

SECTION-IVB

TOWER TESTING

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

TECHNICAL SPECIFICATIONS

SECTION-IV B

TOWER TESTING

Revision History

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TOWER TESTING

1.0 Tower Load Tests

1.1 Testing of Tower

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 design 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. The tower shall be tested for specified loading conditions as approved by employer. The Contractor shall submit to the Employer, 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 has approved the test procedures and programme, the Contractors will intimate the Employer about carrying out the tests at least 30 days in advance of the scheduled date of tests. Employer 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 or their representatives 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. The price for the tower tests will be quoted after allowing rebate for the scrap value of the tower material which will be retained by the Contractor.

- 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 fro 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. The contractor may do the spotting of towers, supply of stubs & casting of foundations before testing of towers at their own risk and cost and if any modification/strengthening is required after successful completion of testing of towers, same shall be carried out by the contractor without any financial implication to employer.
- 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 at the time of approving the rigging chart/ test data sheet.
- 1.1.9 The Employer 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 standards 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 till the load value reaches as specified in approved rigging chart or Lattice Tower fails (whichever is earlier).

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.

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 included in fabrication charges quoted by bidder.

SECTION-IVC

TOWER: MATERIALS, FABRICATION, ERECTION & STRINGING

TECHNICAL SPECIFICATIONS

SECTION-IV C

TOWER: MATERIALS, FABRICATION, ERECTION & STRINGING

Revision History

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TECHNICAL SPECIFICATIONS

SECTION-IV C

TOWER: MATERIALS, FABRICATION, ERECTION & STRINGING

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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 including plates 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 including plates 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 before any substitution and records of such substitutions shall be maintained by the Contractor.

1.1.2 Fasteners: Bolts, Nuts and Washers

- 1.1.2.1 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.
- 1.1.2.2 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). Alternatively, contractor may use 12mm diameter of property class 6.8 in place of 16 mm diameter bolts. However use of both 12 mm and 16 mm diameter bolts simultaneously in the same package is not permitted. Matching Nut for 12 mm diameter bolts shall be property class 6 as specified in IS 1367 (Part-VI).
- 1.1.2.3 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. The shear strength of bolts for 6.8 grade should be minimum 372 MPa. Bolts should be provided with washer face in accordance with IS 1363 (Part-I) to ensure proper bearing.
- 1.1.2.4 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.
- 1.1.2.5 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.
- 1.1.2.6 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.
- 1.1.2.7 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be steel electrogalvanised, positive lock type and 2.5 mm in thickness for 12mm dia bolt ,3.5mm in thickness for 16mm dia bolt and 4.5mm for 24 mm bolt.
- 1.1.2.8 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.
- 1.1.2.9 The bolt positions in assembled towers shall be as per structural drawing.
- 1.1.2.10 Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.

1.1.2.11 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.

1.2 Design and Drawings

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

1.2.1.1 The following design calculation and drawings are required to be furnished to the Employer

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.

1.2.1.2 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 within 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.

1.2.2 In case of Employer design tower: -

- 1.2.2.1 The relevant drawings for all the towers and their extensions shall be furnished to the Contractor by the Employer 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.
- 1.2.2.2 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 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.

Alternatively, in place of physical proto assembly (as specified in (i) and (ii) above), contractor may also carry out proto assembly using any suitable software/3D modelling software.

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.

- 1.2.4 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.
- 1.2.5 The Contractor is required to submit the drawings as mentioned in clause 1.5.1 for Employer's 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 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.
- 1.2.6 The tower accessories drawings like Number plate, Danger plate, phase plate, Circuit Plate, Anti-climbing device, Pole plate, Step Bolt and Earthing Arrangement have been standardized (except Bird Guard) and 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 for approval.
- 1.2.7 The drawings submitted by the Contractor shall be approved/ commented by the Employer as the case may be within fifteen (15) days of receipt of drawings in Employer office. If the designs/ drawings are commented by the Employer, 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.

- 1.2.8 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 and details of submission of revised designs/ drawings.

- 1.2.9 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 3.5 meters and 4.5 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 3.5 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 3.5m 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 be provided and installed by the Contractor. These Danger/ Number/Phase/ Circuit Plate shall be as per the drawings enclosed in the section of drawing. 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.