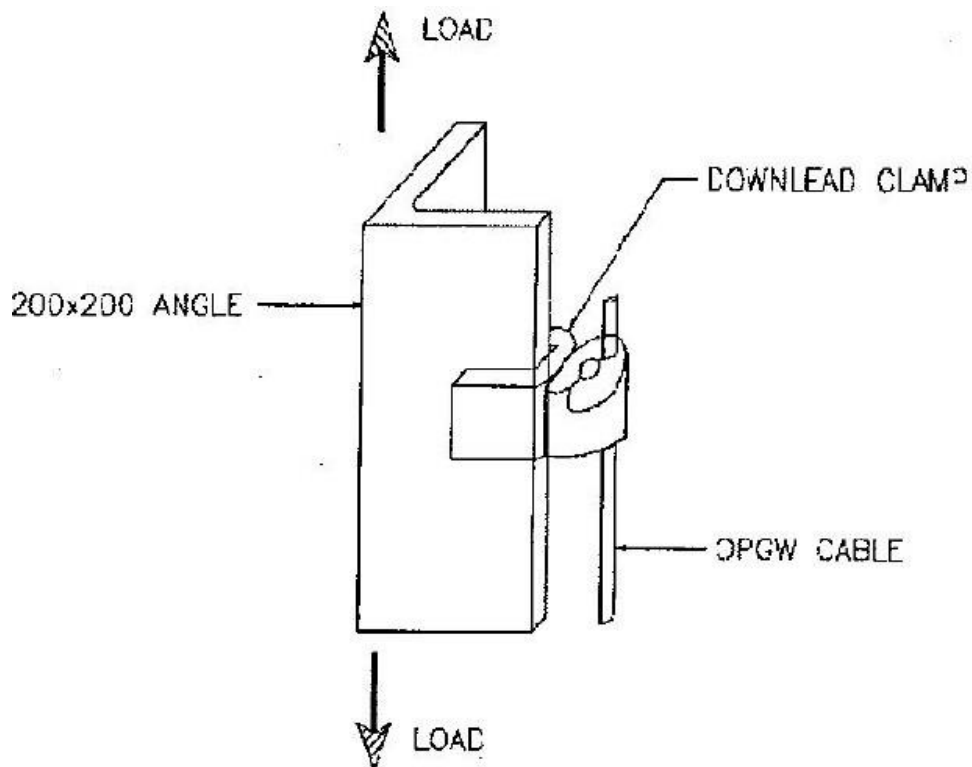


Figure 3: Schematic of structure mounting clamp strength test

Test Procedure:

1. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes.
2. The markings on the structure Down Lead Clamp and OPGW are examined for any signs of visible distortion, slipping or breaking of any components.
3. The load shall be increased to 400 kg and held for 30 seconds.
4. The load is then removed and the markings on the structure, Down Lead Clamp and OPGW are examined for any signs of visible distortion, slipping or breaking of any components.

Acceptance Criteria:

The down lead clamp has passed the test if the following conditions are met. No visible evidence of distortion / slipping or breaking of any components. Any result outside these parameters shall constitute a failure.

Observation, if any:**Test Results:**

S/N	Load (kg)	Description	Comment
1	400		
2	400		
3	400		
4	400		
5	400		

The Structure mounting Clamps for OPGW tested, met / did not meet the requirement specified in technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

STRUCTURE MOUNTING CLAMP FIT TEST

Lab Location :

Manufacturer :

Test Standard : Technical Specification

Test Sample: OPGW

Down lead clamp

} As per approved DRS & Drawings

Objective: To demonstrate the ability of the down lead assembly to withstand a specified load.

Test Set-up:

For structure mounting clamp, fit test shall be conducted with two OPGW cables installed.

Test Procedure:

Structure mounting clamp shall be installed including clamping compound as required on the OPGW cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 40Nm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the OPGW cable and examine all its components for distortion, crushing or breaking. Also the OPGW cable shall be checked to ensure free movement within the core to measure the diameter of the core tube.

Acceptance Criteria:

1. If any visible distortion, crushing, cracking or breaking of the core tube is observed, the test will be defined as a failed.
2. 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, the test will be defined as a failed.

Observations, if any

Test Results: The Structure mounting Clamps Fit tested, met/did not meet the requirement specified in technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

**VISUAL/PHYSICAL VERIFICATION OF QUANTITIES AND SPECIFIC COMPONENT NUMBER
FOR EACH COMPONENT OF SPLICE ENCLOSURES (JOINT BOX) & FODP AND
DIMENSIONAL CHECKS AGAINST THE APPROVED DRAWINGS**

Test location:

Manufacturer:

Test Sample: SPLICE ENCLOSURES (Joint Box)

FODP

(As per approved DRS & Drawings)

Objective: This test confirms the appearance, Quantity and Dimension for Splice Enclosures & FODP for conformance to the relevant DRS/Drawings.

Test set-up:

It shall be verified that the sample are in accordance with their relevant drawings.

The following tolerance shall be allowed on all dimensions to which special tolerance do not apply.

SAMPLING: 100% of Items in the Lot

Dimensions:

The following tolerance shall be allowed on all dimensions to which special tolerances do not apply (i.e.) where tolerances are not indicated in the approved DRS/Drawings.

Dimensions greater than 30 mm $\pm$ 5% up to a max. of $\pm$ 5 mm.

Visual & Quantity: To check the items in Lot & all found to be ok as per approved DRS & Drawings and the following.

No. of splice Trays

No. of holes for cable entry/ diameter of

holes IP Protection Class

Color shade

Specific Component Number

Acceptance Criteria:

Appearance should have no defect. All quantities should be correct.

Specific component number of each component shall be as per approved DRS/Drawings.

Dimensions shall be in accordance with their drawings with the tolerances specified.

Observations, if any:

Test Results : The Splice enclosure/FODP as tested met / did not meet the requirement specified.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

VISUAL MATERIAL VERIFICATION AND DIMENSIONAL CHECKS FOR VIBRATION DAMPER

Test Location:

Manufacturer:

Test Standard: IEC61284:1997, Approved DRS/Drawings in cat-I

Test Sample: Vibration Damper & associated hardware fittings

Objective : This test determines the factory acceptance of the batch quantity of fittings that they confirm to the relevant drawings and where appropriate/ have a sufficient galvanized coating.

Test Procedure:

1. Physical/Visual Verification for the part no. of all the materials as per approved DRS & drawings.
2. It shall be verified that the sample are in accordance with their relevant drawings, particularly as regards any dimensions to which special tolerance apply and indicated in the corresponding approved DRS/Drawings.
3. The following tolerance shall be allowed/on all dimensions to which special tolerance do not apply.

Appearance: To check all and ascertain to be appropriate as per DRS & Drawings.

Dimensions:

(A) Forgings:

- i) Dimensions up to and including 30mm..... $\pm 1.5\text{mm}$.
- ii) Dimensions greater than 30 mm..... $\pm 5\%$ upto max. of $\pm 5\text{ mm}$.

(B) Helical Fittings:

- i) Dimensions up to and including 30mm..... $\pm 1.5\text{mm}$.
- ii) Dimensions greater than 30 mm..... $\pm 5\%$ upto max. of $\pm 5\text{ mm}$.

Galvanizing (Vibration dampers, all nuts & bolts components as per approved DRS & Drawings):

- i) Galvanized coatings shall be tested in accordance with as appropriate.
- ii) All measurements shall be made after galvanizing where galvanizing is the normal finish. Galvanized coatings shall be tested and galvanized coating shall be minimum 85µm.

Acceptance Criteria:

Fittings shall be accordance with their relevant drawings within the tolerance Specified.
Galvanized coatings on general articles shall be minimum thickness of 85µm.

Observation, if any;

Test Results: The Hardware fittings, as tested met / did not meet the requirement as per approved DRS & Drawings.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

GALVANISING TEST FOR VIBRATION DAMPER

Test Location:

Manufacturer:

Test Sample : 4D-20 Stockbridge Type Vibration
Dampers (Messenger Cable, Damper Weights & Clamp
Body)

Test Procedure:

One strand of each of the fittings is subjected to a gravimetric test to determine the coating mass of the galvanizing.

Acceptance Criteria: The minimum coating mass as determined by the above method shall be greater than 85µm.

Test Results:

Damper No.	Coating Mass (µm)

The vibration dampers and its associated hardware fittings, as tested met /did not meet the requirement specified in the technical specification.

Observations, if any:

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

CLAMP SLIP TEST OF THE VIBRATION DAMPER

Test Location:

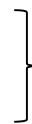
Manufacturer:

Test Standard: Technical Specification, IEC61897:1999

Test Sample: Vibration Damper

As per approved DRS/Drawings

OPGW Cable



Objective: To demonstrate the ability of the vibration damper grip the conductor.

Test set up:

The test shall be performed using the conductor for which the clamp is intended. The conductor shall be “as new” (free of deterioration or damage). The minimum free length of test conductor between its terminating fittings shall be 2 meters. The conductor can be tensioned to 20% of its Ultimate tensile strength (the conductor is free that is accepted). Precautions shall be taken to avoid bird caging of the conductor.

The clamp shall be installed in accordance with their recommended instructions on a different portion of the conductor for each test.

Test Procedure:

The load shall be gradually increased (no faster than 100 N/s) until it reaches 2.5kN (specified minimum slip load). This load shall be kept constant for 60 seconds. Then the load value shall be gradually increased until slippage of the clamp occurs. The value of slip load shall be recorded.

Clamp slip shall be considered as having occurred when a slip distance of 1mm is measured.

Acceptance Criteria:

- 1) No movement of the clamp relative to the conductor greater than 1mm shall occur at or before the end of application of 2.5kN for 60 seconds.
- 2) Surface flattening of the outer strands of the conductor is acceptable.

Observation, if any;

Test Results: The vibration damper tested, met / did not meet the requirement specified in technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

VIBRATION DAMPER RESPONSE (RESONANT FREQUENCIES) TEST AND DYNAMIC CHARACTERISTIC TEST

Test Location:

Manufacturer:

Test Sample: Vibration Damper (As per approved DRS/Drawings)

Objective: To analyze the vibration damper response at Resonant frequencies

Test procedure

The damper was 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 was 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.

- (a) Force Vs frequency
- (b) Phase angle Vs frequency
- (c) Power dissipation Vs frequency

Acceptance criteria:

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies were 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.

- 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:
 $V.D \text{ for OPGW} - 0.060 f \text{ to } 0.357 f \text{ kgf/mm}^*$
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. 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.

Observations, if any:

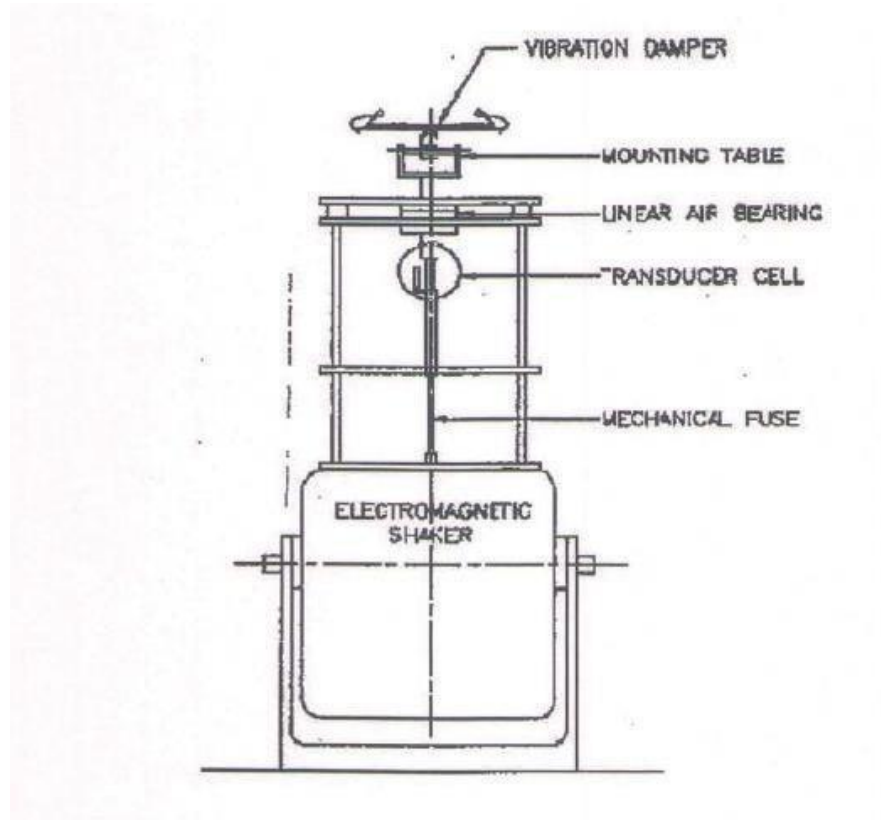


Fig.1 Schematic of Vibration Damper Characteristics

Test Results: The Vibration Damper has met/ did not meet the acceptance criteria for Vibration Damper response at resonant frequencies.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

STRENGTH OF MESSENGER WIRE TEST FOR VIBRATION DAMPER

Test Location:

Manufacturer:

Test Sample : Messenger Cable (As per approved DRS & Drawings)

Objective: To determine the strength of the damper messenger

wire. **Test Procedure:**

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

Acceptance Criteria: The minimum tensile stress of the messenger cable shall be 42 KN

Test Results:

Sample r No.	Tested up to Rated Strength /UTS (KN)	Acceptance Criteria	Pass/Fail
		No Deformation/Breakage	
		No Deformation/Breakage	
		No Deformation/Breakage	

The above as tested met / did not meet the requirement specified in technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

ATTACHMENTS OF WEIGHTS TO MESSENGER CABLE

Test Location:

Manufacturer:

Test Standard: Technical Specification, IEC61897:1999

Test Sample: Vibration Damper (As per approved DRS/Drawings)

Objective: To demonstrate the ability of the weight grips the messenger.

Test Procedure:

On an assembled damper a tensile load shall be applied between the weights coaxial with the messenger cable. The load shall be gradually increased (100N/s maximum) until it reaches 5kN (or specified minimum slip load as per DRS). This load shall be constant for 60 seconds.

The load shall be increased slowly until one weight has been pulled free of the messenger cable. The maximum load obtained during this process shall be recorded, for information purposes only.

Acceptance Criteria:

No relative movement greater than 1 mm between each weight and the messenger cable shall occur at or before the end of the application of 5kN(or specified minimum slip load as per DRS) for 60 seconds.

Observation, if any;

Test Results:

Damper No.	Tensile Strength (KN)	Breaking Stress (KN/mm ²)

The vibration damper tested, met / did not meet the requirement specified in technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

ATTACHMENTS OF CLAMP TO MESSENGER CABLE

Test Location:

Manufacturer:

Test Standard : Technical Specification, IEC61897:1999

Test Sample : Vibration Damper As per approved DRS/Drawings

Objective : To demonstrate the ability of the clamp grips the messenger.

Test Procedure:

On an assembled damper a tensile load shall be applied between messenger cable and the clamp body, coaxial with the messenger cable. The load shall be gradually increased (100N/s maximum) until it reaches 1.5kN (or specified minimum slip load as per DRS). This load shall be constant for 60 seconds.

The load shall be increased slowly until the clamp has been pulled free of the messenger cable. The maximum load obtained during this process shall be recorded, for information purposes only.

Acceptance Criteria:

No relative movement greater than 1 mm between the clamp relative to the messenger cable shall occur at or before the end of the application of 1.5kN(or specified minimum slip load as per DRS) for 60 seconds.

Observation, if any;

Test Results:

Damper No.	Tensile Strength (KN)	Breaking Stress (KN/mm ²)

The vibration damper tested, met / did not meet the requirement specified in technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

CLAMP BOLT TIGHTENING AND TORQUE TEST

Test Location:

Manufacturer:

Test Standard: Technical Specification, IEC61897:1999

Test Sample : Vibration Damper (As per approved DRS/Drawings)

Objective : To demonstrate the ability of the tighten bolt.

Test set up:

The test shall be performed by installing the clamp on a length of conductor for which the damper is intended.

Test procedure:

The bolts or nuts shall be tightened to a torque 10% above the specified installation torque. Lastly, the torque should be increased to either twice the specified installation value or the maximum torque value recommended by the bolt supplier whichever is lower.

Acceptance Criteria:

- 1) The threaded connection shall remain serviceable for any number of subsequent installations or removals and components of the clamp shall be undamaged.
- 2) No unacceptable damage shall occur to the conductor inside the clamp. (Unacceptable damage shall be agreed between the purchaser and supplier)
- 3) The increase to either twice should not result in any breakage of threaded parts or other components.

Observation, if any;

Test Results:

Damper No.	1.1 times torque Comment on condition of components	2 times torque Comment on condition of components

The vibration damper tested, met / did not meet the requirement specified in technical specification.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

FACTORY ACCEPTANCE TEST PROCEDURE FOR OPTICAL FIBRE (ITU-T G.652D)
APPLICABLE STANDARD EIA/TIA 455

Sl. No.	Test Name	Test Procedure	Acceptance Criteria
1	Attenuation Coefficient	EIA/TIA 455-78A	$\leq 0.35\text{dB/km}$ (1310nm) $\leq 0.21\text{dB/km}$ (1550nm)
2	Point Discontinuities of Attenuation	EIA/TIA 455-59	$\leq 0.1\text{ dB}$
3	Attenuation at Water Peak	EIA/TIA-455-78A	$\leq 0.34\text{dB/km}$ at 1383nm
4	Chromatic Dispersion	EIA/TIA 455 -168A/169A /175A	$\leq 18\text{ ps}/(\text{nm}\cdot\text{km})$ at 1550nm
			$\leq 3.5\text{ ps}/(\text{nm}\cdot\text{km})$ from 1288 nm to 1339nm
			$\leq 5.3\text{ ps}/(\text{nm}\cdot\text{km})$ from 1271nm to 1360nm
			Zero Dispersion wavelength: 1300nm - 1324nm; Zero Dispersion slope: $\leq 0.092\text{ ps}/\text{nm}^2.\text{km}$
5	Core - Clad Concentricity Error	EIA/TIA 455- 176	$\leq 0.5\text{ }\mu\text{m}$
6	Cladding Diameter	EIA/TIA 455-176	$125 \pm 0.7\text{ }\mu\text{m}$
7	Fibre Tensile Proof Testing	EIA/TIA 455-31B	$\geq 1.0\%$, 1 sec. $\geq 0.69\text{ Gpa}$ (100kpsi)

Note: The test report of the above tests for the fibres are to be carried out by the Fibre Manufacturer and used in the Approach cable shall be shown to the inspector during Approach cable FAT and shall be submitted along with the Approach cable FAT reports.

**FACTORY ACCEPTANCE TEST PROCEDURE
FOR APPROACH CABLES**

Sl. No.	Factory Acceptance Test	Sampling plan
1	Attenuation Coefficient at 1310nm,1550nm	10% of offered FO approach cable drums/lot and 100% of fibers in selected FO approach cable drums.(Minimum 2)
2	Point discontinuities	10% of offered FO approach cable drums/lot and 100% of fibers in selected FO approach cable drums. (Minimum 2)
3	Visual material verification and dimensional checks as per approved DRS & drawings	Quantity verification: 100% of offered material.

1. Attenuation Coefficient at 1310nm & 1550nm and Point Discontinuities

Test Standard : IEC 60793-1-40, EIA/TIA-455-59 & EIA/T1A-455-61 and ITU-T G.652 D

Test Location :

Manufacturer :

Test Objective : To measure the optical attenuation at wavelengths 1310 nm and 1550 nm & Point discontinuities at both wavelength of 1310 nm and 1550nm.

Test Set-ups:

Prepare the sample under test as per the figure showing below the test setup. The test bench is connected with Optical Time Domain Reflectometer (OTDR) to measure the value of attenuation coefficient and Point discontinuities

Test Procedure:

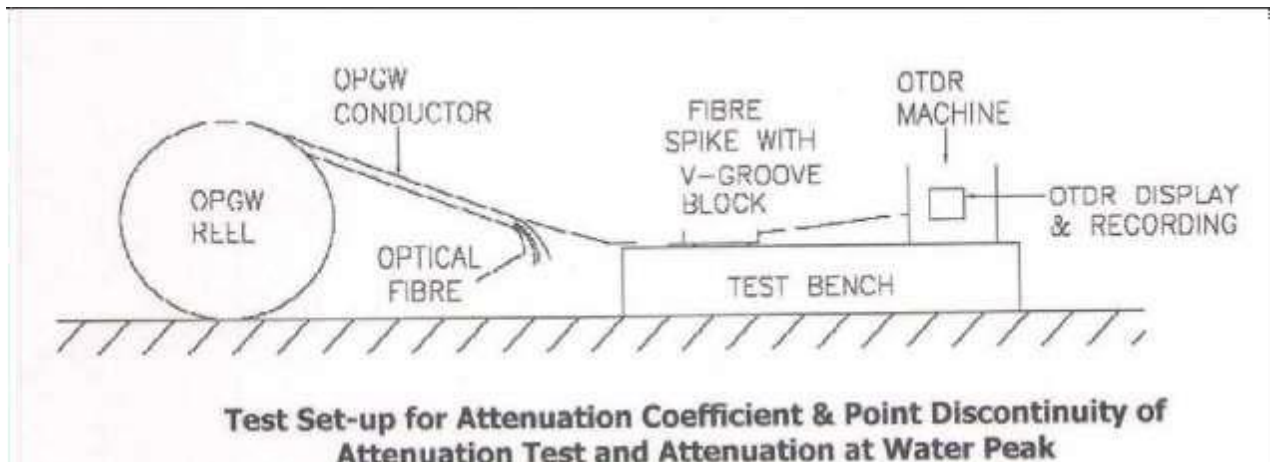
1. Connect the test sample either to the instrument or to one end of end dead-zone fiber (if used). Connect the other end of the dead-zone fiber (if used) to the instrument.
2. If the accurate locations of point defects are to be recorded, the effective group delay index of the test sample is required. If this value is not known, use FOTP-60 (Method A) to determine it.
3. Enter OTDR parameters such as source wavelength, pulse duration, length range, and signal averaging into the instrument, along with the test sample effective group index. The values of some of these parameters may be present in the instrument.
4. Adjust the instrument to display a backscatter signal from the test sample. It may be advantageous to begin with coarse vertical and horizontal scaling to maximize the length displayed. An example is given in Figure.
5. Examine the OTDR signal along the test sample for point defects. If increased resolution is needed, adjust the graphical display, if possible, to expand the section of interest to larger scale (exercising care to assure that proper reading of the true signal can still be distinguished from the noise points).
6. To determine that a point defect (rather than an attenuation non-uniformity situation) exist observe the area in question using two different pulse durations. If the shape of the loss or gain changes with the pulse duration, the anomaly is a point defect. If the shape does not change, the anomaly shall be considered to be attenuation non-uniformity to be measured by FOTP-61.
7. Report any point defect deviations which exceed the values specified in the Detail Specification. Describe the nature of these faults (e.g. apparent loss or gain, reflection, duration, etc.) as required by the Detail Specification.
 - 7.1 Determine the defect location, if required, by placing a cursor at the beginning (or at another point specified by the OTDR manufacturer) of a power rise or drop, this may be difficult to do at a drop. Obtain the distance coordinate via the alphanumeric display.
 - 7.2 Obtain the apparent loss or gain of the defect, if required, by the method described by the OTDR manufacturer .Some instruments required placement of a

pair of cursors on each side of the defect. The two best-fit straight lines (from a two-point or least-squares fit for each) are extrapolated to the defect location .If available, the linear fit method should be

chosen. The vertical separation of the lines gives the apparent loss or gain .Note any reflection peak.

- 7.3 When possible, repeat the test for a single launched into the test sample in the opposite direction. A more accurate loss estimate (and the elimination of apparent gain) is made by averaging readings taken directionally at the same wavelength .This eliminates the effect of any backscatter different for the fiber sections on both side of the defect.

- 7.4 Repeat the test at another wavelength.



Acceptance Criteria:

For Attenuation

Wavelength	Attenuation
1310 nm	< 0.35 dB/Km
1550 nm	<0.21 dB/Km

For Point Discontinuity: Attenuation of fiber shall be uniform throughout its length such that there are no point discontinuity in excess of 0.1dB.

ATTENUATION AND POINT DISCONTINUITY

Ring Mark	Fiber id	At 1310 nm				Ring Mark	At 1550 nm			
		Optical Attenuation	Point Discontinuity	Pass or Fail	Remarks		Optical Attenuation	Point Discontinuity	Pass or Fail	Remarks

Observations, if any:

Test Results:

The attenuation and point discontinuity measured have met/not met the acceptance criteria.

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

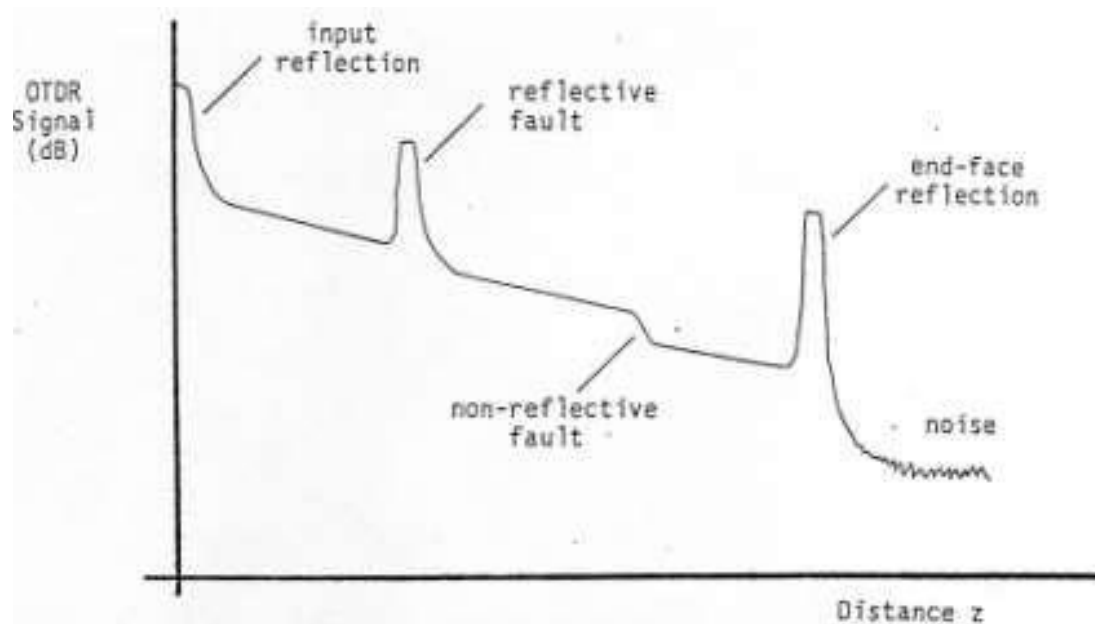


Figure 1. Schematic of an OTDR Trace. Point defects with apparent loss are shown, one reflective and one non-reflective.

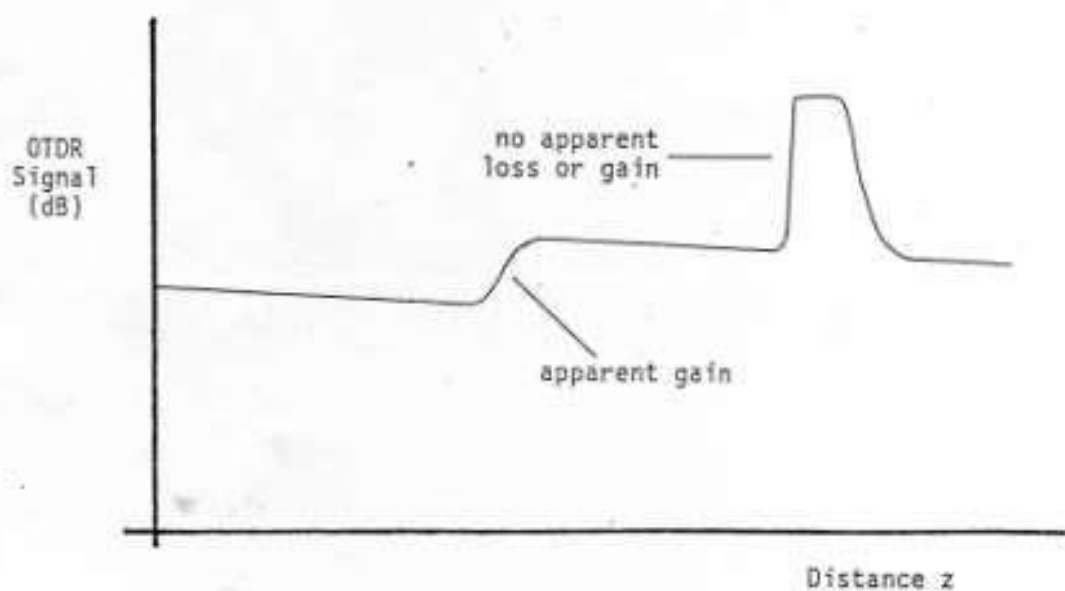


Figure 2. Schematic of an expanded OTDR trace. Two point defects are shown, one with apparent gain, and another with no apparent loss or gain.

2. VISUAL MATERIAL VERIFICATION, CABLE CONSTRUCTION AND DIMENSIONAL CHECKS

Test Standard: IEC 60793 & 60794, EIA/TIA-598

Test Location:

Manufacturer:

Cable Type: Approach Cable.

Reference Doc: Approved DRS & Drawings of Fiber Optical Approach Cable.

Objective: To measure the Visual material verification, Cable construction and dimensional checks for Fiber Optical Approach Cable.

Test Procedure:

The physical/dimensional measurements of the individual parts of the cable shall be taken with suitable measuring device and verified against the approved DRS/Drawings

Drum Checks:

1. Physical Verification for the 100% offered quantity of the offered reels/drums shall be carried out.
2. 100% physical verification of sealing of cable ends with end caps, check for provision of spare cable caps for each drum.
3. 100% verification of Sealing/Pasting the drum details over the end cap with transparent tape.
4. Verification of drum details properly printed and pasted on each drum suitably as per approved document

Checks on Approach cable: The below to be verified as per approved DRS/Drawings for both Fiber Optical Approach Cable.

S.NO.	Description	Acceptance Criteria
1.	No. of Fiber	AS per approved DRS& drawings
2.	Buffer Tube Quantity(Nos.)/Diameter	AS per approved DRS& drawings
3.	No. of Fibers per tube(Nos.)	AS per approved DRS& drawings
4.	Filling Material	AS per approved DRS& drawings
5.	Strengthening Member	AS per approved DRS& drawings
6.	Outside Jacket Coating	AS per approved DRS& drawings
7.	Outside Jacket Thickness	AS per approved DRS& drawings
8.	Armoring Tape provided	AS per approved DRS& drawings
9.	Weight(kg/km)	AS per approved DRS& drawings
10.	Overall Diameter	AS per approved DRS& drawings
11.	Identification of colors of fibers/tube	AS per approved DRS& drawings
12.	Other physical/Technical parameters	AS per approved DRS& drawings

Acceptance Criteria: Visual material verification, Cable construction and dimensional checks shall be as per approved DRS /drawings.

Observations, if any:

Test Results: The Fiber Optic Approach cables as tests met tested met the requirement as approved DRS & Drawings.

Test by:
(sign with date)

Witnessed by:
(sign with date)

SITE ACCEPTANCE TEST PROCEDURES AND PLAN FOR OPTICAL FIBRE CABLES

1. Introduction

The Site Acceptance Test Plan must stimulate the quality during the site work from the storage of materials to the complement of installation.

In addition to stimulating of quality control, it assists in keeping the record of test and remembering the major point of the site work,

2. List of Site Acceptance Test

- 1) Pre-Installation Test (Drum Test)
 - a. Physical Inspection of the cable assembly for damage
 - b. Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
 - c. Fibre Optic Cable length measurement using OTDR
- 2) Post-Installation Test
 - a. Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
 - b. Fibre Optic Cable length measurement using OTDR
- 3) Splice Test
 - a. Per splice bi-directional average attenuation with OTDR
 - b. Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
 - c. Physical inspection of sealing techniques, weatherproofing, etc.
- 4) Commissioning Test
 - a. End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
 - b. End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter
 - c. Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
 - d. Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.

Reference Documents:

- 1) DRS of OPGW/Optical fiber.
- 2) Sag-Tension Chart.
- 3) OPGW Live-Line Installation Procedure.
- 4) Splicing/Jointing Manual.

PRE-INSTALLATION TEST (DRUM TEST)

Title of Test : Pre-Installation Test (Drum Test)

Application : All FO Cables

Purpose of the Test : For precluding cable that may be damaged during shipment and transportation, every spooled FO cable segment shall be tested prior to installation.

Test Equipment : OTDR & physical inspection

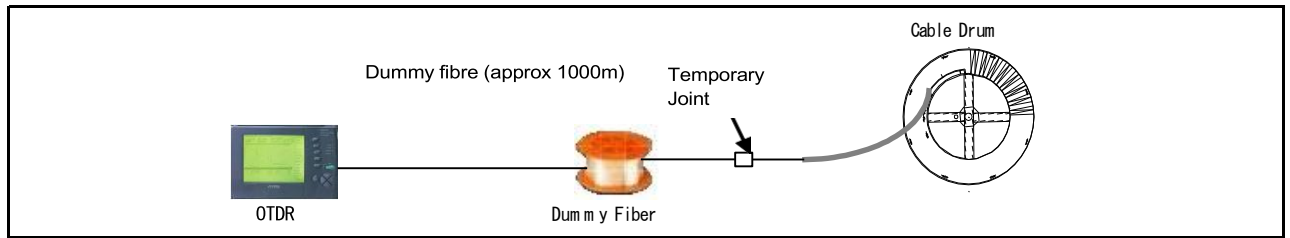
Test Set-up & Procedure : First of all, check the appearance and marking of the Drums.

SHIPPING TAG

Package Name			
Employer 's Name	Power Grid Corporation of India Limited (A Government of India Enterprise)		
Employer 's Address			
Destination Address			
Vendor's Name			
Vendor's address			
Year of Manufacture	Xxxx	Batch No.	Xxxx
Drum No.	(As per the Drum Schedule)		
Type of Cable			
Type of Fibres	DWSM		
No. of Fibres	24 F / 48F		
Total Cable Length	Xxx Mtrs		
Weight of the Drum	Xxx kg		
Year of Production	Day-Month- Year	Factory Date	Inspection Day-Month-Year
Factory Seal			

Xxxx - To be furnished by OPGW manufacturer_____before FAT.

- Check the sealing of the cable ends and spare cable caps
- Carry out the physical inspection of the cable assembly and then check the Fibre Length, continuity and attenuation of optical fibers by OTDR. Compare the observed attenuation data with respect to the pre- shipment / FAT data.



Acceptance Criteria:

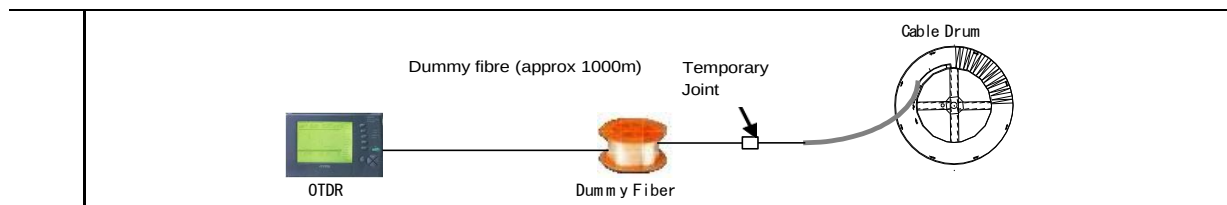
- Appearance shall have no defect and drum marking shall be correct.
- The attenuation of the fibers shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.1dB. The overall optical fibers attenuation should be less than 0.21dB/km at 1550nm and 0.35dB/km at 1310nm.
- Cable ends and spare cable caps shall be properly sealed.
- Every drum, OPGW cable shall be tested for compliance of fibre Length, Continuity & attenuation with the Pre-Shipment data received from manufacturer.

Result/Conclusion:

- Test result shall be filled in the respective test formats as enclosed for Pre -Installation test.
- If there is any excess of attenuation compared with the standard attenuation norms, then the test shall be re-conducted. If the result of retest does not meet the norm, proper action shall be taken promptly in accordance with the flow of trouble slip.

SAT-01-A (24 F)
PRE-INSTALLATION TEST REPORT FOR OPGW CABLE (DRUM TEST)

Date:	Section:		
	Drum		
	No:		
	Drum Length:	(As per Pre-shipment date)	
	Drum Length:	(Actual at site)	
Type of OTDR:	WAVELENGTH	REFRACTION INDEX	MAX ATTENUATION
Testing Date:	1310nm	1.4670	0.35 dB/km
	1550nm	1.4675	0.21 dB/km



S.No:	Description			Result (Yes / No)		Remarks
1	Physical Appearance check					
2	Drum Marking check					
3	Sealing of Cable ends & provision of spare cable caps					
Tube Color	Fiber No	Fiber Color	Length (km)	Attenuation		Remarks
				1310nm dB/km	1550nm dB/km	
BLUE	1	Blue				
	2	Orange				
	3	Green				
	4	Brown				
	5	Slate				
	6	White				
ORANGE	7	Blue				
	8	Orange				
	9	Green				
	10	Brown				
	11	Slate				
	12	White				
GREEN	13	Blue				
	14	Orange				
	15	Green				
	16	Brown				
	17	Slate				
	18	White				
BROWN	19	Blue				
	20	Orange				
	21	Green				
	22	Brown				
	23	Slate				
	24	White				

- OTDR Trace results attached for all fiber (Yes/No):

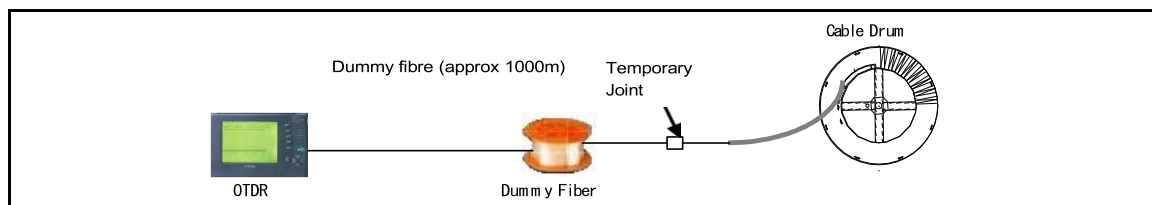
Tested By

Witnessed By

Approved By

SAT-01-A (48 F)
PRE-INSTALLATION TEST REPORT FOR OPGW CABLE (DRUM TEST)

Date:	Section:		
	Drum No:		
	Drum Length:	(As per Pre-shipment date)	
Type of OTDR:	Drum Length:	(Actual at site)	
Testing Date:	WAVELENGTH	REFRACTION INDEX	MAX ATTENUATION
	1310nm	1.4670	0.35 dB/km
	1550nm	1.4675	0.21 dB/km



S.No:	Description			Result (Yes / No)		Remarks
1	Physical Appearance check					
2	Drum Marking check					
3	Sealing of Cable ends & provision of spare cable caps					
Tube Color	Fiber No	Fiber Color	Length (km)	Attenuation		Remarks
				1310nm dB/km	1550nm dB/km	
BLUE	1	Blue				
	2	Orange				
	3	Green				
	4	Brown				
	5	Slate				
	6	White				
	7	Red				
	8	Black				
	9	Yellow				
	10	Violet				
	11	Pink				
	12	Aqua				
ORANGE	13	Blue				
	14	Orange				
	15	Green				
	16	Brown				
	17	Slate				
	18	White				
	19	Red				
	20	Black				
	21	Yellow				
	22	Violet				
	23	Pink				
	24	Aqua				

Tube Color	Fiber No	Fiber Color	Length (km)	Attenuation		Remarks
				1310nm dB/km	1550nm dB/km	
GREEN	25	Blue				
	26	Orange				
	27	Green				
	28	Brown				
	29	Slate				
	30	White				
	31	Red				
	32	Black				
	33	Yellow				
	34	Violet				
	35	Pink				
	36	Aqua				
BROWN	37	Blue				
	38	Orange				
	39	Green				
	40	Brown				
	41	Slate				
	42	White				
	43	Red				
	44	Black				
	45	Yellow				
	46	Violet				
	47	Pink				
	48	Aqua				

- OTDR Trace results attached for all fiber (Yes/No):

Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

POST-INSTALLATION TEST

Title of Test : Post-Installation Test (After Stringing)

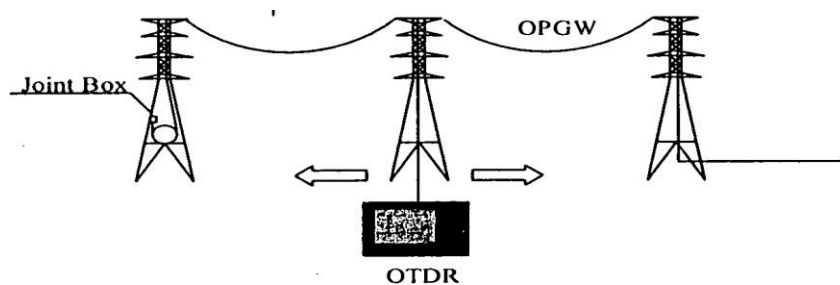
Application : All splicing points

Purpose of the Test : Before splicing work, check for any increase or step Discontinuity in attenuation that may have occurred during Transportation and installation.

Test Equipment : OTDR

Test Set-up & Procedure :

- After successfully completion of the installation work.
- Check for optical attenuation and discontinuity at every splicing point.



Acceptance Criteria:

- The attenuation of the fibers shall be distributed uniformly throughout its length such that there are no point's discontinuities in excess of 0.1dB. The overall optical fibers attenuation should be less than 0.21 dB/km at 1550nm and 0.35 dB/km at 1310nm.

Result/Conclusion:

- Test result shall be filled in the respective test formats as enclosed for Post Installation Test.

Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

SPLICE TEST

Title of Test : Splice Test
Application : All splicing positions

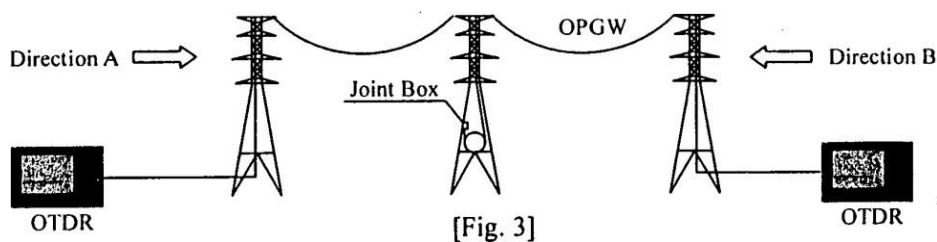
Purpose of the Test:

- Splicing as per approved splicing plan.
- Before closing the splice enclosure, splice loss shall be measured for checking the splicing condition.
- The treatment of surplus fibers on the splice tray and sealing condition shall be checked.

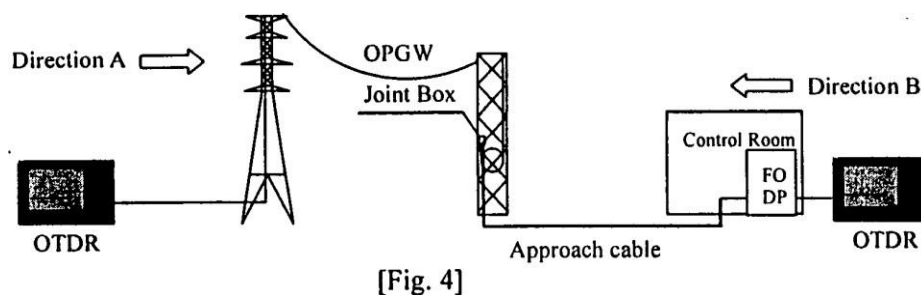
Test Equipment : OTDR & physical inspection

Test Set-up & Procedure:

- All in-line splices shall be encased in splice enclosures with a protective moisture and dust free environment and suitable for outdoor use. All fibers shall be accomplished through the fusion splicing, and then protected by heating shrinkable tube. All splices shall be neatly installed in covered splice trays with 0.5 meter of bare fiber service loop and 1 meter of fiber unit service loop. Before closing the in-line splice enclosure, the splice test shall be executed at both sides (direction A & direction B) of jointing point. The splicing shall be as per approved splicing plan.



- the splice test in the sub-station is the same as that of the in-line splice. In this case, in-line splice enclosure shall be installed on the gantry tower and splicing is between OPGW and approach cable.



- When closing the splice enclosure, the treatment of surplus fibers on the splice tray, sealing conditions and weather proofing shall be checked by physical inspection.

Acceptance Criteria:

- The average of bi-directional attenuation of each fusion splice shall not be more than 0.1 dB at 1550nm & 1310nm. Adequate care shall be taken to minimize the splice loss so as to achieve the required bi-directional average attenuation of splice in the link less than 0.05 dB per splice.
- Appearance of splice enclosure shall have no defect.
- The fibers routing is proper inside the splice enclosure and FODP.
- Splice enclosure shall have good sealing condition to prevent moisture and dust free environment and render it waterproof.
- Splicing is as per approved splicing plan.

- The connector loss shall be less than or equal to 0.5 dB per connector.

- The warning sheet is properly fixed on the splice enclosure.

Result/Conclusion:

- Test result shall be filled in the respective test formats as enclosed for splice test.

Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

COMMISSIONING TEST (LINK TEST)

Title of Test : Link Commissioning Test

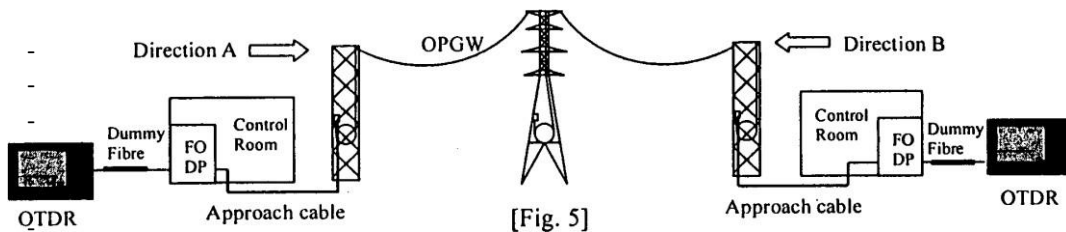
Application : All Links (FODP to FODP)

Purpose of the Test: After completion of splicing of installed section and termination at both ends, the optical fiber path attenuation shall be checked to ensure that the optical fiber shall be in operation satisfactorily.

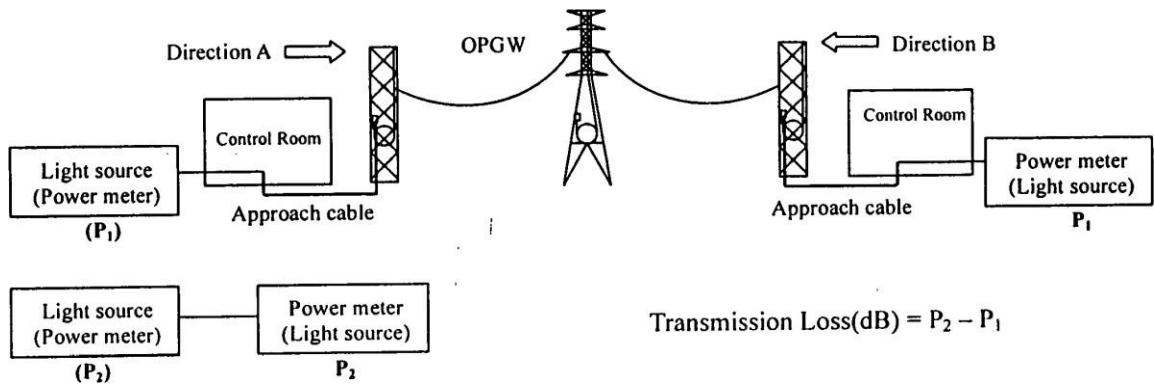
Test Equipment : OTDR, Power Meter & Light Source

Test Set-up & Procedure:

- The numbering and labeling plan shall be checked at each FODP.
- The optical fiber path attenuation shall be measured at both ends of link by OTDR as well as Power meter and laser light at 1310nm and 1550 nm. The bi-directional average attenuation by both methods shall be calculated.



- The measurement using the power meter is as below;



NOTE: The FODP to FODP link distance should be restricted to 70 Kms for the bidirectional test as the attenuation measurement using OTDR for the wavelength 1310nm may not be accurate for the link distances more than 70 Kms.

Acceptance Criteria:

- The numbering and labeling plan at each FODP shall be as per approved plan.
- The overall optical fiber path attenuation at 1550 nm shall be $0.21 \text{ dB/km} + 0.05 \text{ dB/splice} + 0.5 \text{ dB/connector}$.
- The overall optical fiber path attenuation at 1310 nm shall be $0.35 \text{ dB/km} + 0.05 \text{ dB/splice} + 0.5 \text{ dB/connector}$.
- There are no point discontinuities in excess of 0.1 dB

Result/ Conclusion:

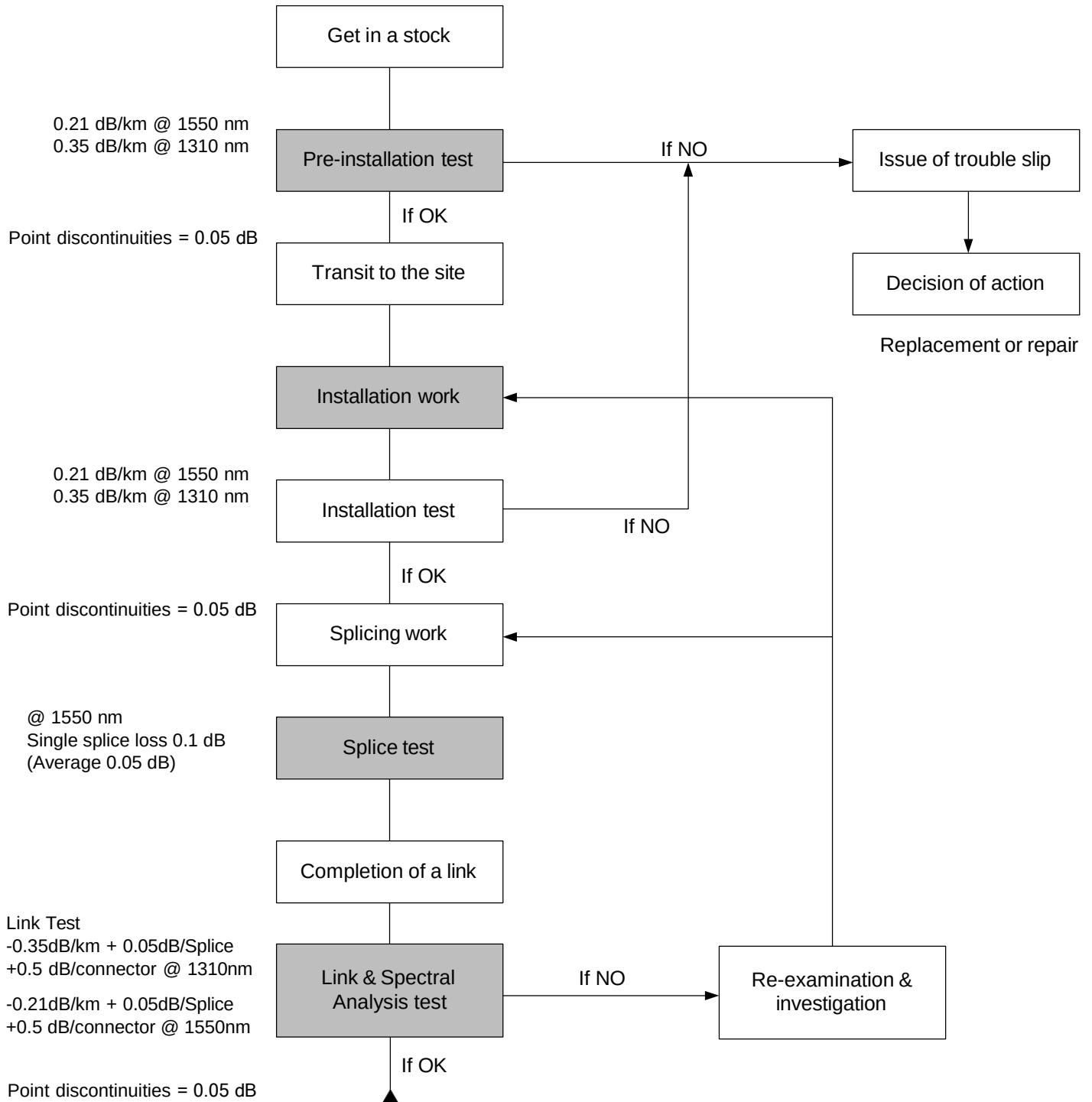
- Test result shall be filled in the respective test formats as enclosed for link commissioning test.
- Bidirectional averages splice loss by OTDR of each splice as well as for all splices in the link (including FODP also).
- Proper termination and labeling of fibers and fiber optic cables at FODP as per approved labeling plan.

Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

PROCEDURE CHART

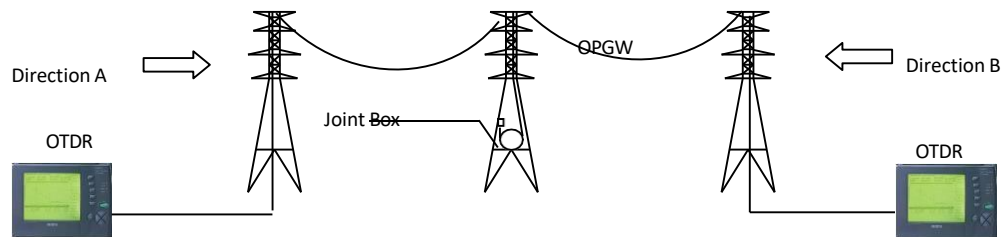


PLAN FOR SAT

Test Title	Function/Parameter	Test Equipment	Criteria	Remarks
Installation Test	The point is whether the cable shall be used for the installation or not. Appearance of drum and cable; Optical fiber continuity end-to-end and attenuation	OTDR	Attenuation: $\leq 0.21\text{dB/km}@1550\text{nm}$ $\leq 0.35\text{dB/km}@1310\text{nm}$ Discontinuity: $\leq 0.1\text{ dB}$	
Installation Test	After completion of installation, check for any increase or step discontinuity in attenuation that may have occurred during transportation and installation.	OTDR	Attenuation: $\leq 0.21\text{dB/km}@1550\text{ nm}$ $\leq 0.35\text{dB/km}@1310\text{ nm}$ Discontinuity: $\leq 0.1\text{ dB}$	
Splice Test	Before closing splice enclosure, splice loss shall be measured from both directions. OTDR Shall be located at the one side of splicing point, loop for measurement of bi-directional splice loss shall be constituted at the other side. $S_1=0 \leq \frac{A+B}{2} \leq 0.1\text{dB}$ Where, A is splice loss from 'A' direction. B is splice loss from 'B' direction.	OTDR	@ 1550 nm, Single splice loss 0.1 dB Average 0.05 dB.	
Commissioning Test (Link Test)	After installation and splicing of each link, path attenuation shall be measured with the help of OTDR & power meter. Splice loss shall be measured with OTDR and average splice loss shall be calculated	OTDR & Power Meter, Laser Source	<Link Test> Path attenuation: $\leq 0.21\text{dB/km} + 0.05\text{dB/splice}$ $+0.5\text{db/connector}@1550\text{nm}$ $\leq 0.35\text{db/km}$ $+0.05\text{dB/splice}$ $+0.5\text{db/connector}@1310\text{ nm}$ Discontinuity: $\leq 0.05\text{dB}$ Average splice loss $= (S_1 + S_2 + \dots + S_n) / N$ Where $S_1, S_2, \dots, S_n$ is average splice loss at joint 1, 2, --- n etc.	

SAT-02-A (24 F)
POST-INSTALLATION TEST REPORT FOR OPGW

Report No:	Sector:		
Date:	Section:		
	Drum No:		
	Drum	(As per Pre-shipment date)	
	Length:		
	Drum Length:	(Actual at site)	
Type of OTDR:	WAVELENGTH	REFRACTION INDEX	MAX ATTENUATION
Testing Date:	1310nm	1.4670	0.35 dB/km
	1550nm	1.4675	0.21 dB/km



Tube Color	Fiber No	Fiber Color	Length (km)	Attenuation dB/km		Remarks
				1550nm	1310nm	
BLUE	1	Blue				
	2	Orange				
	3	Green				
	4	Brown				
	5	Slate				
	6	White				
ORANGE	7	Blue				
	8	Orange				
	9	Green				
	10	Brown				
	11	Slate				
	12	White				
GREEN	13	Blue				
	14	Orange				
	15	Green				
	16	Brown				
	17	Slate				
	18	White				
BROWN	19	Blue				
	20	Orange				
	21	Green				
	22	Brown				
	23	Slate				
	24	White				

OTDR Trace results attached for all fiber (Yes/No):

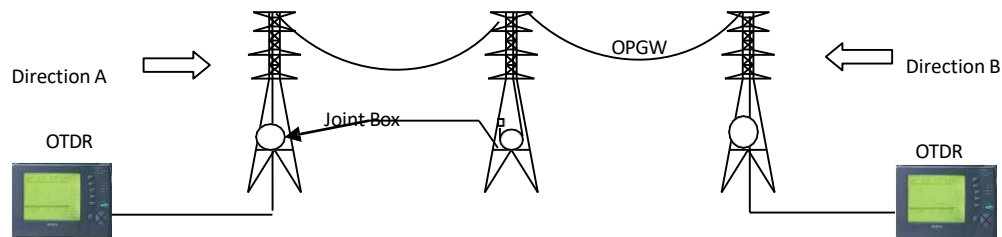
Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

SAT-03-B (24 F)
SPLICE LOSS TEST REPORT FOR OPGW @ 1550nm

Report No:	Sector:		
	Section:		
	TOWER		
Type of OTDR:	WAVELENGTH	REFRACTION	Acceptance criteria
	1550nm		Max.Splice Loss
			0.10dB(Individual splice) Average Splice loss in link



Joint Box	Appearance		Fiber Routing		Sealing		Tower No.
Tube Color	Fiber No	Fiber Color	Length (km)	SPLICE LOSS (dB)		Actual Loss (dB)=(A+B)/2	
				Direction A	Direction B		
BLUE	1	Blue					
	2	Orange					
	3	Green					
	4	Brown					
	5	Slate					
	6	White					
ORANGE	7	Blue					
	8	Orange					
	9	Green					
	10	Brown					
	11	Slate					
	12	White					
GREEN	13	Blue					
	14	Orange					
	15	Green					
	16	Brown					
	17	Slate					
	18	White					
BROWN	19	Blue					
	20	Orange					
	21	Green					
	22	Brown					
	23	Slate					
	24	White					

OTDR Trace results attached for all fiber (Yes/No):

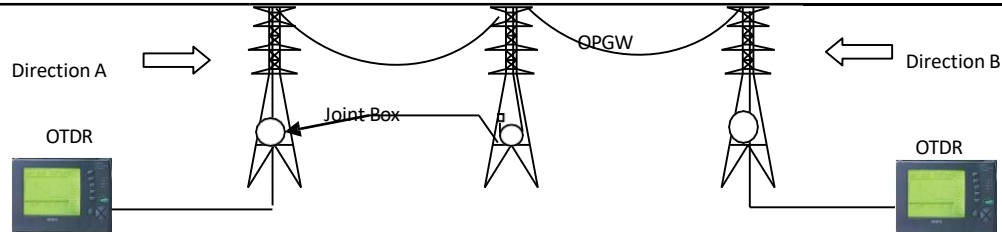
Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

SAT-03-A (24 F)
SPLICE LOSS TEST REPORT FOR OPGW @ 1310nm

Report No:	Sector:		
	Section:		
	TOWER		
Type of OTDR:	WAVELENGTH	REFRACTION	Acceptance criteria
	1310nm		Max.Splice Loss
			0.10dB(Individual splice) Average Splice loss in link



Joint Box	Appearance		Fiber Routing		Sealing		Tower No.
Tube Color	Fiber No	Fiber Color	Length (km)	SPlice LOSS (dB)		Actual Loss (dB)=(A+B)/2	
				Direction A	Direction B		
BLUE	1	Blue					
	2	Orange					
	3	Green					
	4	Brown					
	5	Slate					
	6	White					
ORANGE	7	Blue					
	8	Orange					
	9	Green					
	10	Brown					
	11	Slate					
	12	White					
GREEN	13	Blue					
	14	Orange					
	15	Green					
	16	Brown					
	17	Slate					
	18	White					
BROWN	19	Blue					
	20	Orange					
	21	Green					
	22	Brown					
	23	Slate					
	24	White					

OTDR Trace results attached for all fiber (Yes/No):

Tested By
(Sign with date)

Witnessed By
(Sign with date)

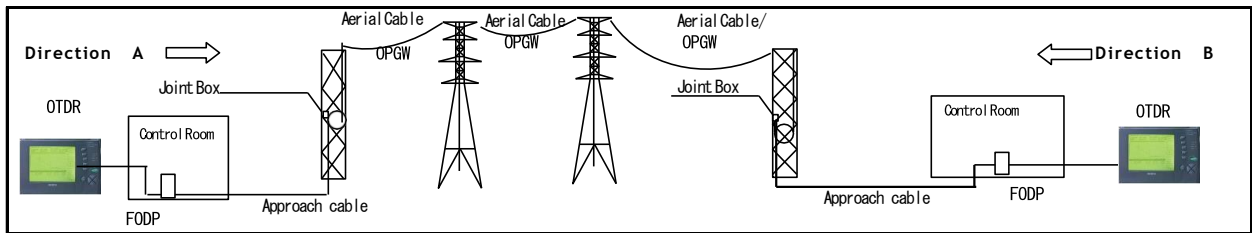
Approved By
(Sign with date)

SAT-04-A (24 F)
FO CABLE END TO END TEST USING OTDR (1310 nm)

Report No:

Date:

SECTOR				
LINE LINK				
FODP to FODP				
Type of OTDR	Testing Date	Wave Length	Max Attenuation of Fiber	Specified Loss
		1310 nm	0.35 dB/km	$\sum 0.35\text{dB/km} \times \text{Total FO length} + 0.05\text{dB/splice} \times \text{Total No. of splice} + 0.5\text{dB/connector} \times \text{No. of connectors}$



Tube Color	Fiber No	Fiber Color	Length (km)	Total LOSS (dB)		Actual Loss (dB)=(A+B)/2
				Direction A	Direction B	
BLUE	1	Blue				
	2	Orange				
	3	Green				
	4	Brown				
	5	Slate				
	6	White				
ORANGE	7	Blue				
	8	Orange				
	9	Green				
	10	Brown				
	11	Slate				
	12	White				
GREEN	13	Blue				
	14	Orange				
	15	Green				
	16	Brown				
	17	Slate				
	18	White				
BROWN	19	Blue				
	20	Orange				
	21	Green				
	22	Brown				
	23	Slate				
	24	White				

- OTDR Trace results attached for all fiber (Yes/No):

Tested By
(Sign with date)

Witnessed By
(Sign with date)

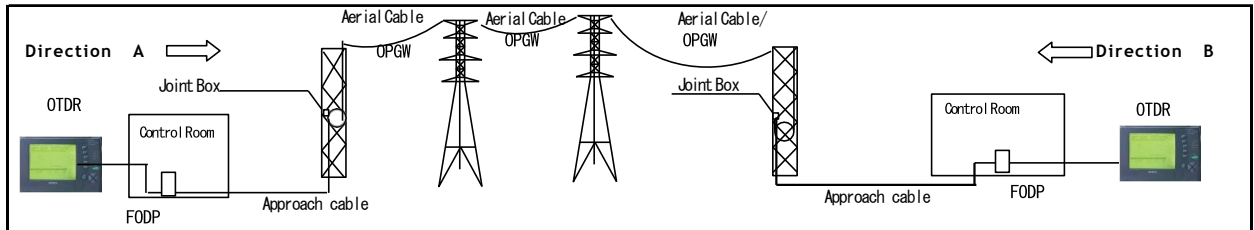
Approved By
(Sign with date)

SAT-04-B (24 F)
FO CABLE END TO END TEST USING OTDR (1550 nm)

Report No:

Date:

SECTOR				
LINE LINK				
FODP to FODP				
Type of OTDR	Testing Date	Wave Length	Max Attenuation of Fiber	Specified Loss
		1550 nm	0.21 dB/km	$\sum 0.21\text{dB/km} \times \text{Total FO length} + 0.05\text{dB/splice} \times \text{Total No. of splice} + 0.5\text{dB/connector} \times \text{No. of connectors}$



Tube Color	Fiber No	Fiber Color	Length (Km)	Total LOSS (dB)		Actual Loss (dB)=(A+B)/2
				Direction A	Direction B	
BLUE	1	Blue				
	2	Orange				
	3	Green				
	4	Brown				
	5	Slate				
	6	White				
ORANGE	7	Blue				
	8	Orange				
	9	Green				
	10	Brown				
	11	Slate				
	12	White				
GREEN	13	Blue				
	14	Orange				
	15	Green				
	16	Brown				
	17	Slate				
	18	White				
BROWN	19	Blue				
	20	Orange				
	21	Green				
	22	Brown				
	23	Slate				
	24	White				

- OTDR Trace results attached for all fiber (Yes/No):

Tested By
(Sign with date)

Witnessed By
(Sign with date)

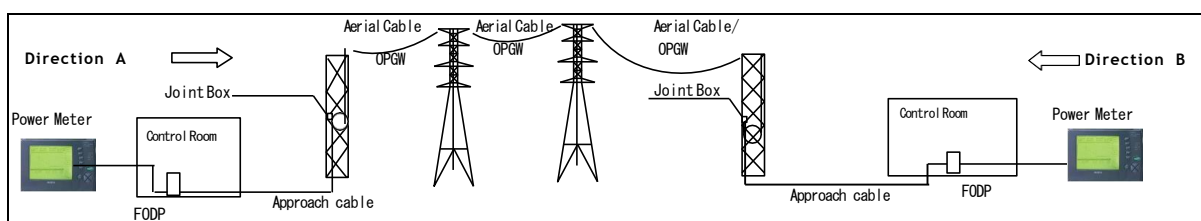
Approved By
(Sign with date)

SAT-05-A (24 F)
FO CABLE END TO END TEST USING POWER METER (1550 nm)

Report No:

Date:

SECTOR	FODP to FODP			
LINE LINK				
REFERENCE POWER : Pr dBm				
A- Power measuring from A Direction dBm			P1: Pr - A dBm	
B- Power measuring from B Direction dBm			P2: Pr - B dBm	
Type of Power Meter	Testing Date	Wave Length	Max Attenuation of Fiber	Specified Loss
		1550 nm	0.21 db/km	$\sum 0.21\text{dB/km} \times \text{Total FO length} + 0.05\text{dB/splice} \times \text{Total No. of splice} + 0.5\text{dB/connector} \times \text{No. of connectors}$



Tube Color	Fiber No	Fiber Color	Length (Km)	Received Power (dB)		Actual Loss (dB) $P=(P1+P2)/2$	Average Loss (dB/km) P/Section length
				Direction-A (P1)	Direction-B (P2)		
BLUE	1	Blue					
	2	Orange					
	3	Green					
	4	Brown					
	5	Slate					
	6	White					
ORANGE	7	Blue					
	8	Orange					
	9	Green					
	10	Brown					
	11	Slate					
	12	White					
GREEN	13	Blue					
	14	Orange					
	15	Green					
	16	Brown					
	17	Slate					
	18	White					
BROWN	19	Blue					
	20	Orange					
	21	Green					
	22	Brown					
	23	Slate					
	24	White					

Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

SAT-05-B (24 F)
FO CABLE END TO END TEST USING POWER METER (1310 nm)

Report No:

Date:

SECTOR	FODP TO FODP			
LINE LINK				
REFERENCE POWER : Pr dBm				
A- Power measuring from A Direction dBm			P1: Pr - A dBm	
B- Power measuring from B Direction dBm			P2: Pr - B dBm	
Type of Power Meter	Testing Date	Wave Length	Max Attenuation of Fiber	Specified Loss
		1310 nm	0.35 db/km	$\sum 0.35\text{dB/km} \times \text{Total FO length} + 0.05\text{dB/splice} \times \text{Total No. of splice} + 0.5\text{dB/connector} \times \text{No. of connectors}$

Tube Color	Fiber No	Fiber Color	Length (Km)	Received Power (dB)		Actual Loss (dB) $P=(P1+P2)/2$	Average Loss (dB/km) P/Section length
				Direction-A (P1)	Direction-B (P2)		
BLUE	1	Blue					
	2	Orange					
	3	Green					
	4	Brown					
	5	Slate					
	6	White					
ORANGE	7	Blue					
	8	Orange					
	9	Green					
	10	Brown					
	11	Slate					
	12	White					
GREEN	13	Blue					
	14	Orange					
	15	Green					
	16	Brown					
	17	Slate					
	18	White					
BROWN	19	Blue					
	20	Orange					
	21	Green					
	22	Brown					
	23	Slate					
	24	White					

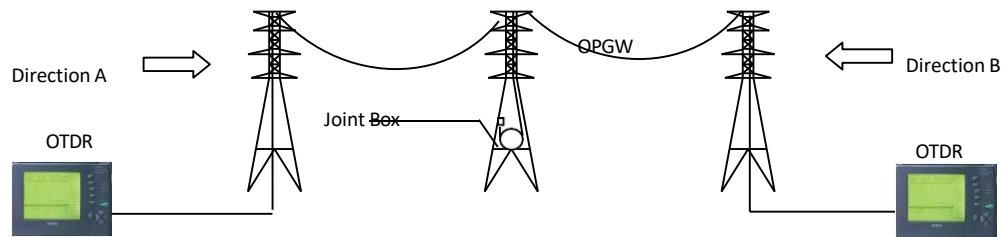
Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

SAT-02-A (48 F)
POST-INSTALLATION TEST REPORT FOR OPGW

Report No:	Sector:		
Date:	Section:		
	Drum No:		
	Drum Length:		(As per Pre-shipment date)
	Drum Length:		(Actual at site)
Type of OTDR:	WAVELENGTH	REFRACTION INDEX	MAX ATTENUATION
Testing Date:	1310nm	1.4670	0.35 dB/km
	1550nm	1.4675	0.21 dB/km



S.No:	Description			Result (Yes / No)		Remarks
1	Physical Appearance check					
2	Drum Marking check					
3	Sealing of Cable ends & provision of spare cable caps					
Tube Color	Fiber No	Fiber Color	Length (km)	Attenuation		Remarks
				1310nm dB/km	1550nm dB/km	
BLUE	1	Blue				
	2	Orange				
	3	Green				
	4	Brown				
	5	Slate				
	6	White				
	7	Red				
	8	Black				
	9	Yellow				
	10	Violet				
	11	Pink				
	12	Aqua				
ORANGE	13	Blue				
	14	Orange				
	15	Green				
	16	Brown				
	17	Slate				
	18	White				
	19	Red				
	20	Black				
	21	Yellow				
	22	Violet				
	23	Pink				
	24	Aqua				

Tube Color	Fiber No	Fiber Color	Length (km)	Attenuation		Remarks
				1310nm dB/km	1550nm dB/km	
GREEN	25	Blue				
	26	Orange				
	27	Green				
	28	Brown				
	29	Slate				
	30	White				
	31	Red				
	32	Black				
	33	Yellow				
	34	Violet				
	35	Pink				
	36	Aqua				
BROWN	37	Blue				
	38	Orange				
	39	Green				
	40	Brown				
	41	Slate				
	42	White				
	43	Red				
	44	Black				
	45	Yellow				
	46	Violet				
	47	Pink				
	48	Aqua				

- OTDR Trace results attached for all fiber (Yes/No):

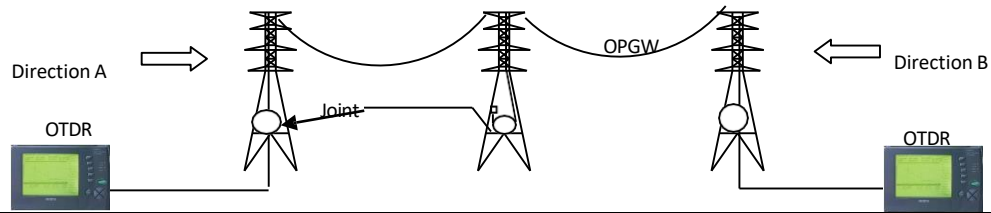
Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

SAT-03-B (48 F)
SPLICE LOSS TEST REPORT FOR OPGW @ 1550nm

Report No:	Sector:		
	Section:		
	TOWER		
Type of OTDR:	WAVELENGTH	REFRACTION	Acceptance criteria
	1550nm		Max.Splice Loss
			0.10dB(Individual splice) Average Splice loss in link



S.No:	Description	Result (Yes / No)		Remarks
1	Physical Appearance check			
2	Drum Marking check			
3	Sealing of Cable ends & provision of spare cable caps			

Tube Color	Fiber No	Fiber Color	Length (km)	SPLICE LOSS (dB)		Actual Loss (dB)=(A+B)/2
				Direction A	Direction B	
BLUE	1	Blue				
	2	Orange				
	3	Green				
	4	Brown				
	5	Slate				
	6	White				
	7	Red				
	8	Black				
	9	Yellow				
	10	Violet				
	11	Pink				
	12	Aqua				
ORANGE	13	Blue				
	14	Orange				
	15	Green				
	16	Brown				
	17	Slate				
	18	White				
	19	Red				
	20	Black				
	21	Yellow				
	22	Violet				
	23	Pink				
	24	Aqua				

Tube Color	Fiber No	Fiber Color	Length (km)	SPlice LOSS (dB)		Actual Loss (dB)=(A+B)/2
				Direction A	Direction B	
GREEN	25	Blue				
	26	Orange				
	27	Green				
	28	Brown				
	29	Slate				
	30	White				
	31	Red				
	32	Black				
	33	Yellow				
	34	Violet				
	35	Pink				
	36	Aqua				
BROWN	37	Blue				
	38	Orange				
	39	Green				
	40	Brown				
	41	Slate				
	42	White				
	43	Red				
	44	Black				
	45	Yellow				
	46	Violet				
	47	Pink				
	48	Aqua				

- OTDR Trace results attached for all fiber (Yes/No):

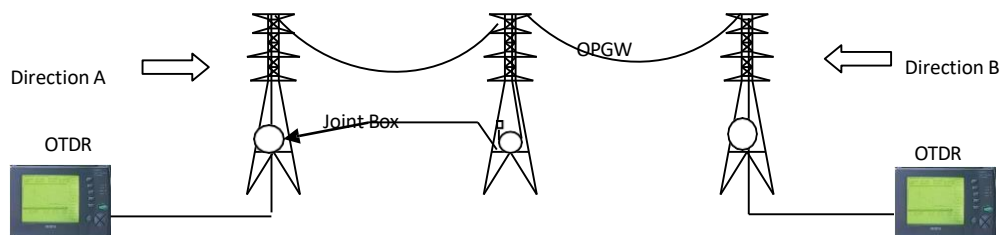
Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

SAT-03-A (48 F)
SPLICE LOSS TEST REPORT FOR OPGW @ 1310nm

Report No:	Sector:		
	Section:		
	TOWER		
Type of OTDR:	WAVELENGTH	REFRACTION	Acceptance criteria
	1310nm		Max.Splice Loss
			0.10dB(Individual splice) Average Splice loss in link



S.No:	Description			Result (Yes / No)		Remarks
1	Physical Appearance Check					
2	Drum Marking Check					
3	Sealing of Cable Ends & Provision of Spare Cable Caps					
Tube Color	Fiber No	Fiber Color	Length (km)	SPLICE LOSS (dB)		Actual Loss (dB)=(A+B)/2
				Direction A	Direction B	
BLUE	1	Blue				
	2	Orange				
	3	Green				
	4	Brown				
	5	Slate				
	6	White				
	7	Red				
	8	Black				
	9	Yellow				
	10	Violet				
	11	Pink				
	12	Aqua				
ORANGE	13	Blue				
	14	Orange				
	15	Green				
	16	Brown				
	17	Slate				
	18	White				
	19	Red				
	20	Black				
	21	Yellow				
	22	Violet				
	23	Pink				
	24	Aqua				

Tube Color	Fiber No	Fiber Color	Length (km)	SPlice LOSS (dB)		Actual Loss (dB)=(A+B)/2
				Direction A	Direction B	
GREEN	25	Blue				
	26	Orange				
	27	Green				
	28	Brown				
	29	Slate				
	30	White				
	31	Red				
	32	Black				
	33	Yellow				
	34	Violet				
	35	Pink				
	36	Aqua				
BROWN	37	Blue				
	38	Orange				
	39	Green				
	40	Brown				
	41	Slate				
	42	White				
	43	Red				
	44	Black				
	45	Yellow				
	46	Violet				
	47	Pink				
	48	Aqua				

- OTDR Trace results attached for all fiber (Yes/No):

Tested By
(Sign with date)

Witnessed By
(Sign with date)

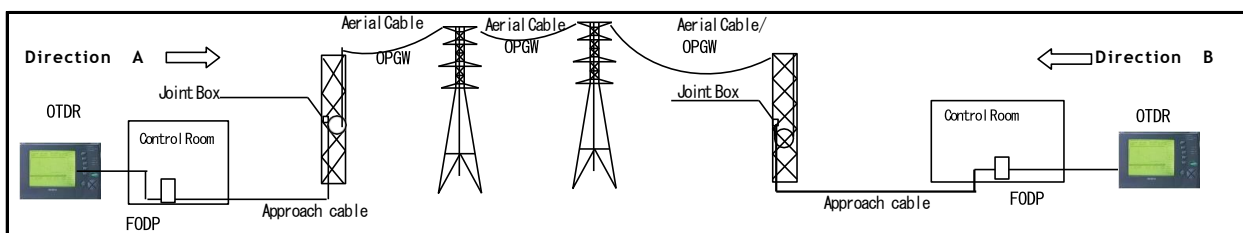
Approved By
(Sign with date)

SAT-04-A (48 F)
FO CABLE END TO END TEST USING OTDR (1310 nm)

Report No:

Date:

SECTOR				
LINE LINK				
FODP to FODP				
Type of OTDR	Testing Date	Wave Length	Max Attenuation of Fiber	Specified Loss
		1310 nm	0.35 db/km	$\sum 0.35\text{dB/km} \times \text{Total FO length} + 0.05\text{dB/splice} \times \text{Total No. of splice} + 0.5\text{dB/connector} \times \text{No. of connectors}$



Tube Color	Fiber No	Fiber Color	Length (km)	Total Loss (dB)		Actual Loss (dB)=(A+B)/2
				Direction A	Direction B	
BLUE	1	Blue				
	2	Orange				
	3	Green				
	4	Brown				
	5	Slate				
	6	White				
	7	Red				
	8	Black				
	9	Yellow				
	10	Violet				
	11	Pink				
	12	Aqua				
ORANGE	13	Blue				
	14	Orange				
	15	Green				
	16	Brown				
	17	Slate				
	18	White				
	19	Red				
	20	Black				
	21	Yellow				
	22	Violet				
	23	Pink				
	24	Aqua				

Tube Color	Fiber No	Fiber Color	Length (km)	Total Loss (dB)		Actual Loss (dB)=(A+B)/2
				1310nm dB/km	1550nm dB/km	
GREEN	25	Blue				
	26	Orange				
	27	Green				
	28	Brown				
	29	Slate				
	30	White				
	31	Red				
	32	Black				
	33	Yellow				
	34	Violet				
	35	Pink				
	36	Aqua				
BROWN	37	Blue				
	38	Orange				
	39	Green				
	40	Brown				
	41	Slate				
	42	White				
	43	Red				
	44	Black				
	45	Yellow				
	46	Violet				
	47	Pink				
	48	Aqua				

- OTDR Trace results attached for all fiber (Yes/No):

Tested By
(Sign with date)

Witnessed By
(Sign with date)

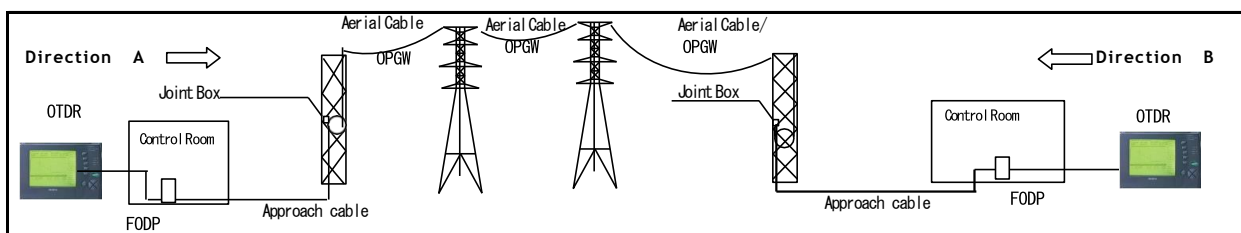
Approved By
(Sign with date)

SAT-04-B (48 F)
FO CABLE END TO END TEST USING OTDR (1550 nm)

Report No:

Date:

SECTOR				
LINE LINK				
FODP to FODP				
Type of OTDR	Testing Date	Wave Length	Max Attenuation of Fiber	Specified Loss
		1550 nm	0.21 db/km	$\sum 0.21\text{dB/km} \times \text{Total FO length} + 0.05\text{dB/splice} \times \text{Total No. of splice} + 0.5\text{dB/connector} \times \text{No. of connectors}$



Tube Color	Fiber No	Fiber Color	Length (km)	Total Loss (dB)		Actual Loss (dB)=(A+B)/2
				Direction A	Direction B	
BLUE	1	Blue				
	2	Orange				
	3	Green				
	4	Brown				
	5	Slate				
	6	White				
	7	Red				
	8	Black				
	9	Yellow				
	10	Violet				
	11	Pink				
	12	Aqua				
ORANGE	13	Blue				
	14	Orange				
	15	Green				
	16	Brown				
	17	Slate				
	18	White				
	19	Red				
	20	Black				
	21	Yellow				
	22	Violet				
	23	Pink				
	24	Aqua				

Tube Color	Fiber No	Fiber Color	Length (km)	Attenuation		Remarks
				1310nm dB/km	1550nm dB/km	
GREEN	25	Blue				
	26	Orange				
	27	Green				
	28	Brown				
	29	Slate				
	30	White				
	31	Red				
	32	Black				
	33	Yellow				
	34	Violet				
	35	Pink				
	36	Aqua				
BROWN	37	Blue				
	38	Orange				
	39	Green				
	40	Brown				
	41	Slate				
	42	White				
	43	Red				
	44	Black				
	45	Yellow				
	46	Violet				
	47	Pink				
	48	Aqua				

- OTDR Trace results attached for all fiber (Yes/No):

Tested By
(Sign with date)

Witnessed By
(Sign with date)

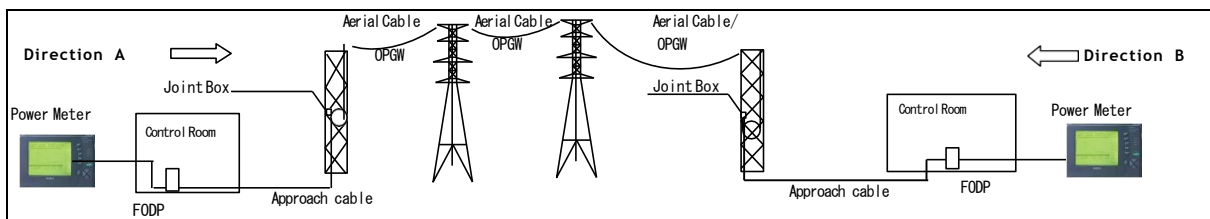
Approved By
(Sign with date)

SAT-05-A (48 F)
FO CABLE END TO END TEST USING POWER METER (1550 nm)

Report No:

Date:

SECTOR	FODP to FODP			
LINE LINK				
REFERENCE POWER : Pr dBm				
A- Power measuring from A Direction dBm			P1: Pr - A dBm	
B- Power measuring from B Direction dBm			P2: Pr - B dBm	
Type of Power Meter	Testing Date	Wave Length	Max Attenuation of Fiber	Specified Loss
		1550 nm	0.21 db/km	$\sum 0.21\text{dB/km} \times \text{Total FO length} + 0.05\text{dB/splice} \times \text{Total No. of splice} + 0.5\text{dB/connector} \times \text{No. of connectors}$



Tube Color	Fiber No	Fiber Color	Length (Km)	Received Power (dB)		Actual Loss (dB) $P=(P1+P2)/2$	Average Loss (dB/km) P/Section length
				Direction-A (P1)	Direction-B (P2)		
BLUE	1	Blue					
	2	Orange					
	3	Green					
	4	Brown					
	5	Slate					
	6	White					
	7	Red					
	8	Black					
	9	Yellow					
	10	Violet					
	11	Pink					
	12	Aqua					
ORANGE	13	Blue					
	14	Orange					
	15	Green					
	16	Brown					
	17	Slate					
	18	White					
	19	Red					
	20	Black					
	21	Yellow					
	22	Violet					
	23	Pink					
	24	Aqua					

Tube Color	Fiber No	Fiber Color	Length (Km)	Received Power (dB)		Actual Loss (dB) $P=(P1+P2)/2$	Average Loss (dB/km) P/Section length
				Direction-A (P1)	Direction-B (P2)		
GREEN	25	Blue					
	26	Orange					
	27	Green					
	28	Brown					
	29	Slate					
	30	White					
	31	Red					
	32	Black					
	33	Yellow					
	34	Violet					
	35	Pink					
	36	Aqua					
BROWN	37	Blue					
	38	Orange					
	39	Green					
	40	Brown					
	41	Slate					
	42	White					
	43	Red					
	44	Black					
	45	Yellow					
	46	Violet					
	47	Pink					
	48	Aqua					

- OTDR Trace results attached for all fiber (Yes/No):

Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

SAT-05-B (48 F)
FO CABLE END TO END TEST USING POWER METER (1310 nm)

Report No:

Date:

SECTOR	FODP TO FODP			
LINE LINK				
REFERENCE POWER : Pr dBm				
A- Power measuring from A Direction dBm			P1: Pr - A dBm	
B- Power measuring from B Direction dBm			P2: Pr - B dBm	
Type of Power Meter	Testing Date	Wave Length	Max Attenuation of Fiber	Specified Loss
		1310 nm	0.35 db/km	$\sum 0.35\text{dB/km} \times \text{Total FO length} + 0.05\text{dB/splice} \times \text{Total No. of splice} + 0.5\text{dB/connector} \times \text{No. of connectors}$

Tube Color	Fiber No	Fiber Color	Length (Km)	Received Power (dB)		Actual Loss (dB) $P=(P1+P2)/2$	Average Loss (dB/km) P/Section length
				Direction-A (P1)	Direction-B (P2)		
BLUE	1	Blue					
	2	Orange					
	3	Green					
	4	Brown					
	5	Slate					
	6	White					
	7	Red					
	8	Black					
	9	Yellow					
	10	Violet					
	11	Pink					
	12	Aqua					
ORANGE	13	Blue					
	14	Orange					
	15	Green					
	16	Brown					
	17	Slate					
	18	White					
	19	Red					
	20	Black					
	21	Yellow					
	22	Violet					
	23	Pink					
	24	Aqua					

Tube Color	Fiber No	Fiber Color	Length (Km)	Received Power (dB)		Actual Loss (dB) $P=(P1+P2)/2$	Average Loss (dB/km) P/Section length
				Direction-A (P1)	Direction-B (P2)		
GREEN	25	Blue					
	26	Orange					
	27	Green					
	28	Brown					
	29	Slate					
	30	White					
	31	Red					
	32	Black					
	33	Yellow					
	34	Violet					
	35	Pink					
	36	Aqua					
BROWN	37	Blue					
	38	Orange					
	39	Green					
	40	Brown					
	41	Slate					
	42	White					
	43	Red					
	44	Black					
	45	Yellow					
	46	Violet					
	47	Pink					
	48	Aqua					

- OTDR Trace results attached for all fiber (Yes/No):

Tested By
(Sign with date)

Witnessed By
(Sign with date)

Approved By
(Sign with date)

APPROACH CABLE INSTALLATION AND HANDLING DOCUMENT

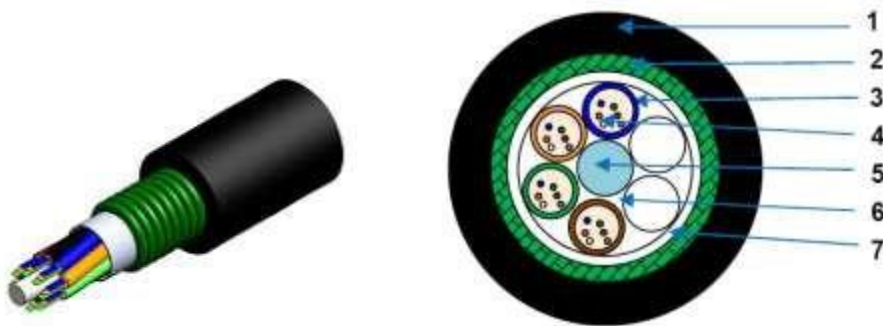
Introduction: -

A fiber optic approach cable is defined as the Armored Underground fiber optic cable required to connect Overhead Fiber Optic Cable (OPGW) between the final in line splice enclosure on the gantry/ tower forming the termination of the fiber cable on the power lines and the fiber Optic Distribution Panel (FODP) installed within the building. The Supply and installation of optical fiber approach cable as required based on detailed site survey. The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval. The approach cable shall be laid in the PLB HDPE duct in all conditions.

Overview: -

Optical fibers require special care during installation to ensure reliable operation. Installation guidelines regarding minimum bend radius, tensile loads, twisting, squeezing, or pinching of cable must be followed. Cable ends should be protected from contamination and scratching at all times. Violation of any of these parameters causes increased attenuation or permanent damage to the cable. Make sure you check the installation instructions of the module for the appropriate cable lengths to ensure proper operation.

Approach Cable Structure



Construction :

1. Outer sheath (PE, Anti-rodent)
2. Armor tape
3. Loose tube
4. Fiber and jelly
5. Center strength member (FRP)
6. Cable jelly
7. Water blocking tape

Technical Characteristics

The unique extruding technology provides the fibers in the tube with good flexibility and bending endurance. The unique fiber excess length control method provides the cable with excellent mechanical and environmental properties multiple water blocking material filling provides dual water blocking function provides good crush resistance.

Dimensions and Properties

Physical	Fibre Count	24 G652D	48 G652D
	No. of Fibre Per Tube	4	8
	Cable OD	11.5 mm	
	Cross Sectional Area	100 mm	
	Cable Weight	Approx. 130 kg/Km	
	Operation Temperature Range	-30° C to + 70° C	
	Installation Temperature Range	-30° C to + 70° C	
	Transport and Storage Temperature Range	-30° C to + 70° C	
Mechanical	Max. Tensile Load	4.5 KN	
	Crush Resistance	3000 N/10 Cm	
	Minimal Installation Bending Radius	20 X OD	
	Minimal Operation Bending Radius	10 X OD	

HANDLING AND LAYING OF PLB HDPE DUCT:

1. The coil of PLB HDPE duct shall be unloaded from either a crane or by any other suitable means very carefully so as not to cause any damage to the duct. The coils at site shall be protected until they are laid. The duct shall be given the same care in handling as that given to the cable. The coils shall be kept as per the guidelines issued by the manufacturer. The coil shall not be set by jerks but shall be handled slowly and care. The walls of the ducts shall not be damaged while moving the coils, if required for unloading.
2. The coil shall normally be unrolled at the same place and the PLB HDPE duct carried by workmen near the trench. The coils shall not be dragged in any case. But where the drums/coils of duct have to be moved should always be rolled in the direction of the arrow, otherwise the coils tend to unwind and the same may get battered. In case no such direction of arrow is given see the direction of winding of the coil and the coil should be rolled pointing in the opposite direction in which the upper end is coiled.
3. All care should be taken in handling the coils with a view to ensure safety of the coils but also of the working party handling them. The coil should not be broken by standing in front of the coil but only from side.

INSTALLATION PROCEDURE OF PLB HDPE DUCT LAYING :

It is advisable to employ the people before commencement of the laying, inspection of the trench and inspection of protection works should be carried out so as to ensure their conformity with the specification. The trench bottom should be clean, smooth and free of small stone. When the soil contains stone or pieces of rock and therefore cannot be raddled, sieved earth about 10 cm. thick should be used both for the bedding on which the duct is being laid. The duct coil should be brought as close to the trench as possible. It should be

lifted carefully with the aid of jacks

1. Supervisor in charge should stand in a commanding position where he can view the entire trenches and shout evenly and call his men to pull. If there is proper synchronization between the mates call in the pulling by the men the duct will leave the coil without difficulty. It is important that the duct shall be pulled with steady and even pulls and there should not be unnecessary twists. Care should be taken to avoid twist as this is likely to damage the PLB HDPE duct. When pulling around bends one or two men should be stationed to give the duct the correct bent when it passes.
2. While laying the duct employ adequate number of men so that the duct can be conveniently carried by them in both hands without stretched arms. The distance between any two persons carrying the duct shall be two to ten meters depending upon the weight such that the maximum sag of the PLB HDPE duct between any two persons is not more than 0.5 meters.
3. While laying work is in progress one man has to continuously observe the PLB HDPE duct along its line in order to determine indentations poles or other damaged parts are apparent. Such damaged parts have to be protected immediately.
4. The conditions of the PLB HDPE duct shall be visually inspected throughout its line and in case damage or defect is noticed, the trench shall be filled up only after ensuring that the damage is not likely to affect the cable.
5. The end of the duct should be sealed with flex to prevent entry of soil before filling back. Adjoining ducts shall be joined by couplers. Duct integrity testing shall be carried out when laying is completed in a block section (1 kms). In case the continuity is not achieved the fault shall be localized and rectified by providing PLB HDPE DUCT couplers/Compression couplers.
6. Tools necessary for laying PLB HDPE Duct is to be checked as physically available before starting the Duct laying. For efficient and safe laying, communication may be provided between following points using portable VHF Walkie talkie sets.
7. The Supervisor In charge of the duct laying. During PLB HDPE duct laying care must be taken not to twist duct in any direction. For this purpose, the survival (rotating hook) shall be attached between pulling line and pulling eye at the end of duct so as to avoid any possible twist during pulling and laying of the cable.
8. During duct laying care must be taken not to twist duct in any direction. For this purpose, the rotating hook shall be attached between pulling line and pulling eye at the end of duct so as to avoid any possible twist during pulling and laying of the cable. In case it is planned to lay the cable in duct by pulling the cable by using a winch; the duct should be provided with a nylon rope for pulling

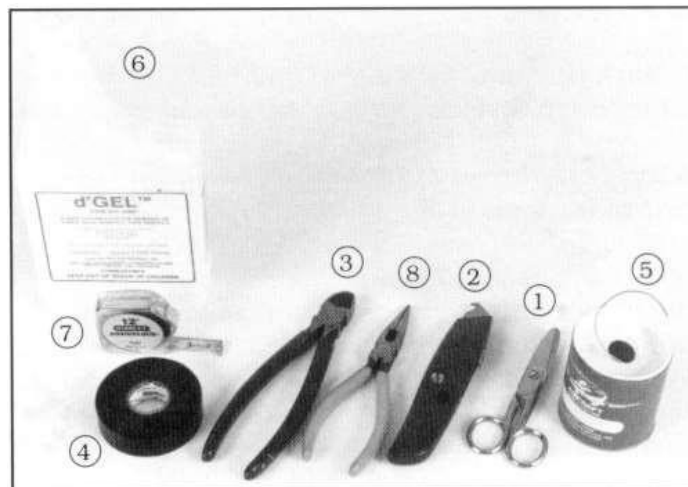
PREPARATION FOR CABLE PULLING GRIP

1. Methods used for placing fiber optic cables in ducts are essentially. However, fiber optic

cable is a high capacity data transmission medium which can have its communication characteristics degraded when subjected to excessive pulling force, sharp bends, and crushing forces. These losses may not be

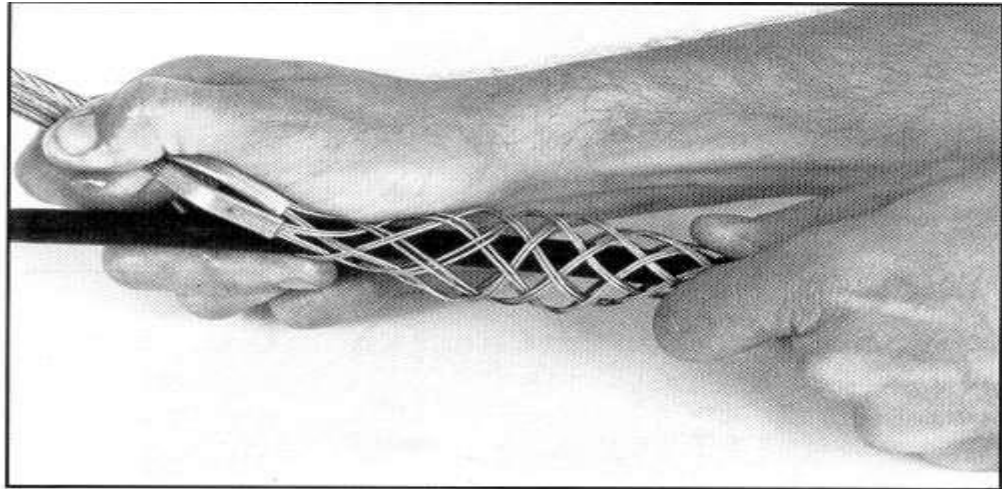
revealed until long after installation is complete. For these reasons extra care must be taken during the entire installation procedure.

2. Cable manufacturers install special strength members, usually aramid yarn, to absorb the stress of pulling the cable. Fiber optic approach cable should only be pulled by these strength members unless the cable design allows pulling by a grip on the jacket. Any other method may put stress on the fibers and harm them. Swivel pulling eyes should be used to attach the pulling rope or tape to the cable to prevent cable twisting during the pull.
3. A Cable pulling grip is installed on fiber optic cable to provide optimum load distribution during cable pulling. When correctly installed, the cable-pulling grip distributes the pulling force equally along the cable strength members. To prevent dangerous cable twisting during the pulling operation.
4. Tools and Materials Required
 - Scissors
 - Utility Knife/Hook Blade
 - Diagonal Pliers/Wire Cutters
 - Vinyl Tape
 - Stainless Steel Wire
 - Cable Cleaner or Approved Solvent
 - Tape Measure
 - Needle Nose Pliers



5. Prior to installation, the proper size grip must be chosen for the cable to be pulled. Grip selection is based on cable inner-outer jacket diameter. Generally, use the smallest grip that will fit over the inner jacket without excessive difficulty. Measure the cable inner jacket diameter and determine the proper grip.

- Remove 1.25 meters (48 inches) or outer sheath exposing the polyethylene jacketed cable core. The length removed depends on pulling grip and should be roughly the length of the grip plus 12-16 inches.
- Mark the outer sheath 48 inches from the cable end with a piece of PVC tape or marking pen.
- Ring cut the outer jacket and armor at the tape mark with utility knife or hook blade.
- Flex the cable to completely sever the jacket and armor sheath. Remove the cable sheath carefully.



- Slide the grip over the end of the cable core and push the cable out through the tape of the mesh leaving about 12 inches of core exposed. (Figure 4)

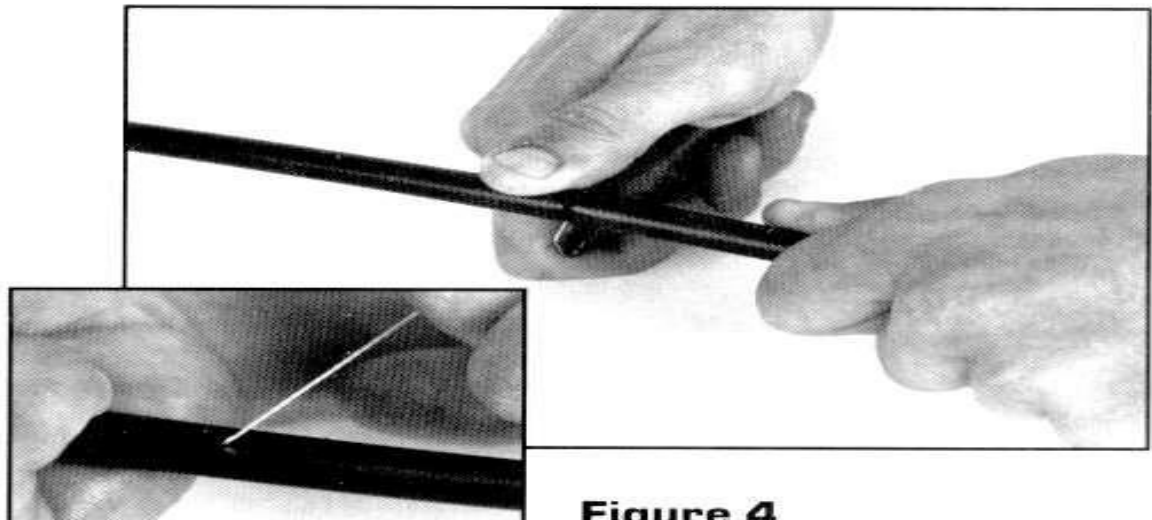


Figure 4

- Remove approximately 12 inches of cable inner sheath from the cable end Cut away all cable Components except the yellow aramid yarn. (Figure 5)



Figure 5

- Secure the yarns to the inner loop of the pulling grip using a square or bowknot. The yarn should be the same length as the pulling grip to insure that pulling forces are equally distributed. (Figure 6)

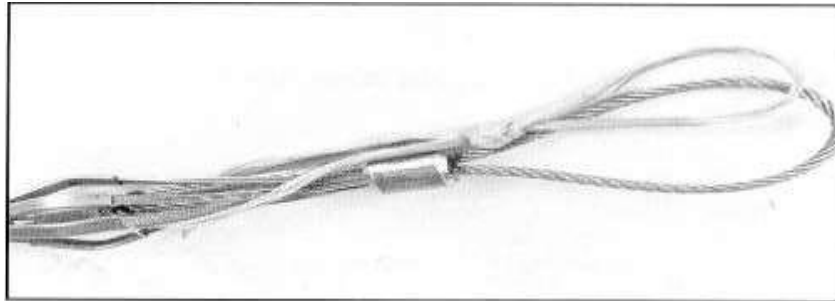


Figure 6

- Adjust the grip position on the inner sheath such that the wire mess section is completely over the cable. Anchor the grip into position by binding with stainless steel wire. (figure 7)

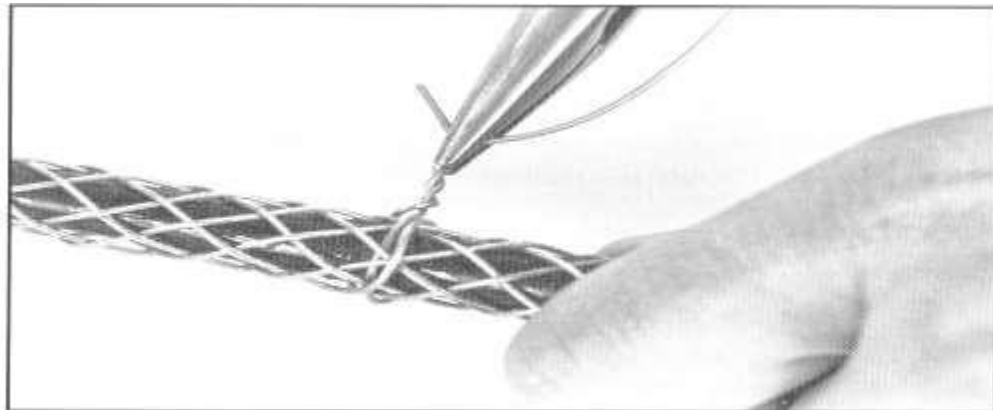
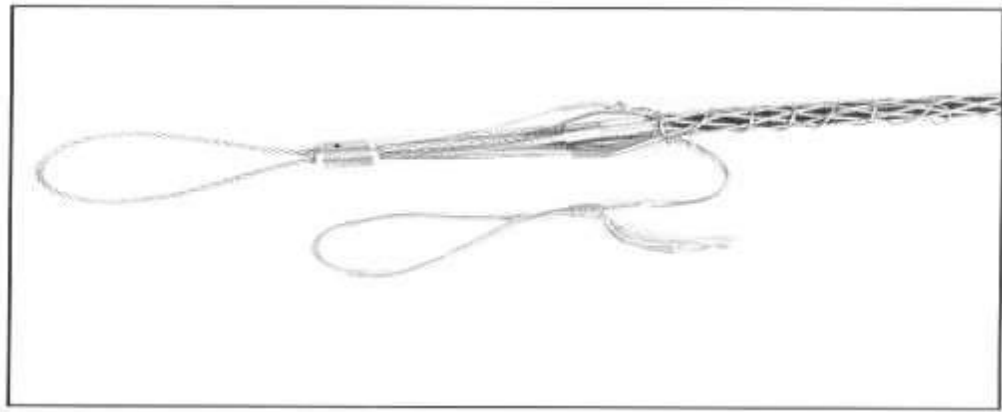
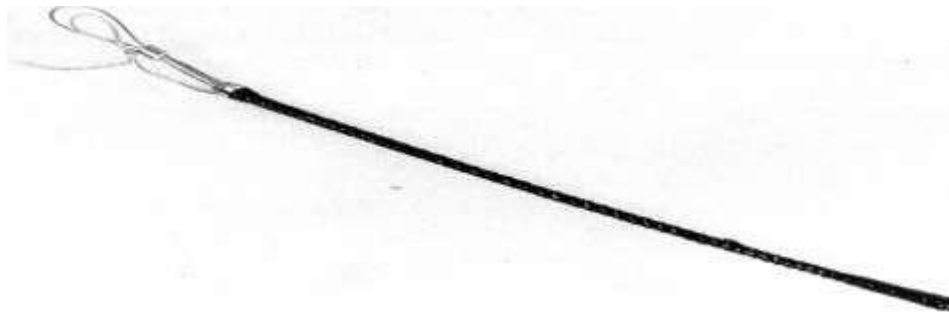


Figure 7

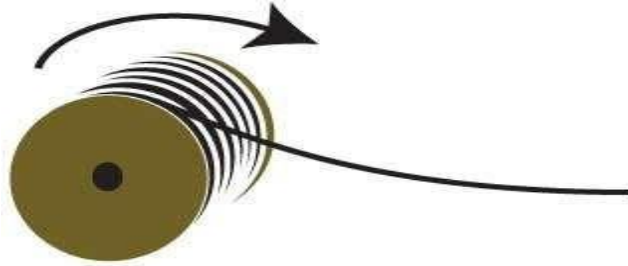
- Place PVC tape over the entire grip and over the junction of the outer sheath to inner sheath. The transition from inner to outer sheath should be smooth. Additionally, the grip ribbing and wire should not be exposed below the tape. The spiral wrap tape should lay from the pulling grip toward the cable to insure smooth pulling. (figure 8)



- Place PVC tape over the entire grip and over the junction of the outer sheath to inner sheath. The tape should lay from the top of the pulling grip toward the cable to insure smooth pulling without snags.
- If applicable, secure the aramid yarns to the inner loop of the pulling grip using a square or bowknot. The yarn should be the same length as the pulling grip to insure that pulling forces are equally distributed.



6. Cables should not be pulled by the jacket unless it is specifically approved by the cable manufacturers. These grips are usually tied to the strength members also. Tight buffer cable can be pulled by the jacket in premises applications if a large (~40 cm, 8 in.) spool is used as a pulling mandrel. Wrap the cable around the spool 5 times and hold gently when pulling. Do not exceed the maximum pulling tension rating. Consult the cable manufacturer and suppliers of conduit, innerduct, and cable lubricants for guidelines on tension ratings and lubricant use. If possible, use an automated puller with tension control and/or a breakaway pulling eye. When laying loops of fiber on a surface during a pull, use "figure-8" loops to prevent twisting the cable.
7. Twisting Cable :- Do not twist the cable. Twisting the cable can stress the fibers. Tension on the cable and pulling ropes can cause twisting. Use a swivel pulling eye to connect the pull rope to the cable to prevent pulling tension causing twisting forces on the cable.

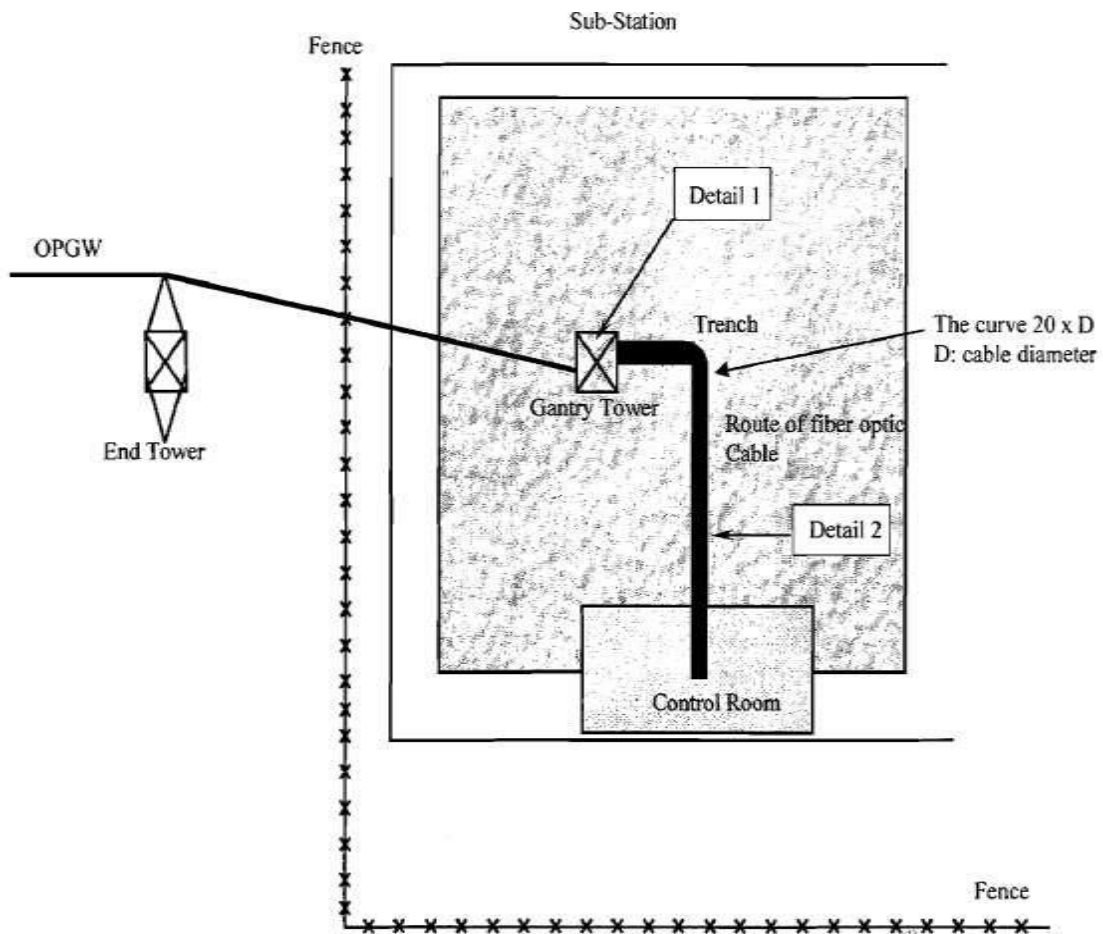


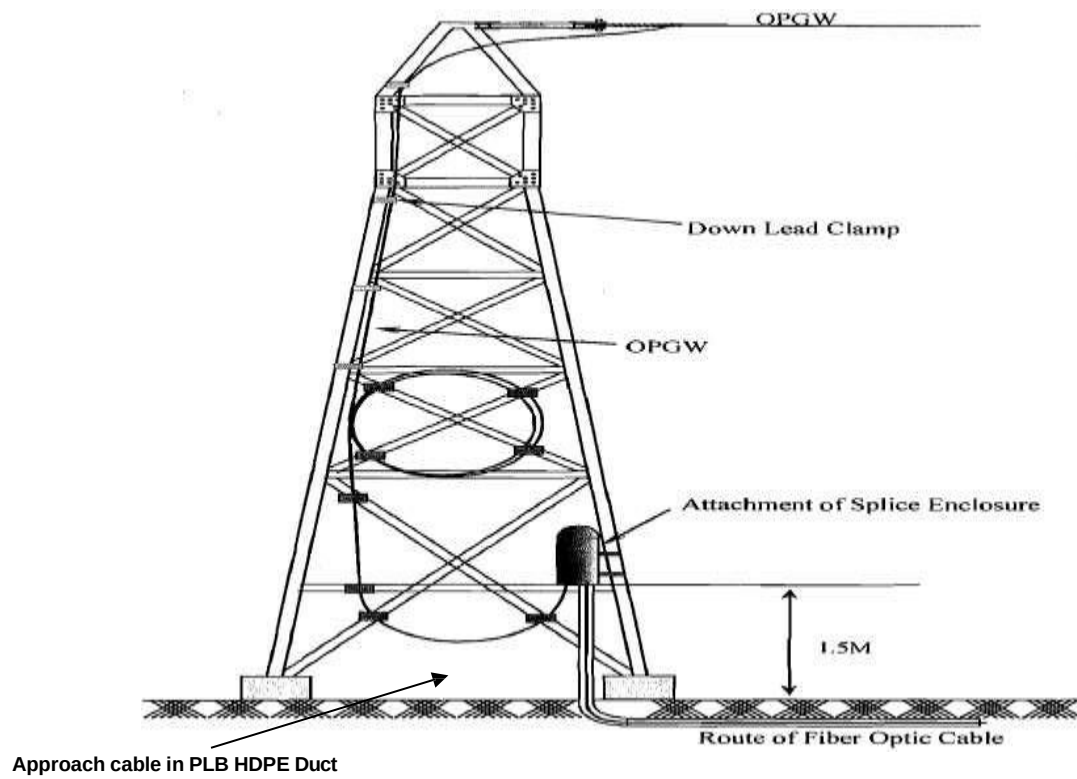
Roll the cable off the spool instead of spinning it off the spool end to prevent putting a twist in the cable for every turn on the spool. When laying cable out for a long pull, use a "figure-8" on the ground to prevent twisting. The figure 8 puts a half twist in on one side of the 8 and takes it out on the other, preventing twists.

PROCEDURE FOR PULLING OF OPTICAL FIBER CABLE:

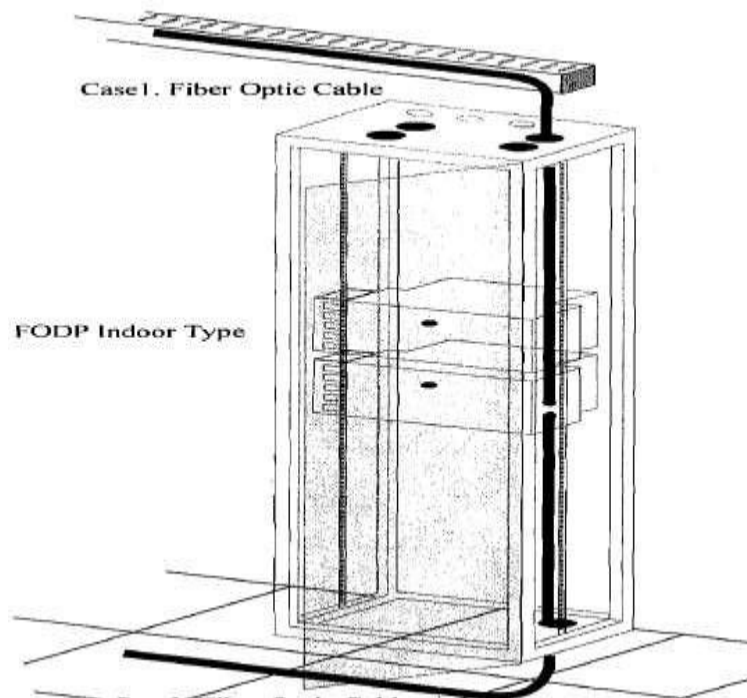
1. Use pulling grip designed for pre-connected fiber optic cables. Grips with a fixed pull ring should use a swivel to attach the pulling rope.
2. Monitor pulling tension. Do not exceed the maximum pulling load rating. On long runs, use proper lubricants and make sure they are compatible with the cable jacket. On really long runs pull from the middle out to both ends. If possible, use an automated puller with tension control or at least a breakaway-pulling eye.
3. Always use a straight pull. Use cable guides to maintain the recommended bend radius. Do not exceed the cable bending radius otherwise it will harm the optical fibers. It may not be immediate but it may even take a few years but eventually by exceeding the recommended bending radius of the cable you reduce life of the cable.
4. Do not twist the cable; putting a twist in the cable can stress the fibers.
5. Roll the cable off the spool. Use the device to aid in uncoiling long cables. Do not spin it off the spool end. This puts a twist in the cable for every turn on the spool. Figure 8 for a long pull. If you are laying cable for a long pull, use a figure 8 on the ground to prevent twisting.
6. Bend Radius: - Do not exceed the cable bend radius. Fiber optic cable can be broken when kinked or bent too tightly, especially during pulling. If no specific recommendations are available from the cable manufacturer, the cable should not be pulled over a bend radius smaller than twenty (20) times the cable diameter. After completion of the pull, the cable should not have any bend radius smaller than ten (10) times the cable diameter.
7. Vertical Cable Runs: - Drop vertical cables down rather than pulling them up whenever possible. Support cables at frequent intervals to prevent excess stress on the jacket. Support can be provided by cable ties (tightened snugly, not tightly enough to deform the cable jacket) grips. Use service loops can to assist in gripping the cable for support and provide cable for future repairs or rerouting.

The route for the fiber optic cable and FODP Lay out in control room. Planned route for approach cable at switchyard of sub-station





Gantry Tower in Sub-station



FODP (Fiber Optic Distribution Panel in Control Room)

Protect cables from excessive or frequent bending. Routing on a cabinet door should be used as a resort and special care must be taken to protect the cable and avoid exceeding the bending radius of the cable.

When routing the cable proper pulling techniques should be used earlier in this manual. When attaching cables with clamps use plastic clamps with large surface areas and avoid pinching or squeezing cable. Cable should be installed manually with gentle pressure.

Cleaning Fiber Optic Connections

We recommend always keep dust caps on connectors, bulkhead splices, patch panels or anything else that is going to have a connection made with it. Not only will it prevent additional dust buildup, but it will prevent contamination from being touched or damaged from dropping.

When testing, we recommend that connectors on both the reference and tested cables be cleaned before every test, as every time the connector is exposed to air, it can accumulate dust.

