Design, Supply and Installation of 132kV & 230kV Transmission Lines

Enhancement of Capacity of Grid Substations and Transmission Lines for Rural Electrification under the Rural Electricity Transmission & Distribution Project of the World Bank

VOLUME 2 OF 2

SCOPE OF WORK
TECHNICAL SPECIFICATIONS
DRAWINGS FORMING PART OF SPECIFICATION

January, 2016
# POWER GRID COMPANY OF BANGLADESH LIMITED

Design, Supply and Installation of 132kV & 230kV Transmission Lines

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POWDER GRID COMPANY OF BANGLADESH LIMITED

Design, Supply and Installation of
132kV & 230kV Transmission Lines

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Scope of Work
Technical Specifications
Drawings forming Part of Specifications
POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT

for

Design, Supply and Installation of 132kV & 230kV Transmission Lines
SCOPE OF WORK
AND
GENERAL INFORMATION

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SCOPE OF WORK

and

GENERAL INFORMATION

1.1 GENERAL

The Extent of Supply is described in the following clauses and in the respective Sections of the Specification. All work not expressly called for in the Specification, but necessary for the completion of the work shall be performed and furnished by the Contractor at no additional cost to the Employer.

The Contract shall comprise the manufacture, testing, supply, insurance, delivery to site of tower, phase conductor, Insulators, OPGW including all associated fittings, Hardware fittings, re-conductoring (by constructing bypass lines if required), phase conductor tension and non-tension joints and clamps, vibration dampers, erection, setting to work, testing and the replacement and/or adjustment of defective material and workmanship for the duration of the 12 month warranty period of the transmission line(s) detailed in the ‘Extent of Supply’ and associated Appendix 1.A1.

1.2 EXTENT OF SUPPLY

1.2.1 Scope

1.2.1.1 Supply, delivery and construction of transmission line(s) as mentioned in the specification and Appendix 1.A1.

1.2.1.2 This Specification covers the following scope of works:

(i) detailed survey including route alignment, profiling, tower spotting, optimization of tower locations, soil resistivity measurement & geotechnical investigation (including special foundation locations, viz. pile/well foundation locations)

(ii) check survey shall be conducted to locate tower locations on ground conforming to the approved profile and tower schedule.

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.

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.

(ii) fabrication and supply of all type of transmission line towers as per Employer design/drawings including fasteners, anti theft fasteners, step bolts, hangers, D-shackles etc.

(iv) all types of tower accessories like phase plate, circuit plate (where ever applicable), number plate, danger plate, anti climbing device, Bird guard, ladder (wherever applicable), resting platform (wherever applicable) etc.

(v) supply of Conductor, Insulators, OPGW, Hardware Fittings and Conductor & OPGW Accessories,

(vi) classification of foundation for different type of tower and casting of foundation (including special foundation locations, viz. pile/well foundation locations) for tower footings as per Employer supplied foundations drawing;

(vi) erection of towers, supply and application of zinc rich primer & two coats of enamel paint, tower earthing, fixing of insulator strings, stringing of conductors, OPGW along with all necessary line accessories,

(viii) painting of towers & supply and erection of span markers, obstruction lights (wherever applicable) for aviation requirements (as required)

(ix) testing and commissioning of the erected transmission lines and

(x) Other items not specifically mentioned in this Specification and / or Schedule of prices but are required for the successful commissioning of the transmission line, unless specifically excluded in the Specification.

1.2.1.3 Employer shall provide structural/erectio drawings, available shop drawings & Bill of Materials of all type of transmission line towers and its extensions, river crossing towers/special towers as required to the Contractor after placement of award, in sequence, suitting the project requirement. The hard copies of available proto type load tested tower’s structural and available shop drawings will be provided to the Contractor by the Employer. However, if the Contractor needs to prepare any additional structural and shop drawings or make any correction of existing drawings, that have to be prepared by the Contractor without any additional cost. The Contractor shall inform the Employer before any change/modification/addition of such drawings. The Contractor is required to prepare soft copies of all the drawings (structural and shop drawings) in AutoCAD and provide Employer complete set of all structural and shop drawings in hard copy and soft copy (AutoCAD version). Bidders are requested to inspect the
available drawings in the Design Dept. of PGCB to satisfy themselves regarding the extent of available drawings.

1.2.1.3 (a) The provisional quantities of fabricated & galvanised steel parts as per specifications required for towers and other items are given in appropriate Schedule of Prices of respective packages. However, the work shall be executed as per approved drawings.

The various items of work are described very briefly in the appropriate Schedule of prices. The various items of the Schedule of Prices shall be read in conjunction with the corresponding sections in the Technical Specifications including amendments and, additions, if any. The Bidder’s quoted rates shall be based on the description of activities in the Schedule of Prices as well as other necessary operations required to complete the works detailed in these Technical Specifications.

(c) The Unit rates quoted shall include minor details which are obviously and fairly intended, and which may not have been included in these documents but are essential for the satisfactory completion of the various works.

(d) The unit rate quoted shall be inclusive of all plant equipment, men, material skilled and unskilled labour etc. essential for satisfactory completion of various works.

(e) All measurements for payment shall be in S.I. units, lengths shall be measured in meters corrected to two decimal places. Areas shall be computed in square meters & volume in cubic meters rounded off to two decimals.

1.2.1.4 The Bidder shall submit his offer taking into consideration that the tower designs/drawings shall be developed/provided by Employer and design rights will be strictly reserved with Employer. Bidder shall quote the unit rates for various items of towers as per units mentioned in appropriate schedule of (SCHEDULE OF PRICE). However, payment of these items identified in the schedule of prices shall be made as follows:

<table>
<thead>
<tr>
<th></th>
<th>Tower/Pole</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Supply items</td>
</tr>
<tr>
<td>ii)</td>
<td>Erection items</td>
</tr>
<tr>
<td>B)</td>
<td>Foundation items:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>On supply of respective complete tower</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On erection of respective complete tower</td>
</tr>
<tr>
<td></td>
<td>On design of foundation of Tower &amp; completion of respective foundation in all respect.</td>
</tr>
</tbody>
</table>

The payment to be made for towers/foundations shall be worked out based on the unit rates and approved Bill of Materials (BOM) for towers and foundation.
1.2.1.5 This specification also includes the supply of Conductor, Insulator, OPGW with all required accessories, hardware fittings and all type of accessories for conductor and earth wire as detailed in the specifications. The technical descriptions of these items are given in relevant section of this Volume of the bidding documents.

1.2.1.5 All the raw materials such as steel, zinc for galvanising, reinforcement steel, cement, coarse and fine aggregates for tower foundation, coke and salt for tower earthing etc. are included in the Contractor’s scope of supply.

1.2.1.6 Bidder shall also indicate in the offer, the sources from where they propose to procure the fasteners, anti theft fasteners, step bolts, hangers, D-shackles etc., tower accessories, aviation signal (if required) etc.

1.2.1.7 Stringing

   a) The entire stringing work of conductor and earth wire shall be carried out by tension stringing technique. The bidder shall indicate in their offer, the sets of tension stringing equipment he is having in his possession and the sets of stringing equipment he would deploy exclusively for each package which under no circumstance shall be less than the number and capacity requirement indicated in Qualifying Requirements for Bidder. However, the Bidder having requisite experience has freedom to use helicopter for stringing. The Bidder intending to use helicopter shall furnish detailed description of the procedure, type & number of helicopter & accessories etc., to be deployed for stringing operation.

   b) In hilly terrain and thick forest or area with site constraints, where deployment of tension stringing machine is not possible, manual stringing may be adopted after getting approval of Employer’s site Engineer. The contractor shall deploy appropriate tools/ equipments / machinery to ensure that the stringing operation is carried out without causing damage to conductor / earth wire/OPGW and conductor / earthwire /OPGW is installed at the prescribed sag-tension as per the approved stringing charts.

1.2.1.8 Reconductoring

   All materials that will be removed from the decommissioned lines shall be packed properly and transported and returned to employer’s stores. The methodology of removal and packaging shall be submitted to the client for approval.
   All removed conductor is to be drummed without any damage and stored as per instruction of site engineer. The old conductor shall be drummed in steel drums to be handed over to the client using the drums from the newly supplied conductors
   Insulators and all other fittings shall be properly packed and stored in strong nonreturnable boxes. These boxes can come from the materials from the newly supplied ones.
The contractor shall make his plans for the usage of the packing materials to ensure availability for storage for the decommissioned lines materials.

Two types of conductor will be used for re-conductoring.
- ACSR Grosbeak conductor
- Higher current carrying capacity conductor (Special type conductor), specification as mentioned in Appendix 11.AI/3.

ACSR Grosbeak will be used for re-conductoring of 132kV Bhulta-Ghorashal (46km) & 132kV Haripur Chouddogram (80km) transmission lines.
Higher current carrying capacity conductor will be used for re-conductoring of 132kv Haripur-Bhulta(17km), Ghorashal-Ashuganj(45km) & Chouddogram-Feni(41km) transmission lines.

1.2.1.8 Special clause on conductor drums.

The specification on packaging (section 17) requires wood drums to be used for the supply of conductors.

Some of the drums however will be used for re-drumming the decommissioned line and as such these drums will need to be made of steel for long storage. In addition all the conductors to be provided as spare shall also be supplied in steel drums.

The drums shall be according to ANSI standards.

The quantity of these steel drums for re-drumming will correspond to about 65% of the total conductor length (excluding spare conductor).

1.3 Details of Transmission Line Routes and Terrain

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

Bidders may however visit the line route to acquaint themselves with terrain conditions, approach/accessibility to the site, salient features of the route and associated details of the proposed transmission lines. Employer may also arrange joint site visit of line route in Bangladesh for all the interested Bidders who intend to participate in the bidding and have purchased the bidding documents.

1.4 Location Details and Terminal Points

1.4.1 Reference shall be made to Appendix 1.A2 for Terminal Points.
1.4.2 The Contractor shall have to construct these transmission line(s) completely up to dead end towers on either ends. Stringing shall also be carried out from dead end tower to terminal Gantry/Tower.

1.5 Access to the Line and Right of Way

Reference shall be made to Vol II, Section 5 “Access” for full description for line access.

1.5.1 Transmission line Right of Way compensation

Compensation for the right of way of transmission line will be paid to the affected owners of land and property along the route of the line. This compensation will be calculated following the Government of Bangladesh’s laws and policies and the World Bank’s environmental and social safeguard policies. The project follows a guiding “Environment and Social Management Framework” prepared for this project. The bidder may access this document following the link mentioned below:


The bidder shall inspect the proposed routes to his satisfaction and assess:

a) the cost for the line route clearance and
b) an estimate for the affected persons compensation along the route according to RPF.

c) The Compensation process will be as follows:

- The contractor will pay this compensation to the affected persons according to the RPF.
- The contractor shall maintain necessary records of the compensation transaction process and will submit to the employer at agreed intervals.

During check survey by the contractor, they shall identify the crops, trees, structures etc. along the route for giving proper compensation to the affected persons as per the GoB and the World Bank’s safeguard policies. In order to allow proper compensation to the affected person, during the check survey, the employer or his representative also will assess the compensation along the route and prepare a Resettlement Action Plan (RAP) which will be approved by the World Bank. The contractor will pay compensation following the RAP. The employer will pay the contractor the actual expenses incurred for implementing the RAP and paying compensation. The employer has kept an estimated budget amount in the BoQ of the bidding document to incur this compensation based on an initial estimate. In case of any dispute in this regard, the assessment of compensation by the employer or his representative will prevail (as specified in its RAP). It will be legally binding upon the contractor to implement the Resettlement Action Plan (RAP) prepared by the employer and pay all compensation amounts accordingly before the commencement of civil works (or phases thereof).

1.6 Temporary – Bypass lines
In some instances where existing transmission lines are heavily loaded it may not be possible to remove one of the two circuits of the double circuit line for re-conductoring. In these cases and as indicated in the price schedules the contractor shall construct a temporary line to bypass the required section to be re-conductored. The sections that needs to be re-conductored will be advised at the time of project execution.

The contractor shall collect all these materials to build the bypass line, from the PGCB stores, as free issue items and shall transport to the required site and install these materials, to commission into service the temporary line. These materials may come from the other decommissioned lines or provided from existing PGCB store materials. In any case this shall be discussed and agreed with PGCB at the time of the works execution to capture current status of system requirements at the time.

After the existing lines/sections to be reconducred have been installed and works completed/commissioned the temporary line will be decommissioned, dismantled and materials shall be packed and returned to the PGCB stores, and the sites where poles have been installed shall be reinstated. Any compensation for the temporary lines shall be handled as per the rest of the works for route clearance.

2.0 Transmission structures and Line data

2.1 General Description of structure

2.1.1 The transmission towers are of self-supporting hot dip galvanised lattice steel type has been designed to carry the line conductors with necessary insulators, earth wires and all fittings under all loading conditions.

2.1.2 The tower shall be fully galvanised using mild steel or/and high tensile steel sections as specified in relevant clause. Bolts and nuts with spring washer are to be used for connections.

2.1.3 The towers are of the following types:

2.1.3.1 132 kV
   a) 132kV Four Circuit (1QL, 1Q15, 1Q30 & 1QT6)
   b) 132kV Double Circuit (1DL, 1D1, 1D25 and 1DT6)

2.1.3.2 230 kV
   a) 230kV Four Circuit (2QL, 2Q15, 2Q30 & 2QT6)
   b) 230kV Double Circuit (2DL, 2D1, 2D25 and 2DT6)

2.2 Classification of Towers

2.2.1 Not used.

2.2.2 The towers for 132 kV Lines are classified as given below:
<table>
<thead>
<tr>
<th>Type of Tower</th>
<th>Deviation Limit</th>
<th>Typical Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1DL and 1QL</td>
<td>0 deg</td>
<td>i) To be used as tangent tower.</td>
</tr>
<tr>
<td>1D1 and</td>
<td>0 deg – 10 deg</td>
<td>i) Heavy suspension towers with suspension insulator string.</td>
</tr>
<tr>
<td>1Q15</td>
<td>0 deg – 15 deg</td>
<td>i) Angle tower with tension insulator string.</td>
</tr>
</tbody>
</table>
| 1D25          | 10 deg-25 deg  | i) Angle tower with tension insulator string.  
|               |                | ii) Also to be used for anti cascading condition. |
| 1Q30          | 0 deg – 30 deg | i) Angle tower with tension insulator string.  
|               |                | ii) Also to be used for anti cascading condition. |
| 1DT6, 1QT6    | 25 deg-60 deg  | i) Angle tower with tension insulator string. |
| 1DT6 and 1QT6 | 0-30 deg.      | i) Dead end (terminal) with 0 deg. To 30 deg. |

2.2.3 The Towers for 230 kV Lines are classified as given below:

<table>
<thead>
<tr>
<th>Type of Tower</th>
<th>Deviation Limit</th>
<th>Typical Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>2DL and 2QL</td>
<td>0 deg</td>
<td>i) To be used as tangent tower.</td>
</tr>
<tr>
<td>2D1</td>
<td>0 deg – 10 deg</td>
<td>i) Heavy suspension towers with suspension insulator string.</td>
</tr>
<tr>
<td>2Q15</td>
<td>0 deg – 15 deg</td>
<td>i) Angle tower with tension insulator string.</td>
</tr>
</tbody>
</table>
| 2D25          | 10 deg-25 deg  | ii) Angle tower with tension insulator string.  
|               |                | ii) Also to be used for anti cascading condition. |
| 2Q30          | 0 deg – 30 deg | ii) Angle tower with tension insulator string.  
<p>|               |                | ii) Also to be used for anti cascading condition. |</p>
<table>
<thead>
<tr>
<th>Type of Tower</th>
<th>Deviation Limit</th>
<th>Typical Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>2DT6 and 2QT6</td>
<td>25 deg-60 deg</td>
<td>i) Angle tower with tension insulator string.</td>
</tr>
<tr>
<td>2DT6 and 2QT6</td>
<td>0-30 deg.</td>
<td>i) Dead end (terminal) with 0 deg. To 30 deg.</td>
</tr>
</tbody>
</table>

Note: The above towers/poles can also be used for longer span with smaller angle of deviations without infringement of ground clearance.

2.2.3 Transposition tower
Not Applicable

2.2.6 Extensions
2.2.6.1 DL, D25, DT6, QL, Q30 and QT6 towers are designed for +1.5M, +3.0M, +4.5MM, +6.0M, +9.0M body extension/leg extension. D1 and Q15 towers are designed for +1.5M, +3.0M, +4.5MM, +6.0M, +9.0M, +12.0 M and +15.0M body extensions/leg extensions for maintaining adequate ground clearances without reducing the specified factor of safety in any manner. However, bidders are requested to carefully study the Outline drawings of all type of towers regarding basic body and extension. Suitable negative (-) extension tower may be used to pass the line below existing lines, if required.

2.2.6.2 NOT USED
2.2.6.3 NOT USED
2.2.6.4 All above extension provisions to towers and foundations shall be treated as part of normal towers and foundations only.
2.2.6.5 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.

2.3 Span and clearances
2.3.1 Standard Span
The normal ruling span of the line is 300m for 132kV line and 380m for 230kV line.

2.3.2 Wind Span
The wind span is the sum of the two half spans adjacent to the support under consideration. For normal horizontal spans this equals to normal ruling span.

2.3.3 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 following span limits shall prevail.

### For 132 kV Towers

<table>
<thead>
<tr>
<th>TOWER TYPE</th>
<th>NORMAL CONDITION</th>
<th>BROKENWIRE CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MAX (m)</td>
<td>MIN (m)</td>
</tr>
<tr>
<td>1DL, 1QL</td>
<td>415</td>
<td>110</td>
</tr>
<tr>
<td>1D1, 1Q15</td>
<td>415</td>
<td>110</td>
</tr>
<tr>
<td>1D25, 1Q30</td>
<td>415</td>
<td>110</td>
</tr>
<tr>
<td>1DT6 (Angle), 1Q6 (Angle)</td>
<td>415</td>
<td>110</td>
</tr>
<tr>
<td>1DT6(Terminal), 1QT6(Terminal)</td>
<td>310</td>
<td>0</td>
</tr>
</tbody>
</table>

### For 230 kV Towers

<table>
<thead>
<tr>
<th>TOWER TYPE</th>
<th>NORMAL CONDITION</th>
<th>BROKENWIRE CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MAX (m)</td>
<td>MIN (m)</td>
</tr>
<tr>
<td>2DL, 2QL</td>
<td>510</td>
<td>180</td>
</tr>
<tr>
<td>2D1, 2Q15</td>
<td>1050</td>
<td>450</td>
</tr>
<tr>
<td>2D25, 2Q30</td>
<td>415</td>
<td>110</td>
</tr>
<tr>
<td>2DT6 (Angle), 2QT6 (Angle)</td>
<td>510</td>
<td>110</td>
</tr>
<tr>
<td>2DT6(Terminal), 2QT6(Terminal)</td>
<td>430</td>
<td>0</td>
</tr>
</tbody>
</table>

2.3.4 In case at certain locations where actual spotting spans exceed the design spans, the cross-arms and certain members of towers are required to be modified/ reinforced, in that case drawings for the modified/reinforced towers will be supplied to the Contractor as per requirement.

### 2.4 Electrical Clearances

#### 2.4.1 Ground Clearance

The minimum ground clearance from the bottom conductor shall not be less than 7000mm for 132kV line and 8000mm for 230kV line at the maximum sag conditions i.e. at 80°C and still air.

- a) An allowance of 150mm shall be provided to account for errors in stringing.
- b) Conductor creep shall be compensated by over tensioning the conductor at a temperature of 26°C lower than the stringing temperature for ACSR.

### 2.5 Electrical System Data

#### 2.5.1 For 132 kV line
<table>
<thead>
<tr>
<th>No.</th>
<th>Specification</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nominal Voltage</td>
<td>kV</td>
<td>132</td>
</tr>
<tr>
<td>2.</td>
<td>Maximum system voltage</td>
<td>kV</td>
<td>145</td>
</tr>
<tr>
<td>3.</td>
<td>BIL (Impulse)</td>
<td>kV (Peak)</td>
<td>650</td>
</tr>
<tr>
<td>4.</td>
<td>Power frequency withstand voltage (Wet)</td>
<td>kV (rms)</td>
<td>275</td>
</tr>
<tr>
<td>5.</td>
<td>Minimum Corona extinction voltage at 50 Hz AC system under dry condition</td>
<td>kV (rms)</td>
<td>phase to earth.</td>
</tr>
</tbody>
</table>

2.5.2 For 230 kV line

<table>
<thead>
<tr>
<th>No.</th>
<th>Specification</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nominal Voltage</td>
<td>kV</td>
<td>230</td>
</tr>
<tr>
<td>2.</td>
<td>Maximum system voltage</td>
<td>kV</td>
<td>253</td>
</tr>
<tr>
<td>3.</td>
<td>BIL (Impulse)</td>
<td>kV (Peak)</td>
<td>1050</td>
</tr>
<tr>
<td>4.</td>
<td>Power frequency withstand voltage (Wet)</td>
<td>kV (rms)</td>
<td>460</td>
</tr>
<tr>
<td>5.</td>
<td>Minimum Corona extinction voltage at 50 Hz AC system under dry condition</td>
<td>kV (rms)</td>
<td>phase to earth.</td>
</tr>
</tbody>
</table>

3.0 NOT USED

4.0 Details of line Material:

4.1 For 132 kV and 230 kV Lines

4.1.1 Conductor, OPGW and earthwire

Please refer to Appendix 11.A1/1.

4.1.2 Insulator Strings

Please refer to Appendices of Section 9.

4.13 Insulator String Hardware (As may be applicable)

a) Anchor Shackle  
b) Chain Link  
c) Ball Clevis  
d) Arcing horn holding plate
e) Yoke plate  
f) Socket clevis  
g) Arcing horns  
h) Corona control ring/grading ring.  
i) Clevis Eye  
j) Free center type/Armour grip suspension clamp for suspension strings.  
k) Compression type dead end clamp for tension string.  
l) Sag adjuster for tension string.  
m) Balancing weight for pilot string

4.1.4 Accessories for Conductor & Earth wire (As may be applicable)

a) Preformed Armour rods  
b) Mid Span compression joint  
c) Repair Sleeves  
d) Flexible copper bonds  
e) Vibration dampers  
f) Twin bundle spacer  
g) Twin Rigid Spacer  
h) Suspension clamp for earth wire.  
i) Tension clamp for earth wire.

5.0 Service Condition

Equipment/material to be supplied against this specification shall be suitable for satisfactory continuous operation under conditions as specified below:

- Maximum ambient temperature: 45 (Degree Celsius)
- Minimum ambient temperature: 4 (Degree Celsius)
- Relative humidity (% range): 10-100
- Maximum annual rainfall & snowfall (cm): as per published Meteorological/climatological data
- Maximum altitude above mean sea level (Metres): Upto 1000 m
- Isokeraunic level (days/years): 80

Climate varies from moderately hot and humid tropical climate to cold climate.

6. Estimated and Final Quantities
The quantities set out in the Schedules are, unless otherwise defined, estimated quantities of the Works required. They are not to be assumed as the actual and final quantities to be executed by the Contractor in fulfilment of his obligations under the Contract.

Final quantities are to be established by the Contractor, and agreed upon by the Employer, immediately after signing of the Contract, after the selection of tower positions has been made on completion of the survey of the transmission line routes.

7. Modifications

The transmission line shall be completely in accordance with the Specification and associated design and general arrangement/outline drawings. Any modifications thereto are subject to written confirmation by the Employer/Engineer.

8. TERMINAL POINTS

The terminal points for the supply and/or installation of the transmission line are defined in Appendix 1.A2.

9. PROGRAMME OF WORK

Within 4 (four) weeks of signing of the contract the Contractor shall submit to the Employer for approval, 5 (five) copies of a bar chart detailing the plant manufacture, testing, delivery and erection programme (as appropriate) for the complete Contract Works.

The bar chart shall indicate the various phases of work for all appropriate items of the Contract, from commencement of the Contract to its final completion eg. design, survey, approval of drawings, ordering of materials, manufacture, testing, delivery, erection and commissioning. The bar chart shall, when appropriate, allow the requisite periods of approval by the Employer, and/or any other regulatory body.

If at any time during the execution of the Contract it is found necessary to modify the approved bar chart, the Contractor shall inform the Employer and submit a modified bar chart for approval. Such approval is not deemed to be consent to any amendments to the contractual completion date(s).

Modifications which may affect site work and associated local arrangements must provide a sufficient notice period to allow for any necessary re-arrangements. It should be recognised that where certain power line outages for crossing purposes have been specified, it may not be possible for these to be replanned due to system operational constraints and this should be allowed for in the overall programme.

The Employer intends that access will be given to a reasonable number of sites to provide continuity of work. However, the Contractor shall accommodate reasonable delays in access to some individual sites which may prevent sequential
foundation installation and support erection work being carried out. Provided he has overall continuity of work, this shall not affect the Contractor's programme.

APPENDIX 1.A1

SCOPE AND EXTENT OF DEFINITE WORK

Design, Supply and Installation of Package 1

132kV & 230kV Transmission Lines

LOT-1: TRANSMISSION LINES

Design, Supply, delivery, installation, testing & commissioning of approximately 388.5km 132kV &230kV double/single circuit overhead transmission line is summarized below and as described after the table:

<table>
<thead>
<tr>
<th>Section</th>
<th>Circuit description</th>
<th>Route</th>
<th>Length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A:</td>
<td>Double Circuit</td>
<td>Keraniganj – Nawabgonj</td>
<td>26.52</td>
</tr>
<tr>
<td>B:</td>
<td>Double Circuit Line</td>
<td>Magura – Narail</td>
<td>40.76</td>
</tr>
<tr>
<td>C:</td>
<td>Single Circuit Line on Double Circuit Tower</td>
<td>Tista – Kurigram</td>
<td>17.60</td>
</tr>
<tr>
<td>D:</td>
<td>Double Circuit Line</td>
<td>Keraniganj(RPP) – Sreenagar</td>
<td>13.20</td>
</tr>
<tr>
<td>E:</td>
<td>Double Circuit In-Out from 230kV Line at proposed Keranigonj 230/132/33kV GIS Substation</td>
<td>230kV Hasnabad – Aminbazar TL to 230/132/33kV GIS SS</td>
<td>1.0</td>
</tr>
<tr>
<td>F:</td>
<td>Four Circuit Interconnecting 132kV line with existing line to Connect proposed Keranigonj 230/132/33kV GIS Substation</td>
<td>Existing 132kV line to proposed Keranigonj 230/132/33kV GIS Substation.</td>
<td>1.6</td>
</tr>
<tr>
<td>G:</td>
<td>Double Circuit In-Out Line at proposed Sherpur Substation</td>
<td>132kV Sirajgonj – Bogra to Proposed Sherpur Substation Stringing of OPGW for Existing 132kV Shahajadpur- Sirajgonj- Bogra Transmission Line.</td>
<td>0.61</td>
</tr>
<tr>
<td>H:</td>
<td>Re-routing of Existing four Circuit 132kv line of Keranigonj Power Plant at new Proposed 230/132/33kV GIS Substation</td>
<td>From existing four circuit tower no. 15 to Proposed Keranigonj 230/132/33kV GIS Substation.</td>
<td>2.38</td>
</tr>
<tr>
<td>I:</td>
<td>Reconductoring of Double</td>
<td>Haripur-Ghorashal-</td>
<td>108</td>
</tr>
<tr>
<td>Circuit Line</td>
<td>Ashuganj 132kV Existing line.</td>
<td></td>
<td></td>
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<tr>
<td>--------------</td>
<td>------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J:</td>
<td>Reconductoring of Double Circuit Line</td>
<td>Haripur-Comilla-Feni 132kV Existing line.</td>
<td>121</td>
</tr>
<tr>
<td>K:</td>
<td>Single circuit stringing of existing</td>
<td>Jhenaidaha-Magura</td>
<td>28</td>
</tr>
<tr>
<td>L:</td>
<td>Single circuit stringing of existing</td>
<td>Rangpur-Tista</td>
<td>23</td>
</tr>
</tbody>
</table>

**Detailed Description of works:**

**Section A:** Construction of Keraniganj – Nawabgonj 132kV Double Circuit Line (26.52km)

The scope of work under this Section is Supply, Erection, Testing and Commissioning of approx. 29.23 km 132kV double circuit three phase transmission line on vertical formation double circuit lattice steel towers with ACSR Grosbeak single phase conductor and one 7×3.25 steel earthwire equivalent OPGW from new constructed 230/132/33kV Keranigonj GIS substation to new constructed 132kV Nawabgonj substation.

Foundation designs are also included in the scope of the Contract.

**Section B:** Construction of Magura – Narail 132kV Double Circuit Transmission Line (40.76 km)

The scope of work under this Section is Supply, Erection, Testing and Commissioning of approx. 39.13km 132kV double circuit three phase transmission line on vertical formation double circuit lattice steel towers with ACSR Grosbeak single phase conductor and one 7×3.25 steel earthwire equivalent OPGW from the existing 132kV substation of Magura to new constructed 132/33kV Narail substation.

Foundation designs are also included in the scope of the Contract.

**Section C:** Construction of Tista – Kurigram 132kV single Circuit Line on Double Circuit Tower (17.60 km)

The scope of work under this Section is Supply, Erection, Testing and Commissioning of approx. 19.1 km 132kV single circuit three phase transmission line on vertical formation double circuit lattice steel towers with ACSR Grosbeak single phase conductor and one 7×3.25 steel earthwire equivalent OPGW from Tista point of Rangpur-Lalmonirhat line to new constructed 132/33kV Kurigram substation.

Foundation designs are also included in the scope of the Contract.
Section D: Construction of Keraniganj (RPP) – Sreenagar 132kV Double Circuit Line (13.20 km)

The scope of work under this Section is Supply, Erection, Testing and Commissioning of approx. 13.3 km 132kV double circuit three phase transmission line on vertical formation double circuit lattice steel towers with ACSR Grosbeak single phase conductor and one 7×3.25 steel earthwire equivalent OPGW from existing 132kV Keranigonj substation (RPP) to new constructed 132/33kV Sreenagar substation. Foundation designs are also included in the scope of the Contract.

Section E: Construction of Four Circuit In-Out from Hasnabad – Aminbazar 230kV Line at proposed Keranigonj 230/132/33kV GIS Substation (1.0 km)

The scope of work under this Section is Supply, Erection, Testing and Commissioning of approx. 1.0 km 230 kV four circuit three phase transmission line on vertical formation four circuit lattice steel towers with ACSR Mallard conductor and one 7×4.0 GS equivalent OPGW, In-Out from Hasnabad – Aminbazar 230kV Line to new constructed Keranigonj 230/132/33kV GIS Substation. Foundation designs are also included in the scope of the Contract.

Section F: Construction of Four Circuit Interconnecting 132kV line with existing line to Connect proposed Keranigonj 230/132/33kV Substation (1.60 km)

The scope of work under this Section is Supply, Erection, Testing and Commissioning of approx. 3.50 km 132kV four circuit three phase transmission line on vertical formation four circuit lattice steel towers with ACSR Grosbeak single phase conductor and one 7×3.25 steel earthwire equivalent OPGW from tower no 36 & 41 of existing Hasnabad – Kallanpur 132kV double circuit line to proposed Keranigonj 230/132/33kV GIS Substation. Foundation designs are also included in the scope of the Contract.

Section G: Construction of Double Circuit In-Out from Sirajgonj – Bogra 132kV Line at proposed Sherpur (Bogra) 132/33kV Substation (0.61 km) and Stringing of OPGW approx. 101 km for Existing 132kV Shahajadpur-Sirajgonj-Bogra Transmission Line.

The scope of work under this Section is Supply, Erection, Testing and Commissioning of approx. 2.0 km 132kV double circuit three phase transmission line on vertical formation double circuit lattice steel towers
with ACSR Grosbeak single phase conductor and one 7×3.25 steel earthwire equivalent OPGW In-Out from Sirajgonj – Bogra 132kV Line to new proposed Sherpur (Bogra) 132/33kV Substation.

Foundation designs are also included in the scope of the Contract.

Supply, Erection, Testing and Commissioning of One 7×3.25 steel earthwire equivalent OPGW on existing 101km 132kV Shahajadpur-Sirajgonj-Bogra transmission line.

**Section H:** Re-routing of Existing four Circuit 132kv line of Keranigonj Power Plant at new 230/132kV Substation (2.38km)

The scope of work under this Section is Supply, Erection, Testing and Commissioning of approx. 2.0 km 132kV four circuit three phase transmission line on vertical formation four circuit lattice steel towers with ACSR Grosbeak single phase conductor and one 7×3.25 steel earthwire equivalent OPGW Re-routing of Existing four Circuit 132kv line of Keranigonj Power Plant from (Four circuit tower no 15 ) to new proposed Keranigonj 230/132kV GIS substation.

Foundation designs are also included in the scope of the Contract.

The hard copies of available proto type load tested tower structural and shop drawings will be provided to the Contractor by the Employer. However, if the Contractor needs to prepare any additional structural and shop drawings or make any correction of existing drawings, that have to be prepared by the Contractor without any additional cost. The Contractor is required to prepare soft copies of all the drawings in AutoCAD and provide Employer complete set of all structural and shop drawings in hard copy and soft copy (AutoCAD version).

Foundation designs are also included in the scope of the Contract.

**Section I:** Re-Conductoring of Existing 132kV Haripur – Ghorasal – Ashuganj Double Circuit Line (108km)

The scope of work under this Section is Supply, Stringing, Testing and Commissioning of approx. 108 km existing 132kV Haripur – Ghorasal – Ashuganj double circuit three phase transmission line with Low Loss thermal & ACSR Grosbeak single phase conductor, Insulators and fittings. Low loss thermal conductor will be used for Haripur-Bhulta(17km) & Ghorasal-Ashuganj(45km) line, ACSR Grosbeak will be used for remaining portion of this line. The scope of works covers removing of existing conductor, removing insulators & fittings, drumming of conductor, storing of drummed/packed conductor, Insulator & fittings. This scope of work is to be completed by keeping one circuit live.

**Section J:** Re-Conductoring of Existing 132kV Haripur – Comilla – Feni Double Circuit Line (121km)
The scope of work under this Section is Supply, Stringing, Testing and Commissioning of approx. 121 km existing Haripur – Comilla – Feni 132kV Double Circuit transmission line with Low Loss thermal conductor & ACSR Grosbeak single phase conductor, Insulators and fittings. Low loss thermal conductor will be used for Feni-Chouddogram (41km; T-396; Tripur& Jatrapur mouza) line. ACSR Grosbeak will be used for remaining portion of this line. The scope of works covers removing of existing conductor, removing of insulators & fittings, drumming of conductor, storing of drummed/packed conductor & fittings. This scope of work is to be completed by keeping one circuit live.

Section K: 132kV Single circuit stringing of existing Jhenaidaha-Magura 132kV line (28km)

The scope of work under this Section is approximate 28.0 km second circuit stringing, Testing and Commissioning of existing Jhenaidaha – Magura 132kV transmission line. This scope of work is to be completed by keeping another circuit live.

Section L: 132kV Single circuit stringing of existing Rangpur-Tista 132kV line (23km)

The scope of work under this Section is approximate 23.0 km second circuit stringing, Testing and Commissioning of Rangpur – Lalmonirhat 132kV transmission line from Rangpur substation to Tista point. This scope of work is to be completed by keeping another circuit live.

APPENDIX 1.A2

TERMINAL POINTS

OPGW terminal boxes and its installation is scope of this contract at each terminal point.

Section A: Construction of Keraniganj – Nawabgonj 132kV Double Circuit Line

Phase conductors and OPGW shall be terminated at the gantry structures of relevant 132/33kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures.

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.

Section B: Construction of Magura – Narail 132kV Double Circuit Transmission Line.
Phase conductors and OPGW shall be terminated at the gantry structures of relevant 132/33kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures.

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.

Section C: Construction of Tista – Kurigram 132kV single Circuit Line on Double Circuit Tower

Phase conductors and OPGW shall be terminated at the gantry structures of relevant 132/33kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures and/or tower.

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.

Section D: Construction of Keraniganj – Sreenagar 132kV Double Circuit Line

Phase conductors and OPGW shall be terminated at the gantry structures of Sreenagar 132/33kV Substation and the other end shall be connected with existing nearest dead end four circuit tower at Keranigonj(RPP). OPGW termination boxes shall be installed at the base of the substations gantry structures and/or tower.

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.

Section E: Construction of Four Circuit In-Out from Hasnabad – Aminbazar 230kV Line at proposed Keranigonj 230/132/33kV Substation

Phase conductors and OPGW shall be terminated at the gantry structures of relevant 230/132kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures and/or tower.

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.

Section F: Construction of Four Circuit Interconnecting 132kV line with existing line to Connect proposed Keranigonj 230/132/33kV Substation

Phase conductors and OPGW shall be terminated at the gantry structures of relevant 132/33kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures and/or tower.
A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.

Section G: Construction of Double Circuit In-Out from Sirajgonj – Bogra 132kV Line at proposed Sherpur (Bogra) 132/33kV Substation and Stringing of OPGW approx. 101km for Existing 132kV Shahajadpur- Sirajgonj- Bogra Transmission Line.

Phase conductors and OPGW shall be terminated at the gantry structures of relevant 132/33kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures and/or tower

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.

Section II: Re-routing of Existing four Circuit 132kv line of Keranigonj Power Plant at new 230/132kV Substation

Phase conductors and OPGW shall be terminated at the gantry structures of relevant 132/33kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures and/or tower

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.

Section I: Re-Conductoring Haripur – Ghorasal – Ashuganj 132kV Double Circuit Line

Phase conductors and OPGW shall be terminated at the gantry structures of relevant 132/33kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures.

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.

Section J: Re-Conductoring Haripur – Comilla – Feni 132kV Double Circuit Line

Phase conductors and OPGW shall be terminated at the gantry structures of relevant 132/33kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures.

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.
Section K: 132kV Single circuit stringing of existing Jhenaidaha-Magura 132kV line

Phase conductors and OPGW shall be terminated at the gantry structures of relevant 132/33kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures.

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.

Section L: 132kV Single circuit stringing of existing Rangpur-Tista 132kV line

Phase conductors and OPGW shall be terminated at the gantry structures of relevant 132/33kV Substation. OPGW termination boxes shall be installed at the base of the substations gantry structures.

A jumper shall be provided with the slack span of sufficient length to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this Contract.
## SECTION 2  SITE PARTICULARS

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### APPENDIX
SECTION 2 SITE PARTICULARS

2.1 GENERAL

The location of the transmission line(s) and associated climatic conditions described in the following clauses are given for guidance only.

2.2 LOCATION

For details of the location of the transmission line(s) reference should be made to Appendix 2.A1 and associated drawings included with the specification.

2.3 CLIMATIC

For details of the climatic conditions associated with the site, reference should be made to Appendix 2.A2. The Contractor is advised to make a thorough study of local climatological records, since no delays to the completion dates due to adverse weather conditions shall be accepted.
APPENDIX 2.A1

Design, Supply and Installation of
132kV & 230kV Transmission Lines

SITE PARTICULARS

Section A: Construction of Keraniganj – Nawabgonj 132kV Double Circuit Line(26.52km)

The line shall pass mostly through agricultural land. The line shall cross the Dhaleshwari river and branch of Isamoti river.

Section B: Construction of Magura – Narail 132kV single Circuit Line on Double Circuit Tower (40.76 km)

The line shall pass mostly through agricultural land. The line shall cross the Chittra river two times & Magura –Jessore highway.

Section C: Construction of Tista – Kurigram 132kV single Circuit Line on Double Circuit Tower (17.60 km)

The line shall pass mostly through agricultural land. The line shall cross the Rangpur-Laomonirhat railway line, Rangpur-Kurigram high way.

Section D: Construction of Keraniganj – Sreenagar 132kV Double Circuit Line(13.20km)

The line shall pass mostly through agricultural land. The line shall cross the Dhaleshwariver two times and Isamoti river. This line also pass through Dhaka-Mawa highway.

Section E: Construction of Double Circuit In-Out from Hasnabad – Aminbazar 230kV Line at proposed Keranigonj 230/132/33kV Substation(1.0 km)

The line shall pass mostly through agricultural land. This line shall also cross some pucca and kacha road.

Section F: Construction of Four Circuit Interconnecting 132kV line with existing line to Connect proposed Keranigonj 230/132/33kV Substation (1.6 km)

The line shall pass mostly through agricultural land. This line shall also cross some pucca and kacha road.

Section G: Construction of Double Circuit In-Out from Sirajgonj – Bogra 132kV Line at proposed Sherpur (Bogra) 132/33kV Substation (0.61km) and
Stringing of OPGW approx. 101km for Existing 132kV Shahajadpur-Sirajgonj-Bogra Transmission Line.

The line shall pass mostly through agricultural land. This line shall also cross some pucca and kacha road.

**Section H:** Re-routing of Existing four Circuit 132kv line of Keranigonj Power Plant at new 230/132kV Substation (2.38km)

Existing condition.

**Section I:** Re-Conductoring Haripur – Ghorasal – Ashuganj 132kV Double Circuit Line (108km)

Existing condition.

**Section J:** Re-Conductoring Haripur – Comilla – Feni 132kV Double Circuit Line (121km)

Existing condition.

**Section K:** 132kV Single circuit stringing of existing Jhenaidaha-Magura 132kV line

Existing condition.

**Section L:** 132kV Single circuit stringing of existing Rangpur-Tista 132kV line

Existing condition.
APPENDIX 2.A2

CLIMATIC CONDITIONS

The following climatic information is given for tender purposes only:

Ambient shade temperature range : 4°C - 45°C
Maximum daily average temperature : 35°C
Relative humidity
  maximum : 100%
  average : 80%
Rainfall : 2.5 m per annum

10 min. mean wind speed at 10-meters above ground level : 46.45 m/sec

Seismic Zone Coefficient : As per Bangladesh National Building Code
Isokeraunic level : 80
## SECTION 3  QUALITY ASSURANCE

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### APPENDIX
SECTION 3

QUALITY ASSURANCES

3.1 GENERAL

3.1.1 The quality assurance arrangements shall conform to the appropriate sections of BS EN ISO 9001.

3.1.2 The Contractor's/Supplier's Quality Programme for the Works shall define the systems and procedures adopted to ensure compliance with the Contract requirements. These systems shall include the following:

Hold Point "A stage in the implementation of project works including material procurement or fabrication/workmanship process beyond which work shall not proceed without the documented approval of the Engineer or their appointed representatives".

Notification Point "A stage in the implementation of project works including material procurement or fabrication/workmanship process for which advance notice of the activity is required to permit attendance".

3.1.3 The Contractor/Supplier is required to give the Engineer or their appointed representatives the requisite period of notice of any Notification Point for which attendance is required.

3.2 QUALITY ASSURANCE PROGRAMME

3.2.1 The Quality Assurance Programme shall give a description of the quality system for the Works and shall include the following details:

(a) The structure of the Contractor's/Supplier's organization.

(b) The duties and responsibilities of staff assigned to ensure quality of the work.

(c) The system for purchasing, taking delivery and verification of materials.

(d) The system for ensuring quality of workmanship.

(e) The system for control of documentation.

(f) The system for retention of records.

(g) The arrangements for the Contractor's/Suppliers auditing.
3.2.2 The Quality Assurance programme for the Works shall be submitted to the Engineer for approval within 30 (thirty) days of signing of contract; unless the Contractor's/Supplier's Quality System has been previously audited and approved by the Engineer on behalf of the Employer/Purchaser. This is a Hold Point.

3.3 QUALITY PLAN

3.3.1 A specific Quality Plan for each section of the work shall be produced by the contractor and/or Supplier. Each Quality Plan shall set out the activities in a logical sequence and shall take into account the following:

(a) An outline of the proposed work and programme sequence.

(b) The structure of the Contractor's and/or Supplier's Organisation for the contract.

(c) The duties and responsibilities of staff assigned to ensure quality of work for the contract.

(d) Hold and Notification points.

(e) Submission of Engineering documents required by this Specification.

(f) The inspection of materials and components on receipt.

Reference to the Contractor's and/or Supplier's quality assurance procedures appropriate to each activity.

(h) Inspection during fabrication/construction.

(i) Final inspection and tests.

3.3.2 The Contractor's and/or Supplier's Quality Plan shall be submitted to the Engineer for approval within 30 (thirty) days of signing of contract. This is a Hold Point.

3.4 RELATED STANDARDS

3.4.1 The IEC and BSI Standards, together with other references referred to in this Specification are listed in Appendix DI of each appropriate section, it is the Contractor's/ Supplier's responsibility to ensure they are in possession of the latest edition, including all amendments current on the defined date prior to the
bid closing date.

3.4.2 Materials or equipment conforming to alternative international or national standards will be considered by the Engineer, provided that these standards ensure an equivalent or higher quality.

3.4.3 The Contractor/Supplier shall bring to the attention of the Engineer any inconsistencies between the requirements of these Standards and this specification.

Where equivalent standard(s) are offered as an alternative, the Contractor/Supplier shall provide two copies of English language translations of the standard(s) at no extra cost to the contract.

3.5 QUALITY CONTROL

3.5.1 Inspection and Testing

The prime responsibility for inspection and testing rests with Contractor/Supplier. The inspection and acceptance of drawings, materials and workmanship; or the waiver of inspection by the Engineer does not relieve the Contractor/Supplier of any obligations or responsibilities to carry out the work in accordance with the Contract. The inspection and testing shall be documented such that it is possible to verify that it was undertaken. Records of inspection shall include as a minimum the contract identity, the name of inspector/tester, date of inspection/test, operation/inspection, technique used, acceptance standard and acceptability.

3.5.2 Type, Sample and Routine Tests

Type, sample and routine tests shall be undertaken as appropriate on all components supplied and/or installed under this contract, in accordance with the requirements of this specification.

3.5.3 Certificate of Conformity

Prior to the issue of the 'Release Certificate' or agreement to shipping, the Contractor/Supplier shall submit to the Engineer 3(three) copies of the completed Certificate of Conformity (see Appendix 3.A1). The certificate shall be supported by copies of the appropriate material test certificates, inspection records, type and sample test reports as detailed in the relevant section of this specification.

3.6 NON CONFORMING PRODUCTS

The Engineer shall review the non-conforming products in accordance with BS EN ISO 9001.
3.7 MONITORING OF QUALITY ASSURANCE ARRANGEMENTS

3.7.1 Monitoring of the Quality Assurance Arrangements may be undertaken by the Engineer/Employer during the course of the contract. This will take the form of surveillance of the activities at work locations and/or by formal audits of the Contractor's/Suppliers systems and procedures which constitute his Quality Assurance Arrangements. Corrective actions shall be agreed and implemented in respect of any deficiencies.

3.7.2 The Contractor/Supplier shall provide all facilities including access (including his suppliers or sub-contractors), which may be required by the Engineer/Employer for monitoring activities.

3.8 SUPPLIERS AND SUB-CONTRACTORS

The Contractor/Supplier shall ensure that any suppliers or sub-contractors appointed by him under the Contract shall conform to the requirements of this Specification. Prior to the appointment of any supplier/sub-contractor the Contractor/Supplier shall ensure that their Quality Assurance Arrangements comply with the requirements of BS EN ISO 9001 and this Specification.

The Contractor's auditing of his supplier's/sub-contractor's Quality Assurance arrangements shall be documented to demonstrate to the Engineer their extent and effectiveness.

3.9 METHOD STATEMENTS

Prior to commencing any section of the work, the Contractor shall submit method statements in accordance with the requirement of the relevant section of this Specification. Submission of these method statements shall be treated as Hold Points.

When requested by the Engineer or their appointed representatives, additional method statements related to specific items of work shall be provided by the Contractor.
APPENDIX 3.A1

CERTIFICATE OF CONFORMITY

To: Director (P&D)  From: (Contractor Details)

Power Grid Company of Bangladesh Ltd
Institution of Engineers Bangladesh (IEB) Bhaban
Ramna, Dhaka-1000
Bangladesh

*To be marked for the attention of .................................................................

We certify that the products detailed below have been inspected, tested and unless noted to the contrary, conform in all respects to the requirements.

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>

ATTACHMENTS

Test reports (details) ---------------------------------------------

(Other details as per relevant section)
APPENDIX 3.B1

ENGINEERING DOCUMENTS TO BE SUBMITTED BY THE CONTRACTOR

<table>
<thead>
<tr>
<th>Clause Reference</th>
<th>Documents Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2.2</td>
<td>Quality Assurance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Programme</td>
<td></td>
</tr>
<tr>
<td>3.3.2</td>
<td>Quality plan</td>
<td></td>
</tr>
<tr>
<td>3.4.4</td>
<td>Equivalent Standards</td>
<td>If applicable</td>
</tr>
</tbody>
</table>

APPENDIX 3.C1

NOTIFICATION AND HOLD POINTS

<table>
<thead>
<tr>
<th>Clause Reference</th>
<th>Notification Points</th>
<th>Hold Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2.2</td>
<td>Quality Assurance</td>
<td>Quality Assurance</td>
</tr>
<tr>
<td></td>
<td>Programme</td>
<td>Programme</td>
</tr>
<tr>
<td>3.3.2</td>
<td>Quality Plan</td>
<td>Quality Plan</td>
</tr>
</tbody>
</table>

APPENDIX 3.D1

REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of the Specification are listed below:

BS EN ISO 9001 - Model for quality assurance in design, development, production, installation and servicing.
APPENDIX

FIELD QUALITY PLAN FOR TRANSMISSION LINES
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description of Activity</th>
<th>Items to be Checked</th>
<th>Tests/Checks to be done</th>
<th>Ref. documents</th>
<th>Check/Testing</th>
<th>Counter Check/Test by EMPLOYER</th>
<th>Accepting authority in EMPLOYER</th>
</tr>
</thead>
</table>
b. Topographical map  
c. Tower spotting data given by Eng. | Contractor | 100% at Field | 100% based on record documents | Project in charge |
|        |                        | b. Route profiling & tower spotting. | 1. Ground clearance  
2. Wt. Span  
3. Sum of Adj. Span (wind span)  
4. Angle of Devn. | a. Sag template  
b. Tower Spotting data  
c. Route alignment | Contractor | 100% at Field | 100% based on record documents | Line in charge |
| 2.     | Check Survey           | Tower Location & Final Length | 1. Alignment  
2. Final Length | a. Route alignment  
b. Tower Schedule  
c. Profile | Contractor  
-do-  
-do- | 100% at Field  
-do-  
-do- | All angle towers in plains and 50% in hilly terrains.  
ii) Final length to be checked on 100% basis based on records/documents | Section in charge |
2. SPT Test  
3. Collection of samples | As per EMPLOYER Specification | Contractor | 100% at Field | To witness 40% at Field | Section in charge |
<table>
<thead>
<tr>
<th>No.</th>
<th>of Activity</th>
<th>done</th>
<th>Agency</th>
<th>Extent</th>
<th>EMPLOYER</th>
<th>authority in EMPLOYER</th>
</tr>
</thead>
<tbody>
<tr>
<td>b.</td>
<td>Tests on samples</td>
<td>As per tech. Specs.</td>
<td>As per EMPLOYER Specification</td>
<td>Lab appd. By EMPLOYER</td>
<td>100% by testing lab</td>
<td>Review of lab test results</td>
</tr>
<tr>
<td>4.</td>
<td>Tower Foundation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>A. Materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Cement</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Physical tests</td>
<td></td>
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</tr>
<tr>
<td>3.</td>
<td>Chemical Tests</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>2.</td>
<td>Reinforcement Steel</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by EMPLOYER</td>
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</tr>
<tr>
<td>3.</td>
<td>Coarse Aggregates</td>
<td>1. Source approval</td>
<td>Source meeting EMPLOYER Specification</td>
<td>Contractor</td>
<td>Proposed by the Contractor, indicating the location of the quarry and based on the test results of Joint samples tested in EMPLOYER approved lab</td>
<td>To review the proposal based on the documents</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Physical tests</td>
<td>As per document at Annexure-3 of this FQP at page 14</td>
<td>Samples to be taken jointly and tested in EMPLOYER approved lab</td>
<td>One sample per lot of 200 cum or part thereof</td>
<td>100% review of lab test results</td>
</tr>
<tr>
<td>4.</td>
<td>Fine aggregate</td>
<td>1. Source approval</td>
<td>Source meeting EMPLOYER Specification</td>
<td>Contractor</td>
<td>Proposed by the Contractor, indicating the location of the quarry and based on the results of Joint samples tested in EMPLOYER approved lab.</td>
<td>To review the proposal based on the documents.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Physical test</td>
<td>As per Annexure-4 of this FQP at page 15</td>
<td>Samples to be taken jointly and tested in EMPLOYER approved lab</td>
<td>One sample per lot of 200 cum or part thereof</td>
<td>100% review of lab test results</td>
</tr>
<tr>
<td>5.</td>
<td>Water</td>
<td>1. Cleanness (Water shall be fresh and clean)</td>
<td>EMPLOYER Specification</td>
<td>Contractor</td>
<td>100% visual check at Field</td>
<td>Verification at random</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Activity</td>
<td>done</td>
<td>Agency</td>
<td>Extent</td>
<td>EMPLOYER</td>
<td>EMPLOYER</td>
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<td></td>
</tr>
<tr>
<td>2. Suitability of water for concreting</td>
<td>EMPLOYER Specification</td>
<td>Contractor</td>
<td>100% Visual Check at Field</td>
<td>Verification at random</td>
<td>Site Engineer</td>
<td></td>
</tr>
</tbody>
</table>

**B. Classification**

1. Visual observation of soil strata
2. Ground water level
3. History of water table in adj. Area/surface water
4. Soil Investigation wherever required

**C. Concrete Works**

**a. Before concreting**

1. Bottom of excavated earth
   - Depth of foundation
     - Appd. Drgs.
     - Contractor
     - 100% at Field
     - 100% check by EMPLOYER
     - Site engineer

   1) Centre Line
   2) Diagonals
   3) Level of stubs

2. Stub setting
   - Placement
     - Bar bending schedule
     - Contractor
     - 100% at Field

3. Reinforcement steel
   - Placement
     - Bar bending schedule
     - Contractor
     - 100% at Field

**b. During concreting**

- a. Section in charge
- b. In case of WBC/SFR/FS acceptance by Line In charge
- c. For Spl. Fdns./pile fdns. Acceptance by Project In charge
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description of Activity</th>
<th>Items to be Checked</th>
<th>Tests/Checks to be done</th>
<th>Ref. documents</th>
<th>Check/Testing Agency</th>
<th>Extent</th>
<th>Counter Check/Test by EMPLOYER</th>
<th>Accepting authority in EMPLOYER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Workability</td>
<td>Slump test</td>
<td>Range 50 mm to 100 mm refer document at Annexure of this FQP at Pg. 16</td>
<td>Contractor</td>
<td>100% at field</td>
<td></td>
<td>40% check at random</td>
<td>Site engineer</td>
</tr>
<tr>
<td>2.</td>
<td>Concrete Strength</td>
<td>Cubes Comp Strength</td>
<td>PWD SPEC as referred in document at annexure of this page at 16</td>
<td>Casting of cubes at site. Cubes to be tested at EMPLOYER appd. Lab for 28 days strength</td>
<td>One sample of 4 cubes in each tower locations / per 6 cum concreting / per day work</td>
<td>100% review of lab test results. Cubes at 40% location are to be taken in presence of EMPLOYER officials</td>
<td>Section In charge</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Pile foundations</td>
<td>1. All materials like cement, steel Coarse/fine aggregate, water</td>
<td>To be tested as per procedure enumerated in the respective columns above</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Before concreting</td>
<td>1. Check for center line of each pile</td>
<td>Appd. Drawings</td>
<td>Contractor</td>
<td>100%</td>
<td>100%</td>
<td>Site Engr.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Check for dia/verticality of each pile</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Check for depth of each pile</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>During Concreting</td>
<td>a. Workability</td>
<td>1. Slump test 150-200 mm as per EMPLOYER Spec.</td>
<td>Contractor</td>
<td>For each pile</td>
<td>100% at field</td>
<td>Site engineer</td>
<td></td>
</tr>
<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by EMPLOYER</td>
<td>Accepting authority in EMPLOYER</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>b. Concrete strength</td>
<td>2. Cubes compressive strength</td>
<td>As per EMPLOYER Specification</td>
<td>Contractor. One set of cubes (Min. 4 nos.) to be taken and tested for 7&amp;28 days strength at EMPLOYER appd. Lab.</td>
<td>One set for each pile. For Pile caps, beams, Chimney, one sample for every 6 Cu.m. or part thereof for each day of concreting.</td>
<td>100% cubes for piles, 20% Pile caps, beams, chimney etc. to be taken in presence of EMPLOYER officials. 100% review of test results.</td>
<td>Section In charge.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Tower member/bolts &amp; nuts/washers/accessories</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Erection of Super-structure</td>
<td>1. Sequence of erection</td>
<td>As per Appd. Drgs./EMPLOYER specification</td>
<td>Contractor</td>
<td>100% at field</td>
<td>100% check</td>
<td>Site Engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Check for completeness</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>Site Engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Tightening of nuts and bolts</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>Site Engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Check for verticality</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>Site Engineer</td>
<td></td>
</tr>
<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by EMPLOYER</td>
<td>Accepting authority in EMPLOYER</td>
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</tr>
<tr>
<td>5.</td>
<td>Tack welding for bolts &amp; nuts</td>
<td>EMPLOYER Specification</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% Check</td>
<td>Site Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Tower footing resistance (TFR)</td>
<td>TFR at locations before and after earthing.</td>
<td>EMPLOYER Specification</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>20% locations to be verified</td>
<td>Line In charge</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Stringing</td>
<td>1. Materials</td>
<td>a. Insulators</td>
<td>1. Visual check for cleanliness/glazing/cracks/white spots.</td>
<td>EMPLOYER Specification</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% verification of records and to carry random checks 10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. IR Value</td>
<td>(min. 50M Ohms)</td>
<td>-do-</td>
<td>One test per sample size of 20 for every lot of 10,000</td>
<td>To verify Contractor's records 100% and joint check 20% of total tests</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. E&amp;M test</td>
<td>-</td>
<td>Insulator supplier</td>
<td>a. 20 per 10,000 for discs b. 3 per 1500 for long rod</td>
<td>Collection of samples, sealing them and handing over by EMPLOYER to Insulator supplier</td>
<td>Tests to be witnessed / Appd. by QA&amp;I at Manufacturer’s works</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Traceability (Make/batch No./Locations where installed)</td>
<td>Packing list/CIP</td>
<td>Contractor</td>
<td>100% at field</td>
<td>100% Review of records</td>
<td>Site Engineer</td>
<td></td>
</tr>
<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing Agency</td>
<td>Extent</td>
<td>Counter Check/Test by EMPLOYER</td>
<td>Accepting authority in EMPLOYER</td>
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<tr>
<td></td>
<td>b. Conductor</td>
<td></td>
<td>On receipt,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Site Engineer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1. Visual check of drum.</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Check for seals at both ends, and EMPLOYER sticker on outer end</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
<td>3. Check depth from top of flange to the top of the outer most layer</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
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<tr>
<td></td>
<td>c. Earthwire</td>
<td></td>
<td>Check for seals at both ends</td>
<td></td>
<td></td>
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<td>2. Field activity</td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>a. Before Stringing</td>
<td></td>
<td>Readiness for stringing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>b. During stringing</td>
<td>(Conductor / Earthwire)</td>
<td>Stringing procedures as per approved specification</td>
<td></td>
<td></td>
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<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by EMPLOYER</td>
<td>Accepting authority in EMPLOYER</td>
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<tr>
<td>1.</td>
<td>Scratch/cut check (Visual)</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>1. Scratch/cut check (Visual)</td>
<td>Appd. Drawings/ EMPLOYER Specn.</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% record &amp; Field check 20%</td>
<td>Site Engineer</td>
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<td>2.</td>
<td>Repair sleeve</td>
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<td>3.</td>
<td>Mid span Joints</td>
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<td>4.</td>
<td>Guying (in case of towers not designed for one side stringing)</td>
<td></td>
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<td>c.</td>
<td>After stringing</td>
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<td>1.</td>
<td>Sag/Tension</td>
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<td>Electrical clearances</td>
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<td></td>
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<td>Ground clearance</td>
<td></td>
<td></td>
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<td></td>
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</tr>
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<td>ii)</td>
<td>Live metal clearance etc.</td>
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<td>3.</td>
<td>Jumpering</td>
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<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by EMPLOYER</td>
<td>Accepting authority in EMPLOYER</td>
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<tr>
<td>5.</td>
<td>Placement of spacer/damper</td>
<td>As per Specn./drgs/placement chart</td>
<td>-do-</td>
<td>100%</td>
<td>100% joint checking</td>
<td>Project In charge</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>b. Commissioning of line</td>
<td>2. Digital photograph of each tower to ascertain the completeness of tower.</td>
<td>As per Apd. Drgns./EMPLOYER latest pre-commissioning procedures</td>
<td></td>
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<td></td>
<td></td>
<td>a. EMPLOYER latest pre-commissioning procedures</td>
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<td></td>
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<td></td>
<td>b. Pre-commissioning Report</td>
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<td>c. CEA clearance</td>
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<tr>
<td></td>
<td></td>
<td>b. Commissioning of line</td>
<td>2. Digital photograph of each tower to ascertain the completeness of tower.</td>
<td>As per Apd. Drgns./EMPLOYER latest pre-commissioning procedures</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>a. EMPLOYER latest pre-commissioning procedures</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>b. Pre-commissioning Report</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>c. CEA clearance</td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>
## Annex-1

**ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CEMENT**

1. Mechanical and physical requirements given as characteristic values

<table>
<thead>
<tr>
<th>Strength class</th>
<th>Early strength</th>
<th>Standard strength</th>
<th>Initial setting time (Min)</th>
<th>Soundness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2days</td>
<td>7days</td>
<td>28days</td>
<td></td>
</tr>
<tr>
<td>32.5N</td>
<td>-</td>
<td>≥ 16.0</td>
<td></td>
<td>≥ 32.5</td>
</tr>
<tr>
<td>32.5R</td>
<td>≥ 10.0</td>
<td>-</td>
<td></td>
<td>≥ 32.5</td>
</tr>
<tr>
<td>42.5N</td>
<td>≥ 10.0</td>
<td>-</td>
<td></td>
<td>≥ 42.5</td>
</tr>
<tr>
<td>42.5R</td>
<td>≥ 20.0</td>
<td>-</td>
<td></td>
<td>≥ 42.5</td>
</tr>
<tr>
<td>52.5N</td>
<td>≥ 20.0</td>
<td>-</td>
<td></td>
<td>≥ 52.5</td>
</tr>
<tr>
<td>52.5R</td>
<td>≥ 30.0</td>
<td>-</td>
<td></td>
<td>≥ 52.5</td>
</tr>
</tbody>
</table>
2. Chemical requirements given as characteristic values

<table>
<thead>
<tr>
<th>Property</th>
<th>Strength class</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss on ignition</td>
<td>All</td>
<td>≤ 5.0%</td>
</tr>
<tr>
<td>Insoluble residue</td>
<td>All</td>
<td>≤ 5.0%</td>
</tr>
<tr>
<td>Sulfate content</td>
<td>32.5N</td>
<td>≤ 3.5%</td>
</tr>
<tr>
<td></td>
<td>32.5R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>42.5N</td>
<td></td>
</tr>
<tr>
<td></td>
<td>42.5R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>52.5N</td>
<td>≤ 4.0%</td>
</tr>
<tr>
<td></td>
<td>52.5R</td>
<td></td>
</tr>
<tr>
<td>Chloride content</td>
<td>All</td>
<td>≤ 0.1%</td>
</tr>
</tbody>
</table>

* A class with ordinary early strength, indicated by N and a class with high early strength indicated by R.
* The requirements are not limited to, those mentioned above. For details of the requirements shall be made to the BS EN 1971.
Annex-2

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR REINFORCEMENT STEEL

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the test</th>
<th>Carbon steel bars as per BS 4449</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grade 250</td>
<td>Grade 460</td>
</tr>
<tr>
<td>i)</td>
<td>Chemical analysis test</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carbon</td>
<td>0.25% Max.</td>
<td>0.25% Max.</td>
</tr>
<tr>
<td></td>
<td>Sulphur</td>
<td>0.06% Max.</td>
<td>0.05% Max.</td>
</tr>
<tr>
<td></td>
<td>Phosphorus</td>
<td>0.06% Max.</td>
<td>0.05% Max.</td>
</tr>
<tr>
<td>ii)</td>
<td>Physical tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specified characteristic strength</td>
<td>250 N/mm²</td>
<td>460 N/mm²</td>
</tr>
<tr>
<td></td>
<td>Minimum elongation</td>
<td>22%</td>
<td>12%</td>
</tr>
<tr>
<td>iii)</td>
<td>Bend &amp; Rebend tests</td>
<td>Pass</td>
<td>Pass</td>
</tr>
</tbody>
</table>

The requirements are not limited to, those mentioned above. For details of the requirements shall be made to the BS 4449.

Annex-3
# ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR COARSE AGGREGATES

## 3. Coarse Aggregates

### i) Physical Tests

#### a) Determination of particles size

<table>
<thead>
<tr>
<th>Sieve Designation</th>
<th>Percentage passing for Single-Sized Aggregate of nominal size</th>
<th>Percentage Passing for Grades Aggregate of nominal size</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 mm 20 mm 16 mm 12.5 mm 10 mm 40 mm 20 mm 16 mm 12.5 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63 mm</td>
<td>100 - - - - -</td>
<td>- - - -</td>
</tr>
<tr>
<td>40 mm</td>
<td>85 - 100 100 - - -</td>
<td>95 - 100 100 - -</td>
</tr>
<tr>
<td>20 mm</td>
<td>0 - 20 85 - 100 100 - -</td>
<td>30 - 70 95 - 100 100 100</td>
</tr>
<tr>
<td>16 mm</td>
<td>- - 85 - 100 100 - -</td>
<td>- - 90 - 100 -</td>
</tr>
<tr>
<td>12.5 mm</td>
<td>- - - 85 - 100 100 - -</td>
<td>- - - 90 - 100</td>
</tr>
<tr>
<td>10 mm</td>
<td>0 - 5 0 - 20 0 - 30 0 - 45 85 - 100</td>
<td>10 - 35 25 - 35 30 - 70 40 - 85</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>- 0 - 5 0 - 5 0 - 10 0 - 20</td>
<td>0 - 5 0 - 10 0 - 10 0 - 10</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>- - 0 - 5 -</td>
<td>- - - -</td>
</tr>
</tbody>
</table>

#### b. Flakiness index
Not to exceed 25%

#### c. Crushing Value
Not to exceed 45%

#### d. Presence of deleterious material
Total presence of deleterious materials not to exceed 5%

#### e. Soundness test (for concrete work subject to frost action)
12% when tested with sodium sulphate and 18% when tested with magnesium sulphate

---

### Annex-4

# ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR FINE AGGREGATES
### Fine aggregates

#### i) Physical Tests

<table>
<thead>
<tr>
<th>Sieve Designation</th>
<th>Percentage passing for graded aggregate of nominal size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F.A. Type I</td>
</tr>
<tr>
<td>10 mm</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>90 - 100</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>60 - 95</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>30 - 70</td>
</tr>
<tr>
<td>600 microns 12.5 mm</td>
<td>15 - 34</td>
</tr>
<tr>
<td>300 microns</td>
<td>5 - 20</td>
</tr>
<tr>
<td>150 microns</td>
<td>0 - 10</td>
</tr>
<tr>
<td>b) Silt content</td>
<td>Not to exceed 8%</td>
</tr>
<tr>
<td>c) Presence of deleterious material</td>
<td>Total presence of deleterious materials shall not exceed 5%</td>
</tr>
<tr>
<td>d) Soundness Applicable to concrete work subject to frost action</td>
<td>12% when tested with sodium sulphate and 15% when tested with magnesium sulphate</td>
</tr>
</tbody>
</table>
Annex-5

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CONCRETE WORK

<table>
<thead>
<tr>
<th>1)</th>
<th>Concrete</th>
<th>a) Workability</th>
<th>Slump shall be recorded by slump cone method and it shall between 50-100 mm for pile cap and chimney, 150mm to 200mm for concrete pile.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>b) Compressive strength</td>
<td>One set for each pile. For Pile caps, beams, Chimney, one set for every 6 Cu.m. or part thereof for each day of concreting. Each set consists of four cubes, one for 7 days testing and two for 28 days testing shall be taken.</td>
</tr>
</tbody>
</table>

Notes:

1) ACCEPTANCE CRITERIA BASED ON 28 DAYS COMPRESSIVE STRENGTHS FOR NOMINAL MIX CONCRETE:
   a) the average of the strength of three specimen be accepted as the compressive strength of the concrete, provided the strength of any individual cube shall neither be less than 70% nor higher than 130% of the specified strength.
   b) If the actual average strength of accepted sample exceeds specified strength by more than 30%, the Engineer-in-charge, if he so desires, may further investigate the matter. However, if the strength of any individual cube exceeds more than 30% of the specified strength, it will be restricted to 30% only for computation of strength.
   c) If the actual average strength of accepted sample is equal to or higher than specified up to 30%, the strength of the concrete shall be considered in order and the concrete shall be accepted at full rates.
   d) If the actual average strength of accepted sample is less than specified strength but not less than 70% of the specified strength, the concrete may be accepted at reduced rate at the discretion of Engineer-in-charge.
   e) If the actual average strength of accepted sample is less than 70% of specified strength, the Engineer-in-charge shall reject the defective portion of work represent by sample and nothing shall be paid for the rejected work. Remedial measures
necessary to retain the structure shall take at the risk and cost of contractor. If, however, the Engineer-in-charge so desires, he may order additional tests to be carried out to ascertain if the structure can be retained. All the charges in connection with these additional tests shall be borne by the Contractor.

General Notes:

1) This standard Field Quality Plan is not to limit the supervisory checks which are otherwise required to be carried out during execution of work as per drawings/Technical specifications etc.

2) Contractor shall be responsible for implementing/documenting the quality plan. Documents shall be handed over by the contractor to Employer after the completion of the work.

3) Project in charge means over all in charge of work. Line In charge means in charge of the line. Section in-charge means in charge of the section.

4) Acceptance criteria and permissible limits for tests are indicated in the Annexure. However for further details/tests EMPLOYER specification and relevant standards shall be referred.

5) Tests as mentioned in this FQP shall generally be followed. However Employer reserves the right to order additional tests wherever required necessary at the cost of the contractor.
## SECTION 4  DESIGN PARTICULARS

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<th>TITLE</th>
<th>PAGE NO.</th>
</tr>
</thead>
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<td>4.2</td>
<td>UNITS OF MEASUREMENT</td>
<td>1</td>
</tr>
<tr>
<td>4.3</td>
<td>DOCUMENT SUBMISSIONS</td>
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</tr>
<tr>
<td>4.4</td>
<td>DESIGN CALCULATIONS</td>
<td>1</td>
</tr>
<tr>
<td>4.5</td>
<td>DRAWINGS</td>
<td>2</td>
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<td>4.5.1</td>
<td>GENERAL REQUIREMENTS</td>
<td>2</td>
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<td>4.5.2</td>
<td>COMPUTER GENERATED DRAWINGS</td>
<td>3</td>
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<td>CONTRACT DRAWING LIST</td>
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<td>4.5.4</td>
<td>CONTRACT RECORD DRAWINGS</td>
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<td>ROUTE MAPS</td>
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<td>SUPPLY AND INSTALLATION MATERIAL MANUAL</td>
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<td>4.8</td>
<td>MAINTENANCE MANUAL</td>
<td>6</td>
</tr>
<tr>
<td>4.9</td>
<td>SAMPLES AND MODELS</td>
<td>6</td>
</tr>
<tr>
<td>4.10</td>
<td>PHOTOGRAPHS</td>
<td>6</td>
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</tbody>
</table>

### APPENDIX
SECTION 4

DESIGN PARTICULARS

4.1 PHILOSOPHY OF DESIGN

The philosophy of design contained within this specification is based upon deterministic principles, whereby the applied loading multiplied by the appropriate safety factor must be less than the ultimate strength of the component.

In bidding the Contractor/Supplier will be deemed to have concurred, as a practical manufacturer, with the design and layout of the Works as being sufficient to ensure reliability and safety in operation, freedom from undue stresses and satisfactory performance in all other essentials as a working plant.

The transmission line(s) shall be designed with high reliability and low cost maintenance as the primary consideration in accordance with the relevant sections of the Specification.

The design shall incorporate all reasonable precautions and provisions for the safety of those concerned in the erection and subsequent maintenance of the Contract Works.

4.2 UNITS OF MEASUREMENT

In all correspondence, technical schedules, design calculations and drawings, the metric (SI) units of measurement shall be used. Angular measurement shall be degrees, with $90^\circ$ comprising a right angle.

4.3 DOCUMENT SUBMISSIONS

The Contractor/Supplier shall submit to the Engineer all design calculation drawings, method statements, test programmes, test records etc as defined in Appendix 4.B1 of the relevant sections of the Specifications, or as otherwise agreed by the Engineer. For details of the number of copies and time periods for approval, reference should be made to Appendix 4.A1.

4.4 DESIGN CALCULATIONS

All sets of calculations shall be complete, bound, properly titled and given a unique drawing number (see Clause 4.5.1). The binding shall be such as to allow the easy introduction of subsequent pages if necessary.
Bound into each set shall be a fully detailed index. Following this shall be a Design Information sheet(s) which shall incorporate the following details:

(a) The design concept shall be summarised;

(b) Full details of manuals, design papers or other aids referred to in the text shall be given, with photocopies of relevant sheets if appropriate;

(c) Full loading shall be reiterated, with their derivation if appropriate;

(d) Design stresses shall be reiterated;

(e) Code or standard references should be quoted, and equations written out in full for initial calculations;

Should the Contractor/Supplier be required to re-submit amended calculation or additional sheet(s), the following annotation shall be adopted:

(f) Amended sheets should retain the same sheet number, but have a lower case revision letter suffix i.e. sheet 14 when amended becomes 14a, then 14b.

(g) Additional sheets that needed to be inserted shall be given the sheet number they are added to, plus an upper case letter prefix i.e. additional sheets to piece 60 become A60, B60 etc. and if subsequently amended A60a etc.

Where computer programs are used for design calculations a full explanation in the English language shall be provided to assist the Engineer's approval of the calculations for each and every program used. Details must include name of program, author, source, comprehensive description of theoretical basis including all references to relevant documentation, checks undertaken on program and a list of projects on which the program has been used.

4.5 DRAWINGS

4.5.1 General Requirements

Drawing shall be to scale, fully detailed and all dimensions shall be in Metric Units. General arrangement drawings submitted shall be to a scale of not less than 1 to 50 and all detailed drawings not less than 1 to 20. Profile drawings shall normally be drawn to vertical scale of 1 to 200 and a horizontal scale of 1 to 2,000.

Drawings sheets shall conform in size to BS ISO 5457, main A0, A1, A2, A3 and A4.

The sheet size is to be stated on the drawing within or adjacent to the title block.

Drawings shall be to BS 308 or equivalent.
The scale used shall be stated on the drawing as a ratio together with a linear scale at a convenient position along the margin of the original drawing sheet.

The physical drafting requirements in respect of line density, strength, contrast, spacing and character liability shall be met to ensure drawings are suitable for microfilming in accordance with BS 5536 and the Specification for micro-copying of drawings to BS ISO 3272.

All drawings shall bear a title in English, serial number of the main Contract, drawing number shall be unique to this Contract and scale. The system of numbering and layout of the title block will be to the approval of the Employer. The title block shall include the name and address of the Employer. The revision notes shall detail the nature of each revision. The revision shall be enclosed in a cloud with the revision letter indicated.

**4.5.2 Computer Generated Drawings/Designs**

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, shop sketches and tower accessories, hardware fittings, plan & profile, sag curve, etc. drawings) shall be submitted to the Employer in CDs.

In addition to the hardcopy of drawings/designs the Contract is required to submit soft copy of all the drawings in AutoCAD format and all related documents in Microsoft Word/Excel format. The drawings/designs developed by PLS software or STAAD PRO or any other software, the soft copy of the input files and other related files are also required to be submitted during submission of hardcopy for approval.

**4.5.3 Contract Drawing List**

At defined intervals the Contractor/Supplier shall submit the requisite number of copies of the Contract Drawing List.

The list shall contain the following information:

- (a) Drawing number;
- (b) Drawing title;
- (c) Revision status;
- (d) Approval status.

All changes since the previous issue shall be clearly indicated and when agreed only the front (index) sheet and revised sheets need to be submitted.

**4.5.4 Contract Record Drawings**

The Contractor/Supplier shall submit to the Engineer:
(a) A final issue of the Contract Drawing List indicating which of the drawings, design calculations, method statements etc. he proposes to issue as final contract drawings. These drawings shall be updated to incorporate all modifications made during erection and commissioning.

(b) Requisite number of prints of each schedule, including where appropriate the Supply and Installation Material Manual.

(c) Requisite number of drawings, including design calculations, schedules including the supply and Installation Material Manual in diskette format in WPG /DXF /PDF /DWG /DOC format. The tower drawings and plan & profile drawings are required to submit in AutoCAD format.

(d) Requisite number of polyester/transparency film copy of each drawing, including design calculations, profiles and route maps.

The distribution of the contract record drawings will be advised by the Engineer.

**4.5.5 Route Maps**

During, the progress of the work the Contractor shall record on profiles, tower and Installation Material Manual (SIMM's) and on a set of Survey Maps of approved scale such particulars as will allow an accurate reference to be made afterwards in case of any faults or projected modifications to the line.

The map and/or profile sheet shall show the exact position of every tower with approved reference marks. The maps shall be supplemented, or profiles marked by sketches where necessary, to delineate boundary positions of towers which cannot be clearly indicated on the maps.

The date included on the maps, profile, sketches and SIMMs shall be submitted to the Engineer, to whom facilities shall be given for examining such records during the progress of the work.

**4.6 SAG TEMPLATES**

The Contractor shall supply the specified sets of templates in strong, stable colourless plastic or similar material not less than 3mm thick. Engraving shall be on the back face of the templates. The templates shall be for the specified equivalent spans, reference Appendix 4.A.2.

Each template shall be accurately shaped to provide the sag curve, to the appropriate scales of the conductor in still air at maximum temperature. The same curve shall be engraved on the template at a distance below representing the minimum allowable vertical clearance to normal ground. A further sag curve in still air at minimum temperature shall also be shown. Each template shall be clearly endorsed with the sagging basis, conductor particulars, equivalent span and unless otherwise specified to a scale of 1:200 vertical and 1:2000 horizontal.

Templates shall be supplied to the Engineer before the submission of the profiles. Failure to do so may result in delay which will be responsibility of the Contractor.
4.7 **SUPPLY AND INSTALLATION MATERIAL MANUAL**

As soon as final support positions have been selected and approved, the Contractor shall provide the requisite copies of the A4 size Supply and Installation Material Manual (SIMM).

Each tower position shall be represented by one sheet of the manual with the following information recorded:

(a) Provisional and final tower numbers;
(b) Profile and Record Map reference drawing numbers;
(c) Span;
(d) Wind span;
(e) Weight span;
(f) Angle of deviation;
(g) Tower type, leg and body extensions and general arrangement (G.A.) drawing reference numbers;
(h) Foundation type and G.A. drawing reference number;
(i) Earthing details and G.A. drawing reference number;
(j) Insulator set details and G.A. drawing reference number;
(k) Sag adjustment setting, and linkage requirements - (where appropriate);
(l) Phase conductor jumper details including spacer and general arrangement drawing reference number - (where appropriate);
(m) Earthwire set details and G.A. drawing reference number;
(n) Earthwire vibration damper G.A. drawing reference number;
(o) Aircraft Navigation (obstruction aids) drawing reference number -(where appropriate);
(p) Fibre optic junction boxes and cabling G.A. drawing reference number -(where appropriate);

In addition the following schedules shall be included:

i) Phase conductor and earthwire sags and tensions (erection and final);
ii) Suspension insulator set off-sets;
iii) Location and spacing of phase conductor spacers and spacer dampers (where appropriate);
iv) Location of all phase conductor and earthwire tension and non tension joints;
v) Location and spacing of all aircraft warning spheres (where appropriate);
vi) Location of all fibre optic joint boxes - (where appropriate);

The appropriate reference drawing numbers shall also be included. Preliminary copies of SIMMs shall be available prior to any site work commencing, together with material summaries. **This is a Hold Point.**
4.8 MAINTENANCE MANUAL

The Contractor/Supplier shall provide at the specified period before the end of the construction period of the Contract, a maintenance manual covering, the following information:-

(a) Type, code number and description of all plant erected, together with names and addresses of manufacturer;
(b) Methods of assembly of all fittings;
(c) Method of replacing any part of the plant including the use of maintenance holes provided on the support, access provisions and where appropriate the application of 'live-line' maintenance techniques;
(d) Recommendations of preventive maintenance including frequency of inspections;
(e) List of recommend maintenance equipment with a description of its use and limitations;
   (f) Type and application of temporary earthing equipment;
   (g) Personnel safety equipment requirements and any risk assessments required.

The above information must be specified in this Contract and entirely in the English language.

Drawings and diagrams shall be used where necessary to enable the Employer/Purchaser properly to maintain the whole of the Works.

The manual shall be suitably bound within a hard cover and all materials used shall be reasonably hard wearing.

The manual shall be submitted to the Engineer. This is a Hold Point.

4.9 SAMPLES AND MODELS

If the nature of the Works makes it desirable, the Contractor/Supplier may be asked to submit or prepare for the Engineer such samples, patterns and models as the Engineer may reasonably require for the purpose of design approval at the expense of the Contractor/Supplier.

4.10 PHOTOGRAPHS

The Contractor/Supplier shall make all arrangements to provide progress photographs of all tests and such sections of the work in progress as directed by the Employer. Each photograph shall be of size 25 cm x 20 cm suitably entitled. The negatives and/or electronic files of the photographs shall be the property of the Employer and no prints from these negatives and/or electronic files shall be supplied to any persons unless under the Authority of the Employer.

The Contractor/Supplier will normally be required to provide every month at his own cost the 3(three) sets of unmounted progress photographs suitably inscribed, on portions of the Work - in progress, throughout the period of construction. Any
variation to these quantities will only be with the permission of the Employer.
APPENDIX 4.A1

TIME INTERVALS FOR DOCUMENTS SUBMISSION, OR TEST & INSPECTION NOTIFICATION AND NUMBER OF SUBMISSION COPIES

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Note: The time interval refers to the appropriate time period in weeks required before or after a specified event e.g. the Contract Drawing List shall be submitted at 4 week intervals, while the Applicable Reference Standards shall be submitted 4 weeks after signing of the Contract.
APPENDIX 4.A2

SAG TEMPLATES FOR PHASE CONDUCTOR

Not Applicable

APPENDIX 4.B1

ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

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# SECTION 5 ACCESS

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## APPENDIX
ACCESS

WAYLEAVES

General

A preliminary line route shall be provided by the Employer to enable the Contractor to start with the Contract works. The line route plan does not include facilities for storing material.

The Contractor will satisfy himself that the necessary rights of entry and access have been obtained before entry is effected.

The Contractor shall indicate to the Engineer such pipes or other obstructions, telephone, telegraph and power lines which infringe the clearances specified or otherwise fail to satisfy the requirements of the Specification.

The necessary permission for the removal of obstructions such as trees, houses, etc. and for the permanent removal or guarding of pipes, telegraph, telephone and power lines will be in the responsibility of the Contractor. The Employer shall assist the Contractor in getting that permission.

Wayleave Schedule

Not used.

ACCESS TO SITE, NOTICE OF ENTRY

Access Routes - General

The Employer may indicate to the Contractor the general route for access to each or any position as agreed by the Employer, otherwise the Contractor shall make all necessary arrangements (other than questions of wayleaves) with the occupier.

Subject to the provisions of the preceding paragraph the Contractor shall before commencing work, at his own expenses, do what is necessary to make the access suitable
for his use and shall take all reasonable precautions to avoid damage, including, if required
the erection of temporary fences or gates where permanent fences, hedges or gates have
been removed. The Contractor shall not be entitled to any additional payment in the event
of a particular access being difficult.

The Contractor shall be responsible for maintaining agreed access routes, without undue
widening, in a usable condition for the duration of the Contract and the occupier shall not
be put to any inconvenience in gaining access to his land or buildings. No unauthorised
access route shall be taken by the Contractor.

Commencement of Work

The Contractor shall be responsible, before beginning work on any property for obtaining
confirmation from the Engineer that wayleaves are in order and any agreed accesses, have
not been altered and for giving not less than 48 hours notice to the occupiers that work is to
begin. Work shall proceed on any land within the requisite period of such notice being
given to the occupier.

Suspension of Work

Where work is to be suspended without the expectation of it being resumed within the
specified period, the Contractor must notify the occupier of such intention and shall
similarly give the occupier prior notification of the resumption of work. The purpose of
this Clause is to assist in maintaining good relations between the occupier, the Contractor
and the Employer and to keep the occupier informed of what is going to happen on or
across his land.

Compliance with Occupier's Requirements

The Contractor shall at all times during the execution of the Works ensure compliance with
all such reasonable requirements of the occupier as are brought to the Contractor's notice
by the Engineer.

Notice to Authorities
Before the Contractor carries out the stringing of conductors alone, or across power or telecommunication circuits, public roads, etc., he shall give the requisite notice to the appropriate Authorities of the time and date when he proposes to perform the work and shall send a duplicate copy of each notice to the Engineer.

**ROUTE CLEARANCE**

For details of the clearance requirements for survey, access routes, line route, tower locations and conductor stringing reference shall be made to Appendix 5.A1.

**ACCESS ROADS**

Access roads/routes shall be identified by the Contractor themselves as and where necessary, and shall be constructed by them at their own expense and necessary compensations for damages thereof shall also be paid by the Contractor. The Employer’s representative shall assist the Contractor in his negotiations with the landowners about such compensation etc.
CROSSING OF OBSTACLES

General

The Contractor shall, at his own expense, make any necessary arrangements and take the necessary precautions where the route crosses buildings, telecommunication, power or pipe lines, orchards, gardens, railways, antiquities or other obstructions or ground over or across which erection cannot be carried out in the normal manner or has to be avoided. These arrangements must be submitted to the Engineer. **This is a Hold Point.**

Where a tower is set across a fence, hedge, bank or wall, the Contractor shall remove and reinstate the fence, hedge, bank or wall at his own expense and he shall be responsible at his own expense for making good to the satisfaction of the Engineer, owners and tenants concerned, all land, property, roads, drains, fences, walls, hedges, gates and the like which he has damaged or disturbed during the execution of tile Contract Works and shall remove all surplus material after erection. The Contractor shall take proper precautions to prevent the straying of and damage to livestock until after the backfilling of excavations and permanent reinstatement of fences, walls, hedges, gates and the like is completed.

Public Utilities

The Contractor shall obtain all necessary permissions, licenses or approvals from authorities which are required for any part of the work. The Employer shall assist the Contractor in obtaining those permissions. All costs for such permissions shall deem to be included in the Contract Price.

The Contractor shall ensure that the erection of the Contract Works does not cause damage to or interference with existing telecommunication, power or pipe lines.

Where appropriate Authorities affected deem it necessary for the protection of their employees, property, or the public or for the assistance of traffic to provide flagmen and watchmen, the cost of such provision shall be borne by the Contractor. Where required by the appropriate Authorities work shall be carried on outside normal hours and at the Contractor's own expense.
The Contractor shall also be liable to make good at least to the original condition or compensate the owners, operators and users or any public undertaking in respect of any damage however caused to their property, lands or roads arising, out of or in consequence of the execution of the Works.

Scaffolding

The Contractor shall provide all necessary scaffolding and the like for the crossing of telecommunications or power lines, roads, railways buildings or other obstacles. The Contractor shall advise the Employer in each instance of the scaffolding he proposes to use. Drawings of the proposed scaffolding shall be submitted to the Employer, and the appropriate regulatory authorities for approval. This is Hold Point.

Live Line Scaffolds

The scaffolding which is used to cross specified low, medium and high voltage power lines shall be of such dimensions and allow such clearances that the power lines being crossed may remain in commission during construction of the new transmission line. Shut-downs on the lines to be crossed may be given for construction of new line but shall not be given continuously for longer periods. Such restrictions in building and use of the scaffolds shall not be grounds for claiming additional costs. Design and construction of the live line scaffold shall not be inferior to the minimum standards outlined in the following clause.

Live Line Scaffold - Construction

The scaffold shall be designed to withstand the maximum design wind speed, except that a reduced return period will be accepted. Consideration shall also be given due to impact loading, due to dropping of the upper phase conductor.

The scaffold shall, unless otherwise approved by the Employer, consist of 3 m wide 300 mm square mesh nylon nets attached to steel wire ropes running perpendicular to the lower line route, carried by metal scaffolding at 3 m intervals. The nets shall be attached to the catenary wires by means that do not require the presence of any persons on the net or the catenary wires whilst the lower line is alive. An additional movable walk net laid over the 300 mesh nets may be used whilst the lower line is dead.
Normally steel or aluminium tubular scaffolding to BS 1139 and BS 6323, should be used, the use of performed units or frames shall be subject to the Employer's approval.

The mechanical construction shall be in accordance with BS 5950. Reference shall also be made where appropriate to BS 5973.

The design of the scaffold shall have due regard to the requirements of safety with particular respect to accidental contact with live conductors during construction, use and removal.

The scaffold including foundations shall be designed and constructed to ensure stability during the process of erection and removal, and also at times when work has ceased for any reason including adverse weather conditions. The foundations shall be suitable for the ground concerned.

The scaffold shall extend at least 5 m either side of the outermost conductors of the upper line. A maximum of 2 m of this distance may be provided by means of catchers.

Catchers shall be provided at each end of each scaffold support. The catchers may be vertical or inclined to a maximum angle of 45° from the vertical. They shall be capable of withstanding the specified impact loads without excessive distortion that would permit a falling conductor to approach or touch a live-line.

The upper parts of the scaffold shall be provided with soft wood rubbing boards or otherwise protected in an approved manner to prevent damage to the conductors resting on or being drawn over the guard. Soft wood poles may be used for this purpose. The height of these boards shall be sufficient to prevent the conductor damaging the nylon net. To avoid damaging the conductors no object other than non-metallic lashing or the catchers shall protrude above the rubbing boards.

Sufficient endless or double ended lead lines for hauling over pilot wires shall be placed over the scaffold prior to re-energising of the lower line.
The side supports shall have working platforms to facilitate the required running of conductors and pilot wires. Working platforms shall be provided with hand rails, toe boards and notices warning of the danger of live conductors. The heights of hand rails shall be 1m and the toeboards 230 mm. Each working platform shall have a notice plate indicating the 'Safe Climbing Height'.

The scaffolds shall be fitted with danger plates at intervals of not more than 6m along the anticliming device with at least one plate on each face of the structure.

The scaffolds shall be constructed to prevent unauthorised access or climbing by the use of barbed wire ant-climbing devices, fences or other means approved by the Employer.

The scaffolding shall be lit with red warning lamps from 1/2 hour before sunset to 1/2 hour after sunrise if erected within 2m from a highway or footpath without an intervening fence. The scaffold contractor shall provide or arrange for the supply and/or maintenance of these lamps (e.g. with the line contractor).

If the scaffolding is constructed adjacent to a roadway, a guard constructed from steel drums filled with soil or a soil bund shall be provided and suitably lit.

Where possible the resistance to earth of the scaffold shall be less than 10 ohms. Special consideration by the Employer and the lower line operator shall be given in cases where this is not attainable with a reasonable number of driven earth rods.

Bonding the scaffold to the earthing systems of either the live-line, or the line under construction is not normally acceptable. In the former case a nearby line fault could cause the scaffold to become live. In the latter case a fault between the live-line and the scaffold could cause components of the line under construction to become alive, particularly as it earthing system may not be complete.

The earth rods should normally be driven into the ground around the outside and approximately 1m from the scaffold structure. The rods should be securely connected electrically and mechanically to the scaffold structure by flexible copper or aluminium leads with minimum cross-sectional areas of 64mm$^2$ or 100mm$^2$ respectively.
Drawings of the scaffold, complete with details of the clearance plates and earthing arrangement, together with supporting, calculations shall be submitted to the Employer and appropriate regulatory authorities for approval. **This is a Hold Point.**

**DAMAGE**

**General**

The Contractor shall take all reasonable precautions to avoid damage to land, property, roads, crops, field drains, fences walls, hedges, gates, trees and the like and shall ensure that the work is adequately supervised so that any damage is reduced to the minimum. The Contractor shall pay compensation to the owners/tenants for damages of crops, trees and houses during the project implementation within the wayleaves (right-of-way) which are unavoidable for construction of the transmission line. The Employer’s representative shall assist the Contractor in his negotiations with the landowners about such compensation.

**Contractor's Responsibility**

The Contractor's liability for loss or damage shall extend to any such loss or damage resulting from the employment of a Subcontractor. This does not relieve the Contractor of his liability for all actions of his Subcontractor.

**Livestock, Dogs**

Adequate provision shall be made by the Contractor to prevent the straying of or injury to livestock during the execution of the Works and until the permanent reinstatement of fences, walls, hedges, gates and the like is completed.

The Contractor shall not bring any dog on or near the site or suffer or permit any of his employees, representatives or agents or any Subcontractor to bring any dog on or near the site and shall cause the immediate removal of any dog which may be on or near the Site in breach of this provision.
The Contractor shall be liable for any injury to or loss of livestock due in the opinion of the Engineer to failure to comply with the above requirements.

APPENDIX 5.A1

ROUTE CLEARANCE

Where clearing is in the opinion of the Employer necessary, the following requirements shall be observed. Trees and tall scrub shall be cleared to a distance of 20 m on either side of the centreline of the route. Trees and bushes shall be cut down to a height of not more than 1.0 m above ground level. In addition, tall trees outside the cleared area, of such height that they could fall within 2 m of conductors, shall be trimmed by the Contractor. No tree may be felled without the express permission of the Employer. This is a Hold Point.

Felled trees and scrub shall be removed from a path 3.5 m wide and running as far as possible continuously along the route. The Contractor shall grub up tree stumps and roots from this track and leave a graded way for negotiation by Landrover, Unimog, or similar four-wheeled drive light vehicle for patrolling and maintenance by the Employer.

All trees, bushes, bamboo and any other vegetation which normally grows to a height of 2.5 m or more shall be treated by an approved non-toxic, non-residual agent to prevent further growth.

The Contractor shall clear a 3.5 m wide agreed construction access track from public roads, of all trees, stumps, scrub and vegetation to tower positions as required by the Employer.
All felled trees or tree trimmings shall remain the property of the landowner.
APPENDIX 5.A2
ACCESS ROADS

Access roads/routes shall be identified by the Contractor themselves as and where necessary, and shall be constructed by them at their own expense and necessary compensations for damages thereof shall also be paid by the Contractor. The Employer’s representative shall assist the Contractor in his negotiations with the landowners about such compensation etc.
APPENDIX 5.B1

ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

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<thead>
<tr>
<th>Clause Reference</th>
<th>Document Description</th>
<th>Comment</th>
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<td>Scaffolding</td>
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<tr>
<td>5.5.4</td>
<td>Live line scaffolding</td>
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APPENDIX 5.C1

NOTIFICATION AND HOLD POINTS

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<td>Scaffolding-drawings</td>
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<td>5.5.4</td>
<td></td>
<td>Live line scaffold-drawing</td>
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</table>

APPENDIX 5.D1

REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of the specification are listed below:

- BS 1139: Metal scaffolding
- BS 5950: Structural use of steel work in building
- BS EN 12811-1: Code of practice for access and working scaffolds and special scaffold structures in steel
- BS 6323: Specification for seamless and welded steel tubes for automobile, mechanical and general engineering purposes.
- BS EN 12810-1: Facade Scaffolds
- EN 10296/10297/10305: Welded circular steel tubes/seamless circular tubes/steel tubes for precision application
SECTION 6

SURVEY, PROFILE AND GEOTECHNICAL INVESTIGATIONS

6.1 GENERAL INFORMATION & SCOPE OF WORK

The Engineer will indicate to the Contractor either on maps or during visits to the Sites the proposed route of the transmission line, with approximate positions of the angle and terminal towers and the positions of such intermediate towers as it may have been desirable to determine during preliminary wayleave negotiations. The Contractor shall give the Engineer the requisite period of notice prior to commencing the survey. This is a Hold Point.

The technical specifications covers detailed survey including route alignment based on the intermediate GPS readings & Tentative route alignment finalized by the Employer, profiling, tower spotting, optimization of locations, check survey, contouring, and soil investigation for the transmission lines / part of the transmission lines covered under this specification as included in the schedule of prices.

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 including maximum velocity discharge, highest flood level (H.F.L), scour depth etc. of the concerned rivers, major streams and nalas (canals).

6.1.1 The scope of work inter-alia shall include the following:-

a. Detailed Survey using GPS, Total Work stations, long range scanners & Digital theodolite of reasonable accuracies or alternatively using ALTM (Airborne Laser Terrain Modeling) techniques, inter-alia including:
i. Digitized 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.

6.1.2 The Provisional quantities for the scope of work are indicated in relevant Price Schedules of bidding documents. The final quantities for route alignment & detailed survey (quantities in “km” unit) shall be the Horizontal route length along the approved route alignment. For contouring at undulated/hilly tower locations and soil investigations (quantities in “Locations.” 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. The route alignment, detailed survey, including profiling & tower spotting, contouring, soil investigation etc shall be carried out by the Contractor as per the technical specifications stipulated herein.

6.1.3 The Contractor must note that the Employer shall not be responsible for loss or damage to properties, trees etc. due to contractor’s work during survey. The Contractor shall indemnify the Employer for any loss or damage to properties, trees etc. during the survey work.

6.1.4 The Contractor should note that Employer will not furnish topographical maps 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.

6.1.5 The bidder shall give along with their bid clause by clause commentary indicating their confirmation / comments/ observation in respect of all clauses of technical specification.

6.1.6 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 computer aided tower spotting etc. available with the bidder or his associates shall also be furnished with the bid.

6.1.7 The Contractor shall also engage services of a reputed geo-technical/geologist consultant or experts from independent educational/research institutions for examining stability aspects of the selected transmission line route & tower
locations in hilly terrain during finalization of tower spotting & construction of foundations.

6.1.8 After carrying out the detailed survey and soil investigations, the contractor shall estimate complete BOQ of the transmission lines and submit the same (as per the BOQ format enclosed with the Technical Specifications) to the Employer.

6.2 CONTRACTOR'S SURVEY

6.2.1 Access for Survey

For details of the access arrangement for survey, reference should be made to Appendix 5.1A1. The Contractor's Surveyor shall in all cases announce himself to the occupier/landowner immediately before entering any private property for the purpose of survey. The Contractor shall comply with all national and local regulations regarding barricades, detour arrangements, and warning signs. Damage to roads, footpaths, bridges, ditches, etc., caused by the Contractor shall be repaired at his expense.

6.2.2 Survey Methodology & Precision

All elevations shall be referenced to benchmarks established by the Public Work Division of Bangladesh / Survey of Bangladesh. Survey operations shall begin and end at benchmarks approved by the Employer.

During the leveling of the profile, check surveys will be affected at intervals not exceeding 50 Kms. with benchmarks of known elevations. The difference in elevations as surveyed by the contractor and as declared by Public Work Division of Bangladesh / Survey of Bangladesh 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 but not exceed 300 mm.

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.

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.

6.2.3 Route Alignment

6.2.3.1 The route Alignment shall be carried out by the contractor using topographical maps and preliminary route alignment finalized by the Employer with GPS.

6.2.3.2 The routing 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.

6.2.3.3 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

6.2.3.4 Large trees completely, then keeping in view of the overall economy, the route should be aligned in such a way that cutting of trees is minimum.

6.2.3.5 The route should have minimum crossings of Major River, National/State highways, overhead EHV power line and communication lines.

6.2.3.6 The number of angle points shall be kept to minimum.

6.2.3.7 The distance between the terminal points specified shall be kept shortest possible, consistent with the terrain that is encountered.

6.2.3.8 Marshy and low lying areas, river beds and earth slip zones shall be avoided to minimize risk to the foundations.

6.2.3.9 It would be preferable to utilize level ground for the alignment.

6.2.3.10 Crossing of power lines shall be minimized. Alignment will be kept at a minimum distance of 300 m from power lines to avoid induction problems on the lower voltage lines.

6.2.3.11 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.

6.2.3.12 Areas subjected to flooding such as nalah shall be avoided.

6.2.3.13 Restricted areas such as civil and military airfield shall be avoided. Care shall also be taken to avoid aircraft landing approaches.

6.2.3.14 All alignment should be easily accessible both in dry and rainy seasons to enable maintenance throughout the year.

6.2.3.15 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.

6.2.3.16 Angle points should be selected such that shifting of the point within 100 m radius is possible at the time of construction of the line.

6.2.3.17 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.

6.2.3.18 The areas requiring special foundations and those prone to flooding should be avoided.

6.2.3.19 For examination of the alternatives & identification of the most appropriate route, besides making use of information/data/details available/extracted through, the contractor shall also carryout reconnaissance/preliminary survey as may be required for verification & collection of additional information/data/details.
6.2.3.20 The contractor shall submit his preliminary observations & suggestions along with various information/data/details collected and also processed satellite imagery data, scanned 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. Digital terrain modeling using contour data from topographical maps shall be done by the contractor for the selected route. A fly through perspective using suitable software(s) shall be developed for further refinement of the selected route, if required. Site visit and field verification shall be conducted by the contractor jointly with the Employer’s representative for the proposed route alignment.

6.2.3.21 Final digitized route alignment drawing with latest topographical and other details/features including all rivers, railway lines, canals, roads etc. up to 8 kms 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.

6.2.3.22 Changes in the route alignment, if any, during detail survey, shall be incorporated in the final digitized route alignment drawings.

6.2.4 Detailed Survey

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

6.2.4.2 Soil resistivity, along the route alignment shall be measured in dry weather by four electrode method keeping inter-electrode spacing of 50 mtrs. For calculating soil resistivity formula $2\pi ar$ (Where $a=50$ m and $r=\text{megger reading in ohms}$) 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.

6.2.5 Route Marking

6.2.5.1 The route of the transmission line shall be recorded using GPS/DGPS of positional accuracy less than 3m.

6.2.5.2 The co-ordinates of all the angle points as well as other important crossings, landmarks etc. shall be recorded using GPS for easy relocating.

6.2.5.3 At the starting point of the commencement of route survey the co-ordinates shall be recorded. A punch mark on the top section of the angle iron shall be made 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 meter along the transmission line to be surveyed up to the next angle point shall also be recorded. Wooden peg 50 x 50 x
650mm size shall also be driven at prominent position at intervals of not more than 750 meter along the transmission line to be surveyed up to the next angle point. Wire nails of 100mm length should be fixed on the top of these pegs to show the location of instrument. The peg shall be driven firmly into the ground to project 100 mm only above ground. 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 Employer markings shall be made and co-ordinates recorded. At angle position stone/concrete pillars of 150 x 150 x 100 mm in size with Employer marked on them shall be embedded into the ground for easy identification.

6.2.6 Profiling

6.2.6.1 The complete profiling along the route shall be carried out using modern surveying equipments viz. total stations, DGPS etc. Reference levels at every 20 meters along the route are to be recorded. R/Ls 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.

6.2.6.2 The complete profiling details shall be digitized and the data shall be prepared & stored in the format compatible to computer-aided tower spotting software.

6.2.6.3 A printed/plotted output of the digitized profiling shall be submitted by the contractor to Employer’s for review before taking up computer-aided tower spotting.

6.2.7 Optimization of Tower Location / Tower Spotting

6.2.7.1 Optimization 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.

6.2.7.2 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 Employer spotting, shall be prepared by the contractor.

6.2.7.3 General description of towers is indicated in Section–I of this specification for information of the Bidders.

6.2.8 Tower Spotting

The Contractor shall submit to the Engineer the requisite copies of route maps and mouza maps, they shall also submit requisite copies of the profile drawings
upon which shall be indicated the proposed location and type of each tower, spans, section lengths, (i.e.) distances between tension towers), equivalent spans, wind and weight span, difference in level between phase conductor attachment points and the sag templates used. This a **Hold Point.** Also on the profile shall be plotted the relevant position of the bottom or lowest phase conductor at the specified maximum conductor temperature and another line parallel to the phase conductor line and at the minimum statutory ground clearance specified below it.

Towers shall be so located that the span criteria specified in Appendix 6.A1 is not exceeded.

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 1D25 type or 1DT6 type towers as applicable for 132 kV line.

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 extns, 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 clearance. Crossing span will not be more than 250 meters.

e) **Railway Crossings**

All the railway crossings coming-enroute the transmission line shall be identified by the Contractor. At the time of detailed survey, the railway crossings shall be finalized as per the regulation laid down by the Railway Authorities.

1. The crossing shall normally be at right angle to the railway track.
II. The minimum distance of the crossing tower shall be at least equal to the height of the tower plus 6 meters away measured from the centre of the nearest railway track.

III. No crossing shall be located over a booster transformer, traction switching station, traction sub-station or a track cabin location in an electrified area.

IV. Minimum ground clearance above rail level of the lowest portion of any conductor under condition of maximum sag shall be maintained at 14 m 400kV transmission lines.

V. The crossing span will be limited to 300 meters.

f) **Power line Crossings**

The angle of crossing shall be as near to 90 degree possible. 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:

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<th>Sl. No.</th>
<th>Nominal System Voltage</th>
<th>132kV</th>
<th>230kV</th>
<th>400kV</th>
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</tr>
<tr>
<td>2</td>
<td>230kV</td>
<td>5.5</td>
<td>5.5</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>400kV</td>
<td>7</td>
<td>7</td>
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</tbody>
</table>

Pipeline crossings shall not be at an angle to the normal greater than 20°. Crossings of power supply and telecommunication circuits shall not be at an angle to the normal greater than 45° without previous agreement from the Engineer.

**g) 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. At the crossing of power supply and telecommunication circuits, no part of the structure of one support shall be placed less than 35 m from any part of the support structure of the other circuit.

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.

**h) Details En-route**
All topographical details, permanent features, such as trees, building etc. 23 m for 400 KV line on either side of the alignment shall be detailed on the profile plan.

6.2.9 Clearance from Ground, Building, Trees etc.

6.2.9.1 Clearance from ground, buildings, trees and telephone lines shall be provided in conformity with criteria specified in Appendix 6.A2.

6.2.9.2 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 Contractor) 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.

6.2.9.3 To evaluate and tabulate the trees and bushes coming within 23 m for 400 KV line 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. The trees list should contain the following:

a) Girth (circumstances) measured at a height of 1 meter from ground level.

b) Approximate height of the tree with an accuracy of +2 meters.

c) Name of the type of the species/tree.

d) The bushy and under growth encountered within the 46 m for 400 kV line should also be evaluated with its type, height, girth and area in square meters, clearly indicating the growth in the tree/bush statement.

6.2.9.4 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 Nos. (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 topology 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.

6.2.10 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.

6.2.11 Profile Drawings - Size & Scales

The profile shall either be drawn on a melinex type material or as otherwise approved with printed grid lines of increasing thickness in 1, 5, 10 and 50 mm squares and shall be drawn on the reverse side of the melinex to the grid lines.

Computer plotted profiles on plain plastic drawing sheets will be accepted by the Engineer. However, the format of the profile shall not differ from the details specified in the following clauses.

Unless specified to the contrary the scale of the profile shall be:

1:2000 horizontally and
1:200 vertically

The profile shall be plotted with the direction of the line route left to right on the profile sheet. In general, individual profile sheets shall commence and finish at tension supports but where this is not practicable and continuation sheets are found to be necessary the ground line is to be drawn so that there is an overlap of at least 300 mm between adjacent sheets. The chainage of each section between tension structures shall start at zero, be on a 50 mm printed grid line and not less than 200 mm from the left hand margin. Each section shall normally be started on a new sheet. The date of survey of each section shall be added.

If more than one section is drawn on one sheet a gap shall be left in the ground line of not less than 200 mm.

6.2.12 Profile Drawings - Details

The following details and information are to be included on the profile drawings:

(a) At each angle position a 'tie-in' sketch shall be provided on the profile sheet. This sketch shall show clearly the location of the support using as reference where possible points which can be located on the ground and on the 1:5,000 or closest available scale of survey map. The direction of the line and angle of deviation are to be shown stating also whether the deviation is left or right. Where reliable maps of reasonable scale and accuracy are not available for locating and plotting support positions, survey methods acceptable to the Engineer shall be employed to establish grid co-ordinates and supports towers and ground features shall be related to these.

(b) Where ground slope across the line route exceeds 1 in 25, the level of ground left and right of the centre line shall be recorded at specified horizontal offset distances, where the side slope is uniform. Where the slope breaks upwards beyond this distance levels will be recorded up to a specified horizontal offset distance. The offset levels shall be indicated on the profile as broken and/or chain lines and the distances off-line stated.
The profile shall show all changes of level of 300 mm or more along the route centre line and alone, the off-set lines. All features such as hedges, fences, graves, ditches, roads, railways, rivers, buildings, canals, telephone and railway lines and all power lines shall be shown. Road numbers or name of roads shall be stated or, if unclassified, the destination. Railways are to be given the destination, number of tracks, whether or not electrified and the level at the top of rail stated.

The chainage is to be shown at each 300 m and at every geographical feature or obstruction. Chainage shall also be given to all line pegs.

The specified Datum shall be the basis for all levels and the level above the specified Datum shall be shown at 10m vertical intervals at the beginning and end of each profile sheet. Levels shall be shown at each peg on line and at every obstruction or geographical feature.

The visual nature of the ground shall be noted, whether cultivated, woodlands, etc. with special reference to marsh, soft ground or rock and other relevant information such as soil instability.

All buildings or high obstructions within 30m of the centre line shall be shown dotted at their measured height with the distance left or right of line indicated.

Where the ground contour rises to a point which would be less than 100 mm from the top of the profile sheet, the ground line shall be terminated and continued on a new sheet with an overlap of 300m of line route.

The following detail shall be shown for crossings of power lines:

Voltage and type of construction;
Ground levels at point of crossing and support structures;
Height of top conductor and earth wire at point of crossing and at points of support;
Distance from crossing point to support structures along route of line to be crossed;
Angle of crossing;
Temperature at time levels were taken (state date and time);
Support structure numbers.
Any other information requested by the Employer’s Engineer.

Along the bottom of the profile sheet shall be drawn, to the same scale as the horizontal scale of the profile, a route map showing all relevant details, within a distance of 30m each side of the route centre line. All items covered by subparagraphs (a) and (i) above, as appropriate, shall be included.

6.2.13 Check Survey

The Contractor shall carry out a check survey of the whole route. Profile drawings will be made available to the Contractor, who will be required to check the profile (ground line) survey. The line routes may need to be changed at some
locations due to site constraints. The Contractor shall propose such changes after surveying the new line routes. No extra cost for survey and preparation of all drawings of such change of route will be paid to the Contractor.

The Contractor is required to check thereon the proposed tower positions and submit the profile drawing to the Engineer. Profile details and tower locations shall be in accordance with the preceding clauses.

### 6.2.14 Survey Report

**6.2.14.1** Complete BOQ of the transmission lines as per format enclosed with this technical specification at Annexure-A shall be furnished in the survey report.

**6.2.14.2** 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.

**6.2.14.3** 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:

**6.2.14.4** 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.

**6.2.14.5** 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.

**6.2.14.6** Suggestions regarding the number of convenient zones (line segments / portions) in which the entire alignment can be divided keeping in view the convenience of corporation are to be given.

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

**6.2.14.8** 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.

**6.2.14.9** Availability of labour of various categories and contractors of civil works shall also be reported.

**6.2.14.10** 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, Power Utilities and Divisional Forest/ wild life Authorities etc.

6.2.14.11 All safety regulation shall be complied by the contractor during routing/survey/construction of line through patches of dense forest/wild life. The employer has however obtained forest clearance on the basis of tentative route alignment.

6.2.14.12 All the requisite data for processing the case for statutory clearances shall be provided along with the report.

6.2.14.13 The contractor shall also collect & report (as per Formats enclosed at B) details pertaining to pollution levels envisaged along the transmission line.

6.2.14.14 Six copies of survey reports shall be furnished by the contractor to the Employer.

6.3 GEOTECHNICAL INVESTIGATION

6.3.1 General

Geotechnical investigation shall be undertaken in accordance with the technical requirements detailed in the following clauses. For details of the type and frequency of the investigation reference should be made to Appendix 6.A4.

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.

All investigation, unless specified otherwise shall be in accordance with the requirements of BS 5930.

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.

The Contractor shall give the Engineer the requisite period of notice prior to commencing the geotechnical investigation. This is a Hold Point.

6.3.2 Scope

6.3.2.1 The scope of work includes detail soil investigations and furnishing bore log data at various tower locations. Based on the bore log data / soil parameter /soil investigation results, the Contractor shall recommend the type of foundations suitable for each locations and the same shall be got approved by the Employer.

6.3.2.2 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. Detailed methodology for
subsoil investigation shall be submitted before implementing the subsoil
investigation. All laboratory tests shall be done at the test facility approved by
the Employer. The Contractor may appoint a sub contractor to carry out the site
gеo­technic­al investigation but aforementioned works shall be supervised by a
contractor’s engineer who had a bachelor’s degree in Civil Engineering and had
at least 5 years of site experience in geotechnical investigation work. All work
and all lab work shall be witnessed by the above mentioned contractor’s
engineer who shall countersign all recorded data.

6.3.2.3 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 (R.L.’s) at these locations with respect to benchmarks used in the detailed
survey. Two reference benchmarks 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 including maximum velocity
discharge, highest flood level (H.F.L), scour depth etc. of the concerned rivers,
major streams and nalas (canals).

6.3.2.4 The field and laboratory data shall be recorded on the proforma recommended in
relevant Standards. Contractor shall submit to Employer two copies of field bore
logs (one copy each to Employer project and Head Office) and all the field
records (countersigned by the Employer) soon after the completion of each
boreholes/test.

6.3.2.5 Whenever Contractor is unable to extract undisturbed samples, he shall
immediately inform the Employer. 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.

6.3.2.6 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.

6.3.2.7 After reviewing Contractor’s geotechnical investigation draft report, Employer
will call for discussions, to be held normally within one week, in order to
comment on the report in the presence of Contractor’s Geotechnical Engineer.
Any expenditure associated with the redrafting and finalizing the report, traveling etc. shall be deemed included in the rates quoted for the geotechnical investigations.

6.3.2.8 Contractor shall carry out all work expressed and implied in these specifications in accordance with requirements of the specification.

6.3.2.9 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.

6.3.3 General Requirements

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

6.3.3.2 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.

6.3.3.3 Contractor shall gather data regarding the removal of overburden in the project area either by performing test excavations, or by observing soil erosion or land slides in order to estimate reconsolidation of the soil strata. Similarly, data regarding recent land fills shall be studied to determine the characteristic of such land fills as well as the original soil strata.

6.3.3.4 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.

6.3.3.5 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.

6.4 Field Investigation for Soils

Tentative numbers of detailed soil investigation to be done is given in Schedule of prices in biding documents.

6.4.1 Boring

Boreholes are required for detailed soil investigations.
6.4.1.1 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 100mm and boring shall be carried out in accordance with the provisions of BS 5930 and the present specification:

b) All boreholes shall be 20m 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 50, 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 15cm 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 BS 5930. 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.

6.4.1.2 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 BS 5930. No water shall be introduced from the top while conducting auger boring.
6.4.1.3 Shell and Auger Boring

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 50 Chisel bits may also be used to extend the bore hole through local obstructions such as old construction. Boulders rocky formations, etc.

6.4.1.3.2 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 stabilize and protect the inside surface of the borehole. Use of percussion tools shall be permitted in hard clays and in dense sandy deposits.

6.4.2 Standard Penetration Test (SPT)

6.4.2.1 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 silt such as strength and compressibility shall not be inferred based on SPT values.

6.4.2.2 The test shall be conducted at depths as follows:

<table>
<thead>
<tr>
<th>Location</th>
<th>Depths (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Soils for open cast foundations</td>
<td>2.0, 3.0, 5.0, 7.0, 10.0</td>
</tr>
<tr>
<td>Pile foundation locations &amp; special locations.</td>
<td>Each level at an interval of 1.5m depth upto 30m depth.</td>
</tr>
</tbody>
</table>

6.4.2.3 The spacing between the levels of standard penetration test and next undisturbed sampling shall not be less than 1.0m. Equipments, accessories and procedures for conducting the test and for the collection of the disturbed soil samples shall conform to BS 5930 respectively. The test shall be conducted immediately after reaching to the test depth and cleaning of bore hole.

6.4.2.4 The test shall be carried out by driving a standard split spoon sampler in the bore hole by means of a 63.5kg hammer having a free fall of 0.76 m. The sample shall be driven using the hammer for 450mm recording the bumper of blows for every 150mm. The number of blow for the last 300mm drive shall be reported as N value.

6.4.2.5 This test shall be discontinued when the blow count is equal to 50. 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.

6.4.1.3.1 Sampling

6.4.3.1 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 BS 5930; all disturbed and undisturbed samples collected in the field shall be classified at site as per BS 5930.

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.

6.4.3.2 Disturbed Samples

a) Disturbed soil samples shall be collected in boreholes at regular intervals. Samples shall be collected at the same level of the SPT implemented 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 0.5m below ground level shall be collected to establish the required properties for use as a fill material. Disturbed samples weighing about 25kg (250N) shall be collected at shallow depths and immediately stored in polythene bags as per BS 5930. The bags shall be sealed properly to preserve the natural moisture content of the sample and placed in wooden boxes for transportation.

6.4.3.3 Undisturbed Samples
In each borehole undisturbed samples shall be collected at every change of strata and at depths as follows:

<table>
<thead>
<tr>
<th>Location</th>
<th>Depths (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Soils for open cast foundations</td>
<td>1.0, 4.0, 6.0, 8.0, 10m</td>
</tr>
<tr>
<td>Pile foundation locations &amp; special Locations.</td>
<td>1.0, 4.0, 6.0, 8.0, 11.0 and thereafter at the rate of 3 m intervals up to 20m</td>
</tr>
</tbody>
</table>

The spacing between the top levels of undisturbed sampling and standard penetration testing shall not be less than 1.0m. Undisturbed samples shall be of 100mm diameter and 450mm 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 BS 5930.

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.

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

Samples shall be obtained using a piston sampler consisting of a cylinder and piston system. In soft clays and silky 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 BS 5930. Sampler operated by compressed air shall be used to sample cohesion less soils below ground water table.

6.4.2 Ground Water

6.4.4.1 One of the following methods shall be adopted for determining the elevation of ground water table in boreholes as per relevant BS standard 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.

6.4.4.2. 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 filed investigation. Levels in nearby wells, streams, etc., if any, shall also be noted in parallel.

6.4.4.3. 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 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.

6.4.5 Vane Shear Test. (required for boreholes where Undisturbed sampling 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 BS 5930. 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 is 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 BS 5930.

6.5 Laboratory Testing

6.5.1 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 British codes or the equivalent codes approved by the Employer. One copy of all laboratory test data records shall be submitted to Employer. 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 borehole;

b) Laboratory tests shall be conducted using approved apparatus complying with the requirements and specification of BS 1377 or other approved standards for this type of work. It shall be checked that the apparatus are 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 screw tube 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;

6.5.2 Tests

6.5.2.1 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;

b) Tests of undisturbed samples:

- Bulk density and moisture content;
- Relative density(for sand);
- Unconfined compression test;
- Direct shear test or Triaxial shear tests (depending on the type of soil and field conditions on undisturbed or remoulded samples):
i. Unconsolidated undrained;
ii. Consolidated drained test;
c) Chemical analysis of sub soil water.

6.5.3 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;

6.6 Test Level
6.6.1 Level 1

Level 1 geotechnical investigation shall be based on a visual-tactile examination of disturbed soil samples for the determination of both soil classification and strength. Visual-tactile examination shall be undertaken in accordance with the recommendations of ASTM D2488. Samples shall be taken from either trial pits, bore holes, hand held augers, or if specified during course of the foundation excavation.

Where dynamic probing is used in conjunction with a higher level geotechnical investigation technique, the probe shall be calibrated to the satisfaction of the Engineer against the results of the higher level tests. Details of the Contractor's calibration proposals and calibration results shall be submitted to the Engineer. This is a Hold Point.

6.6.2 Level 2

Level 2 geotechnical investigation shall be based on in-situ testing for the determination of the soil strength and laboratory tests of disturbed samples for the determination of soil classification such as particle size distribution, Atterberg limits. For details of the soil classification reference should be made to Appendix 6.A6.

In-situ testing, shall comply with the following requirements:

(a) Non-cohesive soil - standard penetration tests (SPTs), cone penetration tests (CPTs), or in the absences of large gravel content pressure meter tests (PMTs).
(b) Cohesive soil - As for non cohesive soils except that use of SPTs is subject to the Engineer's approval. Vane shear tests (VSTS) may also be used in fairly uniform fully saturated soils.

(c) Rock - Weak rock SPTs, medium to hard rock PMTs.

Where it is proposed to determine the soil classification indirectly from the in-situ tests eg. CPTs, cross correlation shall be undertaken at specified intervals using auger borings.

Laboratory soil classification tests for non-cohesive soils shall be particle size distribution, moisture content and relative density, whilst those for cohesive soils shall be moisture content and Atterberg limits. Whilst strength tests shall be direct shear box (immediate) and bulk density for non-cohesive soils and unconfined compressive strength, direct shear box (immediate) and bulk, density for cohesive soils. All laboratory testing shall be undertaken in accordance with BS 1377.

Where appropriate ground water levels shall be recorded in all boreholes.

6.6.3 Level 3

Level 3 geotechnical investigation shall be based on in-situ testing (as for Level 2) for the determination of the soil strength and the recovery of disturbed soil samples for subsequent laboratory testing.

Laboratory soil classification tests for non-cohesive soils shall be particle size distribution, moisture content and relative density, whilst those for cohesive soils shall be moisture content and Atterberg limits. Whilst strength tests shall be direct shear box (immediate) and bulk density for non-cohesive soils and unconfined compressive strength, direct shear box (immediate) and bulk, density for cohesive soils. All laboratory testing shall be undertaken in accordance with BS 1377.

6.6.4 Level 4

Level 4 geotechnical investigation shall be based on a combination of in-situ testing (as for level 2) and recovery of disturbed/undisturbed soil samples for subsequent laboratory testing.

Laboratory soil classification tests shall be as per Level 3, whilst strength tests shall be direct shear and bulk density for cohesive soils and unconfined compressive strength, laboratory vane shear, triaxial compression (undrained) as appropriate and bulk density for Non cohesive soils. All laboratory testing shall be undertaken in accordance with BS 1377.

6.7 Geotechnical Investigation Report

6.7.1 General

Contractor shall submit a formal report containing geological information of the region, procedures adopted for geotechnical investigation, field observations,
summarized 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 Corporate/main site 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. Three 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.

6.7.2 Data to be furnished

6.7.2.1 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., property 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, etc.

d) Observations and data regarding change of course of rivers, velocity, scour depths, slit 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 1 (i) for each sample as well as (ii) for each layer, along with all the relevant charts, tables, graphs, figures, supporting calculations.
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;
**Table-1**

**SUMMARY OF RESULTS OF LABORATORY TESTS ON SOIL AND WATER SAMPLES**

1. **Bore hole test pit. no**
2. **Depth (m)**
3. **Type of sample**
4. **Density(kg/m3)**
   - a) Bulk
   - b) Dry.
   - c) Submerged
5. **Water content (%)**
6. **Particle Size (%)**
   - a) Gravel
   - b) Sand
   - c) Silt
   - d) Clay
7. **Consistency properties**
   - a) LL
   - b) PL
   - c) PI
   - d) LI
8. **Soil**
   - a) Classification -
   - b) Description
   - c) Specific gravity
9. **Strength Test**
   - a) Type
   - b) C (Cohesion)
   - c) Ø (angle of internal friction)
   - d) Angle of repose
10. **Shrinkage limit(%)**
11. **Relative Density (%)**
12. **Remarks**

**Notations:**
I. For type of Sample:
   DB - Disturbed bulk soil sample.
   DP - Disturbed SPT soil sample
   DS - Disturbed samples from cutting edge of undisturbed soil sample.
   RM - Remoulded soil sample
   UB - Undisturbed block soil sample
   US - Undisturbed soil sample by sampler
   W - Water sample

II. For Strength Test:
   SCPT - Static Cone Penetration Test
   UCC - Unconfined Compression Test
   VST - Vane Shear Test
   Tuu - Unconsolidated Undrained Triaxial Test
   Note: Replace T by D for Direct Shear Test
   Tod - Consolidation Drained Triaxial Test

III. For Others:
   LL - Liquid Limit (%)
   PL - Plastic Limit
   PI - Plasticity Index
   LI - Liquidity Index
   C - Cohesion (kPa)
   Ø - Angle of Internal Friction (degrees)
   S-Pr - Swelling Pressure (kPa)
   e_o - Initial Void Ratio
   Pc - Reconsolidation Pressure (kPa)
   Cc - Compression Index
   DP - Change in Pressure (kPa)
   m_v - Coefficient of Volume Compressibility (m2/KN)
   Cv - Coefficient of Consolidation (m2/hr)

IV. For Chemical Test
   As per Specifications - Clause 6.7.4
6.7.3 Recommendations

6.7.3.1 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:

a) 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 and long term components under transient and permanent loading, shall be strictly controlled with regard to settlement, uplift, lateral translation and rotation:

c) Core resistance, frictional resistance total resistance, relation between core resistance, Standard Penetration Test N value.

d) For shallow foundation the following shall be indicated with comprehensive supporting calculations:

e) Net Safe allowable bearing pressure for isolated square footing of sizes 4.0, 5.0, 6.0 & 7.0 m at three different founding depths of 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.

   i. 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.

   ii. Rate and magnitude of settlement expected of the structure.

   iii. 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.

f) 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:

g) 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.

h) 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.

i) 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.

j) 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;

k) Suitability of locally available soils at site for filling, backfilling and adequate compaction shall be investigated.

l) 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;

m) Susceptibility of subsoil strata to liquefaction in the event of earthquake and remedial measures, if required, shall be considered.

n) Any other information of special significance such as dewatering schemes, etc., which may have a bearing on the design and construction shall be provided.

o) Recommendations for additional soil investigations, beyond the scope of the present work, shall be given if Contractor considers such investigations necessary.

6.7.4 Hydrogeological Conditions

6.7.4.1 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 NH4+;

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 SO4-2;

i) aggregate content of chlorides, sulphates, nitrates, carbonates and other salts, mg/l.

6.8 Rates and Measurements

6.8.1 Rates

The contractor’s quoted rates 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.

6.9 FIELD QUALITY PLAN

A standard Field Quality Plan is annexed to Section VI of this document. The bidders are requested to convey their acceptance to the same along with their offer.

6.10 FOUNDATION SETTING LEVEL DIAGRAMS

Where specified foundation setting level diagrams shall be prepared for specific tower positions. At a scale of 1:200 (horizontally and vertically) the foundation excavation and setting levels on the two diagonals (drawn separately) shall be shown, together with a record of the applicable foundation design, leg and body extensions and tower centre-peg-co-ordinates.
APPENDIX 6.A1/1

LINE DESIGN SPAN CRITERIA

Please refer to Appendix of Section 8 of this Specification.
APPENDIX 6.A2
CLEARANCE TO OBSTACLES

The minimum clearances defined below shall not be infringed at the specified maximum conductor temperature with the phase conductors and suspension insulators hanging vertically or deflected to any angle up to 70° from the vertical.

<table>
<thead>
<tr>
<th>Description of Clearance</th>
<th>Minimum Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground (see note d)</td>
<td>8.0</td>
</tr>
<tr>
<td>Roads</td>
<td>9.0</td>
</tr>
<tr>
<td>Buildings, structures, walls or other objects on which a person can stand or against which he can lean a ladder (see note b)</td>
<td>7.0</td>
</tr>
<tr>
<td>Trees (see note c)</td>
<td>5.5</td>
</tr>
<tr>
<td>Shrubs</td>
<td>5.5</td>
</tr>
<tr>
<td>Railways (measured from railway track)</td>
<td>10.0</td>
</tr>
<tr>
<td>River Crossing</td>
<td>25.0</td>
</tr>
</tbody>
</table>

Notes:

(a) Clearances are measured to the nearest projection of an object.

(b) These clearances also apply to earthed metalclad buildings.

(c) Clearances applicable to trees under the transmission line and to trees adjacent to the line. Clearances also applicable to trees falling, towards the line with conductors hanging in a vertical plane.

(d) The clearance shall be measured from the highest flood level.
Clearances where Transmission Lines Cross

Where a transmission line crosses above or below another transmission line, the following clearances shall be obtained.

In still air, and with the phase conductor temperature of the lower transmission line at 5°C or 80°C for 400 kV line whilst the assumed phase conductor temperature of the higher transmission line is at its maximum operating temperature, the following minimum clearances between the lowest conductor (phase or earth) of the higher transmission line are applicable:

<table>
<thead>
<tr>
<th>System voltage (see Note i)</th>
<th>230 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) The highest conductor (phase or earth) of the lower transmission line (see Note ii)</td>
<td>5.5 m</td>
</tr>
</tbody>
</table>

Note:

i) The voltage specified is that for which transmission lines are ultimately designed to operate.

ii) Clearances are determined by the ultimate voltage of either the upper or lower transmission line, whichever is the greater.

iii) Clearances are determined by the ultimate voltage of the upper/lower transmission line.

In addition to the above at the point of crossing, the clearance in (a) shall be obtained assuming the conductors of the lower transmission may swing up to 45° from the vertical.

The sags of the upper and lower transmission lines shall be those at the maximum operating temperature.
APPENDIX 6.A3
CROSSING OF OBSTACLES

Pipeline crossings shall not be at angle to the normal greater than 20 degrees.

Crossings of power supply and communication circuits shall not be at angle to the normal greater than 45 degrees without previous agreement of the Engineer.
APPENDIX 6.A4
GEOTECHNICAL INVESTIGATION

<table>
<thead>
<tr>
<th>Geotechnical Investigation Level</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2</td>
<td>Every tower site excluding river crossing and anchor towers and rigid frame tower.</td>
</tr>
<tr>
<td>Level 4</td>
<td>At river crossing, anchor towers and rigid frame tower.</td>
</tr>
</tbody>
</table>

Ground water samples shall be taken at every tension tower and all river crossing, anchor tower positions for chemical analysis.

APPENDIX 6.A5

Not used
## SOIL CLASSIFICATION BY UNITED SOIL CLASSIFICATION SYSTEM

<table>
<thead>
<tr>
<th>Major Divisions (1)</th>
<th>Subdivisions (2)</th>
<th>USCS Symbol (3)</th>
<th>Typical names (4)</th>
<th>Laboratory classification criteria (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coarse-grained soils (more than 50% retained on No.200 sieve)</strong></td>
<td>Gravels (More than 50% of coarse fraction retained on No.4 sieve)</td>
<td>GW</td>
<td>Well-graded gravels or gravel-sand mixtures, little or no fines.</td>
<td>$C_U \geq 4$ and $1 \leq C_C \leq 3$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GP</td>
<td>Poorly graded gravels or gravelly sands, little or no fines.</td>
<td>Does not meet $C_U$ and/or $C_C$ criteria listed above.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GC</td>
<td>Clayey gravels, gravel-sand-clay mixtures.</td>
<td>Less than 12% fines.</td>
</tr>
<tr>
<td></td>
<td>Sands (50% or more of coarse fraction passes No.4 sieve)</td>
<td>SW</td>
<td>Well-graded sands or gravelly sands, little or no fines.</td>
<td>$C_C \geq 6$ and $1 \leq C_C \leq 3$.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SP</td>
<td>Poorly graded sands or gravelly sands, little or no fines.</td>
<td>Does not meet $C_U$ and/or $C_C$ criteria listed above.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SM</td>
<td>Silty sands, sand-silt mixtures.</td>
<td>Less than 12% fines.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC</td>
<td>Clayey sands, sand-clay mixtures.</td>
<td>Less than 12% fines.</td>
</tr>
<tr>
<td><strong>Fine-grained soils (50% or more passes the No.200 sieve)</strong></td>
<td>Silts and clays (liquid limit less than 50)</td>
<td>ML</td>
<td>Inorganic silts, rock flour, silts of low plasticity</td>
<td>Inorganic soil PI &lt; 4 or plots below A-line</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CL</td>
<td>Inorganic clays of low plasticity, gravelly clays, sandy clays, etc.</td>
<td>Inorganic soil PI &gt; 7 and plots on or above A-line</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OL</td>
<td>Organic silts and organic clays of low plasticity</td>
<td>Organic soil LL(oven dried)/LL(not dried) &lt; 0.75</td>
</tr>
<tr>
<td></td>
<td>Silts and clays (liquid limit 50 or more)</td>
<td>MH</td>
<td>Inorganic silts, micaceous silts, silts of high plasticity</td>
<td>Inorganic soil Plots below A-line</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CH</td>
<td>Inorganic highly plastic clays, fat clays, silty clays, etc.</td>
<td>Plots on or above A-line</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OH</td>
<td>Organic silts and organic clays of high plasticity</td>
<td>Organic soil LL(oven dried)/LL(not dried) &lt; 0.75</td>
</tr>
<tr>
<td><strong>Peat</strong></td>
<td></td>
<td>PT</td>
<td>Peat and other highly organic soils</td>
<td>Primarily organic matter, dark in color, and organic odor</td>
</tr>
</tbody>
</table>

** If $4 \leq PI \leq 7$ and PI plots above A-line, then dual symbols (e.g. CL-ML) are required
APPENDIX 6.B1

ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

<table>
<thead>
<tr>
<th>Clause Reference</th>
<th>Document Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.2.5</td>
<td>Route map, Mouza map &amp; Profile drawings</td>
<td></td>
</tr>
<tr>
<td>6.3.1</td>
<td>Slope stability analysis</td>
<td>If specified</td>
</tr>
<tr>
<td>6.6.1</td>
<td>Dynamic probe</td>
<td>Calibration details</td>
</tr>
<tr>
<td>6.7</td>
<td>Geotechnical Investigation</td>
<td>Test results</td>
</tr>
</tbody>
</table>

APPENDIX 6.C1

NOTIFICATION AND HOLD POINTS

<table>
<thead>
<tr>
<th>Clause Reference</th>
<th>Notification Point</th>
<th>Hold Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td></td>
<td>Survey</td>
</tr>
<tr>
<td>6.2.5</td>
<td></td>
<td>Route maps, mouza maps and profile drawings</td>
</tr>
<tr>
<td>6.7</td>
<td></td>
<td>Geotechnical Investigation</td>
</tr>
<tr>
<td>6.6.1</td>
<td></td>
<td>Dynamic probe Calibration</td>
</tr>
<tr>
<td>6.6.1</td>
<td></td>
<td>Level 1</td>
</tr>
</tbody>
</table>

APPENDIX 6.D1

REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of the Specification are listed below:

BS 1377 : Method of tests for soils civil engineering purposes.
BS 5930 : Code of Practice for site investigation.
7.1 SCOPE

7.1.1 General

The type of foundation to be used at each tower position shall be determined from the results of the geotechnical investigation. The design of the foundation shall be in accordance with the design parameters and associated criteria detailed in this Specification for tender design purposes, but finally in accordance with the parameters of the actual geotechnical investigation.

The Contractor shall ascertain from the geotechnical investigation that the ground conditions are suitable for each foundation. The level of geotechnical investigation specified are the minimum level required at site. The Contractor shall undertake all necessary geotechnical investigation for the foundation design. Any subsidence or failure, due in the opinion of the Engineer to insufficient care having been taken in either the geotechnical investigation, or installation of the foundations shall be the Contractor's responsibility.

In areas where subsidence is likely to occur the Contractor shall if necessary, carry out modifications to the tower foundations as agreed by the Engineer. Collar or tie beams between the individual footings of a tower shall not be used unless specifically authorised by the Engineer. The Contractor shall not be held responsible for failure of tower and foundations arising from adjacent mineral extraction subsequent to the construction of the transmission line. The Contractor shall, however, be held liable for any lack of foundation or tower stability due to causes other than subsidence due to subsequent mineral extraction.

The Contractor is responsible for obtaining approval from the Engineer and where appropriate statutory regulatory bodies for the type and design of the foundations installed. It should be noted as a general requirement that no site work can commence before such approvals have been obtained. **This is a Hold Point.**

7.1.2 Method Statement

The Contractor shall submit to the Engineer a comprehensive method statement giving sequential details of his proposed installation method and include his intended programme. The method statement shall include but not be limited to the following details:

- (a) method of excavation. (for all types of foundations) and dealing with water;
- (b) method of installation of the pile foundations;
- (c) method of installation of rigid frame / river crossing tower foundations,
- (d) methods for heating, welding and site bending of reinforcement;
- (e) method of placing of concrete;
- (f) method of curing and protecting the concrete;
- (g) method of backfilling and compacting;
- (h) Reinstatement of working areas;
- (i) Quality Control procedures;

**This is a Hold Point.**
7.1.3 **Types and Uses**

Foundations for towers for different categories of soil conditions shall be selected from the approved types detailed in Appendix 7.A1.

The bidder may propose any other proven type of piled foundation instead of Drilled Shaft Piled foundation except wooden pile. The bidder shall submit the design of the proposed type of piled foundation along with detailed design calculation, installation procedure with drawings, Quality Control procedure, Standards and Codes of Practices to be followed, Advantages of selecting such type of piles, etc. with the bid. Reinforced concrete pile caps shall be used for all types of piles. Payments of all types of foundations shall be on lump-sum basis per tower as per prices quoted in the Price Schedule.

The contractor or its appointed sub-contractor has to submit relevant documentary evidence that they have previous experience of installing any other type of piled foundation. **This is hold point.**

Unless specified to the contrary, foundations for angle/terminal towers shall not have different designs for compression and tension footings, but shall be satisfactory for the most adverse condition of maximum and minimum angles of deviation/entry and with the wind blowing from the most onerous direction.

Foundations for tower body and leg extensions shall be of the same design and where appropriate utilise the same type of foundation formers as a foundation for the corresponding standard height tower.

### 7.2 DESIGN

#### 7.2.1 General

During design of towers, the tower reactions on the foundation shall be calculated considering appropriate maximum simultaneous loading on the towers. During foundation design the obtained reactions shall be multiplied by the strength factors indicated in Appendix 7.A2, and the resultant reactions shall be used for foundation design.

The geotechnical design of the foundation shall be based on accepted codes of practice, the relevant literature or methods which have been used with satisfactory practical experience by the Contractor, and agreed by the Engineer.

All foundations shall be designed to withstand uplift, settlement and overturning (as appropriate) when subjected to the applied system loading. Allowances shall be made in the foundation design for hydrostatic pressure where this may occur and the effects of seasonal rains, drying, out, cyclic loading, wind induced vibration of tower members, and scour.
7.2.2 Geotechnical Parameters

The geotechnical parameters for tendering purposes are provided in Appendix 7.A4. The Contractor shall however perform the geotechnical investigation during execution of the contract at each location as specified in this bidding document. Foundation designs of different towers locations shall be based on the results of geotechnical investigation done by the Contractor. No extra payment will be made if the actual soil condition is found to be worse than the soil parameter given in Appendix 7.A4.

7.2.3 Foundation Structural Design Parameters

Foundation structural design parameters for concrete shall be based upon the recommendations of BS 8110, except otherwise defined in this Specification.

7.2.4 Stubs

Stubs for tower body and leg extensions shall be of the same design as that for a standard height tower. Only one design of stub shall be permitted for each type of tower, and shall not be bent or cranked.

The thickness of the stub legs shall not be less than the corresponding tower leg member.

In addition to stubs of normal length, short stubs may be used, provided that provision is made for the attachment of bolted cleats.

Cleats shall be capable of transferring 100 percent of the design uplift working load (not factored load) and 50 percent of the design compression working load (not factored load) for shearing and bonding resistance. Two different type of stub design may require for rigid frame foundation and pile foundation. No extra payments shall be made for such two type of stub.

7.2.5 Holding Down Bolts

NOT USED.

7.2.6 Concrete Chimneys

Reinforced concrete chimneys shall be designed to withstand the maximum resultant horizontal residual shear component, with due allowance given where appropriate to resultant lateral (passive) earth pressure of the backfill (assumed to increase linearly with depth).

No allowance shall be made of the nominal strength of concrete in tension and the stub shall not be considered as providing any part of the tensile area of reinforcing steelwork.

The top of chimney of tower foundation shall be at least 300 mm above nominal ground level and in case of pile foundation pile cap shall be at least 300 mm below nominal ground level.
Foundations for lattice steel tower legs with high hillside shear force, due to certain combinations of unequal leg extensions may however differ from those designed for level ground by the addition of extra reinforcement in the chimney.

7.2.7    Types Of Foundation

7.2.7.1    Concrete Pad &Chimney Foundations

This foundation takes the form of a reinforced concrete flat slab surmounted by a chimney. Alternatively, the slab may be replaced by a truncated concrete pyramid surmounted by a chimney.

Uplift resistance is assumed to be provided by the mass of soil within the inverted frustum of a pyramid constructed from the upper edge of the base slabs, or the lower edge for a pyramid. However, where slabs are cast against undisturbed soil, or undercut, the frustum may be constructed from the lower edge of the slab base. The angle of the frustum depending on the soil properties, due consideration shall be taken of buoyancy effects, reduced densities of backfill and design test results.

For design under compression loading, the area of the base is determined by the design ground bearing pressure under ultimate loads. In assessing the bearing pressure beneath the foundation, the additional weight of the foundation over that of the displaced soil shall be multiplied by the appropriate foundation dead weight-factor (Appendix 7.A2).

For soft rock a similar type of foundation may be used, where a nominally reinforced concrete block is cast-in-situ against the undisturbed rock in conjunction with a nominal undercut at the lower edge. Uplift resistance is assumed to be resisted by the skin friction developed at the concrete-rock interface and an inverted frustum in any soil-rock overburden.

7.2.7.2    Piled Foundations

Piled shaft foundations shall comprise piles suitably connected below ground level by a concrete cap. The Contractor shall submit his proposed method of installation and Quality Control procedures to the Engineer prior to commencing his design. And the Contractor shall submit to the Engineer before start of piling works, a detailed description of the equipment, materials and procedures that will be used for the piling work. The description shall include equipment specifications, including catalogue data, manufacturer's published specifications, loading capacities, protective devices and test apparatus; detailed installation procedures test procedures, as well as references concerning previously completed piling work. This is a Hold Point.

The average skin friction or adhesion per unit area of shaft shall be determined from either the soil properties measured on samples in a direct shear test or an undrained triaxial compression test or calculated from SPTs (Standard Penetration Tests), or calculated from CPTs (Cone Penetration Tests). The average value shall be taken over the effective length of the shaft.

Where shear forces are resisted by a cap, an appropriate reduction in the average value of the skin friction/adhesion shall be taken for the cap design.
Piled foundations shall comprise either:

(a) **Multiple Piled Foundations Using Raked Piles**

The pile loads shall be determined by the vector summation of the horizontal and vertical components of the total reactions at ground level. One multiple pile foundation shall be constructed for each leg, and since the pile group provides all the lateral stability, no interconnecting ground beam between the legs are required. Raked piles are not to be used where ground settlement is likely to impose unacceptable bending stresses in the piles.

(b) **Multiple Piled Foundations Using Vertical Piles**

This type of foundation shall be used when ground settlement is likely to impose unacceptable bending stresses on raked piles, or where the type of pile cannot be installed raked. In this case lateral stability shall be provided by the passive resistance of the ground acting on the piles, pile cap and their interconnecting ground beams where present. In addition to the loading derived from the tower, ground beams where appropriate shall be designed to accept a specified wheel load.

Ultimate uplift resistance shall be obtained assuming the actual weight of piles, pile caps etc. plus the guaranteed ultimate uplift resistance of the piles. Allowance shall be made for buoyancy effects. The minimum component of the uplift resistance provided by the dead weight of the piles and pile caps should not be less than the value specified in Appendix 7.A4.

Ultimate compressive loads shall include the superimposed weight of soil; pile caps (and tie beams, etc.) multiplied by the dead load factor (as per Appendix 7.A2) and shall be obtained by the guaranteed ultimate resistance of the piles.

### 7.2.7.3 Raft Foundations

Raft foundations for wide based lattice towers shall only be used in areas subject to mining settlement, or very poor ground where piling is not possible.

### 7.2.7.4 Rigid frame Foundation

Rigid framed foundation, which is adopted at high water level area, shall be consisted of rigid frame and pile. An example of the foundation is shown in the drawings.

As for foundation design, foundation shall be designed as a rigid frame to withstand against uplift load, compression load and horizontal load. The contractor will consider friction between pile and soil against uplift load and against compression load, displacement of pile against horizontal load respectively. Individual footings shall be interconnected by tie beams, which shall be adequate to resist lateral forces and hydrostatic pressure exerted by the flood water. Allowances shall be made in the foundation design for hydrostatic pressure and the effects of seasonal rains, and scour.
In flooding area, the top of chimney concrete of the foundation shall be above the highest flood level. The contractor shall confirm the water level and adjust the foundation setting level to meet the requirement. Such foundation site shall be dewatered by pumping or other approved means during excavation all other necessary arrangements to perform the foundation work in water logged condition, concrete works and backfilling works. Those costs shall be deemed to be considered in the Contractor’s expense.

Depending on the height of water height, rigid frame foundation may varies from 2m to 6m. The Contractor shall submit his proposed method of installation and Q.C. procedures to the Engineer prior to commencing his design. This is a **Hold Point**.

### 7.2.8 Concrete Mix Design

The Contractor shall be entirely responsible for the control of the quality of concrete mixed and placed, in the Works. Before the commencement of any concrete work, the Contractor shall submit to the Engineer, a complete specification giving details of the materials used, source of supply, storage and quality control requirements, including preliminary trial mixes and works’ tests. **This is a Hold Point.**

To ensure the durability of the concrete, the requirements specified in Appendix 7.A6 shall be adhered to with regard to characteristic strength, minimum cement content and maximum free water/cement ratio.

### 7.2.9 Concrete Cover

All structural steelwork and reinforcing including links and stirrups below ground level shall be completely encased in concrete to ensure a minimum cover as specified in Appendix 7.A7. Such cover shall exist from the point of entry into the concrete base to either 450 mm above final ground level, or to the top of the concrete leg extension.

All foundation concrete to a point 450 mm above final ground level shall be undertaken at the same time and using the same design mix as the main part of the foundation.

### 7.2.10 Stability Analysis

All foundations on slopes greater than 1:4 shall be checked for stability against rotation where appropriate. Due consideration shall be given to the increased upslope lateral loading of the soil and the decrease in downhill resistance provided by the soil, when compared to foundations installed on level ground.

Due consideration shall also be taken of any decrease in the uplift resistance of the foundation. Where appropriate decrease in soil bearing resistance shall also be considered.

Where required by the Engineer the overall long term stability of the slope, including any proposed slope modifications for constructional purposes e.g. benching shall be considered by an approved geotechnical consultant appointed by the Contractor.
7.2.11 Installation Criteria

The Contractor shall prepare a schedule for construction purposes which clearly indicates the soil class and type of foundation to be installed at each tower site. The schedule shall show the basis for selection, taking into account the following items:

(a) The results of the geotechnical investigation;
(b) The results of any foundation design test;
(c) The design criteria;
(d) The results of any stability analysis;
(e) Those areas which due to the aggressiveness of the sub-soil or sub-soil water a greater mass of cement per cubic meter of concrete than that specified is required.

The schedule shall be submitted to the Engineer, prior to any foundation installation commencing. This is a Hold Point.

7.2.12 Design Submission

The Contractor shall submit the following, design submissions to the Engineer:

(a) Foundation design calculations;
(b) Foundation general arrangement drawing,
(c) Slope stability analysis;
(d) Bar bending schedule (information only) - if appropriate;
(e) Foundation formwork drawings (information only) - if appropriate;
(f) Foundation setting template.

Reference should be made to Clause 7.1.1 for approval procedures and Hold Point.

MATERIALS

7.2.13 Concrete

All works shall further be carried out in full compliance with all local rules and regulations and the specification. All materials used in the production of concrete, including all admixtures shall be in accordance with the requirements of BS 8500 and BS EN 206.

Cement shall be either:

(a) Portland cement in accordance with BS EN 197-1 strength grade 42.5N;
(b) Sulphate resisting Portland cement in accordance with BS 4027 strength grade 42.5N LA;
(c) Portland cement combined with a minimum of 25% and a maximum of 40% of p1a. Complying with BS 3892 Part 1.

The maximum particle size of the aggregates shall be so chosen as to be compatible with mixing, handling, placing, and workability of the concrete.
Throughout the construction period the quality of concrete mixed at and/or delivered to Site has to be controlled. Tests shall be carried out in the presence of the Engineer or under the supervision of an approved office for testing of such kind of works. The Contractor shall submit to the Engineer, test schedules on the following test at least one month prior to commencement.

(a) Aggregates  
(b) Cement  
(c) Water  
(d) Admixtures and Additives

In case of placing ready mixed concrete, concrete tests can be replaced by the manufacturer’s test results.

Concreting for pile foundation shall be done through tremie-pipes or equivalent devices to prevent segregation. For concreting in hot weather, ACI Standard 305R "Hot Weather Concreting” shall be followed and various means may be employed to lower the temperature of concrete such as:

- Cooling coarse aggregate with water by sprinkling and shading  
- Using chilled water  
- Avoiding the use of the hot cement  
- Adequately watering of sub-grade, form-work and reinforcement  
- Intensive moist-curing with potable water of the concrete placed

No admixtures shall be used without approval of the Engineer

7.2.14 Potential Alkali Reactivity

Aggregate shall not contain any materials that are reactive with alkalis in the aggregate itself, the cement, the mixing water or in the water in contact with the finished concrete or mortar in amounts sufficient to cause excessive localised or general expansion of the concrete or mortar.

The Contractor may initially assess an aggregate source by testing in accordance with ASTM C289. If potential reactivity is indicated, then mortar bar tests in accordance with ASTM C227 shall be carried out and the results shall comply with the limits given in ASTM C33, before use of the aggregate is approved. Details of the tests shall be submitted to the Engineer. This is a Hold Point.

7.2.15 Reinforcement

Unless specified to the contrary high yield steel reinforcement shall be either hot rolled deformed bars or cold worked deformed bars to BS 4449 and shall have type 2 bond classifications.

Mild steel reinforcing shall be plain hot rolled bars to BS 4449. Steel fabric or wrapping fabric shall be to BS 4483. Where mild steel hot rolled deformed bars are used they shall be generally in accordance with BS 4449. Reinforcement shall not be manufactured from scrap steel, unless otherwise approved by the Engineer.
Where specified fusion bonded epoxy coated reinforcement shall be in accordance with the requirements of BS ISO 14654 and 14656. Coated reinforcement shall be delivered to site in its cut and bent form.

Cropped ends and minor discontinuities of the fusion bonded coating shall be factory coated using a suitable repair compound formulated in accordance with the manufacturer’s specification.

Where specified fibre enhanced concrete shall contain fibres manufactured from 100 percent virgin polypropylene fibre and designed to achieve maximum distribution and freedom from clustering in the mix.

**7.2.16 Reinforcing Bar Coupler**

The use of proprietary reinforcing bar couplers to extend reinforcement will be permitted. Details of the coupler system shall be submitted to the Engineer prior to their use. This is a **Hold Point**.

**7.2.17 Spacers**

Dense sand/cement mortar spacing blocks shall be of a low permeability having similar strength, durability and appearance to the surrounding concrete.

Details of patent spacers shall be submitted to the Engineer. This is a **Notification Point**.

**7.2.18 Tying Wire**

Tying wire shall be 1.6 mm diameter black annealed mild steel wire for uncoated mild or high yield steel reinforcement.

Coated bars shall be fixed with plastic coated annealed mild steel tying wire.

**7.2.19 Anchor Tendons**

All the materials used in the installation of anchor tendons including those used for the grout shall be in accordance with the requirements of BS 8081 BS EN 1537.

**7.2.20 Gabion Baskets**

Gabion baskets and mattresses shall be manufactured from cold drawn steel wire. Minimum wire diameter for baskets galvanised to BS EN ISO 1461 shall be 3.0mm whilst for plastic coated wire galvanised to BS EN 10244-2 shall be 2.7mm. The minimum radial plastic coating thickness shall be 0.25mm.

All steel wires shall be electrically welded at every intersection.

**7.2.21 Holding Down Bolts**

**NOT USED.**

**7.2.22 Piles**
If pre-cast concrete or steel piles are used all materials shall be in accordance with the requirements of the IEC 'Specification for Piling'.

7.2.23 Stubs

Stub steelwork and bolts shall not be inferior to the requirements of Clause 8.3.1.

7.2.24 Earthing

All mild steel used in the manufacture of earthing rods shall comply with the requirements of BS EN 10083 etc.: (minimum strength 600N/m) Earthing rods shall have a minimum diameter of 14 mm.

Phosphor-bronze used in the manufacture of earthing rod couplings shall comply with the requirements of BS 12163 etc.

All compression fittings shall be manufactured from electrolytic tough pitch high conductivity copper, complying with the requirements of BS 13600 and BS EN 1057 and 12449, designation C101.

Earthing conductors shall be in accordance with the following requirements:

(a) Copper strip to BS EN 1652, 1653 and 1654, Grade C101 or C102, minimum cross sectional; dimensions 20 mm x 3 mm.
(b) Hard drawn copper strand to BS 7884, minimum overall diameter 10.65 (7 x 3.55 mm);
(c) Galvanised steel wire to BS 183, minimum overall diameter 9.75 mm (7 x 3.25 mm).

7.3 WORKMANSHIP

7.3.1 General

All workmanship shall be in accordance with the requirements of this Specification, the appropriate British Standard and local regulations including the appropriate health and safety requirements. The Contractor shall comply with all local regulations in respect of safety measures during construction at site. All local regulations shall also be adhered to. Proper strutting, sheeting and bracing, including rearrangement of the installations when necessary, protection of slopes, methods of excavation to reduce risk of slides, etc., shall be the Contractor's responsibility to meet the for design and construction requirements. And workmanship, shall be in accordance with the requirements of ACI 308.1, 301M, 301, 117-117R also.

7.3.2 Site Working Area
The Contractor will be restricted to a specified maximum working area at each tower site. He shall where required mark this area to clarify boundary lines to other parties. The Engineer shall be kept informed of any activities by others within the working area.

The Contractor shall remove all vegetation and other debris from the tower site, which will interfere with his operation. Vegetation and debris removed from the tower site shall be disposed of outside the right of way as directed by the Engineer and/or in accordance with local regulations. The Contractor shall dispose of material and regulate the movement of equipment, and slopes necessary to develop required loading characteristics shall be maintained, especially in side-hill locations.

7.3.3 Supports of Excavation

Excavations shall be adequately supported or formed to ensure stability of the sides and prevent any damage to the surrounding ground or structures. The design of suitable sheet piling and/or timbering for the tower of foundation excavation shall be in accordance with the recommendations of BS 8004 Section 5.

When the Contractor is requested, shall submit details of his temporary support to the Engineer.

Excavation material suitable for re-uses, as backfill shall be stored within the site working area. Excavation top-soil shall be stored separately.

Excavated material unsuitable for re-use shall be removed from site to a recognised dumping area provided by the Contractor, and approved by the relevant authorities.

For excavation in cohesive material the final 150 mm above formation level shall only be removed immediately prior to placing the blinding concrete. This activity shall be programmed to be carried out on the same day.

Excavation shall not be carried out below or adjacent to existing building foundations until under-pinning and shoring has been completed by the Contractor. Existing structures, foundations, and services shall be adequately protected or re-routed by the Contractor.

The Contractor shall not permit water to accumulate in any excavation unless otherwise agreed. Any water whether arising from the excavation or draining into shall be drained or pumped to an approved location well clear of the excavation area in a manner that does not cause erosion, silting or contamination of existing drains and watercourses. Before the method of ground water lowering is selected, adequate knowledge of the ground and water conditions has to be obtained from the results of a soil investigation and/or information, which may be available from the Engineer.

The Contractor shall take adequate steps to prevent adjacent ground from being, adversely affected by loss of fines in any de-watering process.

7.3.4 Use of Explosives
The Contractor shall familiarise himself and comply with the laws and local customs concerning the use, handling and storage of explosives.

(a) **Permission**

Explosives shall not be used on the Site without the prior approval of the appropriate Military and Civil Security Authorities and without prior written approval of the Engineer. This is a **Hold Point.**

(b) **Control**

The handling of all explosives on site shall be carried out in accordance with local requirements.

(c) **Approval**

The Employer shall be given a minimum of 24 hours notice of a proposal to use blasting and shall be given any details they may require concerning the charges and their positions. This is a **Notification Point.**

The Employer may regulate, restrict or prohibit blasting, if in their opinion it is necessary to do so for the safety of persons, property, limit noise or to safeguard the works.

(d) **Blasting**

For explosives to be allowed in any area of the site, the following and any local requirements shall be strictly observed.

i) The Contractor will be required to strip overburden and vegetation to expose rock which requires to be blasted;

ii) Where there is any danger of flying rock engineering persons or property, blasting screens made of approved materials shall be laid over the rock to be blasted, to help prevent dangerous projection of fragments;

iii) The use of electric detonators will not be permitted within 60 meters of any overhead power lines;

iv) Delay blasting techniques will be mandatory for all primary blasting with charge limits per delay period being imposed in order that ground vibration from the blasting can be controlled to a peak particle velocity of 25 mm/sec. in the vicinity of any structures or installations;

v) All charges prior to firing will be covered with thick gunny sacking and 1.8m squares of steel mesh weighed down with filled sandbags in order to prevent the projection of rock fragments;

vi) The Contractor will be required to take adequate and effective precautions to prevent debris rolling onto public or private roads and property.
The erection of magazines for storing explosives on site will not be permitted.

7.3.5 Reinforcement

(a) Storage

All reinforcement shall be adequately stored to prevent contamination or damage.

(b) Cutting and Bending

All reinforcement shall be bent cold unless otherwise permitted by the Engineer. Reinforcement shall not be straightened or re-bent in a manner which may cause injury to the material. All reinforcement shall be cut and bent in accordance with the requirements of BS 8666 and BS EN ISO 4066. The reinforcement shall be clearly identified with securely fixed, durable tags.

(c) Fixing

All reinforcement shall be rigidly fixed in position to the concrete cover specified by an approved means. The Contractor shall be responsible for ensuring that the reinforcement is properly towered and maintained in position by the adequate use of chairs, spacers and tying wire.

The reinforcement shall be free of all loose rust, scale or contamination of any kind. The reinforcement shall be inspected/checked after being fixed and no concrete shall be placed around the reinforcement until such checking/inspection has taken place and concrete permission has been signed by the Engineer.

(d) Site Bending

Bending and subsequent straightening of reinforcing bars projecting from the existing concrete shall be undertaking as follows:

i) Unless noted otherwise on the drawings, the minimum distance from the existing concrete to the beginning of a bend and the minimum inside diameter of the bend shall be:

<table>
<thead>
<tr>
<th>Bar Diameter</th>
<th>Min Distance from surface to beginning of bend (mm) radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-24</td>
<td>3 Bar Diameters</td>
</tr>
<tr>
<td>25-32</td>
<td>4 Bar Diameters</td>
</tr>
<tr>
<td>&lt;32</td>
<td>5 Bar Diameters</td>
</tr>
</tbody>
</table>

ii) Bars of 10 to 16 mm diameter may be bent once without heating, heating is required for subsequent straightening or bending.
Bars of 20 to 32 mm diameter may be bent once and subsequently straightened, heating is required in all cases.

Bars having a diameter greater than 32 mm may be bent only with the approval of the Engineer, heating are required in all cases.

iii) Heat shall be applied as uniformly as possible over a length of bar equal to 10 bar diameters. The centre of the heated length shall be at the centre of the completed bend. The temperature shall be maintained consistent during bending and straightening operations and shall not exceed 350°C. Temperature measuring crayons or a contact pyrometer shall be used to determine the temperature. Care shall be taken to prevent quenching of the heated bars either by application of water, or by a high volume of air.

iv) Straighten bars shall be visually inspected before and after straightening to determine whether they are cracked or otherwise damaged. This is a Notification Point.

(e) Epoxy Coated Bars

i) The Contractor shall take all necessary precautions to minimise damage to the coating during off-loading, handling and fixing. All equipment used for handling of coated bars shall have padded contact areas. Coated bars or bundles shall not be dropped or dragged.

ii) Coated bars shall be stored separately to uncoated bars.

iii) Coated bars shall not be cut or bent on site without the prior approval of the Engineer. This is a Hold Point.

Cut ends and any damage to the coating shall be repaired in accordance with Clause 7.5.

iv) Coated bars shall be towered on epoxy coated wire chairs or on chairs of dielectric material.

7.3.6 Concrete Trial Mixes

Trial concrete mixes using representative materials shall be carried out under full scale conditions using the Contractor's proposed method subject to the Engineer's approval. In case of use of ready mixed concrete, trial mixes shall only be waived, if an earlier proven mix design is used.

Testing shall be carried out in accordance with BS EN 12350. Trial mix test specimens shall be prepared and tested at approved laboratory. Aggregate used in trial mix shall be collected from the source proposed by the Contractor and approved by the Engineer. The target mean strength of the trial mixes shall be specified concrete cube strength plus a current margin of 15 N/mm².

The tests shall be carried out on three different days during which the workability will be recorded and nine cubes made. Among the nine cubes, three will be crushed at seven days; three will be crushed at fourteen days and the remaining three at twenty eight days. This is a Notification Point.
7.3.7  **Batching**

The aggregate and cement shall be proportioned by means of efficient weigh batching machines. The machine shall be carefully maintained and cleaned and they shall be provided with simple and convenient means of checking the weighing mechanism and they shall be checked when required by the Engineer.

Batch materials, shall be measured out within the following tolerances and shall be discharged into the mixer without loss.

- **Cement** - ± 2 percent of the mass of the cement in the batch.
- **Aggregate** - ± 2 percent of the mass of each aggregate in the batch.
- **Admixtures** - ± 5 percent of the amount to be added to the batch.

7.3.8  **Mixing Concrete by Machine**

The concrete is to be mixed in batches in machines which comply with the requirement of BS 1305. The machines are to ensure that all the concreting materials including the water are thoroughly mixed together between the time of their deposition in the mixer and before any portion of the mixture is discharged. The machines must be capable of discharging their content while running.

7.3.9  **Workability**

The Contractor shall carry out slump or other workability tests as required during concreting of the works in order to relate the degree of workability of the mix with the numerical value obtained during the trial mixes. Concrete slump requirement at the field for the Pile is 125mm-175mm and for the Pad & Pile cap is 30-75 mm respectively.

7.3.10  **Blinding Concrete**

Blinding concrete shall be provided under specified foundations to a minimum thickness of 75 mm.

7.3.11  **Formwork**

All formwork shall be accurately constructed to prevent loss of grout and to produce the correct foundation shape. Formwork shall be sufficiently strong to withstand the pressures arising from the concrete during placing and compaction and shall be capable of removal without undue disturbance to the concrete.

All form-work and moulds shall be of such tight construction that slurry cannot flow out at the joints during pouring and compaction. If required, joints shall be sealed with foam rubber strips.

Formwork shall be retained in position after concreting for a minimum period of 48 hours.
7.3.12 Placing and Compacting

Concrete shall normally be discharged from the delivery vehicle within two hours after the time of loading at the ready mix plant in accordance with the requirements of BS 8500 and BS EN 206. With the Engineer's approval these periods may be exceeded with the use of a suitable retarder and/or plasticizer, provided that there is no change in the quality of the concrete. Concrete must at all times have the desired workability and characteristics at the point of placing. Any concrete which no longer meets this requirement shall be removed from site.

Placing by pump, conveyor or pneumatic method shall be subject to approval by the Engineer. There shall not be any loss of quality in the concrete, nor harmful effects to the works by such methods. Concrete pumps shall be operated by mechanically applied pressure and shall produce a continuous stream of concrete without air pockets.

Where pumps are used the velocity of discharge shall be regulated, by suitable baffles or hoppers where necessary to prevent segregation or damage and distortion of the reinforcement, embedded items and formwork, caused by impact.

When pumps are used on large or complicated pours a standby pump shall be provided.

Precautions shall be taken to avoid depositing water or grout in the Works during starting up operations, or influshing, or clearing the pipeline. The pipeline shall pass its own length of concrete in not more than 20 minutes.

Chutes used to deliver concrete shall not be sloped so as to cause segregation of the mix.

Concrete shall be fully, compacted by vibration or other approved means and shall completely fill the shutter. Immersion vibrators shall be inserted in such a manner and at intervals as will ensure the satisfactory uniform compaction of the concrete. The vibrator shall penetrate the full depth of the layer and where the underlying layer of concrete has not initially set, they shall enter and re-vibrate the layer to ensure that succeeding layers are well bonded together. Withdrawal of vibrators shall be such as to prevent the formation of voids. Piles of concrete within the formwork shall not be moved by immersion of the vibrator, nor shall segregation be caused by over vibration. Undue laitance or leakage through the formwork shall be avoided. It shall be fully, worked around reinforcement and other embedded items which shall not be disturbed. The Contractor shall provide standby vibrators.

The Contractor shall maintain records of daily returns of the quantity, concrete mix and location within the Works of all concrete placed. These shall be forwarded to the Engineer when requested.

7.3.13 Joints

Construction joints shall be made across planes of minimum shear and away from planes of maximum bending moments. Vertical construction joints shall be made against properly constructed stop boards firmly fixed and holed where necessary to pass reinforcement. To ensure bond between old and new concrete at construction joints, surfaces of the cast (old) concrete shall be cleaned of all defective concrete, laitance, oil, grease, dirt, loose concrete, etc. and shall properly be roughened by chipping, hammering or other techniques to expose the aggregates and provide sufficient key for the two layers.
The pad and chimney (for pad and chimney type foundations) shall normally be cast in one operation without construction joints. Where the formation of a joint is unavoidable the surface against which the fresh concrete is to be placed shall be prepared in accordance with Clause 6.12 of BS 8110: Part 1. This is a Notification Point.

Construction joints in anchor or pile caps, monoblock and raft foundations shall be treated in similar manner to that described above. When the embedded reinforcement is insufficient to transmit the required design load, additional reinforcement in the form of 'starter' bars shall be provided. No construction joints are permitted in cast-in-situ concrete piles, drilled shaft or side bearing foundations.

7.3.14 Curing and Protection

Curing and protection shall start immediately after the compaction of the concrete and shall ensure adequate protection from:

(a) Premature drying out, particularly by solar radiation and wind;
(b) Leaching out by rain and flowing water;
(c) Rapid cooling during the first few days after placing;
(d) High internal thermal gradients;
(e) Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement or other embedded items.

Where curing compounds are used to protect exposed surfaces from solar radiation and improve moisture retention, they shall be subject to the approval of the Employer. This is a Hold Point.

The temperature of the fresh concrete at the time of delivery on site shall be in accordance with requirements of BS 8500 and BS EN 206.

7.3.15 Grouting of Anchor Tendons

The installation and subsequent grouting of anchor tendons shall be in accordance with the requirements of BS 8081 and BS EN 1537.

7.3.16 Drilled Shaft piled Foundations

Drilled shaft shall be installed and concreted strictly in accordance with the recommendations of BS 8004 Sub-clause 7.4.5 and as summarised below:

(a) To ensure drilled shafts remain uncontaminated with spoil, shafts shall be extended by 300 mm or a depth equivalent to the total pitch of the auger blades (excluding continuous flight augers) below the calculated depth of the auger;

(b) When shafts are installed using bentonite slurry techniques the stability of the sides of the shaft shall be maintained throughout the installation by an adequate head of bentonite slurry in conjunction with the temporary casing;
Reinforcing cages shall be provided with roller spacers of an approved type to ensure that the minimum specified concrete cover is achieved, especially as regards the cover at the bottom of the shaft;

The tremie pipe shall have a minimum diameter of 150 mm and shall be filled with an effective plug prior to charging with concrete;

Effective means shall be provided for raising or lowering the tremie quickly by towering the hopper from a crane. The hopper shall have a minimum capacity equivalent to that of the tremie;

The tremie shall always be kept full of concrete and shall adequately penetrate into the concrete to prevent accidental withdrawal if the pipe is surged to discharge the concrete.

Piled foundations shall be installed in accordance with the requirements of the IEC 'Specification for Piling'.

7.3.17 Stub Setting

Stubs shall be held firmly in position by a stub setting template or other device while the concrete is placed. This tower shall be maintained until backfilling of the foundation is complete, or for drilled shaft, anchor and pile caps, monoblocks, rafts etc until a minimum period of 48 hours has elapsed after concreting.

Concrete blocks may be used to tower the lower end of the stub, and they shall have similar strength and durability to the surrounding concrete.

Where holding bolt assemblies are used, setting templates shall be used and retained in position for a minimum of 48 hours.

Stub setting templates shall be used to maintain the position of steel grillage foundation during backfilling.

7.3.18 Backfilling of Foundations

Backfilling shall be compacted in 300 mm layers to achieve a bulk density of 1.6 t/m³, or the value assumed in the design analysis (if this is less than 1.6 t/m³).

Commencement of backfilling shall be a Notification Point.

During backfilling, the side sheeting to the excavation shall, where possible, be progressively withdrawn such that the toe of the sheeting is never more than 600 mm below the surface of the compacted material.

Extreme care shall be taken by the Contractor during compaction to ensure that the foundation is not damaged nor caused to move out of position. During the placing of backfill the hole shall be kept free from water. All temporary timbering and all decomposable material shall be removed from the excavations prior to backfilling.
Refilling around the pile head pits shall be carried out only after all works within the excavations have been inspected and approved by the Engineer.

The Contractor shall select the compaction plant most suitable for achieving the required bulk density. Acceptable methods of compaction shall include, but not be restricted to, the use of vibrating plate compactor or diesel hand operated vibrating Wacker plate. The actual method of compaction selected will depend on the type of material to be compacted and the difficulty in accessing areas within the excavation.

Backfilling of the directly embedded pole annulus shall be undertaken using crushed rock aggregate in accordance with BS EN 12620, with a nominal maximum size of 40 mm.

7.3.19 Site Clearance

As soon as possible at each tower site, backfilling should be completed, surplus soil removed and the site cleared at the Contractor's cost. Final site clearance normally carried out at the same time as fitting of anti-climbing guards and danger and notice plates, shall be undertaken without delay. The Contractor shall be responsible for compacting and re-levelling ground to the original surface level and gradient. Where agreed by the Engineer a percentage of the spoil may be disposed of by local spreading and the balance, if any shall be removed from site.

7.3.20 Reinstatement of Working Areas

Reinstatement of all working, access and storage areas shall be the responsibility of the Contractor.

A programme for reinstatement works shall be submitted to and approved by the Engineer prior to the issue of the taking over certificate.

Reinstatement where specified shall include all necessary topsoil preparation, hydro-seeding and the planting of shrubs and trees to a standard at least equal to the condition of the site prior to construction. The sequence of work shall be such as to ensure establishment of all species and the age and state of growth of plants shall be such as to ensure successful replanting at site.

All such work shall be completed to the satisfaction of the Engineer and the relevant regulatory authorities.

7.3.21 Site Stabilisation

Where foundations are installed on sloping or unstable ground the Contractor shall be responsible for ensuring the stability of the area and the safety of the public, all to the satisfaction of the Engineer and local regulatory authorities.

Stabilisation shall be achieved by approved methods such as retaining walls, buttresses, sprayed concrete, rock bolts, dowels or gabion baskets/mattresses.
Site assembly of gabion baskets and mattresses shall be carried out in accordance with the manufacturer's instructions. Gabions shall be placed in position prior to filling and secured to adjoining gabions with lacing wire. Filling material shall be between 100 and 150 mm; 90 percent of the fill to be retained on a 100 mm ring. The fill shall be tightly packed with no apparent voids, and shall be overfilled by 25-50 mm to allow for settlement. Lids shall be laced immediately after filling.

Where necessary to prevent erosion and as stipulated by the Engineer, or the appropriate authority, surface drainage channels shall be provided; surge chambers stopped ends and sublets shall be formed as required. Where surface vegetation has been removed from sloping ground such that erosion could occur, the area shall be reinstated by planting of grasses using hydro-seeding methods or band sprigging.

7.3.22 Site Protection

Where specified tower legs or foundations are in areas open to vehicle access, the Contractor shall install barriers of a type approved by the Engineer to prevent vehicle coming into contact with the tower or foundation.

7.3.23 Earthing

The maximum tower footing resistance with earthwires disconnected shall be 5 ohms. Earthing shall be provided with all diagonal legs of each tower as shown in enclosed drawing. If additional earthing is required, additional earthing conductor shall be attached to the tower at the earthing holes specified and shall be sufficiently buried to prevent accidental excavation. The amount of earthing conductor to be buried or earthing rods installed will be dependent upon achieving the required footing resistance.

The excavation for the earthing conductor shall be 400 mm wide and not less than 800 mm deep in cultivated land where required by the Employer. The earthing conductor shall be laid at a depth of approximately 700 mm, being placed centrally in the trench. The trench shall be backfilled with a suitable medium.

The connection between the additional earthing conductor and tower leg shall be by approved thermo-weld joints.

Where necessary in areas of high resistance 90 mm diameter holes shall be drilled along the tower diagonal, each having, an earthing rod surrounded by a Bentonite/ sodium carbonate mix. The depth of hole depending on the resistance of the soil. The earth rod shall comprise standard rods coupled together and connected back, to the tower leg.

For towers within 150 m of a substation and connected to the substation earthing system, no additional earthing, will normally be required.

7.3 PROTECTIVE TREATMENT

7.4.1 Galvanising
All stub steelwork, pole sections and holding down bolts shall be protected by hot-dipped galvanising to comply with the requirements of BS EN ISO 1461.

7.4.2 Epoxy Coal Tar Paint

All directly embedded pole sections, steel pile and caisson sections, guy anchor rods shall be protected by two coats of epoxy coal tar paint. For steel pile sections, this treatment shall only apply to the initial 50mm below final-round level.

7.4.3 Epoxy Coated Reinforcement

Coating, damaged during transit handling or fixing shall be repaired only with the approved repair compound supplied, to ensure compatibility with the Fusion Bonded Epoxy Coating. All repairs shall be carried out strictly in accordance with the manufacturer's instructions.

When the extent of the coating damage on any metre length of bar exceeds 1% of the surface area, the bar shall be rejected. This is a Notification Point.

7.4.4 Tower Steelwork and Stub-Concrete Interface

After curing has been completed all exposed concrete above ground level and 300 mm below ground level shall be coated with Coal Tar Epoxy coating applied by either conventional spraying or brushing to give a minimum dry film thickness of 300 μm. The surface of the concrete shall be allowed to cure for at least 28 days prior to surface preparation unless otherwise agreed with the Engineer. After adequate curing all surface laitance, dirt and other contaminants shall be removed. Prior to the application of the coating, cracks in the concrete greater than 2mm in width and surface irregularities, including blow holes, with a depth greater than 10mm, shall be filled with a proprietary fairing coat compatible with the coating system. The surface of the substrate shall be prepared in accordance with the coating manufacturers recommendations. Primers where necessary, shall be obtained from the same manufacturer as the top coat.

All tower steelwork below the maximum anticipated flood level shall be protected by Coal Tar Epoxy coatings. All steelwork to a minimum height of 3m above ground level shall be protected by factory application with the remainder applied on site, including the stub above concrete level.

For factory application the galvanised steel members should be blast cleaned to a minimum Sa2 standard BS 7079 using a fine grade mineral blasting medium. The coating shall be applied by either conventional spraying or brushing to give a minimum dry-film thickness of 300 μm. Prior to application, the Coatings Applicator shall submit procedures for coating, application and quality control measures for approval by the Engineer. This is a Hold Point.

The method of application of the coating system shall be in accordance with the approved procedures and manufacturer's instructions. The contractor shall ensure that the proposed coverage rates will enable the specified minimum dry film thickness of each coat to be
attained. Wet film thickness gauges shall be used to check the thickness of the applied coating.

Each application of the coating shall be generally free from surface defects, particularly cratering, pin-holing, ravelling, sagging, bittiness, dry spray and cissing. The finished system shall have a uniform appearance.

For site application the same procedure shall be adopted except that use of a 'etch primer' instead of blast cleaning on site will be permitted. The 'etch primer' must be obtained from the same supplier as the coating and applied strictly in accordance with the manufacturers instructions including the cleaning and decreasing of the tower steelwork on site.

7.4.5 Earthing Material

Steel earth rods shall be clad with 99.9 percent electrolytic pure copper molecularly bonded to the steel, with a minimum thickness of 0.35 mm. The earthing conductor at the ground interface and at the connection to the tower shall be protected against corrosion.

7.4.6 Protection of Buried Steelwork

Where it is necessary for tower steelwork to be buried, it shall be buried not more than 1.0 m and shall be protected by an approved medium e.g. mastic impregnated tape or bitumastic paint. Details of the proposed materials, application and Quality Control procedure shall be submitted to the Engineer. This is a Hold Point.

7.5 QUALITY CONTROL

7.5.1 General

Type, sample and routine tests shall be undertaken on all materials used in the construction of the foundations, and where appropriate on the complete foundations, or parts of the complete foundation in accordance with the requirements of this Specification.

7.5.2 Bentonite Slurries

Bentonite slurries used to tower the sides of the drilled shaft foundations shall be prepared and controlled in accordance with the recommendations of BS 8004 Clause 6.5.3.8 and as summarised below:

(a) Bentonite shall be supplied in accordance with the Oil Companies Materials Association Specification No. DFCP4;
(b) After mixing, with clean fresh water the fully hydrated bentonite slurry shall have a density of less than 1.10 g/ml, a viscosity as measured by the Marsh cone between 30s to 90s and a 10 minute gel strength in the range of 1.4 to 10 N/m²;
(c) Immediately prior to concreting, the density of the slurry at a level of 200 mm above the bottom of the shaft shall be less than 1.5 g/ml;
(d) The pH value of the slurry shall be maintained within the range of 9.5 to 12.

7.5.3 Reinforcement
All reinforcement shall be supplied from approved suppliers, complete with the appropriate test certificates in respect of the test requirements of BS 4449 or BS 4483 as appropriate. Copies of these certificates shall be made available to the Engineer upon request. Where test certificates are not available the Contractor shall arrange for the tests to be undertaken in accordance with the specified standards.

7.5.4 Inspection Prior to Concreting

The Contractor shall give the requisite period of notice to the Engineer of his intention to commence any concreting and shall submit at the same time a record of his inspection of completed preparatory works. This shall include all works related to the fixing of reinforcement. This is a Notification Point.

7.5.5 Trial Mixes

A trial mix will be approved when the requirements of BS 8500 and BS EN 206 are met. Copies of the trial mix test results shall be submitted to the Engineer.

7.5.6 Workability

The Contractor shall carry out slump or other workability tests as required during concreting of the works in order to relate the degree of workability of the mix with the numerical value obtained during the trial mix.

Slump tests shall be carried out in accordance with the procedure laid down in BS EN 12350-1. A slump test will be accepted as complying with the Specification when the results are within the following limits: ±25 mm.

7.5.6.1 Works Cubes

Compliance with the specified characteristic strength shall be based on tests made on cubes at 28 (twenty eight) days. Cubes shall be made, cured and tested in accordance with BS EN 12350-1. Samples of Concrete shall be taken at the point of discharge from the delivery point.

Unless otherwise directed by the Engineer, one set of cubes shall be prepared for each pile. For Pile caps, beams, Chimney, one set for every 6 Cu.m. or part thereof for each day of concreting shall be prepared. Each set consists of four cubes, one for 7 days testing and two for 28 day testing shall be taken.

Each set of cubes shall be accompanied by a certificate noting the details required by BS EN 12350-1.
Cubes shall be tested in accordance with BS EN 12350-1 to determine the density and characteristic strength as follows:

(a) One cube shall be tested at seven days to provide an early indication as to whether the twenty eight day strength is likely to be achieved;
(b) Two cubes shall be tested at twenty eight days, the average strength shall be deemed the test results;
(c) One cube shall be held in reserve for further testing, if required.

The test report shall provide information in accordance with BS EN 12350-1.

Concrete shall be assumed to have achieved its characteristic strength when, at twenty eight days, the conditions specified in BS 8500 and BS EN 206 are met.

Copies of the test reports shall be made available to the Engineer on a regular basis. This is a Notification Point.

The Employer will consider whether the concrete in the Works represented by cubes falling below the limits laid down can be accepted, and he may order that any or all of the following, actions shall be taken:

i) Penetration resistance or surface hardness tests;
ii) The drilling of test cylinders in the concrete and testing the samples to destruction by compression;
iii) The cutting out and replacement of such volumes at their discretion which they consider to be defective;

7.5.7 Setting Out Tolerance

Towers shall be centre-pegged with a displacement along the line of the route not greater than 50mm relative to the profile, and to a displacement in transverse alignment not greater than 50 mm relative to a theoretical line adjoining the adjacent angle pegs.

7.5.8 Foundation Setting Tolerances

The maximum permitted stub tolerances measured at the top of the stubs shall be as detailed in Table 7.1 and are to apply immediately prior to erecting the tower. Should these tolerances not be achieved the Contractor shall submit details of his proposed remedial measures to the Engineer for approval. This is a Hold Point.

Records of the foundation setting out measurements shall be made available to the Employer.

Table 7.1 - Foundation Setting Tolerances
### Principal Dimension | Tolerance
--- | ---
Nominal face dimension | 10 mm or ± 0.1% of face dimension (whichever is greater)
Nominal diagonal dimension | ±15 mm or ± 0.1% of diagonal dimension (whichever is greater)
Rake of stub from required face or hip slope | 1:100
Stub level | 10 mm or 0.05% of diagonal four stubs of a foundation
(a) Maximum difference in level between all dimension (whichever is greater) | ±6mm
(b) Maximum difference between the mean levels of pairs of diagonally opposite stubs | 1° about longitudinal axis

### 7.5.9 Backfilling

Testing of the backfill to ensure that the design value of soil bulk density is achieved may be undertaken using an approved penetrometer. Results of the tests shall be made available on request to the Engineer. However, the Engineer reserves the right to request the Contractor to undertake in-situ density tests in accordance with BS 1377 Part 9 as necessary.

Where imported backfill is required the following details shall be supplied to the Engineer:

(a) the type of fill
(b) evidence that when compacted a bulk density consistent with the value assumed in the design can be achieved.

### 7.5.10 Foundation Tests - General

When requested by the Engineer full scale foundations tests both design and routine/proof shall be undertaken on all types of foundations.

Tests shall unless specified otherwise be undertaken in accordance with IEC 61773.

When design tests are required, the sites selected shall be representative of the geo-technical conditions throughout the length of the transmission line, in which the Contractor proposes to install that type of foundation.

The Contractor shall submit to the Engineer the following information:
(a) Details of the test sites, including all geotechnical parameters;
(b) Details of the proposed test equipment, test layout, measuring equipment, test procedure and the test program. This is a **Hold Point**.
(c) On completion of the design tests the requisite number of test reports shall be submitted to the Engineer.

The ultimate resistance of the foundation shall unless otherwise specified be determined from the lesser of:

i) the resistance equivalent to a temporary displacement of 25 mm or,
ii) the resistance equivalent to a permanent displacement of 10 mm.

Reports on pile testing shall be submitted to the Engineer and shall contain, among others, the following information:

(a) Layout of test equipment and description
(b) Pile identification, diameter and length
(c) Sketch of soil conditions and ground water location
(d) Complete records of level, load cell and dial gauge readings against date and time throughout the test in a tabulation
(e) Graphs of load and settlement/heave versus time
(f) Graphs of settlement/heave versus load
(g) Remarks concerning any unusual occurrences during the loading of the pile.
(h) Test reports on integrity testing of piles shall include clear sample diagrams of acceptable signals for comparison purpose, as well as sample graphs indicating defects or doubts on the integrity of the pile.

The Engineer will decide on completion of tests and evaluations whether the test piles shall be left in place or shall be extracted. No extra payment will be made for the extraction of test piles.

**7.5.11 Concrete Pad & Chimney Foundation - Tests**

Unless otherwise specified only design uplift tests on pad and chimney foundations shall be undertaken.

The Contractor shall give the Engineer the requisite period of notice prior to undertaking the tests. This is a **Hold Point**.

**7.5.12 Piled Foundation - Tests**

Unless specified to the contrary, design uplift and compression tests on piled foundations (service piles selected by Employer) shall be undertaken. The Contractor shall give the Engineer testing procedure for approval and the requisite period of notice prior to undertaking the tests. This is a **Hold Point**.

The tested pile shall be deemed to comply with its specified ultimate load when, after the load is held for at least 30 minutes, the following criteria are satisfied:
i) The displacement at the head of the pile is less than 25 mm or
ii) The movement of the head of the pile shall be slowing down and less than 0.25 run/hour
iii) The displacement at the head of the pile after all load is removed (after 10 minutes) is less than 10 mm.

7.5.13 Integrity Testing

Integrity tests shall be performed on drilled shaft concrete piled foundations selected by Employer for checking the uniformity, continuity and length of such piles using the acoustic pulse echo method shall be undertaken by a specialist subcontractor appointed by the Contractor. Details of practical experience of the subcontractor along with details of the test equipment, procedure of testing, presentation of test data/results shall be submitted to the Engineer before the implementation of actual field work. The integrity test shall be done at least one pile of each leg. The actual method of performing the tests and the interpreting the results shall be subject to the Engineer's approval. This is a **Hold Point**.

The Contractor shall give the Engineer the requisite period of notice prior to undertaking the tests. This is a **Notification Point**.

The results of the integrity testing shall be made available to the Engineer upon request.

7.5.14 Earthing Resistance Test

Earth electrical resistance tests shall be undertaken at each tower prior to the erection of the earthwire. The Contractor shall give the Engineer the requisite period of notice prior to undertaking the tests. This is a **Notification Point**.

On sites subject to seasonal variations in the rainfall, or the level of the water table and sites requiring special earthing arrangements additional earth resistance tests shall be carried out at intervals to establish the affects on the resistance of such seasonal variations.

The method of measurement and equipment to be used shall be subject to the approval of the Engineer. This is a **Hold Point**.

The results of the earth resistance tests both initial and final i.e. after additional earthing has been installed shall be forwarded to the Engineer.

7.5.15 Protective Coatings

Where protective coatings are applied to buried tower steelwork or to exposed concrete surfaces, appropriate routine tests to demonstrate the quality of application shall be undertaken.

The Contractor shall submit to the Engineer his routine test proposals.

This is a **Hold Point**.

The Contractor shall give the Engineer the requisite period of notice prior to undertaking the tests. **This is a Notification Point.** The results of the tests shall be made available to
the Engineer upon request.
APPENDIX 7.A1

FOUNDATION TYPES & USES

<table>
<thead>
<tr>
<th>Soil Category</th>
<th>Allowable Foundation Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concrete Pad &amp; Chimney/Drilled Shaft Piled*/Rigid Frame Foundation**</td>
</tr>
<tr>
<td>2</td>
<td>Concrete Pad &amp; Chimney/Drilled Shaft Piled*/Rigid Frame Foundation**</td>
</tr>
<tr>
<td>3</td>
<td>Raft/ Drilled Shaft Piled*/Rigid Frame Foundation**</td>
</tr>
<tr>
<td>4</td>
<td>Drilled Shaft Piled*/Rigid Frame Foundation**</td>
</tr>
</tbody>
</table>

Note: Seismic zone coefficient, G=0.1 shall be considered.

* The bidder may propose any other proven type of piled foundation instead of Drilled Shaft Piled foundation except wooden pile. The bidder shall submit the design of the proposed type of piled foundation along with detailed design calculation, installation procedure with drawings, Quality Control procedure, Standards and Codes of Practices to be followed, advantages of selecting such type of piles, etc. with the bid. Reinforced concrete pile caps shall be used for all types of piles. Payments of all types of foundations shall be on lump-sum basis per tower as per prices quoted in the Price Schedule.

** Foundations at high flood level area shall be rigid frame with multiple drilled or mechanically excavated cast-in-situ piled. The Contractor shall submit his proposed method of installation and Quality Control procedures to the Engineer prior to commencing his design. This is a Hold Point.

Due cognizance shall be taken of the setting level of the base of the tower relative to ground level, the maximum depth of flood water. Individual footings shall be interconnected by tie beams, which shall be adequate to resist lateral forces and hydrostatic pressure exerted by the flood water. A Cyclonic surge of 6m shall be considered for detailed design of tower and foundation for river crossing in the estuary.

As the location of river crossing towers are supposed to be submerged during most of the year, temporary islands will be required to be built by the Contractor for foundation works of river crossing towers.
### APPENDIX 7.A2/1

**FOUNDATION STRENGTH FACTOR**

Please refer to Appendices of Section 8

### APPENDIX 7.A4

**GEOTECHNICAL PARAMETERS**

(Tender Purposes only)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Soil Category</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Soil Classification</td>
<td>Dense Sand Or Very Stiff to Hard Clay</td>
</tr>
<tr>
<td>SPT ‘N’ blows</td>
<td>&gt;20</td>
</tr>
<tr>
<td>1. Average SPT of top 75% of length in case of pile foundation.</td>
<td></td>
</tr>
<tr>
<td>2. Average SPT of top 5 meter soil from existing ground level.</td>
<td></td>
</tr>
<tr>
<td>Water level</td>
<td>At depth of foundation level plus width of foundation from EGL.</td>
</tr>
<tr>
<td>Soil Density</td>
<td>kN/m³</td>
</tr>
<tr>
<td>Backfill Density</td>
<td>kN/m³</td>
</tr>
<tr>
<td>Concrete Density</td>
<td>kN/m³</td>
</tr>
<tr>
<td>Allowable Bearing Pressure under Ultimate Applied Loading</td>
<td>kN/m²</td>
</tr>
<tr>
<td></td>
<td>SAND: 350</td>
</tr>
<tr>
<td>Lateral Earth Pressure (For Shallow Foundation)</td>
<td>kN/m²</td>
</tr>
<tr>
<td>Frustum angle</td>
<td>(degrees to vertical)</td>
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</table>

Water level at ground level.
Shear characteristics based on direct shear test.
APPENDIX 7.A4 (Continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Soil Category 2,3 &amp; 4</th>
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</thead>
<tbody>
<tr>
<td>For sandy soil</td>
<td></td>
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<tr>
<td>Ultimate skin friction = ( \frac{1}{2} K_s \rho_d \tan \delta A_s )</td>
<td></td>
</tr>
<tr>
<td>Bored piles</td>
<td>( K_s ) 0.7</td>
</tr>
<tr>
<td>( \delta )</td>
<td>( \Phi )</td>
</tr>
<tr>
<td>Driven piles: Steel</td>
<td>( K_s ) 0.5</td>
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<tr>
<td>( \delta )</td>
<td>20°</td>
</tr>
<tr>
<td>Concrete</td>
<td>( K_s ) 1.0</td>
</tr>
<tr>
<td>( \delta )</td>
<td>( \frac{3}{4} \Phi )</td>
</tr>
</tbody>
</table>

For clay soil

Ultimate skin friction = \( \alpha C_U A_s \)

\( \alpha = 0.7 \sim 0.3 \)

where

\( \rho_d = \) effective overburden pressure;

\( \phi = \) angle of shearing resistance

\( A_s = \) surface area of pile shaft (m²)

Minimum Requirement for Piled Foundations:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum factor of safety for piles or drilled shafts i.e.</td>
<td>1.5</td>
</tr>
<tr>
<td>Ultimate resistance to allowable load (For all types of soil categories)</td>
<td></td>
</tr>
<tr>
<td>Minimum percentage of ultimate uplift load (without foundation strength factor) to be resisted by dead weight of piles &amp; pile cap (For soil category 4 only)</td>
<td>28%</td>
</tr>
</tbody>
</table>
APPENDIX 7.A5

PARTIAL MATERIAL FACTORS

NOT USED
## APPENDIX 7.A6

### CONCRETE MIX PARAMETERS

<table>
<thead>
<tr>
<th>Grade of Concrete</th>
<th>Cement Type</th>
<th>Minimum Cement Content kg/m³</th>
<th>Maximum Freewater/cement ratio</th>
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<tbody>
<tr>
<td>C30</td>
<td>Ordinary Portland Cement (OPC)</td>
<td>370</td>
<td>0.5</td>
</tr>
<tr>
<td>C30</td>
<td>Portland Composite Cement (PCC)</td>
<td>370</td>
<td>0.5</td>
</tr>
<tr>
<td>C30</td>
<td>Sulphate Resisting Portland Cement (SRC)</td>
<td>As per BSEN 197-1 CEMII/B-V</td>
<td></td>
</tr>
</tbody>
</table>

**Notes**

1. Maximum nominal aggregate size 20 mm.
2. For installation of drilled shaft piled foundations using bentonite slurries minimum cement content shall be increased to 400 kg/m³.
3. Slump range for cap and chimney is 50 mm to 100 mm and for pile 150 mm to 200 mm.

* If required as per soil and ground water test report.
## APPENDIX 7.A7

### CONCRETE COVER

<table>
<thead>
<tr>
<th>Reinforcement (mm)</th>
<th>Stub Steelwork or Reinforcing Designed as ‘Stub’ Steelwork (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>150</td>
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</tbody>
</table>
## APPENDIX 7.B1

### ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

<p>| Clause Reference | Documents Description                                           | Comment                        |
|------------------|----------------------------------------------------------------|.ucp; |
| 7.1.2            | Installation Method Statement                                   |                               |
| 7.2.1            | Contractor's proposed c.o.v.                                   |                               |
| 7.2.7.2          | Drilled Shaft foundation Method Statement                      |                               |
| 7.2.7.2          | River Crossing Tower Foundations Method Statement               |                               |
| 7.2.13           | Concrete Specification                                         |                               |
| 7.2.11           | Installation Criteria                                          |                               |
| 7.2.12           | Design Submissions                                             |                               |
| 7.2.14           | Potential Alkali Reactivity-Test Results                       |                               |
| 7.2.16           | Reinforcing Bar Couplers                                       |                               |
| 7.2.17           | Spacers                                                       | Details of system              |
| 7.1.1            | Temporary Tower Details                                        | If requested                   |
| 7.3.12           | Concrete daily returns                                         | If requested                   |
| 7.3.20           | Working area reinstatement                                     | Programme of work              |
| 7.4.6            | Protection of Buried steelwork                                 | Quality Control proposals      |
| 7.5.3            | Reinforcement - test certificates                              | If requested                   |
| 7.5.4            | Inspection prior to concreting                                 | Inspection record              |
| 7.5.5            | Trial mixes – Test results                                     |                               |
| 7.5.6.1          | Works cubes – Test results                                     |                               |
| 7.5.8            | Foundation Incorrect setting,                                  | Remedial Measure               |
| 7.5.8            | Foundation Setting out-records                                 |                               |
| 7.5.9            | Imported backfill – detail                                     |                               |
| 7.5.10           | Foundation Tests – test proposal                               |                               |
| 7.5.10           | Foundation Tests – test results                                |                               |
| 7.5.10           | Anchor foundation – Routine test records                       | If requested                   |
| 7.5.10           | Integrity Testing – test records                               | If requested                   |
| 7.5.15           | Earth Resistance Tests – test records                          |                               |
| 7.5.16           | Protective coating – Routine tests                             |                               |
| 7.5.16           | Protection coatings – test records                             | If requested                   |</p>
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<tr>
<th>Clause Reference</th>
<th>Notification Points</th>
<th>Hold Points</th>
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<tr>
<td>7.1.1</td>
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<td>Foundation Design</td>
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<td>7.1.2</td>
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<td>7.2.7.2</td>
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<td>Drilled Shaft - Method statement</td>
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<td>7.2.8</td>
<td></td>
<td>Concrete Mix Design -Specification</td>
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<td>Potential Alkali Reactivity</td>
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<td>Reinforcing Bar Couplers</td>
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<td>7.3.4</td>
<td>Use of Explosives</td>
<td>Epoxy bars site cutting</td>
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<td>Straightening of bars</td>
<td>Curing compounds</td>
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<td>7.3.6</td>
<td>Concrete Trial mixes</td>
<td>Steelwork and stub-concrete Interface</td>
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<td>7.3.13</td>
<td>Joints</td>
<td>Protection of buried steel work</td>
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<td>7.3.14</td>
<td>Backfilling</td>
<td>Foundation Setting remedial measure</td>
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<td>Epoxy Coating repair</td>
<td>Foundation test program</td>
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<td>Anchor Foundation – Suitability test</td>
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<td>Anchor Foundation – Design test</td>
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<td>Anchor Foundation – Routine Tests</td>
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<td>Protective coating tests</td>
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</tbody>
</table>
APPENDIX 7.D1

REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of the Specification are listed below:

BS EN 197-1: Specification for Portland cement
BS 183: Specification for general purpose galvanised steel wire strand
BS EN 10244-2: Specification for testing zinc coating on steel wire & for quality requirements
BS EN ISO 1461: Specification for hot dip galvanised coatings on iron & steel articles
BS EN 12620: Specification for aggregates from natural sources of concrete
BS EN 10083,4,5: Specification for wrought steel for mechanical and allied engineering purposes
BS EN 10088
BS EN 10089
BS 1305: Specification for batch type concrete mixers
BS 1377: Method of tests for soils for civil engineering purposes
Part 9: In-situ tests
BS EN 12350-1: Testing concrete
Method of sampling fresh concrete on site
BS EN 12390-3: Method of determining compressive strength of concrete
BS EN 13600: Specification for high conductivity copper tubes for electrical purposes
BS EN 1652, 3, 4: Specification for rolled copper and copper alloys, sheet, strip and foil
BS EN 1057: Specification for copper and copper alloys. Tubes
BS EN 12449
BS EN 12163, 4, 7: Specification for wrought steel for mechanical and applied engineering purposes.
BS 3643: ISO Metric screw threads
BS 3892: Pulverised - fuel ash
Part 1: Specification for pulverised - fuel ash for use Alith Portland cement
BS 4027: Specification for sulphate - resisting Portland cement
BS 4190: Specification for ISO metric black hexagon bolts, screws and nuts
BS 4449: Specification for carbon steel bars for the reinforcement of concrete
BS 8666: Specification for scheduling, dimensioning, bending & cutting of steel reinforcement for concrete
BS EN ISO 4066
BS 4483: Specification for steel fabric for the reinforcement of concrete
BS 8500-1, 2: Concrete
BS EN 206-1 Guide to specifying, concrete
Methods for specifying concrete mixes
Specification for the procedure to be used in producing, and transporting concrete
Specification for the procedure to be used in sampling, testing and assessing compliance of concrete
BS 7079 Visual Assessment of surface cleanliness
BS ISO 14654: Fusion bonded epoxy coated carbon steel bars for the reinforcement of concrete
<table>
<thead>
<tr>
<th>Specification for coated bars</th>
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<tbody>
<tr>
<td>BS ISO 14656:</td>
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<td>BS 8081:</td>
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PILE DATA SHEET

1. Reference No. Location (Co-ordinates)______ area.
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
      liquid limit
      sand content
      density
      marsh viscosity
      Swelling index
      pH value
   ii) Contaminated mud
       density
       sand content
14. 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. Date and time of start and completion of concreting
17. Method of placing concrete
18. Concrete quantity:

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19. Ref. Number of test cubes
20. Grade and slump of concrete
21. Results of test cubes
22. Reinforcement details:

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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.
# SECTION 8

## TOWERS

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APPENDIX
SECTION 8
TOWERS

8.1 SCOPE
The scope includes design, testing, fabrication, supply and erection of towers on the basis of tender specification.

It may be mentioned here that the 132kV & 230kV towers are not to be designed by the Contractor. The available drawings of 132kV & 230kV towers shall be provided by the Employer. The Contractor has to prepare the shop drawings from above available tower drawings. In case, any information missing in the above available tower drawings, the Contractor has to assume the same as per relevant International Standard which will be finalized after discussion with Employer.

8.1.1 Classes of Towers
Reference shall be made to Appendix 8.A1 for the classes of tower required.

8.1.2 Designation of Tower Types
Reference shall be made to Appendix 8.A2 for the designation and use of the different tower types.

8.1.3 Standard Height Towers
All standard height towers are those designed to support the conductors at the defined clearance above designated ground under the specified ultimate limit state system loading assuming such towers are at the same level on level ground and at the standard span apart.

Unless specified to the contrary, after taking account of the length of the insulator set all standard height towers shall be arranged so that the point of attachment or suspension of the phase conductors above the ground shall be the same for all tower types.

8.1.4 Extensions
Where specified each type of tower shall be designed to allow for variations in height. Towers with any specified combination of extensions to the standard height tower, shall be capable of carrying all required phase conductors, earthwires, insulator sets and fittings under the specified system loading.

Reference shall be made to the Appendix 8.A3 for the range and type of extensions required. Tower with different leg extensions shall be used as per requirement of the route.

Where individual leg extensions are specified for lattice steel towers they shall be directly inter-connectable and fully compatible with the basic tower body and all specified body extensions.
8.1.5 Span Criteria

The span lengths specified in Appendix 8.A4 shall be deemed to be the horizontal distance between centre lines of adjacent support. When a span in excess of the specified maximum span is unavoidable, advice on the application should be obtained from the Engineer.

All angle towers when used with the corresponding maximum angles of deviation and all intermediate type towers shall be used so that the sum of the two adjacent spans stated in Appendix 8.A4 is not exceeded, provided that no single span length exceeds the specified maximum. Designs shall allow for the adjacent spans of the maximum specified length with one of the spans at the maximum allowed for a single span.

Section type tower may be used at straight line positions where necessary for uplift conditions or for sectioning and tensioning of the phase conductors and earthwires in a straight run of transmission line route.

Angle towers shall be suitable for minimum weight spans combined with maximum wind span through the full angular range of line deviations for which the angle towers are designed.

8.1.6 Minimum Conductor Weight at Intermediate Tower

The total weight supported by any intermediate tower suspension insulator set shall not be less than the specified percentage (see Appendix 8.A4) of the total weight of the corresponding phase conductors in the two adjacent spans. This condition shall apply under the specified loading conditions.

8.1.7 Angle Towers

For angle Towers at the mean angle of deviation, the mean horizontal separation between circuits shall not be less than that of an intermediate type support.

For bundled phase conductors the phase conductor attachment points on each crossarm/gantry shall be arranged to ensure that the nominal horizontal separation between sub-conductors at the tension joint (dead end), is not reduced by more than 25 mm.

8.1.8 Terminal Towers

Terminal Towers shall provide the corresponding separation at the specified line entry. Additional phase conductor attachment points shall be provided at the specified angles of entry. Additional crossarms for down-leads or for use in junction arrangements with full phase tension shall be provided when specified.

8.2 DESIGN

8.2.1 General

Towers shall have the general arrangements and configurations shown in the drawings included with the Specification. They shall be designed to resist the
specified system loading taking into consideration the required strength co-
ordination factors. Clearances between live parts and supporting steelwork and
between the phase conductors and ground or other obstacles shall be as specified.

All tower designs shall be such as to facilitate inspection, painting, maintenance,
repairs and operation with the continuity of supply being the prime consideration.

The design shall be such that the number of different parts shall be as few as
possible to facilitate transport, erection and inspection. The maximum weight of
the heaviest single member should be limited to that within the normal lifting
capability of the proposed erection equipment.

Main leg members of lattice steel towers shall be formed of the maximum single
lengths appropriate to the body or leg extensions, and shall not without the
Engineer's approval, incorporate additional spliced sections.

For lattice steel towers a fully triangulated system of bracings shall preferably be
adopted. If full triangulation is not adopted, the overall stability and secondary
bending, stresses must be considered in the design.

Where fabrication processes employed adversely affect the material properties, or
introduce zones of high stress concentration the overall design of the structures
shall take such factors into account.

Crossarms shall be so arranged that they can be disconnected in the plane of the
longitudinal face of the tower without disturbing any members forming part of the
tower body.

All panels below the prototype test tower height must be of K-braced.

8.2.2 Attachments to Towers

The attachment of phase conductors, earthwires and erection/maintenance brackets
shall be undertaken as follows;

(a) Intermediate Lattice Steel Towers

   i) Suspension insulator set and earthwire attachments shall be of an
      approved swivel or shackle arrangement;

   ii) Adjacent to and either side of all suspension insulators set attachment
       points, additional maintenance points shall be provided, capable of
       resisting the specified construction and maintenance (C&M) load;

   iii) Adjacent to the earthwire suspension set attachment point, an additional
       maintenance point shall be provided, capable of resisting the specified
       C&M load;

   iv) At each tower body crossarm connection point (bottom chord level)
       maintenance plates/brackets shall be provided for the attachment of
       rigging blocks, capable of resisting the specified C&M load;
v) Where it is proposed to erect complete sections of the tower by crane or helicopter then permanent lifting points shall be provided.

(b) **Angle/Tension Lattice Steel Tower**

i) Tension insulator set attachments shall be of an approved swivel or shackle arrangement;

ii) Adjacent to and either side of all tension insulator set attachment points, additional maintenance points shall be provided, capable of resisting the specified C&M loading. The additional maintenance points shall provide the necessary mountings for stringing and maintenance equipment;

iii) Adjacent to all tension insulator set attachment points, a vertical maintenance attachment point shall be provided, capable of resisting either the specified C&M loads or that imposed by the use of a conductor stringing platform;

iv) Adjacent to the earthwire tension set attachment point, an additional maintenance point shall be provided, capable of resisting the specified C&M loads;

v) At each tower body crossarm connection point (bottom chord level) maintenance plates/brackets shall be provided for the attachment of rigging, blocks, capable of resisting the specified C&M loads.

All tower general arrangement drawings and/or erection diagrams shall clearly indicate the safe working, load capacities of all maintenance points.

### 8.2.3 Stubs

Stubs for the standard height tower, tower body and leg extensions shall be of the same design. Unless specified to the contrary only one design of stub shall be permitted for each type of tower and the stubs shall be identical for all four legs. Two different type of stub design may require for rigid frame foundation and pile foundation. No extra payments shall be made for such two type of stub. For details of the cleat design, reference shall be made to Clause 7.2.4.

The thickness of the stub leg members shall not be less than the corresponding tower leg members.

### 8.2.4 Loading Criteria

132Kv & 230 kV towers shall be designed in accordance with the provisions of Clause 8.2.4 to 8.2.26 and relevant Appendices at end of this Section.

The towers shall be designed and dimensioned for maximum simultaneous load. The design load shall be calculated as per standard codes of practice taking into following load assumptions:
i. Maximum working tension (MWT) for conductor and earthwire (OPGW) shall be applied 50% of ultimate tensile strength (UTS).

ii. Maximum operating temperature shall be of 80°C and minimum temperature shall be of 5°C.

iii. Maximum wind on conductor and earthwire shall be of **46.45 m/sec** (10 minute mean wind speed at 10m elevation). Effect of height on wind speed shall be considered as per criteria given in Climatic loading.

The effect of oblique wind 30° & 45° shall be considered in addition to 0° in normal condition. All tower load cases shall be considered in minimum and maximum angles.

### 8.2.5a Climatic Loading

The climatic loadings on the conductors and insulators have been calculated using the following expressions:

The Contractor shall apply the reliability factor such as $K_1 = 1$ to calculate for climatic loadings.

(a) **Conductors**

\[ F_c = q_{des} \cdot C_f \cdot A \cdot \cos^2 \phi \]

where:

- $q_{des}$ = design wind pressure including height and spatial effects (kg/m$^2$)
  - $q_0 \alpha K_1$
  - $q_0 = 1/2 \rho V^2$
  - $\rho = 0.12$

Conductor: $V$ (Average wind) = wind speed at 10m height, corresponding to an averaging period of 10min. having a return period of 50years = **46.45 m/sec**

Earthwire: $V$ (Average wind) x 1.1

\[ \alpha = (H/10)^{1/n} \rightarrow (n=5) \]

$H$ = Conductor average height and earthwire height

$C_f$ = Force coefficient

= 1.00 Conductors & Earthwire

$A$ = full projected area perpendicular to the wind (m$^2$)

$\phi$ = angle of incidence of the wind to the conductors.

Note: The effective force is perpendicular to the conductor.
The total effect of the wind upon bundle conductors will be equal to the sum of the actions on the individual sub conductor.

(b) **Insulators**

\[ F_1 = q_{des} C_f A \]

where:

- \( q_{des} \) = design wind pressure including height and spatial effects (kg/m\(^2\))
- \( q_0 \alpha K_1 \)
- \( q_0 = 1/2 \rho V^2 \)
- \( \rho = 0.12 \)
- \( V \) (Average wind) = wind speed at 10m height, corresponding to an averaging period of 10min. having a return period of 50years = **46.45 m/s**
- \( \alpha = (H/10)^{1/n} \rightarrow (n=5) \)
- \( H \) = Insulator average height
- \( C_f = \) Force coefficient (1.4)
- \( A = \) area of insulator perpendicular to the wind (m\(^2\))

(c) **Lattice Towers**

For lattice towers the following formulae shall be used to calculate the wind loading on the tower.

\[ F_t = q_0 K_1 \{H/10\}^\alpha (1+0.2\text{Sin}^22\phi) (A_1 C_{f1} \text{Cos}^2\phi + A_2 C_{f2} \text{Sin}^2\phi) \]

where:

- \( q_0 = 1/2 \rho V^2 \)
- \( \rho = 0.12 \)
- \( V \) (Average wind) = wind speed at 10m height, corresponding to an averaging period of 10min. having a return period of 50years = **46.45 m/s**
- \( H = \) height to the centre of pressure of the panel (m) under consideration, except High Intensity Local Wind load case
- \( \alpha = 0.2 \) for all load cases except High Intensity Local Wind load case
- =0.2 for High Intensity Local Wind load case where H=h, h=total height of the tower
- \( \phi = \) angle of incidence of the wind to face 1
- \( A_1, A_2 = \) area of members in face 1 and 2
\[ C_{f1}, C_{f2} = \text{Force coefficient for faces 1 and 2} \]

For flat sided members \( C_{ff} = 3.96 \left( 1 - 1.5\Omega + \Omega^2 \right) \)
\[ \Omega = \text{solidity ratio} \]

For circular section members \( C_{fc} = 2.25 \left( 1 - 1.5\Omega + 3.125\Omega^2 \right) \)

For mixed construction \[ C_f = C_{ff} \frac{A_f}{A} + C_{fc} \frac{A_c}{A} \]

where: \( A = \text{total area of members}, A_f = \text{area of flat sided members} \) and \( A_c = \text{area of circular members} \).

Note: 1) Where access ladders are fitted, they should be included in the respective face area;
2) For horizontal formation towers between the gantry and the waist, for any wind direction apart from 'longitudinal' both inner and outer transverse faces should be considered;

For non symmetrical towers, the formulae given in (c) shall not be used, but either single or multi-frames shall be considered.

(d) **Single frames**

\[ F_f = q_0 K_1 \{H/10\}^\alpha C_f A \cos^2 \varphi \]

where \[ q_0 = \frac{1}{2} \rho V^2 \]
\[ \rho = 0.12 \]
\[ V \text{ (Average wind) as per IEC 60826 = wind speed at 10m height, corresponding to an averaging period of 10min. having a return period of 50years} \]
\[ \{H/10\}^\alpha = \text{as defined in (c)} \]
\[ A = \text{area of the members in the frame} \]
\[ C_f = \text{force coefficient factor defined below:} \]

\[ [1.58 + 1.05(0.6 - \Omega)^{1.8}] \times \frac{[A_f + (0.6 + 0.4 \Omega^2) A_c]}{A} \text{ for } \Omega \leq 0.6 \]

where \[ A_f = \text{area of flat sided members (m}^2) \]
\[ A_c = \text{area of circular members (m}^2) \]
\[ \Omega = \text{solidity ratio} \]

For multi-frames the shielding of the 2nd frame should be considered, utilizing the
expression:

\[ A = (A_1 + \eta A_2) \]

where

\[ A_1 = \text{area of frame 1 determined above} \]
\[ A_2 = \text{area of frame 2 determined in accordance with the above} \]
\[ \eta = \text{shielding factor} \]
\[ \eta = \eta^1 + 0.15 (\omega - 1) (\bar{\omega} - 0.1) \text{ but } \leq 1.0 \]
\[ \eta^1 = (1 - \bar{\omega}) 1.89 \left( \frac{A_f + 0.83A_c}{A} \right) \text{ but } \leq 1.0 \]
\[ \omega = \text{spacing ratio} \]

8.2.5b Normal Load Condition

The towers shall be designed for the following loads considered to be applicable simultaneously.

(a) Vertical Loads

Dead weight of tower, weight of insulators and all other fittings, actual dead weight of conductor, earthwire and OPGW of specified weight span lengths, and a load of 200kg regarding the weight of a lineman with tools.

(b) Transverse Loads

Wind pressure at right angle to the line on the whole projected area of conductors and earthwires of the specified lengths (wind spans), tower members, insulators and all other fittings and the transverse components of the maximum working tensions of conductor & earthwire due to maximum horizontal deviation angle of the line.

(c) Longitudinal Loads

Please refer to the Appendix.

(d) Eccentric Loads

Towers shall be checked for eccentric loading caused by the conductors and earthwire strung on one side of the tower. In checking the tower for this kind of loading the loads mentioned above for vertical, transverse and longitudinal loads shall be considered for three phase conductors and earthwire on one side of the tower in addition to wind on tower and weight of tower.

For terminal towers, torsion loads caused by the unbalanced longitudinal working tension due to one circuit conductors and earthwire strung shall be considered.

8.2.6 High Intensity Local Wind Loadings
High intensity local wind is required to be considered by applying wind pressure on tower body at directions shown in the sketch of Appendix 8.A5. The wind pressure shall be calculated as per criteria given in Climatic Loading.

8.2.7 Security Loading

Two conditions of security loadings have been considered in the design of the towers:

(a) Broken Wire

The maximum working tension of conductor and earthwire for unbalanced longitudinal loads due to breakage of phase conductors and earthwire shall be considered under broken wire condition.

Towers shall be designed to keep safely the tensional loads generated by breakage of conductor and earthwire as specified in Appendix.

All attachment points with no broken wire load shall have the vertical, transverse and longitudinal loads as specified under normal loading condition. The points with broken wire longitudinal loads shall have the vertical and transverse loads due to the broken wire weight and wind spans together with the transverse component of the phase or ground wire from the unbroken span. Wind speed specified in clause 8.2.4 is required to be considered.

Each tower shall be designed so that no failure or permanent distortion occurs when tested with applied forces considering the safety factors as mentioned in Clause hereunder.

The specified broken wire loading (residual static loads) shall be applied to the defined phase conductor and earthwire attachment points; whilst the intact security loading shall be applied to the remaining phase conductor and earthwire attachment points.

For towers fitted with suspension insulator sets the alleviating effects of the insulator set movement have to be considered as mentioned in clause 8.2.5. No allowance shall be taken of any movement of the tower, unless specifically stated.

(b) Anti Cascade Condition

2Q30 and 2Q1T6 towers shall be checked for the following anti-cascading conditions with all conductor and earthwire intact only on one side of the tower:

(i) Transverse loads

These loads shall be taken no wind condition for tensions of conductor/earthwire under everyday temperature due to the maximum horizontal angle deviation of the line.
(ii) **Vertical loads**

These loads shall be the sum of weight of conductor/earthwire as per weight span of intact conductor/earthwire, weight of insulator strings and accessories.

(iii) **Longitudinal loads**

These loads shall be the pull of conductor/earthwire at everyday temperature and no wind applied simultaneously at all points on one side with zero degree line deviation.

8.2.8 **Construction and Maintenance Loading**

The specified construction and maintenance loading shall be applied to all phase conductor and earthwire attachment points in the combinations stated.

Where appropriate that loading and/or their individual components shall also be applied to the corresponding maintenance points e.g. the vertical component shall be applied to vertical maintenance attachment points, whilst the longitudinal is distributed to the horizontal maintenance plates.

All members with an inclination of 40 degrees to 90 degrees to the vertical, shall be checked for the effects of point loading of 1.5kN at its most onerous position. No other loading shall be considered under this condition.

All cross-arm tie members shall be checked for the effect of point loading of 2.1 kN at each connection point of fall arrester.

It is the Contractor's responsibility to consider all constructional loading due to his proposed method of tower erection and conductor stringing. Where necessary, any additional loading due to these methods shall be considered in the design of the tower and especially the specified maintenance, lifting or attachment points. Under these conditions a minimum partial safety factor of 1.5 shall be considered.

8.2.9 **Downlead Tensions**

The maximum downlead tension shall be as specified in Appendix 8.A5. However, for the purpose of tower design they shall be assumed to be zero except where the vertical load component increases the stresses in tower members. These tensions shall be assumed to apply at both ends on low duty tension insulator sets.

8.2.10 **Down droppers to Substation Equipment**

The design of down droppers shall take into account the limiting strength of substation equipment specified in Appendix 8.A5.
8.2.11 Ultimate Applied Loadings

The following overload factors (factor of safety) shall be applied to all loads to convert to the ultimate loading for tower design:

<table>
<thead>
<tr>
<th>Normal (Reliability) Condition (NC)</th>
<th>Security (Broken Wire) Condition (BWC)</th>
<th>Cascade Condition (CC)</th>
<th>High Intensity Local Wind Condition (HILWC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspension Towers &amp; Heavy Suspension Towers</td>
<td>1.25</td>
<td>1.05</td>
<td>1</td>
</tr>
<tr>
<td>Angle &amp; Terminal Towers</td>
<td>1.25</td>
<td>1.05</td>
<td>1</td>
</tr>
</tbody>
</table>

8.2.12 Allowable Ultimate Unit Stresses

The allowable ultimate unit stresses used in the determination of the nominal strength of support members shall be based on the following criteria:

(a) For lattice steel tower shall be based on the recommendations contained in BS 8100-3 or ANSI/ASCE Std 10-97. For Std 10-97 the appropriate reference stress levels shall be based on the values specified in BS 5950, and as summarised below:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Reference Stress Level (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S235JRG2</td>
<td>235 ≤ 16 mm Nominal Thickness</td>
</tr>
<tr>
<td></td>
<td>225 &gt; 16 ≤ 40mm</td>
</tr>
<tr>
<td>S275JR</td>
<td>275 ≤ 16mm</td>
</tr>
<tr>
<td></td>
<td>265 &gt; 16 ≤ 40mm</td>
</tr>
<tr>
<td>S355JO</td>
<td>355 ≤ 16mm</td>
</tr>
<tr>
<td></td>
<td>345 &gt; 16 ≤ 40mm</td>
</tr>
</tbody>
</table>

(b) For lattice steel tower where the appropriate design stresses are not contained in the specified code of practice/manual, reference shall be made to BS 5950;

8.2.13 Design Criteria

The maximum allowable slenderness ratios for members of lattice steel towers shall
8.2.14 Bolted Joints

Where appropriate all metal parts shall be secured with bolts and nuts with single spring washers. All nuts and bolts shall be in accordance with clause 8.3.3 unless specified to the contrary.

When in position all bolts shall project through the corresponding nuts by at least three threads, but such projections shall not exceed 10 mm. No screwed threads shall form part of a shearing plane between members.

The nuts of all bolts attaching phase conductor insulator sets, earthwire sets, maintenance brackets/plates, access ladder brackets, fall arrest system attachment brackets shall be locked in an approved manner preferably by locknuts.

The diameter of bolts used for towers shall be 16mm and 24 mm only for new design. For existing design, bolt sizes are mentioned in the relevant approved design drawings which are enclosed in the drawing section.

The bolts of any one diameter in a tower shall be one grade of steel.

Leg members shall be joined in such a way that electrical continuity is maintained to ground.

8.2.15 Electrical Clearances - Live Metal and Earthed Steelworks

Minimum clearance between live metal and earthed steelwork shall be in accordance with the requirements of Appendix 8.A7.

8.2.16 Downlead Clearances

The clearance in still-air between downleads shall be in accordance with the requirements of Appendix 8.A7. In exceptional circumstances and with the
approval of the Engineer, under conditions of maximum (opposing) conductor swing and sag, the clearance may be reduced to the values specified in Appendix 8.A7.

8.2.17 Anti-Climbing Devices

Each support shall be fitted with an approved type of anti-climbing device as specified in Appendix 8.A8. The height of the anti-climbing device shall be adjustable and shall be within the limits specified in the Appendix.

Where specified the anti-climbing device shall be provided with a hinged section where access for personnel is required. The hinged section shall be capable of being bolted and locked in the closed position with either a bolt, nut and locknut or a padlock. In the open position, no projection to impede safe access shall be permitted.

In no case shall an anti-climbing device be installed where it can be bypassed from a side slope or internal bracing.

Barbed wire type anti-climbing devices shall comply with the following requirements:

(a) Barbed wire shall be of the mild steel type with high security long barbs 15 mm long set at 50 mm spacing, but in all other respects the barbed wire shall comply with BS 4102, Section 4;
(b) For lattice steel towers the minimum distance between strands or between strands and horizontal tower member/pole sections shall not be less than 150 mm;
(c) No unprotected space greater than 230 mm across shall be left inside the device;
(d) Spacers shall be fitted at 1.5 m intervals and shall be attached to tower members where possible;
(e) Normally 5 strands of barbed wire are required outside the tower face and 3 strands inside;

Spiked type anti-climbing devices shall comply with the following requirements:

(a) The minimum spike diameter shall not be less than 10 mm, and shall project horizontally 50 mm and curve vertically down by 40 mm.
(b) Where spikes are bolted to the support frame the spike threads must be clenched after installation.

8.2.18 Livestock Guards

Means shall be provided on all lattice steel towers and tower extensions to avoid the risk of livestock being caught between tower members and being injured.

Tower members near the around shall be sufficiently robust to avoid being damaged by livestock. To enable supplementary livestock guards to be added, spare holes, normally 17.5 mm diameter and 300 mm apart, shall be provided on
each face of the main leg members and the appropriate faces of bracing members, for a distance of approximately 1200 mm from ground level.

**8.2.19 Bird Guards**

Where specified bird guards of an approved type shall be fitted to intermediate towers fitted with suspension insulator sets. The bird guard shall either comprise a saw-tooth plate, or a length of earthwire suitably de-stranded and splayed out at each end and clamped to the cross arm member.

**8.2.20 Access Facilities**

Each support shall be fitted with approved access facilities as specified in Appendix 8.A8. The following requirements for specific types of access facilities shall apply as appropriate.

(a) **Step Bolts**

i) Step bolts shall be fitted between specified levels at 380 mm spacing;
ii) On double circuit towers they shall be fitted on the right hand leg on both transverse faces; for single circuit towers they shall be fitted on the right hand leg on one transverse face;
iii) The first step bolt below each cross arm or gantry shall be located on the transverse face of the leg, and all remaining step bolts shall be fitted, alternatively on the remaining of the support;
iv) On terminal and junction towers, provision shall be made for fitting of step bolts on all legs;
v) Step bolts shall not be less than 16 mm diameters, fitted with nut, washer and nut and shall project not less than 200 mm from the support when fitted;
vii) For steel poles, removable step bolts or step brackets in accordance with the requirements of (v) shall be fitted. The step bolt brackets shall be permanently attached to the pole;
vii) Where support legs are fabricated from solid round sections, clamp type steps shall be provided at similar spaces and projection as step bolts.

(b) **Ladders**

i) Ladders shall be fitted between specified levels, support faces and either externally or internally;
ii) Ladders shall be in accordance with BS 4211, 350 mm between internal faces and 300 mm rung spacing;
iii) Rest platforms shall where specified be fitted at approximately 10m height increments with the rest platform 850 mm square and fitted with a guard rail (1000 mm above the platform), intermediate rail and toe board (projecting 100 mm);
iv) Ladders shall project 1100mm above platforms, unless other hand holds are provided and shall be between 150 to 230 mm from the platform where side access to the platform is provided.

(c) Fall Arrest Systems
   i) Fall arrest system shall be in accordance with the requirements of BS EN 360;
   ii) The system shall be either a guided type fall arrester on a rigid anchorage line to BS EN 353-1, or a guided type fall arrester on a flexible anchorage line to BS EN 353-2.

(d) Work Platforms
   i) Work platforms shall be provided with hand rails as detailed in clause (b) iii);
   ii) Platforms shall be designed for a transient load of 1.5kN vertically concentrated load over any square with a 300 mm side, plus a 1.5 kN/sqm vertically distributed load applied simultaneously to produce the worst loading condition.
   iii) Flooring for platforms shall be the open type metal in accordance with BS 4592 and BS EN ISO 14122-1 to 3.

8.2.21 Danger and Identification Plates
   All towers shall be fitted with danger and identification plates as specified in Appendix 8.A 8.

8.2.22 Earthwire Bonding
   Attachment holes for the connection of earthwire bonds shall be provided adjacent to the earthwire attachment point.

8.2.23 Earthing of Towers
   Attachment holes for the connection of the ground earthing conductor shall be provided on all lattice towers standard heights adjacent to the stub connection, leg and body extension and cleats of stubs.

8.2.24 Design Calculations
   **132kV & 230kV 4 Circuit Towers**
   The Contractor shall submit the following design calculations to the Engineer:
   (a) wire clearance diagram;
   (b) line diagram;
   (c) tower design calculations (in an approved format) indicating the applied loading along with calculation, loading tree, body wind load calculation,
the design load for each member under the critical loading case, member size, slenderness ratio, allowable load and end connection details;

(d) when requested the load for each member for each loading case shall be made available;

(e) foundation load schedule;

(f) wire clearance diagrams for each terminal and junction position.

The Contractor shall not proceed with any tower prototype test until after the approval of the design calculation. This is a Hold Point.

The Contractor shall submit three sets shop drawing alongwith AutoCAD soft copy of each tower for record purpose after the successful proto assembly.

**132kV & 230kV Double Circuit Tower**

The scope does not include design of towers. Previously designed and tested towers will be used for this line.

The drawings of Tower type 2DT6 with 6 m extension required by this bid will be provided with the bid document. The bidders are requested to carefully check the available drawings of this tower before submission of bid. The Contractor shall prepare shop drawings, fabricate and supply towers according to these drawings. The Contractor shall submit three sets shop drawings alongwith AutoCAD soft copy of each tower for record purpose after the successful proto assembly. In case, any information missing in the above available tower drawings, the Contractor has to assume the same as per relevant International Standard which will be finalized after discussion with Employer.

The Contractor shall not be allowed to change the size of any member/plates or bolt of these towers without prior approval of the Employer. However, no extra cost will be paid to the Contractor due to change in member size (if any).

As the tower drawings are being provided by the Employer, the Bidder’s are requested not to quote any price against tower design in the Price Schedule.

The ultimate foundation reaction forces (including required factor of safety) for these towers are provided in Appendix 8.E1. These foundation reaction forces shall be used for foundation design for the respective towers during Contract execution.

**8.2.25 Fabrication Drawings**

The copy of these structural drawings shall be provided to the Contractor after signing of the Contract as mentioned earlier. The Contractor shall prepare shop drawings, fabricate and supply towers according to these drawings. The Contractor shall not be allowed to reduce the size of any member/plates or bolt of these towers.

However, the Contractor shall submit the drawings of each tower for record and erection purposes.

The Contractor shall submit the following fabrication drawings to the Engineer;
Panel assembly drawings shall show all material in place, complete with all fabrication and connection details. A complete tabulation listing all pieces for the portion of the support detailed shall be shown on each drawing.

Each erection diagram shall show one support panel, together with a key diagram indicating its location on the complete support. Each piece shall be identified by its mark number. The number and length of bolts and number and type of nuts and washers required for proper assembly shall be shown at each connection. A complete tabulation listing all the material needed for the support panel including all bolts, nuts, fill and bevel washers and locknuts, shall be shown on each drawing. The tabulation shall show the quantity, the mark number, the description of the piece (including size and length), the total mass (including the allowance of 3.5% additional mass for galvanising) to the nearest 0.1 kg of all the pieces of the same mark, and the number of the drawing on which the shop detail of the piece can be found. The quantities including 5% excess of step bolts, bolts, nuts, fill and bevel washers, and locknuts shall be shown.

The Contractor shall make all changes to the detail (fabrication) and the erection drawings which the Engineer determines necessary to make the finished support fabrication conform to the requirements and intent of this Specification. The Contractor shall not proceed with any fabrication until after the submission of the fabrication drawings. **This is a Hold Point.**

### 8.2.26 Cradle Guards

Cradle guards shall be installed at highway crossings and railway crossings and shall be designed for 126kg/m² wind pressure.

### 8.3 MATERIALS

#### 8.3.1 Steel

All steel shall comply with BS EN 10025 or BS EN 10210 as appropriate and shall be suitable for all the usual fabrication processes, including hot and cold working within the specified ranges.

The quality of finished steel shall be in accordance with BS EN 10163. All steel shall be free from blisters, scale, laminations, segregation and other defects. There shall be no rolling laps at toes of angles or rolled-in mill scale.

The following grades of steel shall be applicable:

(a) Mild steel shall be either grade S235JRG2 or S275JR.
(b) High tensile steel shall be grade S355JR for sections less than 20 mm thick and S355JO for sections greater or equal to 20 mm thick, except for plates which shall be greater or equal to 40 mm thick.

(c) Steel plate used for folded, pressed braked or stretch bending pole towers shall be grade S275JO for mild and grade S355JO for high tensile.

(d) Mild and high tensile steel hollow sections shall be grades S275JOH respectively.

(e) High tensile steel solid round sections shall be grade S355J, IG3.

Steel section profiles shall be in accordance with the requirements of BS 4: Part 1, BS EN 10210-2, BS EN 10056-1, BS EN 10024, BS EN 10034 and BS EN 10056-2 as appropriate.

Hot rolled steel plate 3 mm thick- or above shall be in accordance with the requirements of BS EN 10029.

8.3.2 Malleable Cast Iron

Malleable cast iron shall be in accordance with the requirements of BS EN 1562 for whiteheart or pearlite and BS EN 1563 for spheroidal graphite.

8.3.3 Bolts, Nuts, Clevis Pins and Washers

Unless specified to the contrary the following grades of steel shall be applicable:

(a) Material quality of bolts of 12 mm diameter shall be Grade 4.6 according to ISO 898.

(b) Material quality of bolts and clevis pins of 16 mm diameter and over shall be Grade 5.6 according to ISO 898.

(c) Material quality of non-structural step bolts shall be Grade 4.6 according to ISO 898.

(d) Material quality of nuts shall be Grade 8.8 according to ISO 898 and appropriate to the material quality of bolts.

Unless other specified, bolts and nuts shall be ISO Metric Black Hexagon to BS 4190, and shall be threaded ISO Metric Course Pitch to BS 3643: Part 2, Tolerance Class 7H/8g.

Countersunk and other bolts without hexagon heads shall have slotted heads.

All flat washers shall comply with the requirements of BS 4320, Form E, Grade 4.6 or 5.6 appropriate to the material quality of bolts. Unless specified to the contrary they shall be 3 mm thick. Pack washers shall have an external diameter of twice the nominal bolt diameter +15 mm, a hole diameter of nominal diameter +2 mm and a thickness as specified on the appropriate fabrication drawing,
Single core spring washers shall comply with the requirements of BS 4464, Type B.

Split pins shall comply with the requirements of BS 1574 and shall be of austentic stainless steel capable of complying with the requirements relating to the intercrystalline corrosion test of BS EN 10083 etc.

8.3.3 Welding
Consumable for use in metal arc welding shall be in accordance with the requirements of BS EN 1011-1 and -2.

8.3.4 Flooring
Open type floor shall be fabricated from either steel complying with BS EN 10025 Grade S275JR or BS EN 515, 573, 755 and 12020. Minimum thickness for load bearing, transverse and pressed bars shall not be less than 3.0 mm.

8.4 WORKMANSHIP
8.4.1 General
The work shall be carried out in a thoroughly reliable and workmanlike fashion in order to ensure satisfactory assembly and erection, interchangeability of similar members, accuracy of dimensions, position and alignment of holes.

Punched holes, shall wherever practicable, be Jig, NC or CNC punched true to form and free from rags, burrs and distortions. Punches and dies shall be strictly monitored to ensure that any producing, irregular holes or defects previously mentioned shall be immediately replaced. Drilled holes shall be clean, free from burrs and square to the surface of the material.

Hole diameters shall be in the black unless specified to the contrary. For bolts up to but not including 30 mm diameter - nominal diameter +1.5 mm. For bolts 30 mm diameter or greater- nominal diameter +2.0 mm.

8.4.2 Cutting
Cutting of materials by either cropping, shearing, guillotining will be permitted upto and including the thickness specified below:

<table>
<thead>
<tr>
<th>Quality (sub-grade)</th>
<th>JR</th>
<th>- 16 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>JO</td>
<td>- 20 mm</td>
</tr>
</tbody>
</table>

Materials of either greater thickness or higher quality (sub-grade) must be either machine frame-cut or cold sawn. Hand held flame-cutting is not permitted.

Where materials are cropped, sheared or Guillotined, the finished edge shall be free from rags, burrs, notches and distortions. Flame-cutting of grade S355 steel shall be preceded by a slight pre-heat by passing the cutting, flame over the area to be cut and the cutting speed reduced in comparison to those normally used for Grade S275.
steels of similar thickness. Every effort shall be made to avoid having the flame-cut edge in tension, especially in grade S355. The flame-cut edges shall be lightly dressed after cutting to remove notches etc.

8.4.3 Drilling and Punching

Punching, full sized holes will be permitted up to and including the thickness specified below:

<table>
<thead>
<tr>
<th>Quality (sub-grade)</th>
<th>JR</th>
<th>JO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-16 mm</td>
<td>-20 mm</td>
</tr>
</tbody>
</table>

No hole shall be punched where the thickness of the materials exceeds the finished diameter of the hole. Finished holes shall be true to form and free from rags, burrs and distortion.

Materials of either greater thickness or higher quality (sub-grade) must be either drilled to final diameter or punched 2 mm undersize and reamed or core drilled to final diameter.

The welding, up of misplaced holes is not permitted without the prior approval of the Employer. This is a Hold Point.

In the case where approval is granted, the new hole must be drilled where it passes through or adjacent to the weld area of the previous hole irrespective of material grade or thickness.

8.4.4 Presswork/Bending

All bends in Grades S355JO and S355J2G3 steel over 90 in 1000 shall be made hot within the temperature range of 850 to 1000 degrees Celsius, but normal cold correction will be permitted. Means shall be provided for the random checking of temperatures (Tempilstiks or Pyrometer).

Bends in Grades S235JRG2 and 275JR steel plates up to 10 mm thick may be made cold up to an including 1175 in 1000.

Bends, open and close flanges in angle sections may be made cold up to and including 600 in 1000.

However, in both of the above cases, the Contractor shall take adequate precautions to avoid the risk of subsequent galvanising embrittlement.

Bends shall be of even, profile and free from surface damage due to press tools indentations.

The formation of bends by the 'cut and weld' method unless specified on the drawings, is not permitted without prior approval of the Employer. This is a Hold
8.4.5 **Welding**

All welding shall be carried out in accordance with BS EN 1011-1 and -2.

Pre-heating, where required, shall be checked by the use of Tempilstiks or similar over an area of 150 mm either side of the weld area.

Assembly welds (tacks) shall be carried out to the same procedures and welding conditions as the main welds and shall be at least 50 mm long.

Stop-start positions shall be kept to a minimum and shall be kept clear by a minimum of 25 mm of all corners and edges of plates (i.e. the weld must be laid down continuously at these points). Where the first run in multi-run welds is larger than subsequent runs, welding should continue until completed, thereby ensuring the weld area is not allowed to cool. After completion the unit should be allowed to cool slowly and should not be subjected to draughts or low temperatures.

Where materials are to be galvanised, all welds shall be continuous so as to ensure a pickle-tight connection and shall be thoroughly cleaned (preferably by shot-blasting) to remove all slag, manganese (Carbon Dioxide welding), and weld splatter.

8.4.6 **Erection Marks**

Before leaving the fabricator's works, all members shall be stamped with distinguishing numbers and/or letters corresponding to those on the general arrangement or fabrication drawings. Additionally, the agreed fabricator's identification symbol must appear adjacent to the erection mark.

Erection marks shall be stamped on before galvanising, using characters at least 10 mm high and shall be clearly legible after galvanising.

Erection marks shall be located as follows:

(a) All members - stamped within 600 mm of the end but clear of holes;
(b) Plates or flat bars - stamped at most suitable position between holes;
(c) Main leg and elevation diagonal members - stamped at top end of bar;
(d) Horizontal members - stamped at either end of bar;
(e) Steel poles 100 mm either side of the joint.

Where malleable cast iron fittings are used the erection mark shall be 6 mm high raised characters, where appropriate the following information shall be included:

(f) specified minimum failing load;
(g) date of manufacture (month and year)
(h) cast code.

The erection marks shall be as bellow:
AAAA-BBB-C

Where,
AAAA – Tower Type
BBB – Mark Number
C – Steel Grade (H for high tensile steel and M for mild steel)

Erection Mark coding shall be agreed with the Employer. This is a Hold Point.

8.5 PROTECTIVE TREATMENT

8.5.1 Galvanising

Unless otherwise specified after completion of all fabrication processes (including all drilling, punching, stamping, cutting bending and welding) support steelwork, poles and pole steelwork, including nuts, bolts and washers shall be hot-dip galvanised and tested in accordance with the requirements of BS EN ISO 1461. Electro-galvanising is not an acceptable alternative.

The minimum average coating thickness shall be as follows:

<table>
<thead>
<tr>
<th>Thickness µm</th>
<th>(Mass g/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel articles which are not centrifuged:</td>
<td>\n</td>
</tr>
<tr>
<td>under 5 mm but not less than 2 mm</td>
<td>64</td>
</tr>
<tr>
<td>Grey and malleable iron castings</td>
<td>85</td>
</tr>
<tr>
<td>Threaded works and other articles which are centrifuged</td>
<td>43</td>
</tr>
</tbody>
</table>

Excessively thick or brittle coatings due to high levels of silicon or phosphorus in the steel, which may result in an increased risk of coating damage and/or other features that make the final product non-fit-for-purpose shall be cause for rejection.

The ingot zinc used for galvanising shall comply with the requirements of BS EN 1179.

All materials prior to galvanising shall be free from oil, grease or any substance which may adversely effect the quality of finish.

Castings should be as free as possible from surface porosity and shrinkage holes and should be cleaned by grit blasting, electrolytic pickling or by other means specially suitable for castings.

The preparation for galvanising and the galvanising itself shall not adversely affect the mechanical properties of the coated materials.
Unless otherwise specified, all materials shall be treated with Sodium Dichromate in order to prevent wet storage stains (white rust) during storage and transport.

All bolts and screwed rods, including the threaded portions, shall be galvanised. The threads shall be cleaned of all surpluses on packing, clear of the ground and away from all materials that might stain or corrode the galvanising. Black steel packing or bins shall not be spelter by spinning or brushing. Dies shall not be used for cleaning threads other than on nuts. Nuts shall be galvanised and tapped 0.4 mm oversize and threads shall be oiled.

Bolts shall be delivered with nuts run up the full extent of the thread.

All galvanised materials shall be stored used.

8.6 TOWER ERECTION

8.6.1 General

The Contractor shall provide the Employer with a method statement giving sequential details of the erection method and including his intended program.

The method statement shall be submitted to the Employer for acceptance the requisite period before support erection commences. This is a Hold Point.

8.6.2 Safety

The erection shall be carried out in accordance with guidance given in the relevant parts of BS 5531 and current health and safety legislation.

8.6.3 Site Storage

All support steelwork stored at site shall be kept clear of the ground where possible. Contact with brackish water, or other substances likely to attack galvanising shall be avoided and all tower members kept in a clean and tidy condition.

Preventative measures shall be taken to prevent deterioration of galvanised or other protective surfaces during transport, storage and erection. Superficial rust stains shall be removed without causing damage to the protective surfaces.

8.6.4 Damaged Steelwork

Unless otherwise directed, steelwork damaged during off-loading, transportation, storage or erection shall be replaced.

8.6.5 Damaged Galvanising

The renovation of damaged area of galvanising shall be carried out using a technical agreed with the Employer. This is a Hold Point.
8.6.6 Workmanship

The Contractor shall ensure that Towers are not strained or damaged in any way during erection.

As far as practical, bolt heads, rather than nuts, shall be on the inner or downward faces of support joints. Bolt locking, after erection shall be in accordance with the requirements of Appendix 8.A.8.

All holes that align through both components of double angle (back to back) members shall be filled by fitting, a bolt, with suitable pack washers between components. All spare holes (e.g. holes for alternative positions of supplementary fittings) in double angle members shall be included in this requirement.

Towers shall be erected vertically within a tolerance of 0.1 percent of the overall height before conductor erection.

8.6.7 Anti-Climbing Devices, Danger and Identification Plates

As soon as practical after completion of support erection, anti-climbing devices, danger and identification plates in accordance with the requirements of the Sub-clause 8.2.19 shall be fitted.

All ladders and temporary step bolts below the anti-climbing device shall be removed when erection work is not in progress.

8.6.8 Aircraft Navigation (Obstruction Aids)

Where required aircraft navigation obstruction lights complete with all necessary cabling, control equipment, solar panels, storage batteries, access ladders and platforms shall be fitted.

All installation shall be in accordance with approved general arrangement drawings and supplier's instructions.

8.7 QUALITY CONTROL

8.7.1 General

Routine tests on raw material and fabricated individual members (components) of lattice steel towers and associated steelwork shall be undertaken in accordance with the requirements of this Specification. Prototype (type) tests on lattice steel towers shall be undertaken when required by the Employer in accordance with the requirements of Clause 8.7.7.

All steel ex-mills or received from merchants' stocks shall be marked to identify the cast or casts from which it was made in accordance with Section 9 of BS EN 10025 and Section 10 of BS EN 10210, and be covered by a test (mill) certificate stating the mechanical, chemical and where specified the impact properties and carbon equivalent value and clearly showing the cast numbers; to prove compliance with
tables 2 and 5 of BS EN 10025 and tables Al and A3 of BS EN 10210.

The optional impact test BS EN 10210 option 1.6 for quality JO steel hollow sections is required.

Unless agreed to the contrary the following maximum Carbon Equivalent Values (CEV) for steel supplied in accordance with BS EN 10025 and BS EN 10210 shall not be exceeded:

<table>
<thead>
<tr>
<th>Grade</th>
<th>CEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>S235</td>
<td>0.35</td>
</tr>
<tr>
<td>S275</td>
<td>0.41</td>
</tr>
<tr>
<td>S355</td>
<td>0.45</td>
</tr>
</tbody>
</table>

see also BS 5950 Part 2, Clause 4.2

All high tensile steel solid round sections shall be ultrasonic tested for laminations at the rolling mills in accordance with the requirements of BS EN 10160.

In the event of test certificates being unobtainable, the Contractor shall arrange, at his own cost, for the independent testing and analysis of materials. Testing shall be in accordance with the requirements of BS EN 10025, Section 8 and BS EN 10210, Section 7.

The material grades of all individual pieces shall be capable of positive identification at all stages of fabrication.

Steels of different quality shall be stored separately.

Bolts and nuts shall be covered by the appropriate test certificate in respect of the tests requirements stated in BS 4190.

Copies of all test certificates shall be made available to the Employer.

8.7.2 Welding

Unless specified to the contrary all structural welded joints shall be undertaken using approved welding procedures in accordance with BS EN 288.

Copies of the welding procedures shall be made available to the Employer upon request. However, for all welding associated with the fabrication of high tensile steel solid round sections, or where the combined thickness of the material is in excess of 60 mm, the welding procedures shall be submitted to the Employer for approval, together with the related quality control documentation such as electrode storage, drying and handling requirements. This is a Hold Point.

All welders shall be tested to meet the requirements of BS EN 287 Part 1 using the appropriate test corresponding to the weld positions and parent materials to be used. Copies of the test certificates shall be made available to the Employer upon request.

The Employer reserves the right to have any welding operator retested at any time at no extra cost.
Unless specified to the contrary all welding shall be subjected to a non-destructive testing (NDT) programme. Where necessary, this may involve the appointment by the supplier of an independent NDT organization approved by the Employer who will undertake the NDT programme. **This is a Hold Point.**

The NDT organisation shall have operators suitably qualified to Level 2 of PCN/WSB/MT/001/87. The NDT organisation shall submit their proposed procedures for approval. **This is a Hold Point.** The Contractor shall then ensure that the approved procedures are rigidly adhered to.

The Contractor shall arrange for the appropriate level of weld/inspection to be undertaken, which shall not be less than the following minimum requirements. For details of the required level of inspection reference should be made to Appendix 8.A9.

- **Level 1:** 100 percent visual inspection in accordance with the requirements of BS EN 970
- **Level 2:** 10 percent of the overall output shall be magnetic particle tested to the acceptance criteria stated in BS EN 1011-1 and -2 for butt and fillet welds respectively.
- **Level 3:** 10 percent of each welder's output shall be magnetic particle tested to the acceptance criteria stated in BS EN 1011-1 and -2 for butt and fillet welds respectively.
- **Level 4:** 20 percent of each welder's output shall be magnetic particle tested to the acceptance criteria stated in BS EN 1011-1 and -2 for fillet welds.
- **Level 5:** 10 percent of each welder's output shall be ultrasonic tested, with a further 10 percent of each welder's output magnetic particle tested - both to the acceptance criteria in BS EN 1011-1 and -2 for butt welds.

**Note:**
A All welds, especially butt welds must be continuous to ensure a pickle-tight connection when galvanised.
B Ultrasonic testing to be in accordance with BS EN 1714.
C Magnetic particle testing to be in accordance with BS EN ISO 9934.

All weld inspection/testing, shall be undertaken a minimum of 48 hours after the completion of the respective weld. **This is a Notification point.**

Copies of the NDT inspection reports for weld inspection levels 5 and 4 shall be made available to the Employer.

Copies for the NDT inspection reports for weld inspection level 3 and 2 shall be made available to the Employer upon request.
8.7.3 Castings

All malleable cast iron castings shall be thoroughly inspected after sand blasting, and any casting with castings defects e.g. sand inclusions and metal penetrations, cracking, raised core, porosity shall be scrapped.

8.7.4 Check Erection

Prototype structures (and, where required by the Employer repeat structures) shall be check erected in order to verify the accuracy of detailing and fabrications, including forming, location and size of bolt holes, clipping and shearing.

The degree of check erection shall be sufficient to verify not only the main structure, but all ancillary steelwork such as platforms, walkways, ladders etc.

In the case of lattice towers, the minimum check erection required shall be one face lying horizontally and the adjacent face erected in the vertical plane, complete with hip and plan bracings. Crossarms and earthwire peaks shall be completely assembled.

Sufficient blocking and support shall be provided to prevent distortion and overstressing of the members to ensure proper fit. Assembly shall be accomplished without extraordinary effort to align bolt holes or to force pieces into position. Bolt holes shall not be reamed or enlarged.

All modifications found necessary at the time of check erection shall be accurately recorded and the Contractor's drawings, NC tapes etc., shall be amended. Where necessary, modified G.A. drawings shall be forwarded to the Employer.

Unless otherwise specified the check erection may be undertaken in either the black or galvanised condition. Where materials are check erected galvanised, all modified items, those subjected to damage or prolonged contact with black steel, shall be re-galvanised at the supplier's cost.

The Contractor shall give the Employer the requisite period of notice prior to a check erection being ready for inspection. This is a Hold Point.

8.7.4 Galvanising

Tests for galvanised members and components shall be carried out at the works to ensure compliance with the requirements of BS EN ISO 1461. Details of the test results shall be made available to the Employer upon request.

Certificates relating to the ingot zinc used for galvanising shall also be made available to the Employer upon request. When requested the fabricator shall, at his own cost, provide a pot melt analysis.

8.7.5 Tolerances

The fabrication tolerances after galvanising, which are not to be considered
cumulative, shall be as follows:

(a) On linear dimensions of nominal sections as per BS 4, BS EN 10210-2, BS EN 10024, BS EN 10029, BS EN 10034 & BS EN 10056-2
(b) On overall length of member ± 1 mm
(c) On centres of holes ± 1 mm
(d) On centres of groups of holes ± 2 mm
(e) On back-gauges ± 1 mm
(f) On corresponding holes in opposite faces of angle or channel sections ± 1 mm
(g) On specified hole diameter on the punch side + 0.3 mm
   (in the black) or where drilled - 0 mm
(h) Taper on punched holes as measured between the specified hole diameter on the punch side and the hole diameter on the die's side (in the black) shall not exceed + 1.00 mm
(i) On specified bends, open and close flange ± 20/1,000
(j) On the specified included angle (in plan) between welded leg connections or bracing connection plates ± 20/1,000

The permitted tolerance from straightness after galvanising shall not exceed an offset of 1: 1,000, except for hollow sections which shall not exceed 1:600 measured at the worst point. For members greater than 3 m in length, the offset shall be measured over any 3 m length in the member.

8.7.6 Tests - Lattice Steel Tower

Proto Assembly

Proto Assembly tower tests shall be conducted before batch manufacturing of the towers.

The type and extension of the structures to be proto assembly tested shall be in accordance with those specified in Appendix 8.A10.

After successful proto assembly testing, the respective towers shall be manufactured as per required quantity for supply and installation. Before shipment of such manufactured towers, randomly selected samples shall be tested for each lot as per relevant IEC/British Standard. Dimension check, galvanization thickness test, tensile tests, elongation measurement, impact test and any other test as per Standard shall be performed in this regard at the Contractor's expense. The results of these tests together with test report and certificate shall be made available to the Engineer.

The Contractor shall furnish all test structures, testing facilities and shall perform all work herein specified or implied. All items not specifically mentioned shall be deemed inclusive to testing.

The Contractor shall give the Engineer the requisite period of notice prior to undertaking the tests.
8.7.7 Certificate of Conformity

The certificate of conformity shall be supported by the following documentation:

(a) material test (mill) certificates;
(b) bolt and nut certificates;
(c) NDT welding inspection (levels 5 & 4);
(d) test reports of any prototype or sample tests undertaken;
(e) the results of any ultrasonic testing of solid round sections;
the results of any welding NDT inspections (levels 3 & 2);
Welder's test certificates;
galvanising thickness records;
the ingot zinc certificates;
(j) galvanising pot melt analysis;

8.7.8 Quality Control after Erection

The Contractor shall be responsible for checking that the Towers are complete and that all bolts have been correctly tightened before conductor commences. A record of this work shall be kept by the Contractor and made available to the Employer on request.

Critical bolts are to be marked after erection with red paint to ensure priority checking during maintenance.

Where appropriate, test on the aircraft obstruction lighting shall be undertaken to prove compliance of the system. Records of the tests shall be made available to the Employer upon request.
APPENDIX 8.A1

CLASSES OF TOWER

The steel towers requires in this Project is as follows:

1. 230kV double circuit and four circuit towers: three phase in vertical formation lattice steel towers with twin Mallard (795 MCM ACSR) phase conductors and two 7X4.00mm earthwire equivalent OPGW.

2. 132kV double circuit and four circuit towers: three phase in vertical formation lattice steel towers with single Grosbeak (636 MCM ACSR) phase conductors and two earthwire equivalent OPGW.
# APPENDIX 8.A2
## DESIGNATION & USES OF TOWERS

<table>
<thead>
<tr>
<th>Designation</th>
<th>Angle of Deviation/Entry</th>
<th>Description</th>
<th>Type of Insulator Set</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>230kV Four Circuit Tower</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2QL</td>
<td>0°-1°</td>
<td>Intermediate</td>
<td>Suspension</td>
</tr>
<tr>
<td>2Q1</td>
<td>0°-3°</td>
<td>Intermediate</td>
<td>Heavy Suspension</td>
</tr>
<tr>
<td>2Q15</td>
<td>0° – 15°</td>
<td>Angle</td>
<td>Tension</td>
</tr>
<tr>
<td>2Q30</td>
<td>0° – 30°</td>
<td>Angle/Section</td>
<td>Tension</td>
</tr>
<tr>
<td>2QT6</td>
<td>30° – 60°</td>
<td>Angle</td>
<td>Tension</td>
</tr>
<tr>
<td></td>
<td>0° – 30°</td>
<td>Terminal</td>
<td>Tension</td>
</tr>
<tr>
<td><strong>230kV Double Circuit Tower</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2DL</td>
<td>0°-1°</td>
<td>Intermediate</td>
<td>Suspension</td>
</tr>
<tr>
<td>2D1</td>
<td>0° – 10°</td>
<td>Angle</td>
<td>Heavy Suspension</td>
</tr>
<tr>
<td>2D25</td>
<td>10° – 25°</td>
<td>Angle/Section</td>
<td>Tension</td>
</tr>
<tr>
<td>2DT6</td>
<td>{25° – 60°, 0° – 30°}</td>
<td>Angle</td>
<td>Tension</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Terminal</td>
<td>Tension</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Designation</th>
<th>Angle of Deviation/Entry</th>
<th>Description</th>
<th>Type of Insulator Set</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>132kV Four Circuit Tower</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1QL</td>
<td>0°</td>
<td>Intermediate</td>
<td>Suspension</td>
</tr>
<tr>
<td>1Q15</td>
<td>0°-15°</td>
<td>Intermediate</td>
<td>Heavy Suspension</td>
</tr>
<tr>
<td>1Q30</td>
<td>15° – 30°</td>
<td>Angle/Section</td>
<td>Tension</td>
</tr>
<tr>
<td>1QT6</td>
<td>30° – 60°</td>
<td>Angle</td>
<td>Tension</td>
</tr>
<tr>
<td></td>
<td>0° – 30°</td>
<td>Terminal</td>
<td>Tension</td>
</tr>
<tr>
<td><strong>132kV Double Circuit Tower</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1DL</td>
<td>0°</td>
<td>Intermediate</td>
<td>Suspension</td>
</tr>
<tr>
<td>1D1</td>
<td>0° – 10°</td>
<td>Angle</td>
<td>Heavy</td>
</tr>
<tr>
<td>Tower Type</td>
<td>Type of Extension</td>
<td>Range (m)</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-------------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td><strong>230kV Four Circuit</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2QL</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0, 9.0 &amp; 12.0</td>
<td></td>
</tr>
<tr>
<td>2Q1</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 6.0, 9.0, 12.0, 15.0, 18.0, 21.0 &amp; 25.0</td>
<td></td>
</tr>
<tr>
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<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 6.0 &amp; 9.0</td>
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</tr>
<tr>
<td>2Q30</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0 &amp; 9.0</td>
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</tr>
<tr>
<td>2QT6</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0 &amp; 9.0</td>
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</tr>
<tr>
<td><strong>230kV Double Circuit</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2DL</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0, 9.0, 12.0</td>
<td></td>
</tr>
<tr>
<td>2D1</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 6.0, 9.0, 12.0, 15.0, 18.0, 21.0, 25.0</td>
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</tr>
<tr>
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<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0, 9.0, 12.0, 15.0</td>
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</tr>
<tr>
<td>2DT6</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0 &amp; 9.0, 12.0, 15.0</td>
<td></td>
</tr>
<tr>
<td><strong>132kV Four Circuit</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1QL</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0, 9.0</td>
<td></td>
</tr>
<tr>
<td>1Q15</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 6.0, 9.0, 12.0, 15.0</td>
<td></td>
</tr>
<tr>
<td>1Q30</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0, 9.0</td>
<td></td>
</tr>
<tr>
<td>1QT6</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0 &amp; 9.0</td>
<td></td>
</tr>
<tr>
<td><strong>132kV Double Circuit</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1DL</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0, 9.0</td>
<td></td>
</tr>
<tr>
<td>1D1</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 6.0, 9.0, 12.0, 15.0</td>
<td></td>
</tr>
<tr>
<td>1D25</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0, 9.0</td>
<td></td>
</tr>
<tr>
<td>1DT6</td>
<td>Body/Leg</td>
<td>Std., 1.5, 3.0, 4.5, 6.0 &amp; 9.0</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1QL, 1Q15, 2QL & 2Q1: Earthwire crossarms to be designed for both suspension and tension OPGW earthwire sets.

1QT6, 1DT6, 2QT6 & 1DT6: Auxiliary crossarms to be designed for downleads only.
### APPENDIX 8.A4

### APPENDIX 8.A4.1

### SPAN CRITERIA

#### 1.0 Climatic Loadings and Security Loadings (Intact Conditions)

#### 1.1 Suspension, Heavy Suspension & Tension Towers

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th>230kV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Suspension Towers</td>
<td>(m)</td>
<td>375</td>
</tr>
<tr>
<td>(a)</td>
<td>Wind span (A)</td>
<td>Heavy Suspension Towers</td>
<td>(m)</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>Tension Towers</td>
<td>(m)</td>
<td>375</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>Maximum weight span</td>
<td>Suspension Towers</td>
<td>(m)</td>
<td>510</td>
</tr>
<tr>
<td></td>
<td>Heavy Suspension Towers</td>
<td>(m)</td>
<td>1050</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tension Towers</td>
<td>(m)</td>
<td>510</td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>Minimum weight span</td>
<td>Suspension Towers</td>
<td>(m)</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Heavy Suspension Towers</td>
<td>(m)</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tension Towers</td>
<td>(m)</td>
<td>zero</td>
<td></td>
</tr>
</tbody>
</table>

#### 1.2 Terminal Towers

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Wind span (A)</td>
<td>-</td>
<td>(m)</td>
<td>315</td>
</tr>
<tr>
<td>(b)</td>
<td>Maximum weight span</td>
<td>-</td>
<td>(m)</td>
<td>430</td>
</tr>
</tbody>
</table>
### 1.3 Unbalanced tension in front and back span in Normal Condition

<table>
<thead>
<tr>
<th></th>
<th>Suspension &amp; Heavy Suspension Tower</th>
<th>3% of maximum working tension of conductor &amp; earthwire</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>2Q15/2Q30 Tower</td>
<td>33% of maximum working tension of conductor &amp; earthwire</td>
</tr>
<tr>
<td>(b)</td>
<td>2QT6 Tower (Angle)</td>
<td>33% of maximum working tension of conductor &amp; earthwire</td>
</tr>
<tr>
<td>(c)</td>
<td>2QT6 Tower (Terminal)</td>
<td>100% of maximum working tension of conductor &amp; earthwire</td>
</tr>
</tbody>
</table>

### 2.0 Security Loadings (Broken Wire Conditions)

#### 2.1 Suspension & Tension Support

<table>
<thead>
<tr>
<th></th>
<th>Wind span (A)</th>
<th>Suspension Towers (m)</th>
<th>Heavy Suspension Towers (m)</th>
<th>Tension Towers (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Suspension &amp; Heavy Suspension Tower</td>
<td>275</td>
<td>450</td>
<td>275</td>
</tr>
<tr>
<td>(b)</td>
<td>Maximum weight span</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>Minimum weight span</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2.2 Unbalanced Tension to be Considered (230kV only)

<table>
<thead>
<tr>
<th></th>
<th>Suspension Towers</th>
<th>0.6 x Max. working tension of Earthwire. 1.2 x Max. working tension of Conductor.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Heavy Suspension Towers</td>
<td>0.6 x Max. working tension of Earthwire. 1.2 x Max. working tension of Conductor.</td>
</tr>
<tr>
<td>(b)</td>
<td>Tension/Terminal Towers</td>
<td>1.0 x Max. working tension of Earthwire. 2.0 x Max. working tension of Conductor.</td>
</tr>
</tbody>
</table>

### 3.0 Security Loadings (Cascade Conditions)
3.1 2Q30 and 2QT6 Type Towers

<table>
<thead>
<tr>
<th></th>
<th>Wind span (A)</th>
<th></th>
<th>Tension Towers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>(m)</td>
<td>zero</td>
<td>(m)</td>
<td>570</td>
</tr>
<tr>
<td>(b)</td>
<td>Maximum weight span</td>
<td>(m)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.2 Unbalanced Tension to be Considered (230kV only)

<table>
<thead>
<tr>
<th></th>
<th>Tension/Terminal Towers</th>
<th>100% of conductor and earthwire tensions under everyday temperature and no wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.0 Broken Wire Assumption

4.1 Suspension & Heavy Suspension Tower

<table>
<thead>
<tr>
<th></th>
<th>Earthwire/OPGW is broken. However, earthwire/OPGW is not broken with conductor at the same time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>Both the conductors of one phase are broken.</td>
</tr>
</tbody>
</table>

4.2 Tension Towers

<table>
<thead>
<tr>
<th></th>
<th>One earthwire and both the conductors of one phase of same side with the earthwire are broken.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>Two phases (including both conductors per phase) of the same side are broken. However 4.2(a) and 4.2(b) shall not occur at the same time.</td>
</tr>
</tbody>
</table>

APPENDIX 8.A5
ASSUMED SYSTEM LOADING CRITERIA
APPENDIX 8.A6

MINIMUM THICKNESS & DIAMETER OF MATERIAL

The minimum thickness and diameter of material used in members and bolts shall be as detailed below:

(a) For leg members and compression chords in gantries and cross arms. (mm) 6

(b) For other members (including earthwire peaks) carrying calculated stress. (mm) 5

(c) For secondary members without calculated stress. (mm) 4

(d) Gusset plates for lattice towers. (mm) 6

(e) Bolt diameter for members carrying calculated stress. (mm) 16, 24 & 32

(f) Minimum bolt diameter for secondary members without calculated stress (mm) 16

APPENDIX 8.A7

1. ELECTRICAL CLEARANCES - LIVE METAL & EARTHED STEELWORK

Please refer to the Bid Drawing Section 19, Volume 2 of 3 of the Bidding Document.
2. SPATIAL DISTANCES

(a) Minimum height of phase conductors at the support on standard height, from ground level

(b) Minimum shielding angle of the earthwire (still air) from the vertical

(c) Maximum swing of the earthwire from vertical

(d) Minimum vertical spacing between adjacent phases

(e) Minimum projected horizontally spacing between adjacent phases spaced vertically

(f) Minimum vertical spacing between phase conductor and earthwire

(g) Minimum horizontal spacing between adjacent phase conductors spaced horizontally.

<table>
<thead>
<tr>
<th>230kV Overland</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Minimum height of phase conductors</td>
</tr>
<tr>
<td>(b) Minimum shielding angle</td>
</tr>
<tr>
<td>(c) Maximum swing</td>
</tr>
<tr>
<td>(d) Minimum vertical spacing</td>
</tr>
<tr>
<td>(e) Minimum projected horizontally spacing</td>
</tr>
<tr>
<td>(f) Minimum vertical spacing</td>
</tr>
<tr>
<td>(g) Minimum horizontal spacing</td>
</tr>
</tbody>
</table>

3. DOWNLEAD CLEARANCES

(a) The minimum clearance in still air at the assumed maximum conductor temperature between adjacent downleads shall not be less than.

(b) In exceptional circumstances and with the approval of the Employer, based on the condition of maximum (opposing) conductor swing and sag, the clearance may be reduced to.
APPENDIX 8.A8

1. **ANTI-CLIMBING DEVICES (ACD)**

<table>
<thead>
<tr>
<th>Required / Not Required</th>
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</thead>
<tbody>
<tr>
<td>(a) Barbed wire type at a minimum height above ground level ……… (m)</td>
</tr>
<tr>
<td>(b) Spiked type at a minimum height above ground level …………(m)</td>
</tr>
<tr>
<td>(c) Ladder to be fitted with spike type.</td>
</tr>
<tr>
<td>(d) All bolts below the bottom cross-arm level shall be locked by locknuts (Anti-theft type).</td>
</tr>
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</table>

2. **ACCESS FACILITIES**

<table>
<thead>
<tr>
<th>Required / Not Required</th>
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</thead>
<tbody>
<tr>
<td>(a) Step bolts fitted between Ground level &amp; within 1m of top of towers</td>
</tr>
<tr>
<td>(b) Ladders fitted between</td>
</tr>
<tr>
<td>(c) Rest platforms</td>
</tr>
<tr>
<td>(d) Work platforms</td>
</tr>
<tr>
<td>(e) Fall arrest system Every Cross-arm tie member</td>
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</table>

3. **DANGER & IDENTIFICATION PLATES**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>(a) Danger Plate</td>
</tr>
<tr>
<td>(b) Tower Number, Circuit Identification &amp; Phase Color Plate.</td>
</tr>
</tbody>
</table>
APPENDIX 8.A9

QUALITY CONTROL WELD INSPECTION LEVELS

Level 1: All welded items not covered by higher level of inspection

Level 2: 

Level 3: Conductor attachment fittings for all types of towers.

APPENDIX 8.A10

TOWER TEST REQUIREMENTS

Proto Assembly:

All towers with all extensions shall require proto assembly tests to be performed in the manufacturer’s premises before starting the batch manufacturing of towers.

All costs related to such tests shall deem to be included in the Contract Price.

Visual Check, Galvanizing test and Mechanical Test of Members/Nuts & Bolts/Plates:

Before mass (batch) fabrication/manufacturing of tower materials the Contractor shall submit the proto assembly test report of towers for acceptance of the Employer. The Contractor shall proceed mass fabrication of towers after acceptance of the said test report by the Employer. After mass fabrication, tower members shall visually checked for dimension and galvanizing thickness (which shall include weight basis test also). Mechanical tests shall also be done on the finished tower materials.

All costs related to such tests shall deem to be included in the Contract Price.
# APPENDIX 8.BI

ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

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<th>Document Description</th>
<th>Comment</th>
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<td>Design Calculation</td>
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<td>8.2.25</td>
<td>Fabrication Drawings</td>
<td></td>
</tr>
<tr>
<td>8.6.1</td>
<td>Method Statement</td>
<td></td>
</tr>
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<td>Bolt &amp; Nut Test Certificates</td>
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<td>8.7.2</td>
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<td>If requested</td>
</tr>
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<td>8.7.2</td>
<td>Welders test certificates If requested</td>
<td>If requested</td>
</tr>
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<td>8.7.2</td>
<td>NDT procedures</td>
<td></td>
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<td>8.7.2</td>
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<td>If requested</td>
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<td>Pot melt analysis</td>
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<td>Damaged Galvanizing</td>
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<td>Prototype tower test programme</td>
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<td>8.7.7</td>
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<td>Prototype tower test</td>
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APPENDIX 8.D1

REFERENCE STANDARDS

The reference standards and other documents referred to in this specification are listed below:

IEC 60652: Loading Tests on Overhead Line Towers
BS 4: Structural Steel Sections
Part 1: Specification for hot rolled sections
BS 183: Specification for general purpose galvanised steel wire strand
BS EN 10244-2: Specification for testing zinc coatings on steel wire and for quality requirements.
BS EN 134411-1: Specification for thimbles for wire ropes.
BS EN ISO 1461: Specification for hot-dipped galvanising coating, on iron and steel article.
BS 970: Specification for wrought steel for mechanical and allied engineering purposes.
General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steel
BS EN 10083, 4, 5, 7, 8
BS EN 10095,
BS EN 10250-4
BS PD 970
BS EN 515: Specification for wrought aluminium and aluminium alloys for general engineering purposes, bars, extruded round tubes and sections.
BS EN 573-3, 4
BS EN 755-1 to 9
BS EN 12020-1,2
BS 1574: Specification for split cotter pins.
BS EN 1563: Specification for spheroidal graphite or nodular graphite cast iron.
BS 3643: ISO Metric screw threads.
Part 2: Specification for selected limits of size
BS EN 1714: Method of ultrasonic examination of welds.
Method of manual examination of fusion welds in ferric steel.
BS 4102: Steel wire and wire products for fences.
BS 4190: Specification for ISO metric hexagon bolts, screws and nuts.
BS 4211 Ladders for permanent access to chimneys, other high structures, silos and bins.
BS 4320: Specification for metal washer for general engineering purposes.
Metric series.
BS 4464: Specification for spring, washers for general engineering and automobile.
BS 4592: Industrial type metal flooring, walkways and stair treads.
BS EN ISO 14122-1 to 3
BS EN 10210-2: Hot rolled structural steel sections.
Specification for hot-finished hollow sections.
BS EN 10056-1: Equal and unequal angles.
BS EN 1011-1,2: Specification for arc welding of carbon and carbon manganese steels
BS 5531 Code of practice. For safety in erecting structural frames.
BS 5950: Structural use of steelwork in buildings.
BS ISO 10160: Methods of ultrasonic testing and specifying, quality grades of ferric steel plates.
BS EN ISO 9934: Methods for magnetic particle flow detection.
BS EN 1562: Specification for malleable cast iron.
BS EN 287: Approval testing of welders for fusion welding.
BS EN ISO 15607: Specification and approval of welding procedures for metallic materials.
BS EN ISO 15609 BS EN ISO 15610, 15611, 15612, 15613, 1561
BS EN 353: Personal protective equipment against falls from heights
BS EN 353-1: Guided type fall arresters including a rigid anchorage line.
BS EN 353-2: Guided type fall arresters including a flexible anchorage line.
BS EN 360: Personal protective equipment against falls from a height. Retractable type fall arrestors.
BS EN 1179: Specification for Zinc & Zinc Alloys – Primary zinc.
BS EN 10024: Hot rolled taper flange I-sections. Tolerance on shape and dimensions.
BS EN 10025: Specification for hot rolled products of non-alloyed structural steels a their technical delivery requirements.
BS EN 10029: Tolerance on dimensions, shape and mass of hot rolled steel plate 3 mm thick or above.
BS EN 10034: Structural steel I and H sections. Tolerance on shape and dimensions.
BS EN 10056: Specification for structural steel equal and unequal angles Part 2 Tolerance on shape and dimension
BS EN 10163: Delivery requirements for surface conditions of hot rolled steel plates, wide flats and sections.
Part 1 General requirements
Part 2: Plates and wide flats
Part 3: Sections
BS EN 10210-1: Hot finished structural hollow sections of non-alloy and fine grained structural steels- Technical delivery requirements
BS 8100-3 Code of Practice for strength assessment of members of lattice towers masts.

ANSI/ASCE Std 10-97 Design of Steel Transmission Towers.
### ULTIMATE TOWER REACTIONS

230 kV Double Circuit Towers  
(Narrow Base Width)  
(Excluding Foundation Strength Factor)

<table>
<thead>
<tr>
<th>Tower Type</th>
<th>Down Thrust (Along Leg Direction)</th>
<th>Uplift (Along Leg Direction)</th>
<th>Horizontal Component</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>kN</td>
<td>kN</td>
<td>Hz (Transverse)</td>
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<tr>
<td></td>
<td></td>
<td>kN</td>
<td>Hz (Longitudinal)</td>
</tr>
<tr>
<td>2DL</td>
<td>2655</td>
<td>2357</td>
<td>312</td>
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<tr>
<td></td>
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<td>255</td>
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<td>2D1</td>
<td>3268</td>
<td>2793</td>
<td>447</td>
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<td>357</td>
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<td>2D25</td>
<td>5257</td>
<td>4719</td>
<td>832</td>
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<td>2DT6 (Terminal)</td>
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<td></td>
<td></td>
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### FOUNDATION STRENGTH FACTOR

230kV Double Circuit Towers

The following strength factors shall be used to increase the ultimate tower reactions on the foundations for the design of the foundations:

<table>
<thead>
<tr>
<th>Applied Loading Case</th>
<th>Strength Factor</th>
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</thead>
<tbody>
<tr>
<td>Tower Type</td>
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</tr>
<tr>
<td>All load cases</td>
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</tr>
<tr>
<td></td>
<td>2D1, 2D25, 2DT6</td>
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<tr>
<td></td>
<td>1.23</td>
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<td>1.35</td>
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</table>
ULTIMATE TOWER REACTIONS
230 kV Four Circuit Towers
(Excluding Foundation Strength Factor)

<table>
<thead>
<tr>
<th>Tower Type</th>
<th>Down Thrust (Along Leg Direction)</th>
<th>Uplift (Along Leg Direction)</th>
<th>Horizontal Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg</td>
<td>Kg</td>
<td>Kg</td>
</tr>
<tr>
<td>2QL</td>
<td>315602</td>
<td>285770</td>
<td>44184</td>
</tr>
<tr>
<td>2Q1</td>
<td>499498</td>
<td>443000</td>
<td>79920</td>
</tr>
<tr>
<td>2Q15</td>
<td>694320</td>
<td>648407</td>
<td>124978</td>
</tr>
<tr>
<td>2Q30</td>
<td>743235</td>
<td>693450</td>
<td>148647</td>
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<tr>
<td>2QT6</td>
<td>925312</td>
<td>870000</td>
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</table>

FOUNDATION STRENGTH FACTOR
230kV Four Circuit

The following strength factors shall be used to increase the ultimate tower reactions on the foundations for the design of the foundations:

<table>
<thead>
<tr>
<th>Applied Loading Case</th>
<th>Strength Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower Type</td>
<td></td>
</tr>
<tr>
<td>2QL, 2Q1</td>
<td>1.33</td>
</tr>
<tr>
<td>2Q15, 2Q30, 2QT6</td>
<td>1.60</td>
</tr>
<tr>
<td>Normal Condition, High Intensity Local wind condition</td>
<td>1.33</td>
</tr>
<tr>
<td>Security Condition</td>
<td>1.60</td>
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</tbody>
</table>

APPENDIX 8.E1/2
FOUNDATION REACTION FORCES
### 132 kV Double Circuit Towers
(Narrow Base Width)
(Including Foundation Strength Factor)

<table>
<thead>
<tr>
<th>Tower Type</th>
<th>Down Thrust (Along the Leg)</th>
<th>Uplift (Along the Leg)</th>
<th>Horizontal Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kg</td>
<td>Kg</td>
<td>Hx (Transverse)</td>
</tr>
<tr>
<td>1DL</td>
<td>115226</td>
<td>107703</td>
<td>772</td>
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<tr>
<td>1D1</td>
<td>190459</td>
<td>177936</td>
<td>3339</td>
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<tr>
<td>1D25</td>
<td>264413</td>
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<td>1DT6 (Angle)</td>
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</table>

### FOUNDATION REACTION FORCES

132 kV Double Circuit Towers
(Normal Base Width)
(Including Foundation Strength Factor)

<table>
<thead>
<tr>
<th>Tower Type</th>
<th>Down Thrust (Along Global Axis)</th>
<th>Uplift (Along Global Axis)</th>
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<tbody>
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<td></td>
<td>Kg</td>
<td>kg</td>
<td>Hx (Transverse)</td>
</tr>
<tr>
<td>1DL</td>
<td>55235</td>
<td>48413</td>
<td>2217</td>
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<td>1D1</td>
<td>86118</td>
<td>76892</td>
<td>2669</td>
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<td>1D25</td>
<td>115198</td>
<td>104239</td>
<td>4172</td>
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<td>1DT6 (Angle)</td>
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<td>146903</td>
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<td>1DT6 (Terminal)</td>
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<td>1DAX</td>
<td>653454</td>
<td>657055</td>
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<td>423418</td>
<td>401070</td>
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### FOUNDATION REACTION FORCES

132 kV Four Circuit Towers
(Normal Base Width)
(Including Foundation Strength Factor)
<table>
<thead>
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<th>Tower Type</th>
<th>Down Thrust (Along the Leg)</th>
<th>Uplift (Along the Leg)</th>
<th>Horizontal Component</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Kg</td>
<td>kg</td>
<td>Hz (Transverse)</td>
</tr>
<tr>
<td>1QL</td>
<td>127705</td>
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<td>306244</td>
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<td>6808</td>
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<td>502180</td>
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## SECTION 9  INSULATORS

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</table>

## APPENDIX
9.1 SCOPE

Both the type of insulator unit and insulator set, whether suspension or tension used on each type of support shall be approved, and shall have proven use under similar environmental and operational conditions.

Insulator strings shall comprise of porcelain disc insulator units. All types of insulators to be supplied under this Contract shall be supplied from the same manufacturer.

Reference shall be made to Appendix 9.A1 for details of the specific requirements. Where specified porcelain insulators shall be glazed Munsell Grey in accordance with BS 5252 or equivalent.

9.2 DESIGN

9.2.1 General

All insulator units shall be designed to withstand the design service voltages including lightning, switching and power frequency, the mechanical loads relevant to the installation-service-maintenance conditions, the service temperature and environmental effects. Internal stresses due to expansion and contraction of any part of the insulator unit shall not lead to deterioration.

The design of insulator units shall be such as to avoid local corona formation and no significant radio interferences shall be exhibited. Cap & Pin insulator units shall comply with the general requirements of the IEC 60305 standard, except where specified otherwise in this Specification and insulator units shall have straight head design to avoid concentration of mechanical stress. Cross section sketch of insulators unit showing the head design is included in the enclosed drawing in Section 19.

9.2.2 Electrical and Mechanical Characteristics

The individual insulator units shall be complete insulator sets shall have the electrical and mechanical characteristics stated in Appendix 9.A2.

9.2.3 Couplings

Couplings between individual insulator units shall be as specified in Appendix 9.A1. Ball and socket couplings shall be in accordance with the requirements of IEC 60120. Sockets shall either have W type security clips, or a split pin (R) clip in accordance with the requirements of IEC 60372 as specified.
9.2.4 Pollution

The design of insulator units shall take into account the principles contained in IEC 60815 for the specified pollution category. However, minimum creepage values (mm/kV) shall be as specified.

9.2.5 Zinc Sleeve

Cap and pin insulator units shall where specified be fitted with zinc sleeve pins to prevent cracking due to pin corrosion caused by the effects of pollution and high humidity. The exposed part of the sleeve shall have a mass of at least 5(five) gram and metallurgic alloy bonded to the insulator pin.

9.2.6 Insulator Protective Device

The design of insulator protective fittings including corona shields shall comply with the following requirements:

(a) Shall effectively protect the insulator units, and the fittings from damage caused by power arcs;
(b) shall effectively improve the voltage distribution along the insulator string;
(c) shall effectively improve the corona performance of the insulator set;
(d) shall be designed in such a way as not to be subject to breakage fatigue due to wind induced vibration;
(e) shall withstand a specified mechanical load.
(f) shall be suitable where specified for live-line maintenance.

For details of the materials, workmanship and quality control requirements for insulator protective fittings reference shall be made to Section 10 of this Specification.

9.2.7 Low Duty Insulator Sets

Low duty tension sets shall be used for the downleads between terminal supports and substation gantry structures or other positions where the conductor tensions are of a reduced value. At the lower end of the downleads the low duty tension sets shall be capable of having their units reversed.

9.2.8 Tension Insulator Sets-Earth End Linkages

Additional earth end adjustable linkages shall be provided where necessary to ensure that either the specified clearance is maintained between the tension insulator set and the support body/crossarm, or that satisfactory pairing is achieved between the phase sub-conductors.
9.3 MATERIALS

High grade, wet process porcelain used in the manufacturer of insulator units shall comply with the requirement of IEC 60672.

Insulator caps and bases of malleable cast iron shall be manufactured from a suitable grade of MCI complying with the requirement of BS EN 1563 for spheroidal graphite, or BS EN 1562 for whiteheart and pearlytic. Ductile cast iron of suitable grade may be used for caps and bases.

Insulator end fittings of forced or cast aluminium alloy shall be manufactured from a suitable grade of aluminium alloy complying with the requirements of BS EN 515, 573, 586, 603, 604 or BS EN 1559, 1676, 1706 and/or BS EN 1676 or equivalent respectively.

Security 'W' clips shall be of phosphor-bronze composition in accordance with the requirements of BS EN 1172, 1652, 1653, 1654 or equivalent and supplied in the half-hard condition with a minimum harness of 155 VPN.

Security 'R' clips shall be of austenitic stainless steel capable of complying with the requirements of relating to inter-crystalline corrosion tests of BS 970: Part 1 and BS EN 10084, 10085, 10087, 10095, 10250 and PD 970.

Zinc sleeve shall have a total impurity not greater than 0.2 percent and shall comply with the requirement of BS EN 1179 or equivalent.

9.4 WORKMANKSHIP

9.4.1 Insulator Units

The dimensions of all insulator units, together with materials and grades and other pertinent information shall be shown on the contract drawings. Contract drawings shall be submitted to the Engineer. **This is a Hold Point.**

Particular regard shall be paid to those dimensions which involve interchangeability, correct assembly and those for which gauges are specified. Where appropriate insulator caps and pins shall comply with the requirement of IEC 60120, IEC 60372 and IEC 60471.

Porcelain shall be sound, thoroughly vitrified and free from defects and blemishes which might adversely affect the life of the insulator units.

Cement used in the construction of an insulator unit shall not fracture by virtue of expansion, nor loosen by contraction and proper care shall be taken to locate the individual parts correctly during assembly. The cement shall not give rise to chemical reaction with metal fittings nor the zinc collars. The cement thickness shall be as uniform as possible.

All insulator caps and bases are to be free from flaws, blowholes and shall be of a close-grained quality.
Insulator pins shall be round, free from cracks, surface flaws, lamination and other defects.

The zinc sleeve shall not be porous and all mould lines shall be removed. The cement level shall be approximately at the mid-point of the sleeve.

9.4.2 Identification and Marking

All insulator units shall be marked to ensure a system of traceability. Each unit shall be clearly and indelibly marked as follows on the insulating component according to the requirements of IEC 60383-1:

(a) Electromechanical failing load
(b) Name or trade mark of the manufacturer
(c) Year of manufacture.

9.4.3 Installation Criteria

The manufacturer shall where necessary provide comprehensive instructions in a suitable format regarding, the handling and installation of insulator units.

9.4.4 Erection

The Contractor shall provide the Engineer with a method statement giving sequential details of the proposed erection method. The method statement shall be submitted to the Employer, the requisite period before insulator set erection commences. This is a Hold Point.

Care shall be exercised in the handling and erection of insulator units to prevent scratches, chipping or cracking of the insulation medium.

The Engineer shall be reasonable entitled to request the removal and destruction of any insulator units from a string which they notice has been severely handled or knocked during erection. All units which are scratched, chipped or abraded shall be removed and replaced. Insulator units and fittings shall be laid on plastic sheets prior to erection and any foreign matter shall be removed prior to installation.

The Contractor shall ensure that insulator units are not strained or damaged in any way during erection.

All bolt threads shall be coated with an approved grease immediately before erection.

9.5 PROTECTIVE TREATMENT

All insulator caps, bases and pins shall either be inherently resistant to atmospheric corrosion or suitably protected against corrosion, such as may occur in transit, storage and in service. All ferrous parts which will be exposed to the atmosphere in service, except those made in the appropriate grade of stainless steel, shall be
protected by hot dipped galvanising to comply with the requirements of BS ISO 1461. All manufacturing processes shall be completed prior to galvanising.

The ingot zinc used for galvanising shall comply with the requirements of BS EN 1179 or equivalent.

All galvanised materials shall be stored on packing, clear off the ground and away from all materials that might stain or corrode the galvanising. Black steel packing, or bins shall not be used.

9.6 QUALITY CONTROL

9.6.1 General

Type, sample and routine tests shall be undertaken on all insulator units and type tests on insulator sets in accordance with the requirements of this Specification. Details of the test requirements are summarised in Table 9.1.

Acceptance criteria for Thermal Mechanical Performance Test and Electromechanical Failing (EMT) load test shall be governed by the following, formula, irrespective of sample size:

\[
3 \leq C = \frac{X - SFL}{\sigma}
\]

where, 
- \(C\) = Acceptance Constant
- \(X\) = Mean value of failing load
- \(SFL\) = Specified EMT load
- \(\sigma\) = Standard deviation

Test result of each sample shall not be less than the specified EMF load. The results (mean value and standard deviation) of Thermal-Mechanical Performance Test shall not differ from the results of the ordinary Electro-Mechanical Failing Load Tests.

In addition electrical puncture shall not occur before ultimate fracture.

Contract drawings previously submitted to the Employer shall be available at the time of testing.

The Contractor shall give the Employer the requisite period of notice prior to undertaking the tests, and shall submit to the Employer a test program and procedures. This is a Hold Point.

9.6.2 Type Tests

(i) String Insulator Units

Type test for string (cap and pin), insulator units shall be in accordance with all the requirements of IEC 60383-1.
Methods of tests shall comply with the requirements of the above standard, unless otherwise specified in the following clauses.

(ii) **Insulator Sets**

Type tests for insulator sets comprising cap and pin, insulator units complete with all appropriate fittings including insulator protective fittings shall be undertaken in accordance with the requirements of IEC 60383-2, to determine the dry lightning impulse withstand voltage, wet switching impulse withstand voltage and the power frequency withstand voltage as appropriate.

The manufacture shall submit details of the proposed simulation of the support structure and mounting arrangement of the insulator sets to the Employer. **This is a Hold Point.**

(iii) **Radio Interference & Corona**

Radio interference type tests shall be under-taken both on single insulator units followed by a complete insulator set test. All radio noise measurements shall be made at a frequency of 1.0 MHZ (9 kHz band width), using a radio interference measuring set having a response conforming to CISPR Publication 1. The test circuit shall conform to IEC 60437 and shall be calibrated in-situ to determine any circuit losses. The set shall be adjusted to indicate correctly, or alternatively an appropriate correction (in dB) shall be added to the measurement. Ideally the measurement shall be made using a 300 ohm load resistance. All readings shall be converted to dB above 1μV across 300 ohms, taking into account any corrections necessary.

The single unit test voltage shall be that which would appear across the live end unit in the complete set test and shall be determined by an initial voltage distribution measurement.

Before final readings of the radio noise are taken it is permissible to wipe the unit with a dry clean cloth, and to condition it at not more than 50% above the test voltage for upto 2 minutes. This may be repeated if the first measurement exceeds the first level.

The maximum permitted radio noise levels per insulator unit shall not exceed the values stated in Appendix 9.A2.

The number of units tested shall be either 1.5 times the number of units in a complete string or six units whichever is the greater. The choice of set make up to be tested shall be that likely to give the highest voltage across the live end unit with the shortest arc gap. Three pairs of units shall be selected from those previously tested as single units (the most noisy units).

Each pair shall comprise the live end and penultimate live end unit of a single string or the pair of live end units for a duplex string, each pair shall be tested
in turn in the set.

The radio noise test voltage and limits shall be in accordance with IEC 60437. None of the tests shall give rise to radio noise levels exceeding the specified limits. Each set shall also be tested for visible corona extinction. Light shall be excluded from the laboratory and the observer's eyesight allowed time to become accustomed to the dark. The voltage shall be increased until corona appears on the string. The voltage shall be gradually reduced until all discharges on the string are extinguished. The extinction voltage shall be measured, and shall be minimum 0.8 times the nominal system voltage plus 5%. All appropriate action shall be taken to eliminate discharges from test equipment, thereby avoiding spurious corona observations and radio inference readings.

(iv) Type Tests - Pollution

Artificial pollution tests (salt fog method) in accordance with the requirements of IEC 60507 shall be undertaken.

The salinity of the salt solution and the power frequency withstand voltage shall be in accordance with Appendix 9.A3

(v) Power Arc Tests

(a) Power Arc Test for complete Insulator Set.

Power arc tests to simulate the effect of short circuit current shall be undertaken on the complete insulator set.

The power arc current shall be in accordance with Appendix 9.A2.

The function of the insulator protective devices shall not be greatly affected by the power arc.

(b) Power Arc Test for Insulator Unit.

Power arc test shall also be performed to prove the ability of the insulator units to withstand the heat generated by power arc. This test shall be performed in the following manner:

Nine (9) insulator units of each type shall be chosen for the power arc test. Tests shall be conducted on the above chosen insulator units in three (3) strings of three (3) insulator units each. Strings shall be mounted vertically without arcing horns or conductors. The current and duration of power arc shall be 12kA (symmetrical r.m.s) and 0.1s or 6kA (symmetrical r.m.s) and 0.2 s.

No shed breakage shall occur during the power arc test. Peeling-off or burn out of glaze on the insulator surface and partial rib chip shall be permitted. If two or more insulator units string break in the power arc test, this insulator design is considered to have failed to meet the specifications. In case one
insulator unit fails in the test, re-test on another nine (9) insulator units shall be conducted in the same manner. Failure of anyone unit in the re-test means that the insulator design has failed to meet the specification.

(vi) **Impulse Voltage Puncture Tests**

Impulse voltage puncture tests shall be undertaken in accordance with the requirements of IEC 61211.

(vii) **Residual Strength Tests**

Residual strength tests shall be undertaken in accordance with the recommendations of IEC 60797. With all the outer shed material removed, the insulator stubs shall be capable of withstanding 80% of the rated minimum failing load for 1 minute.

The test shall be continued to destruction (where it is practicable) to obtain a representative value of the actual failing load, and allow the modes of failure to be determined.

### 9.6.3 Sample Tests

The Contractor shall, give the Employer the requisite period of notice prior to undertaking Sample Tests. This is a Notification Point.

Sample tests for string insulator (cap & pin) insulator units shall be undertaken in accordance with the requirements of IEC 60383-1, see also Table 9.1.

Sample tests in respect of radio noise shall be undertaken on single units only in accordance with the requirement of Clause 9.6.2(iii) of this Specification. The sample size shall generally be 0.5% of the batch offered for acceptance.

The number of sample to be checked regarding the metallurgical bond of the zinc sleeve to the pin shall be in accordance with IEC 61325.

The metallurgical purity of the zinc shall be established by chemical analysis to ensure that any impurities do not sensitise the zinc to intergranular corrosion.

The zinc sleeve of each sample tested for mechanical strength shall also be inspected according to IEC 61325, to ensure no radial and circumferential cracking has occurred.

Three insulators shall be selected at random from each lot of the order and their straight head design checked against the straight head design of the manufacturer’s cross-section drawing.

### 9.6.4 Routine Tests

Routine tests for string insulator (cap and pin) insulator units shall be undertaken in accordance with the requirements of IEC 60383-1, see also Table 9.1.
9.6.5 Galvanising

Tests for galvanised insulator caps, bases and pins shall be carried out at the works to ensure compliance with the requirements of ISO 1461. Details of the test results shall be made available to the Employer upon request.

Certificates relating to the ingot zinc used for galvanising shall also be made available to the Employer upon request.

9.6.7 Test Certificates

All metallic materials used in the manufacture of insulator caps, bases and pins shall be covered by test certificates stating their mechanical, chemical and where specified the impact properties and clearly showing the cast numbers to prove compliance with the requirements of this Specification and BS EN 1563, BS EN 1562, BS 970 and BS EN 10084, BS EN 10085 etc., BS EN 515, 573, 586, 603, 606, BS EN 1559, 1676, 1707, BS EN 1172, 1652, 1653, 1654, BS EN 1179 as appropriate.

Test certificates for metallic materials and bolts shall be made available to the Employer upon request.

Test certificates covering Type and Sample tests shall be made available to the Employer upon request.

9.6.8 Certificate of Conformity

When requested copies of the following certificates/records shall also be forwarded:

(a) Routine test records
(b) Metallic material test certificates
(c) Galvanizing test records
(d) Ingot zinc certificates
(e) Metallurgical purity test records for zinc sleeve.

9.6.9 Installation

The Contractor shall be responsible for checking that all insulator sets are complete and that all bolts, split pins and security clips have been correctly installed. A record of this work shall be kept by the Contractor and made available to the Employer upon request.
### TABLE 9.1 - TEST REQUIREMENTS

<table>
<thead>
<tr>
<th>Test</th>
<th>String Insulator Units Cap &amp; Pin (Type B)</th>
<th>Insulator Sets</th>
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<tr>
<td><strong>Type Tests:</strong></td>
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</tr>
<tr>
<td>Verification of dimensions</td>
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<td>X</td>
</tr>
<tr>
<td>Dry lightning, impulse w. voltage</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Wet power frequency w. voltage</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Thermal mechanical performance</td>
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<tr>
<td>Mechanical or EMF load</td>
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<td></td>
</tr>
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<td>Radia Interference Voltage (RIV)</td>
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<td>X</td>
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<tr>
<td>Pollution performance</td>
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<td>Power arc</td>
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<td>X</td>
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<tr>
<td>Impulse voltage puncture</td>
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<td></td>
</tr>
<tr>
<td>Zinc sleeve</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Residual strength</td>
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<td></td>
</tr>
<tr>
<td><strong>Sample Tests:</strong></td>
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<td></td>
</tr>
<tr>
<td>Verification of dimensions</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Verification of locking system and displacement</td>
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</tr>
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<tr>
<td>X Porosity</td>
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- Indicates not applicable.
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</thead>
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<tr>
<td>Galvanising,</td>
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</tr>
<tr>
<td>RIV</td>
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<td></td>
</tr>
<tr>
<td>Impulse Voltage puncture</td>
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<td></td>
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<tr>
<td>Zinc sleeve test</td>
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<td></td>
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<tr>
<td>Head design test</td>
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**Routine Tests:**

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<tr>
<td>Electrical</td>
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**Notes:**

(a) $Um \leq 245$ kV  
(b) Insulator string without fittings
# APPENDIX 9.A1/1

## INSULATOR TYPES & USES

### 230KV LINE

<table>
<thead>
<tr>
<th>Insulator Set Type</th>
<th>Suspension/Heavy Suspension*</th>
<th>Tension</th>
<th>Low Duty Tension</th>
<th>Jumper Suspension</th>
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<tr>
<td>Nominal System Voltage</td>
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<tr>
<td>String Configuration</td>
<td>Single</td>
<td>Twin</td>
<td>Single</td>
<td>Single</td>
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<tr>
<td>Reference Drawing</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Insulator Unit type</td>
<td>{Cap &amp; Pin type disc insulator}</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Coupling Type as per IEC 60305</td>
<td>{Ball &amp; Socket}</td>
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<tr>
<td>Insulating Material</td>
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<tr>
<td>Security Clip type</td>
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<tr>
<td>Zinc Sleeve</td>
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<tr>
<td>Head design</td>
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# APPENDIX 9.A1/2

## INSULATOR TYPES & USES

### 132KV LINE

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<th>Insulator Set Type</th>
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<td>Reference Drawing</td>
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<td>Insulator Unit type</td>
<td>{Cap &amp; Pin type disc insulator}</td>
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<tr>
<td>Coupling Type as per IEC 60305</td>
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<td>Insulating Material</td>
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<tr>
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<tr>
<td>Head design</td>
<td>{Straight Head}</td>
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<td>Head design</td>
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## APPENDIX 9.A2/1

### ELECTRICAL & MECHANICAL CHARACTERISTICS

#### 230KV LINE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Suspensions/ Jumper Suspensions</th>
<th>Heavy Suspension</th>
<th>Tension (Twin)</th>
<th>Upright Low Duty</th>
<th>Inverted Low Duty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollution Category</td>
<td>{……………………..Medium II……………………}</td>
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<tr>
<td>Nominal Creepage</td>
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<tr>
<td>Insulator type</td>
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<td>{……………….Cap &amp; Pin type disc insulators….}</td>
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<td>Insulator Unit Reference</td>
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<tr>
<td>Unit Puncture Voltage kV</td>
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<tr>
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<tr>
<td>Max. Insulator String length without fittings m m</td>
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<td>Dry Lightning Impulse Withstand voltage kV</td>
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<td>Wet power frequency Withstand voltage kV</td>
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<td>{…………………….460}</td>
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<td>Power Arc for insulator set</td>
<td>kA s</td>
<td>{…………………….31.5}</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>-Current</td>
<td></td>
<td>{……………………}</td>
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<tr>
<td>-Duration</td>
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<td>{…………………….0.5}</td>
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<td>Power arc for string insulator units: Current for duration kA for s</td>
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<td>{…………………….12 for 0.1 or 6 for 0.2}</td>
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<tr>
<td>Arc Gap Nominal m m</td>
<td>2100 2100 2100 1910 1910</td>
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</table>
## ELECTRICAL & MECHANICAL CHARACTERISTICS
### 132KV LINE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Suspension/ Jumper Suspension</th>
<th>Heavy Suspension</th>
<th>Tension Upright Low Duty</th>
<th>Inverted Low Duty</th>
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<tbody>
<tr>
<td>Pollution Category</td>
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<td>Nominal Creepage</td>
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<tr>
<td>Insulator type</td>
<td>{..............................Cap &amp; Pin type disc insulators}</td>
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<tr>
<td>Insulator Unit Reference</td>
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<td>U120B</td>
<td>U70BL</td>
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<td>Grey</td>
<td>Brown</td>
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<td>Unit Puncture Voltage</td>
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<td>Dielectric material</td>
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TYPE TEST - POLLUTION IEC 60507

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REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of Specification are listed below:

IEC 60120: Dimensions of ball and socket couplings of string, insulator units
IEC 60305: Characteristics of string, insulator units of cap and pin type
IEC 60372: Locking devices for ball and socket coupling of string insulator units - Dimensions and tests
IEC 60383: Insulators for overhead lines with a nominal voltage above 1000V
  Part 1: Ceramic or glass insulator units for ac systems Definitions, test methods and acceptance criteria
  Part 2: Insulator string and insulator sets for ac - Definitions, test method and acceptance criteria
IEC 60437: Radio interference tests on high voltage insulators
IEC 60471: Dimensions of clevis and tongue couplings of string insulator units
IEC 60507: Artificial pollution tests on high-voltage insulators to be used on a.c. systems
IEC 60672: Specification for ceramic and glass insulating materials
IEC 60797: Residual strength of string, insulator units of glass or ceramic, materials for overhead lines after mechanical damage of the dielectric
IEC 60815: Guide for selection of insulators in respect of polluted conditions
IEC 61211: Insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000V - Puncture testing
IEC 61325: Insulators for overhead lines with nominal voltage > 1000 V
ISO 1461: Specification for hot-dipped galvanizing coating on iron and steel articles
BS EN 10084: Specification for wrought steel for mechanical and applied Engineering purposes
BS EN 10085
BS EN 10087
BS EN 10095
BS EN 10250
PD 970
BS EN 515: Specification for wrought aluminium and aluminium alloy
BS EN 573
BS EN 586
BS EN 603
BS EN 604
BS EN 1559: Specification for Aluminium and aluminium alloy ingots and casting for general engineering purposes
BS EN 1676
BS EN 1706
BS EN 1172: Specification for Rolled Copper and Copper Alloys: Sheet, strip and foil
BS EN 1652
BS EN 1653
BS EN 1654
BS EN 1563
BS 4190: Specification for ISO metric hexagon bolts, screws and nuts
BS 5252: Framework for colour co-ordinations of buildings
BS EN 1562: Specification for malleable cast iron
BS EN 1179: Specification for Zinc & Zinc Alloys
BS EN 1676: Aluminium & aluminium alloys - Alloyed ingots for re-melting
CISPR: Publication 1 Specification for CISPR radio interference measuring apparatus for the frequency range 0.15 to 30 MHz.
## INSULATOR AND CONDUCTOR FITTINGS

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APPENDIX
SECTION 10

INSULATOR AND CONDUCTOR FITTINGS

10.1 SCOPE

10.1.1 Types and Uses

The type and arrangement of all insulator and earthwire sets inclusive of all insulator and earthwire set fittings, suspension clamps, conductor tension fittings and insulator protective devices shall be approved.

Reference shall be made to Appendix 10.A1, A2 and A3 for details of the specific requirements.

10.2 DESIGN

10.2.1 General

All insulator and conductor fittings shall be designed so as to:

(a) avoid damaging the conductor under all service conditions;

(b) withstand the mechanical loads relevant to the installation-service-maintenance conditions, the design service current including short circuit effects, the service temperature and environmental effects;

(c) be free from visible and audible corona discharge and radio interference at the voltage levels specified, except those designed exclusively for use on earthwires;

(d) minimise the number of parts and the possibility of incorrect assembly and installation;

(e) ensure that individual components are secured against becoming loose in service, and all threaded fasteners shall be locked;

(f) Compression fittings after compression shall not permit relative movement between the individual layers of the conductor.

(g) from material, which have sufficient strength, ductility and environmental resistance to withstand the static and dynamic loading.

Where appropriate insulator and conductor fittings shall be in accordance with the requirements of IEC 61284. Ball and socket coupling shall be in accordance with the requirements of IEC 60120. Socket fitting shall be designed for 'W' type security clips or 'R' type security pins in accordance with the requirements of IEC 60372 as appropriate, clevis tongue couplings shall be in accordance with the requirements of IEC 60471.
All factory formed helical fittings shall be performed with a right hand lay and shall completely enclose the conductor except for small gaps required to ensure that all rods make good contact with the conductor over their entire length.

### 10.2.3 Live-Line Working

Where live-line working is specified in Appendix 10.A1 the design of the fittings shall take into account the following requirements:

- **(a)** both suspension and tension insulator sets shall include either clevis fittings, or yoke plates incorporating cut-outs correctly dimensioned suitable for live-line working;
- **(b)** the minimum distance between the attachment point and the shoulder for clevis fittings shall not be less than 125 mm, where no yoke plate is adjacent;
- **(c)** clevis and tongue and clevis-clevis connections shall be provided with 'R' type security pins;
- **(d)** insulator protective devices attached to yoke plates shall utilise captive bolts.

### 10.2.4 Sag Adjusters

All tension insulator sets shall incorporate sag adjusters for adjusting the sag of either Individual phase conductors or sub-conductors forming a phase conductor bundle. The total range of linear adjustment and individual steps shall be as specified in Appendix 10.A1.

When specified low-duty tension insulator sets shall incorporate a turnbuckle for adjusting the sag of the complete downlead. The turnbuckle where appropriate shall comply with the requirements of BS 4429 and shall be fitted with locknuts. The total range of linear adjustment shall be as specified in Appendix 10.A1. The turnbuckle shall be fitted in the earth end of the low duty tension insulator set.

### 10.2.5 Insulator Protective Fittings:

The design of insulator protective fittings including corona shields shall comply with the following requirements:

- **(a)** shall effectively protect the insulator units, and the fittings from damage caused by power arcs;
- **(b)** shall effectively improve the voltage distribution along the insulator string;
- **(c)** shall effectively improve the corona performance of the insulator set;
(d) shall be designed in such a way as not to be subject to breakage fatigue due to wind induced vibration;
(e) shall withstand a specified mechanical load.

For details of the materials, workmanship and quality control requirements for insulator protective fittings reference shall be made to Sub-clause 10.3, 10.4 & 10.6 of Section 10 of this Specification.

The end of all arcing horns shall be formed into smooth hemispheres. The end of tubular arcing horns shall also be sealed.

10.2.6 Electrical and Mechanical Characteristics

The insulator and earthwire set fittings, suspension clamps, conductor tension fittings and insulator protection devices shall have the electrical and mechanical characteristics specified in Appendix 10.A1, A2 and A3.

10.2.7 Suspension Clamps

Suspension clamps shall be designed to meet the following requirements:

(a) so that the effects of vibration both on the conductors, or the earthwire and on the clamp themselves are minimised;
(b) to avoid localised pressure or damage to the conductor or earthwire, and shall have sufficient contact surface to avoid damage by fault currents;
(c) shall be free to pivot in the vertical plane of the conductor/earthwire and shall have a minimum range of movement of plus or minus 30 degrees;
(d) shall have a slipping capacity between specified minimum and maximum slipping loads so as to meet the requirement of Sub-clause 10.6.4 of Section 10 of this specification;
(e) suspension clamp assemblies shall have sufficient strength and durability to prevent deterioration in service;
(f) The mouth of the suspension clamp shall be rounded and slightly flared, with a minimum radius of curvature in the vertical plane of 150 mm.

10.2.8 Earthwire Suspension Clamps

Where specified earthwire suspension clamps and all suspension clamps for use with earthwire with embedded optical fibre cable and ADSS optical fibre cable shall be of the armour grip type, generally in accordance with the requirements of Clause 10.2.5, except that they shall be capable of being used in conjunction with factory formed helical armour rods and neoprene liners.
10.2.9 Counterweights

When specified counterweights shall either be fitted below the suspension clamp by extension of the clamp-keeper retaining bolts, by attachment to the yoke plate, or by replacement of the complete assemblies for multi-bundled conductors for use with pilot suspension insulator sets.

Where the complete clamp assembly is replaced, the counterweight shall be fitted with permanently bonded aluminium liners and all retaining bolts, nuts and washers shall not protrude beyond the cylindrical section of the weight.

10.2.10 Connectors and Joints

Connections and joints shall be designed to meet the following requirements:

(a) that after installation the initial contact area of the fitting to the conductor or earthwire does not raise stresses which may lead to failure under aeolian vibration or other conductor oscillation conditions;

(b) localised pressures which may cause excessive cold flow of the conductor or earthwire shall be avoided;

(c) to minimise internal voids and to prevent the ingress of moisture during service;

(d) full tension joints (dead ends and midspans) shall not permit slipping of, or cause damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the rated ultimate strength of the conductor;

(e) non tension joints and connectors shall not permit slipping of, or cause damage to the conductor at a load less than 25% of the rated ultimate strength of the conductor;

(f) those connectors and joints with auxiliary eyes intended for use during construction or maintenance shall be marked with the specified minimum failing loaded stated by the manufacturer.

10.2.11 Tee Connector

Tee connectors shall be as specified either interlocking compression type or bolted type.

10.2.12 Full Tension Joints (Dead End)

Full tension joints (dead end) shall be of the following types:

(a) Compression
Compression dead ends shall have either integral jumper terminals or jumper terminal flags for use with bolted jumper palms. Integral jumper terminals shall either be straight or 30 degree line type.

(b) **Bolted**

Bolted dead ends shall be designed to ensure that once the bolts have been tightened to the manufacturer's recommended torque, no slackening of the clamp can occur.

(c) **Wedge**

Wedge clamps shall be designed with the attachment straps. The body and the wedges shall be of forged aluminium alloy. The body shall be hinged and the design shall incorporate dovetail interlocking wedges and body. The performance of the clamp shall be unaffected by manufacturing tolerances in the wedges and the bodies. The design of the conductor guide assembly shall ensure that it is possible to tighten the bolts with the wedge clamp straps assembled in their correct position.

(d) **Factory Formed Helical**

For details of the exact requirements reference shall be made to Appendix 10.A3.

Helical dead ends for earthwires or ADSS optical fibre cables shall be supplied complete with solid thimbles in accordance with the requirements of BS EN 1311-1.

10.2.12 **Full Tension Joints (Midspans)**

Full tension midspan joints shall be of the compression type, joints for metallic conductors shall include a longitudinal centring key. Joints for mono-metallic conductors shall include a central barrier stop to ensure correct longitudinal centring of the joint.

10.2.13 **Non-Tension Joints**

Non-tension joints shall be of the following types:

(a) **Disconnectable**

Disconnectable joints shall comprise two identical straight palms, and shall be supplied complete with bolt assemblies. Bolt assemblies shall consist of bolts and nuts, grade 8.8/8 in accordance with BS 4190 complete with load spreading washers.

(b) **Non-disconnectable**

Non-disconnectable joints shall be of the compression type.

(c) **Jumper Palms**
Jumper palms for connecting jumper loops to dead ends, or tee connectors shall be of the compression type with either straight or 30 degree lugs. Bolt assemblies shall be in accordance with requirements specified for disconnectable joints.

10.2.14 Repair Sleeves

Repair sleeves shall be either compression types, or factory formed helical type. The compression type shall be two part interlocking sleeve or key type. Reference shall be made to Appendix 10.A3 for the specified requirements.

Repair sleeve shall be designed to make good a conductor of which not more than one-third of the strands of the outermost layer have been severed.

10.2.15 Line Termination Fittings

Line termination fittings shall be either bimetallic or aluminium. Bimetallic fittings shall be designed to prevent corrosion between dissimilar metals, they shall include both a waterproof barrier at the end of the compression termination and a waterproof joint adjacent to the substation equipment terminal.

Reference shall be made to Appendix 10.A3 for the specific requirements.

10.2.16 Armour Rods

Armour rods shall be of the factory formed helical type and comprise sets of individual rods compatible with the conductor. The rods shall completely enclose the conductor except for small gaps required to ensure that all the rods make good contact with the conductor over the entire length.

10.2.17 Jumper Weights

Jumper weights for multi-bundled phase conductors shall be fitted with permanently bonded aluminium liners, and all retaining bolts, nuts and washers shall not protrude beyond the section of the weight.

10.2.18 Tubular Jumpers

Tubular Jumpers where specified shall be supplied complete with integral compression jumper terminals. Earthing bars for tubular jumpers shall have captive locking bolts opposite to the hinge bolt. The earthing bar shall be of solid aluminium rod.

10.2.19 Earthwire Bonding Clamps

Earthwire bonding clamps for the connection of flexible earthwire bonds to the earthwire shall be explosively applied wedge tap assemblies C-type, in accordance with the requirements of BS EN 61238-1 Part 3. For OPGW termination positions the C-type connectors shall be complete with a lug. The lug shall have a 18 mm
10.2.20 Earthwire Bond

Earthwire bonds shall be manufactured from multi-strand, multi-wire fatigue resistant aluminium alloy to BS EN 50183, with a minimum nominal cross sectional area of 100mm². The overall bond and individual strands shall be thoroughly greased with an approved conductor grease (see Clause 11.3.2), before being covered by an extruded flexible PVC sheath, of minimum thickness 1.5 mm.

The bond shall be fitted with either a compression type lug or a compression type pin 20 mm diameter as appropriate. Compression lugs shall accommodate either M 16 or M 12 bolts.

10.3 MATERIALS

10.3.1 Insulator and Conductor Fittings

Materials used in the manufacture of insulator and conductor fittings shall be of:

(a) adequate strength for the intended application and service life requirements (including mechanical loads, vibrations, electrical currents and environmental effects) and free from defects which would affect the performance of the fitting;

(b) shall not be liable to intergranular or stress corrosion;

(c) the materials of compression fittings shall be capable of withstanding the cold working of the material due to compression;

(d) steel compression components shall have sufficient impact strength after compression;

(e) compatible with the conductor material, or capable of being used with an intermediate material such that there can be no detrimental effects on the conductor, or fittings resulting from their use;

(f) the material shall not be adversely affected in the long term by a coating applied for corrosion protection.

All phase conductor fittings shall have aluminium or aluminium alloy only in contact with the phase conductor.

All mild and high tensile steel used in the manufacture of insulator and conductor fittings including suspension saddles shall comply with the requirements of BS EN 10025. Minimum steel grades shall be S275JR and S355JR for mild and high tensile steel respectively.

Tubular steel used in the manufacture of insulator protective fittings shall be medium steel complying with requirements of BS 1387. Forged steel fittings shall
be made from steel of suitable grade, complying with the requirements relating to the inter-crystalline corrosion tests of BS 970: Part 1.

Malleable cast iron fittings shall be made from whiteheart or pearlitic MCI or spheroidal graphite MCI of a suitable grade complying with the requirements of BS EN 1562 or BS EN 1563 respectively.

Forged aluminium and aluminium alloy fittings shall be made from aluminium or aluminium alloy of a suitable grade, complying with the requirements of BS EN 515, 573, 586, 603 and 604.

Cast aluminium and aluminium alloy fittings shall be made from aluminium or aluminium alloy of a suitable grade, complying with the requirements of BS EN 1559, 1676 and 1706.

Twin-single bridging plates shall be manufactured from 99.9% pure EC grade aluminium.

Bolts and nuts shall be either ISO Metric Black Hexagon to BS 4190, and shall unless otherwise specified be threaded ISO Metric Course Pitch to BS 3643: Part 2, Tolerance Class 7h/8g, or ISO Metric Precision Hexagon to BS 3692.

Flat washers shall either comply with the requirements of BS 4320, Form E, Grade 4.6, or ISO Metric to BS 4320, 'bright series'. Spring washers shall be ISO Metric to BS 4464.

Split pins including 'R' type security pins shall comply with the requirements of BS 1574 and IEC 60372 respectively, and shall be of austenitic stainless steel capable of complying with the requirements relating to the intercrystalline corrosion tests of BS 970: Part 1 and BS EN 10084, 10085, 10087, 10095, 10250 and PD 970.

Security 'W' clips shall be of phosphor-bronze composition in accordance with BS EN 1172, 1652, 1653 and 1654, and supplied in half-hard condition with a minimum hardness of 155 VPN.

Non metallic materials used shall have:

(a) good resistance to ageing;

(b) capable of withstanding service temperatures without detrimental change of properties;

(c) adequate resistance to the effects of nitrogen oxides, ozone, ultra-violet radiation and air pollution over the whole range of service temperatures.

10.3.1 Oxide Inhibiting Compound

Compression fittings shall be filled with oxide inhibiting compounds prior to despatch from the manufacturers with the ends of the fittings temporarily protected. The quantity of oxide inhibiting compounds shall be sufficient to ensure the integrity of the fitting.
Where grease is used as an oxide inhibiting compound, it shall be of a neutral soft type with a high melting point, and shall be in accordance with the requirements of Clause 11.3.2.

10.4 WORKMANSHIP

10.4.1 General

The dimensions of all insulator and conductor fittings shall be shown on the contract drawings, together with material types and grades, protective treatment and any other pertinent information. Contract drawings shall be submitted to the Employer. This is a Hold Point. Particular regard shall be paid to those dimensions which involve interchangeability, correct assembly and those for which gauges are specified. Tolerances where appropriate shall be in accordance with the requirements of IEC 60372 or IEC 60471.

All castings shall be free from flaws, blowholes and shall be of a closed-grained quality. No repair of any casting shall be carried out without the approval of the Employer. This is a Hold Point.

The welding of all ferrous metals shall be carried out in accordance with BS EN 1011.

For river crossing suspension saddles all welding shall be undertaken in accordance with Clause 8.7.2. Inspection levels shall be level 4 or 5 as appropriate for fillet and butt welds, except that 100% of each welder’s output shall be tested.

Ball ended fittings shall be free from cracks, surface flows, laminations and other defects.

Fittings shall be free from sharp edges, burrs and swarf, particular attention shall be paid to insulator protective devices to prevent corona in service. The faces of flat faced fittings shall be sufficiently parallel and flat to provide a suitable contact service and shall remain so after fabrication. In addition care shall be taken to remove any surface contaminates prior to packing, other than material introduced by the manufacturer as a protective measure.

The mouth of suspension and top (trunnion) clamps, counterweight, wedge and bolted jumper weight clamps shall be free of sharp radius of curvature, ridges or other irregularities which may lead to localised pressure or damage to the conductors, or the separation of individual strands.

Factory formed helical fittings shall have rounded ends, when used with ADSS optical fibre cable the ends shall be relieved.

10.4.2 Identification and Marking

All insulator and conductor fittings shall be marked to ensure a system of traceability for each component part of the fittings. Where practicable, and unless
otherwise agreed between the Engineer and the manufacturer, fittings shall be clearly and indelibly marked with minimum 3 mm high characters as follows:

(a) Identification of fitting (reference number/specified minimum failing load);
(b) Maker's identification;
(c) Date of manufacture (month and year);
(d) Cast code - if appropriate;
(e) Conductor size or diameter range or code name - if appropriate;
(f) Fitting bolt installation torque - if appropriate;
(g) Compression die size - if appropriate;
(h) Length and direction to be compressed - if appropriate.

In the case of factory formed helical fittings, the information as required above shall be provided on tear-off labels; additionally they shall be marked with paint to an agreed colour code either at the cross-over point or at the centre of the fitting.

10.4.3 Installation Criteria

The supplier shall provide comprehensive instructions in a suitable format covering the selection and installation, including the installation torque of any bolt, compression die sizes and direction of compression.

Installation instructions shall include directions for the use of any additional materials to the fittings, including the selection of such materials and of the conductor preparation.

Joints and connectors intended for the restoration of electrical and mechanical properties of a conductor, shall have clearly defined manufacturer's instructions as to the extent of the damage which they are intended to repair.

10.5 PROTECTIVE TREATMENT

All parts of insulator and conductor fittings shall be either inherently resistant to atmospheric corrosion or suitably protected against corrosion, such as may occur in transit, storage and in service. All ferrous parts which will be exposed to the atmosphere in service, except those made in appropriate stainless steel, shall be protected by hot-dipped galvanising to comply with the requirements of BS ISO 1461. All manufacturing processes shall be completed prior to galvanising.

The ingot zinc used for galvanising shall comply with the requirements of BS EN 1179.

All external threads shall be cut or rolled before hot-dipped galvanised. Nuts to be galvanised shall be subsequently tapped 0.4 mm oversize with the threads oiled.
Where tubular steel insulator protective fittings are provided with galvanising vent-holes, these holes shall be effectively plugged after galvanising with zinc plugs.

The rough machined surfaces of bolted palm joints and aluminium line termination fittings shall be protected with a removable dry waterproof coating.

All galvanised materials shall be stored on packing, clear of the ground and away from all materials that might stain or corrode the galvanising. Black steel packing or bin shall not be used.

10.6 QUALITY CONTROL

10.6.1 General

Type, sample and routine tests shall be undertaken on insulator and conductor fittings in accordance with the requirements of this Specification. Type and sample test requirements are detailed in Table 10.1. Type tests specified in Table 10.1 shall be undertaken on a minimum of three samples, which shall be identical in all essential details, with the fittings to be supplied. Heat cycle tests shall be undertaken on four samples.

Contract drawings previously submitted to the Employer shall be available at the time of testing. The Contractor/Supplier shall give the Employer the requisite period of notice prior to undertaking the tests and shall submit to the Employer a test programme and procedures. **This is a Hold Point.**

In addition to the tests specified, when required by the Employer, electrical type tests shall be undertaken on complete insulator sets. For details of these tests reference should be made to Section 9 of this Specification.

**Mechanical Tests:**

10.6.2 Insulator Set and Earthwire Set Fittings

Each fitting shall withstand its specified minimum failing load for one minute, and shall be tested in a manner as far as practical to that in service. One sample shall if practical be taken to failure and the mode of failure recorded.

10.6.3 Insulator Protective Fittings

Insulator protective fittings shall be mechanically tested to withstand the specified loads for 1min without failure. A force of 1.8kN shall be applied to the tip of suspension arc horns, and 0.9 kN to tension arc-horns. The direction of the force shall correspond to that which would be applied by a linesman with the insulator set in service.

10.6.4 Conductor/Earthwire Suspension Clamps

(a) Tensile Test
The clamp supported by its trunnions as appropriate shall be installed at its recommended installation torque on a rigid bar of a suitable size and a tensile load equal to half its specified minimum failing load applied to 90 degrees to the conductor axis. The load shall be steadily increased, no failure shall occur at a load less than the specified minimum failing load.

(b) Conductor Slip Test

A length of conductor shall be fitted into the clamp and the clamp bolts tightened to the recommended torque. An axial tensile force shall be applied either to the conductor, or the clamp. The conductor shall not slip through the clamp below a load of 7kN or 5% of the nominal breaking load of the conductor, whichever is the greater value. The conductor shall slip through the clamp at a load not greater than 30% of the conductor minimum breaking load. The conductor shall not be damaged, other than some flattening of the strands.

10.6.5 Tension Joints, Tee Joints and Sleeves

The fitting shall be assembled in accordance with the manufacturer's instruction on conductors of the size and type with which it is to be used. The assembly shall be mounted in a tensile testing machine, the end fixings of the conductor shall be such as to prevent bird-caging or slipping of the individual strands. The length of conductor between fittings under test and any other clamp or joint in the test assembly shall not be less than 100 times the overall diameter of the conductor.

For factory formed helical tension terminations, the fitting shall be assembled in accordance with the manufacturer's instructions. A tensile load of 40% of the conductor breaking load shall be applied and maintained for 1min. The load shall be relaxed and the fitting removed. The fitting shall be reapplied and the test repeated, after subsequent removal and replacement the test shall be continued as detailed above.

For wedge clamps the test shall be carried out on a maximum size body and minimum size wedges and on a minimum size body and maximum size wedge. The maximum and minimum sizes shall be defined by the Manufacturer.

(a) The following additional requirement shall be applicable to wedge clamps:

- A 5kN load shall be applied to the assembly and the position of the wedges relative to the clamp body recorded.

- Loads of 20, 30 and 40% of the conductor's nominal breaking load shall be applied to the conductor and the relative position of the wedges recorded. After the application of each load the torque on the wedge and conductor guide bolts shall be removed and no conductor slip, shall occur. After 40% of the load when the wedge bolts are released to check for no slip, it shall then be confirmed that the wedges and body may be separated with the recommended extractor tool.
The number of strands severed for repair sleeves shall be the nearest whole number to one-third of the total number of strands in the outermost layer and shall be severed at a uniform spacing along the conductor.

A tensile load of 50% of the breaking load of the conductor shall be applied and the conductor marked so that any relative movement of the fitting can be easily detected. Without any subsequent adjustment of the fitting, the load shall be increased to 95% of the breaking load and then reduced to 90% and held for 1min. There shall be no movement of the conductor relative to the fitting due to slip during this period of 1min and no failure of the fitting.

For tests on OPGW and ADSS fittings there shall be no degradation in the fibre optic signal strength after the completion of the test. The signal strength shall be measured using an OTDR.
<table>
<thead>
<tr>
<th>Fitting</th>
<th>Name of Test</th>
<th>Mechanica l resistance</th>
<th>Heat Cycle</th>
<th>Corona</th>
<th>Bolt Torque</th>
<th>Conductor Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulator set fittings</td>
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</table>
10.6.6 Non-Tension Joints, Line Termination Fittings and Tubular Jumpers

A tensile load of 0.6kN shall be applied and the conductor marked so that any relative movement of the fitting can be easily detected. Without any subsequent adjustment of the fitting, the load shall be increased to 10% of the conductor's nominal breaking load and this load held for 1min. There shall be no movement of the conductor relative to the fitting due to slip during this period and no failure of the fitting.

10.6.7 Compression Fittings

All compression fittings after installation in accordance with the manufacturer's instructions shall remain straight after compression.

10.6.8 Resistance

The fitting shall be assembled in accordance with the manufacturer's instruction on a length of conductor. The electrical resistance shall be measured between two points on the conductor on either side of and immediately adjacent to, the fitting. The test shall be made with direct current. The current connections shall be at a distance of not less than 50 times the conductor diameter from the fitting. A micrometer having an accuracy of 0.1% with current reversal and averaging shall be used for measurement. The measured resistance shall not exceed 75% of the equivalent length of conductor.

10.6.8 Heat Cycle

Heat cycle tests shall be undertaken in accordance with the requirements of IEC 61284.

10.6.10 Current Pulse

In addition to the heat cycle test described in Clause 10.6.9, non-tension fittings shall be subject to the current pulse test undertaken in accordance with the requirements of IEC 61284.

The test assembly shall be so arranged that current is passed through the fitting from the main conductor to the jumper conductor on tension joints (dead ends) and from the main conductor to the tee conductor on the tee joints.

10.6.11 Corona and RIV

All fittings, other than those used exclusively for earthwire application shall be erected as in service, (which may necessitate representation of the tower body) and subjected to a visible corona and RIV test. The test shall be undertaken in accordance with the requirements of IEC 61284.

10.6.12 Bolt Torque

The bolts shall be tightened to twice the recommended torque on the conductor. No
damage shall occur to the fitting or its bolts at less than this torque.

10.6.13 Conductor Damage

The fitting shall be installed on the conductor and where appropriate the bolts tightened to the recommended torque. In the case of factory formed helical fittings, these shall be checked to ensure that the rods make contact with the conductor over their entire length. The position of the fitting shall be marked and then removed from the conductor. No indentations in the outer strands of the conductor shall be present in the area of the fitting.

10.6.14 Sample Tests

Sample tests identical to type tests shall be undertaken as indicated in Table 10.1. In addition, verification of compliance with the 'contract drawings' and surface finish compatible with the reference fitting shall also form part of the sample test.

The Contractor shall give the Employer the requisite period of notice prior to undertaking Sample Tests. This is a Notification Point.

The number of samples selected for test shall be in accordance with the following requirements, where 'p' is the numbers of fittings to be tested, and 'n' is the number of fittings produced in a batch.

\[
p = \begin{cases} 
1 & \text{when } 25 < n \leq 50 \\
2 & \text{when } 50 < n \leq 75 \\
3 & \text{when } 75 < n \leq 100 \\
4 & \text{when } 100 < n \leq 500 \\
4 + 1.5n/1000 & \text{when } n > 500 
\end{cases}
\]

If the randomly selected samples meet the test requirement, the batch(s) shall be deemed to comply with Specification. In the event of any sample not meeting this requirement, a further set of 'p' samples shall be tested. Should any further failure occur the whole batch(s) from the samples have been selected shall be liable to rejection.

10.6.15 Routine Tests

Unless otherwise specified routine mechanical tests shall be undertaken on insulator set and suspension clamp castings and those fittings in which a weld is subject to service load, insulator protective fittings and tension joints.

All fittings, tested shall be subjected to the routine test load of 50 percent of the specified minimum failing load. The application of the test load for 30 seconds shall not cause any permanent deformation or damage.
10.6.16  **Galvanising**

Tests for galvanising conductor and insulator fittings shall be carried out at the works to ensure compliance with the requirements of BS ISO 1461. Details of the tests results shall be made available to the Employer upon request.

Certificates relating to the ingot zinc used for galvanising shall also make available to the Employer request.

10.6.17  **Test Certificates**

All metallic materials used in the manufacture of conductor and insulator fittings shall be covered by test certificates stating their mechanical, chemical and where specified the impact properties and clearly showing the cast numbers, to prove compliance with the requirements of this Specification and BS EN 10025, BS 970 and BS EN 10084, 10085, 10087, 10095, 10250, PD 970, BS EN 1562, BS EN 1563, BS EN 515, 573, 586, 603, 604, BS EN 1559, 1676, 1706, BS EN 1172, 1652, 1653, 1654, BS EN 1676 as appropriate.

Test certificates for metallic materials and bolts and nuts shall be made available to the Employer upon request.

Test results covering Type and Sample tests shall be made available to the Employer.

Test results covering Routine tests shall be made available to the Employer upon request.

10.6.18  **Certificates of Conformity**

When requested copies of the following certificate/records shall also be forwarded:

(a)  Routine test records

(b)  Metallic materials and nuts/bolts test certificates

(c)  Galvanising test records

(d)  Ingot zinc certificates.
## APPENDIX 10.A1/1 – 230 KV

### INSULATOR SETS – TYPES & USES

<table>
<thead>
<tr>
<th>Insulator Set Type</th>
<th>Suspension</th>
<th>Tension</th>
<th>Low Duty</th>
<th>Pilot Suspension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Drawing</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set configuration</td>
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<td>Single</td>
<td>1</td>
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<td>No. of insulator strings</td>
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<td>1</td>
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<tr>
<td>Min. separation between centres of parallel strings (mm)</td>
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<td>Ball &amp; Socket</td>
<td>Ball &amp; Socket</td>
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<td>R</td>
<td>R</td>
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<td>Not required</td>
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</tr>
<tr>
<td>Sag adjuster type</td>
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<td>Quadrant</td>
<td>Turnbuckle</td>
<td>---</td>
</tr>
<tr>
<td>Linear Range (mm)</td>
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<td>230</td>
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</tr>
<tr>
<td>Increment (mm)</td>
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<td>---</td>
</tr>
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<td>3600-3900</td>
<td>3500 (A)</td>
<td>4100-4330(B)</td>
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<td><strong>Min Failing load of complete set:</strong></td>
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<td>120</td>
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### Insulator Protective Devices:

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<th>Raquet Single Point</th>
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<tr>
<td>- Earth End</td>
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Notes: (A) Upright  
(B) Inverted

### APPENDIX 10.A1/2 - 132 KV

**INSULATOR FITTINGS – TYPES & USES**

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<thead>
<tr>
<th>Insulator Fittings Type</th>
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<th>Tension</th>
<th>Low Duty</th>
<th>Pilot Suspension</th>
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<td>Reference Drawing</td>
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<td>Single Point</td>
<td>Single Point</td>
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<td>Type - Live End</td>
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<td>Single Point</td>
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EARTHWIRE/OPGW SETS – TYPES & USES

230KV OVERLAND PORTION

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<th>Suspension</th>
<th>Tension</th>
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<td>Reference Drawing</td>
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</tr>
<tr>
<td>Overall set length (mm)</td>
<td>350</td>
<td>700</td>
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<tr>
<td>Min. Failing Load Complete set (kN)</td>
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EARTHWIRE/OPGW SETS – TYPES & USES

230KV RIVERCROSSING PORTION (NOT USED)

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<tr>
<td>Overall set length (mm)</td>
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<td>700</td>
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<tr>
<td>Min. Failing Load Complete set (kN)</td>
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**CONDUCTOR JOINTS & CLAMPS – TYPES & USES**

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<td><strong>Suspension Clamp-type</strong></td>
<td><strong>795MCM ACSR Mallard</strong></td>
<td><strong>7 x 4.0 S equiv. OPGW</strong></td>
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<tr>
<td>Armour Rods</td>
<td>Trunnion Corona Free</td>
<td>Armour grip</td>
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<td><strong>Counterweights (kgs)</strong></td>
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<td>Tension Joints :</td>
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<tr>
<td>Dead end-type</td>
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<tr>
<td>Jumper terminal-type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midspans-type</td>
<td></td>
<td></td>
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<tr>
<td>Repair Sleeves – type</td>
<td></td>
<td></td>
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<tr>
<td>Tee connectors-type</td>
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<td>Non-Tensile Joints :</td>
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<td>Non-disconnectable</td>
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<tr>
<td>Jumper palms – type</td>
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<td>Line Termination fittings-type</td>
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<td>Jumper weights (kgs)</td>
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<td>Earthwire bonds – end fitting type</td>
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### CONDUCTOR JOINTS & CLAMPS – TYPES & USES

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<td>636 MCM ACSR Grosbeak</td>
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<td>Midspans-type</td>
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<td>Jumper weights (kgs)</td>
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<td>Tubular Jumpers</td>
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<td>Earthwire bonds – end fitting type</td>
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<td>Lug-lug</td>
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## APPENDIX 10.C1

### NOTIFICATION AND HOLD POINTS

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<td>Insulator &amp; Conductor Fittings – sample tests</td>
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APPENDIX 10.D1

REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of the Specification are listed below:

IEC 60120: Dimensions of ball and socket couplings of string insulator units
IEC 60372: Locking devices for ball and socket couplings of string insulator units
IEC 60471: Dimensions of clevis and tongue couplings of string insulator units
IEC 61284: Overhead lines Requirements and tests for fittings
BS EN 13411: Specification for thimbles for wire rope
BS EN ISO 1461: Specification for hot-dipped galvanising coating on iron and steel articles
BS 970: Specification for wrought steel for mechanical and applied engineering purposes
BS EN 10084
BS EN 10085
BS EN 10087
BS EN 10095
BS EN 10250
PD 970
BS 1387: Specification for screwed and socketed steel tubes and tubular and for plain end steel tubes suitable for welding or screwing to BS 21 pipe threads
BS EN 515: Specification for wrought aluminium and aluminium alloy
BS EN 573
BS EN 586
BS EN 603
BS EN 604
BS EN 1559: Specification for aluminium and aluminium alloy ingots and castings for general engineering purposes
BS EN 1676
BS EN 1706
BS 1574: Specification for split cotter pins
BS EN 1563: Specification for spheroidal graphite cast iron
BS EN 1172: Specification for rolled copper and copper alloys: Sheet strip and foil
BS EN 1652
BS EN 1653
BS EN 1654
BS EN 50183: Aluminium alloy stranded conductors for overhead power lines
BS 3643: ISO Metric threads
Part 2: Limits and tolerances for course pitch series threads
BS 3692: Specification for ISO Metric Precision hexagon bolts, screws and nuts
BS 4190: Specification for ISO Metric hexagon bolts, screws and nuts
BS 4320: Specification for metal washers for general engineering purposes. Metric series
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<thead>
<tr>
<th>BS 4429:</th>
<th>Specification for rigging screws and turnbuckles for general engineering, lifting purposes and pipe hanger applications</th>
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<td>BS 4579:</td>
<td>Part 3 Performance of Mechanical and Compression Joints in Electric Cables and Wire Connectors</td>
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<tr>
<td>BS EN 1011:</td>
<td>Specification for arc welding of carbon and carbon manganese steel</td>
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<tr>
<td>BS EN 1562:</td>
<td>Specification for Malleable cast iron</td>
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<tr>
<td>BS EN 1676:</td>
<td>Aluminium and aluminium alloys - Alloyed ingots for remelting.</td>
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<td>BS EN 1179:</td>
<td>Zinc and Zinc Alloys.</td>
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<tr>
<td>BS EN 10025:</td>
<td>Specification for hot rolled products of non-alloy structural steels and their technical delivery requirements.</td>
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# SECTION 11 CONDUCTORS

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SECTION 11 CONDUCTORS

11.1 SCOPE

11.1.1 Types and Uses

The type and configuration of the phase conductor and earthwire shall be in accordance with the requirement of this Specification. For types of conductor reference should be made to Appendix 11.A1.

11.1.2 Definition

The following definitions are used throughout this Specification:

- **AAC** All Aluminium Conductor
- **AAAC** All Aluminium Alloy Conductors
- **ACSR** Aluminium Conductor Steel Reinforced
- **ACAR** Aluminium Conductor Alloy Reinforced
- **AACSR** Aluminium Alloy Conductor Steel Reinforced
- **ACSR/AW** Aluminium Conductor Aluminium clad steel reinforced
- **S** Galvanised Steel Conductor
- **SA** Aluminium clad steel conductor

11.1.3 Sub conductor Configuration

For details of sub conductor configuration and spacing reference should be made to Appendix 11.A2.

11.1.4 Optical Fibre Cable

For details of embedded optical fibre cable reference should be made Section 14 of this Specification.

11.2 DESIGN

11.2.1 General

All AAC, AAAC, ACSR, AACAR and AACSR conductors shall comply with the requirements of IEC 61089. Where applicable the selection of parameters not quantified nor specified in IEC 61089, reference shall be made to the appropriate standard Specification stated in Appendix 11.A.1.

The design of non-standard conductors including thermal resistant, fibre optic earthwire and those incorporating shaped wire sections shall be submitted to the Employer. **This is a Hold Point.**
11.2.2 System Loading Conditions

Reference should be made to Appendix 11.A3 for details of the applicable phase conductor and earthwire system loading.

11.3 MATERIALS

11.3.1 Conductors

Aluminium wire used for AAC, ACSR, ACAR, and ACSR/AW or incorporated in fibre optic earthwire shall comply with the requirements of IEC 60889. The aluminium shall be of the highest purity commercially obtainable, the copper content shall not exceed 0.04%.

Aluminium alloy wire used for AAAC, AACSR or incorporated in fibre optic earthwire shall comply with the requirements of IEC 60104. The copper content shall not exceed 0.05%. Galvanised steel core wire used for ACSR and AACSR shall comply with the requirements of IEC 60888. Aluminium clad steel wire for ACSR/AW, SA or incorporated in fibre optic earthwire shall comply with the requirements of IEC 61232.

Shaped aluminium or aluminium alloy wire sections shall conform to the requirements of the appropriate IEC standard. Galvanised steel earthwire shall comply with the requirements of IEC 60888.

11.3.2 Conductor Grease

All grease applied to the specified inner aluminium, aluminium alloy or steel strands of the conductor shall be of a neutral type and shall have the following properties:

(a) The grease shall protect the conductors from corrosion in service which may include operation in atmospheres containing salt spray or industrial pollution.

(b) The grease shall not corrode steel, aluminium or aluminium alloy wires or any combination of wires.

(c) The grease shall be compatible with any wire drawing lubricant present on the conductor wires.

(d) The grease or any component of the grease shall not flow within, nor exude from the conductor during storage, transport, erection or during service at temperatures up to 100° C.

(e) The grease shall retain its properties at all operating temperatures specified in Appendix 11.A.1.
(f) The grease shall not be damaged by storage or by the conductor manufacturing process (hot applied grease shall be unimpaired after heating to 20° C above its dropping point for 150 hours, or 10° C above the temperature reached during the application of the grease to the conductor, whichever is greater).

(g) The grease shall have adequate resistance to oxidation.

(h) The grease shall not present a health hazard and shall conform to relevant current health and safety requirements.

11.4 WORKMANSHIP

Precautions shall be taken during the manufacture, storage and delivery of conductors to prevent contamination by copper or other materials which may adversely affect the aluminium or aluminium alloy.

Where permitted in IEC 61089 for aluminium or aluminium alloy wires the preferred method of jointing single wires is cold pressure welding.

11.5 PROTECTIVE TREATMENT

All steel core wires unless specified to the contrary shall be hot-dipped galvanised to comply with the requirements of IEC 60888.

Aluminium clad steel shall comply with the requirements of IEC 61232.

Unless specified to the contrary all conductors shall be uniformly covered with a neutral grease (i.e. as case 2 appendix C IEC 61089). The minimum fill factor of the grease shall not be less than 70%. Each layer of wire except the outer layer shall have, both lengthwise and peripherally, an even and continuous coating of grease. Wax thickened greases shall be applied at a temperature above the dropping point, and shall be substantially free from contaminants. No grease must be visible on the exterior of the conductor and every effort should be made to minimise the presence of drawing oil on the surface of the finished conductor.

11.6 CONDUCTOR ERECTION

11.6.1 Method Statement

The contractor shall provide the Engineer with a method statement giving sequential details of the conductor stringing, sagging, jointing, clamping-in etc. methods and including his intended program. Full tension stringing shall be undertaken, unless otherwise agreed in writing by the Engineer.

The method statement shall be submitted to the Employer for acceptance the requisite period before conductor stringing commences. This is a Hold Point.
11.6.2 Conductor Lengths and Joints

The fullest possible use shall be made of the maximum conductor lengths in order to reduce to a minimum the number of mid-span joints. The number, span and location of any phase conductor or earthwire mid-span joints used on the line shall be approved by the Employer. There shall not be more than one such joint per conductor in any one span. A conductor schedule detailing the lengths of conductors and positions of mid-span joints in the section, shall be submitted to the Employer for approval; this requisite period before conductor stringing commences. This is a Hold Point.

Mid-span joints shall not be used:

(a) Within 3m of the conductor suspension clamp or tension joint (dead end).

(b) In sections between tension towers of less than three spans unless specifically approved.

(c) In spans over railways, navigable rivers, main roads, trunk routes, buildings or spans covered by special wayleave conditions. A line shall be deemed to be over a building when, at the specified maximum conductor temperature with an assumed conductor swing of 45 degrees from the vertical, any part of the building is vertically below any conductor.

(d) In any span immediately adjacent to a span as described in (c), unless the tower between such span and adjacent spans is fitted with tension insulator sets.

11.6.3 Repair Sleeves

In the case of local damage to individual wires of a conductor during erection, repair sleeves may be permitted with the approval of the Employer and subject to no repair sleeve being nearer than 1.2 m from any conductor fitting other than spacer dampers. This is a Hold Point.

11.6.4 Line Terminations

Line termination fittings either bimetallic or aluminium shall be fitted as specified at line terminations, to provide the connection interface between the downleads and/or downdroppers and the substation equipment and/or cable sealing ends.

11.6.5 Inelastic Extensions of Conductors

The contractor shall be responsible for evaluating the inelastic extension which is likely to occur in the conductor over the defined period of years. Reference shall be
made to the recommendations contained in CIGRE Electra No. 75 for the evaluation. Compensation for the inelastic extensions so determined shall be made by the selection and use of an optimum pretension and time period and over tensioning the conductor at the time of erection. Over tensioning of the conductor shall be made by an allowance in the erection temperature i.e. sagging temperature equals conductor temperature minus equivalent temperature correction. However, it should be noted that the maximum conductor tension under the defined system loading must not be exceeded at the time the transmission line is handed over.

The Contractor shall ensure that the erection tensions do not exceed the appropriate system loading on the supports. The Contractor's proposals shall be submitted to the Employer in conjunction with the erection sags and tensions.

11.6.6 Sags and Tensions

The Contractor shall prepare sag and tension calculations and schedules (see also Clause 4.7) for the phase conductor and earthwire for every span at the proposed range of sagging operations, the design loading condition and at the maximum conductor operating temperature.

Due allowance shall be made for any severe gradient in the transmission line route, in addition the suspension insulator sets shall be vertical at the specified temperature immediately after stringing.

These schedules shall be submitted to the Employer the requisite period prior to the commencement of conductor stringing and for inclusion within the supply and install manual. This is a Hold Point.

11.6.7 Conductor Stringing

The Contractor shall take special care that during the stringing of the phase conductor and earthwire to ensure that no contact is made with the ground or any obstacles such as walls, fences, or buildings etc., nor shall they be over-strained during this process.

Drum battens shall not be removed until conductor drums are properly mounted at the drum station on the line and the battens shall be immediately refitted to the drums if any surplus conductor is left thereon. Drums will be transported and positioned on station with the least possible amount of rolling.

Approved means shall be provided to prevent any damage to conductors where they are run over temporary supports.

The conductors, joints and clamps shall be erected in such a manner that no bird caging, over-tensioning of individual wires or layers, or other deformation, or damage to the conductors shall occur.

Clamps or hauling devices shall, under erection conditions, allow no relative
movement of strands or layers of the conductor. If required by the Employer, this property shall be demonstrated by actual tests.

The Contractor shall at his own expense make suitable arrangements for temporary guying of supports where necessary. Suitable plates (detachable or otherwise) shall be provided on the supports for the attachment of any temporary guys. The additional loads imposed on specific support during conductor stringing by the use of temporary guys shall be calculated and submitted to the Employer for appraisal prior to conductor stringing commencing. **This is a Hold Point.**

Each conductor shall be clamped in at suspension points and the adjacent spans fitted with spacer dampers or vibration dampers at a concurrent operation, after having been sagged and tensioned off at section supports. The maximum time period between clamping-in and fitting of spacer dampers or vibration dampers shall not exceed 36 hours, or such other time agreed with the Engineer.

If this period is exceeded the Employer reserves the right to undertake a random inspection of the unclamped and lowered conductor and if necessary the cutting out and replacement of any suspect conductor. All expenses involved in the unclamping, conductor lowering, conductor replacement and re-sagging of the conductor shall be borne by the Contractor, whether or not any damage is found.

**11.6.8 Running Out Blocks**

Conductor running out blocks shall be free running on ball or roller bearings and of an approved design to avoid damage to the conductor. The blocks shall have an electrical conducting path between their suspension fittings and the conductors supported by the blocks.

If conductors are being erected on one circuit of a double circuit line with the other circuit live or in other situations likely to induce a voltage into the conductor all running-out blocks shall be bonded to the support steelwork by means of flexible connections approved by the Employer.

The diameter of the running out block shall not be less than 20 times the diameter of the respective conductor. Alternatively, where a group of smaller blocks are used these shall be arranged such that the conductor passes over an equivalent radius of not less than 20 times the conductor diameter.

The hangers for the running out blocks should be of a uniform length so that the conductors and the sheaves are held at a uniform distance, not exceeding 500 mm above, or below their final position when clamped in.

**11.6.9 Sagging**

The Contractor shall use approved dynamometers, accurate sighting and/or other apparatus necessary for the proper checking of the work. Every section shall be offered to the Employer for inspection of the results before sagging equipment, dynamometers, sighting or other apparatus is removed from that portion of the
Works. **This is a Notification Point.**

The assumed temperature of the conductor for the purposes of sagging, will be determined from an accurate thermometer basket suspended clear of the support steelwork at a point adjacent to the bottom crossarm level of one support at one end of the span being used to control sagging. The basket shall have been in position 15 min before temperature reading is taken.

**11.6.10 Earthing of Conductor During Erection (Safety)**

During the erection of conductors and subsequently when any work is being carried out on the support above the anti-climbing device level, the Contractor shall ensure the conductors are adequately earthed at points not more than three spans apart, or such other spacing as may be necessary or directed by the Employer.

The earthing equipment shall be approved by the Employer and shall be designed to be clearly visible from the ground.

**11.6.11 Crossings Over Roads, Railways, Buildings, Structures, etc.**

Where the transmission line crosses over roads or tracks liable to be used by traffic of any description, or railways, buildings, structures and obstacles of any kind the Contractor shall provide temporary scaffolding during stringing operations. Scaffolding in accordance with this Clause and Clause 5.5.3 shall be of adequate construction and height. Drawings and supporting calculations shall be submitted to the Employer and governmental or statutory bodies. **This is a Hold Point.**

**11.6.12 Live Line Scaffolds**

Where it is possible only to have a restricted outage on a distribution or a transmission line sufficient only to erect the upper portion and 'net' the scaffold a live-line scaffold shall be used. Live line scaffolds shall be in accordance with the requirements of Clause 5.5.5. Drawings and supporting calculations shall be submitted to the Employer and governmental or other statutory bodies. **This is a Hold Point.**

**11.6.13 Downleads**

Downlead spans between terminal supports and substation anchor points shall be erected at reduced tensions in accordance with Clause 8.2.10. Downleads shall be considered as slack span.

The Contractor shall include within his Method Statement details of his proposal for tensioning downleads.

**11.6.14 Conductor Cutting**

Conductor joints shall be made over protective sheeting and waste materials shall be removed from site. Cutting of layers of conductors shall be carried out with tools designed to prevent damage to underlying strands. Preparation prior to jointing
shall be carried out in accordance with Clause 11.6.15

11.6.15  Jointing

Before the conductor is inserted into compression type joints, clamps, connectors, compression spacers or repair sleeves, it shall be prepared in the following manner, using an approved grease for phase conductors and earthwires.

The Contractor shall include within his Method Statement full details of his proposed jointing procedures, including where necessary appropriate diagrams.

(a) New Conductor: The outer layer of the conductor throughout the whole length of the joint shall be wiped clean, coated with grease, wire brushed (stainless steel) through the grease which shall be left on and assembled in the fitting after a further liberal application of grease.

(b) Old Conductor: Where a compression joint is to be made on to old conductor the Employer shall be given the requisite period of notice. This is a Notification Point.

Unless otherwise agreed with the Employer who will take account of the degree of corrosion of the conductor, all the aluminium layers, after preliminary cleaning of the individual aluminium wires with a fine grade of abrasive paper or cloth, shall be coated with grease, wire brushed through the grease which shall be left on and assembled in the fitting after a further liberal application of grease. The innermost layer of aluminium wires should not be unlaid but treated on their external surfaces only. Care shall be taken to avoid damage to the wires especially by kinking or excessive removal of metal. If however, damage does occur the whole conductor shall be cut clear of the damage and as a fresh joint prepared.

All compression joints shall be fitted strictly in accordance with the manufacturer's instructions. During compression all dies shall fully close at each end of the bite and the bites shall overlap by a minimum of 5 mm. All flashes shall be removed.

11.6.16  Surface Greasing of Conductor

Except where specified to the contrary, the conductor shall be coated with an approved grease at the point of attachment of fittings immediately before the final assembly of any fittings and all surplus grease shall be removed after assembly.

11.6.17  Greasing of Bolted Interfaces

For bolted jumper connections, non-tension joints, tee connectors and bonding leads, the lug and clevis contact faces shall be greased with an approved grease, wire brushed through the grease liberally before assembly. All nuts and bolts shall be tightened to the supplier's recommended torque.

Where jumper or non-tension joint bolts are found to be loose the Contractor shall dismantle and re-assemble the joint as above before re-bolting and tightening.
All bolts shall face towards the centre line of each conductor bundle.

11.6.18 Inspection Holes

Where a tension joint is supplied with an inspection hole the aluminium alloy drive screw shall be hammered in firmly until smooth and flush with the surface of the aluminium sleeve using the flat face of a hammer. Final smoothing over may be carried out using a flat file if necessary.

11.6.19 Tension Support Jumpers

All tension support jumper loops shall be erected complete with all fittings in accordance with the approved wire clearance diagram.

Where quadruple bundle sub conductors are specified a reduced spacing twin spacer shall be fitted on the lowest pair of the jumper sub-conductors. They shall be adjusted on site to give the best possible clearance to prevent contact between the phase and jumper sub-conductors.

Where specified bonding spacers shall be located at a point suitable for the application of temporary earthing bonds, normally near the middle of the jumper. In the case of non-tension joint bonding spacers the conductors must butt in the centre. Jointing shall be in accordance with the requirements of Clause 11.6.14 and resistance measurement in accordance with Clause 11.7.9.

Where tubular jumpers are fitted, the earthing bar shall be arranged as near as practical to a step-bolt of the support.

11.6.20 Spacer Dampers

Spacer dampers where specified shall be fitted to the phase conductors strictly in accordance with the manufacturer's instructions.

Where there is a midspan joint or repair sleeve on a conductor, the adjacent spacer damper must not be closer than 2 m, or further away than 12 m from the midspan joint or repair sleeve. If possible, this should be achieved using the correct configuration of spacer damper positions. This configuration can be used in reverse by taking the measurement from the other support. Where the configuration given does not allow a spacer damper to be in the correct juxtaposition with the midspan joint or repair sleeve an additional spacer damper should be fitted.

11.6.21 Vibration Dampers

Vibration dampers shall be fitted to the earthwires and where specified the phase conductors, strictly in accordance with the manufacturer's instructions.

11.6.22 Aircraft Warning Spheres

Where specified aircraft warning spheres shall be fitted to the earthwires, complete with factory formed helical armour rods. The spheres shall be located in
accordance with the requirements of ICAO Annex 14 unless specified to the contrary.

11.6.23 Earthwire Bonds

Flexible earthwire bonds in accordance with the requirements of Clause 10.2.20 shall be fitted between all earthwire suspension and tension sets and the support. Where OPGW is used the connection to the earthwire shall if necessary be via a 'C' type connector (Ref. Clause 10.2.19).

No bond is required at terminal support positions where the earthwire jumper shall be attached directly to the support. At other tension positions the earthwire shall be continuously jumpered through. Where OPGW is used the jumper shall be formed from a short length of equivalent conductor attached to the earthwire via a 'C' type connector.

11.7 QUALITY CONTROL

11.7.1 Conductors

Sample tests shall be undertaken on all conductors in accordance with the requirements of IEC 61089 as applicable and this Specification. This is a Notification Point.

The mechanical tests shall be taken on straightened samples of individual wires taken after conductor stranding. In the event of the sample from any length not passing the mechanical or resistance tests, a second and third sample shall be taken from the same length, and if one of these also fails under test, the length of conductor (i.e. drum) from which it has been taken shall be rejected. For the ductility tests, should any variation occur in the results between the torsion and elongation methods of testing the results of the torsion test shall prevail.

In the event of any machinery used for conductor manufacture being used for materials, other than aluminium, galvanised or aluminium clad steel, the manufacturers shall furnish the Employer with a certificate stating that the machinery has been thoroughly cleaned before use on aluminium, aluminium alloy, galvanised or aluminium clad steel wire and that the conductor is free from contamination.

11.7.2 Grease

The manufacturer's type test proposals for proving compliance with this Specification with regard to the following grease properties shall be submitted to the Employer. This is a Hold Point.

(a) Dropping Point Tests;

(b) Thermal History Test;
(c) Reversibility;
(d) Oxidation;
(e) Corrosive Substances in grease;
(f) Anti-corrosion properties;
(g) Complete conductor test, to ensure that the grease does not appear through the outer wires at less than the specified temperature.

Sample tests on grease shall be undertaken at the same time as sample tests on the conductor. The mass and length of the conductor sample shall be measured and recorded. The sample shall be inspected to ascertain that no grease is visible on the exterior. The wires shall then be separated progressively layer by layer whilst being inspected to verify the coating requirements are met.

Grease for the dropping test shall be removed without heating, the remaining grease may then be removed by a convenient method. The mass of the cleaned conductor sample shall be determined and recorded. The mass of grease shall be determined from the difference in masses and shall be recorded.

The mass of grease per unit length of conductor shall not be less than the minimum value given in Appendix 11.A1.

All drums of conductor shall be routinely inspected for traces of visible grease on the exterior of the conductor.

11.7.3 Galvanising

Tests for galvanised steel wire shall be carried out at the works to ensure compliance with the requirements of IEC 60888. Details of the test results shall be made available to the Employer upon request.

11.7.4 Aluminium Clad Steel

Tests for aluminium clad steel wire shall be carried out at the works to ensure compliance with the requirements of IEC 61232. Details of the test results shall be made available to the Employer upon request.

11.7.5 Test Certificate

All metallic materials used in the manufacture of conductors shall be covered by test Certificates stating their mechanical and chemical properties to prove compliance with this Specification and IEC as appropriate.

These certificates shall be made available to the Employer upon request.

Test records covering Type and Sample tests shall be made available to the Employer.
11.7.6 Certificate of Conformity

When requested copies of the following certificate/records shall also be forwarded:

(a) Metallic material test certificate;
(b) Conductor stranding equipment non contamination certificate;
(c) Galvanising test records;
(d) Ingot zinc certificate;
(e) Aluminium cladding test records.

11.7.8 Sagging Tolerance

Immediately after the conductors have been sagged and clamped in, the mean sag of the conductors forming any phase shall not differ from the calculated erection sag by more than 4% and the sub-conductors forming each phase conductor bundle shall not differ from each other by more than 40mm. In addition the sag of any one phase shall not differ by more than 150mm from the mean sag of all phases in the same span. The linear adjustment available on the sag adjusters, unless specified to the contrary, at the end of the maintenance period shall not be less than ±75mm.

11.7.9 Jointing Competence

Tension and non-tension compression joints, repair sleeves, tee connectors and bimetallic connectors shall be fitted to the conductors only by linesmen whom the Contractor posses written approval of their Jointing Competence issued by the Employer. Where necessary the Contractor shall arrange for the appropriate tests to be witnessed by the Employer allowing the requisite period of notice. This is a Hold Point.

11.7.10 Electrical Resistance of Joints and Clamps

The maximum resistance, measured overall (primary measurement), of all joints shall not exceed 75% of the resistance of an equivalent length of conductor.

11.7.11 Bolt Tightness

The Contractor shall be responsible for checking that the bolts in all fittings including spacers, spacer dampers, vibration dampers etc, have been correctly tightened to the Supplier's recommended torque value. A record of this work shall be kept and made available to the Engineer upon request.

11.7.12 Clearances

Clearance between phase conductors, including jumpers and ground and between jumpers and support structures shall be checked during erection and before handing over the line.
11.7.13 Final Inspection

Immediately prior to hand over of the transmission line, the Contractor shall conduct a final line route inspection to ensure that the specified clearances are available to all supports, ground etc. all temporary earthings have been removed and that extraneous objects are removed. **This is a Notification Point.**

Where specified after the final route inspection the Contractor shall demonstrate by means of a low voltage test, to the complete satisfaction of the Employer, that there is complete continuity over each phase. **This is a Hold Point.**

11.7.14 Records

During the course of the Work, the SIMM document (reference Clause 4.7) shall be updated with details of the actual phase conductor and earthwire erection sags, location of phase conductor and earthwire tension joints including repair sleeves and the electrical resistance of all joints and clamps including the name of the linesman responsible and the date of assembly.
## APPENDIX 11.A1/1 - 230KV
### CONDUCTOR - TYPES AND USES

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Phase</th>
<th>OPGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation (Code Name)</td>
<td>Mallard (230KV)</td>
<td>7 x 4.0 S equiv.</td>
</tr>
<tr>
<td>Type</td>
<td>ACSR</td>
<td>“A”</td>
</tr>
<tr>
<td>Reference standards</td>
<td>ASTM B232</td>
<td>IEC 61089</td>
</tr>
<tr>
<td>Aluminium Alloy Grade</td>
<td>-</td>
<td>as appropriate</td>
</tr>
<tr>
<td>Steel Grade</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Galvanising Thickness</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Aluminium class (AS wire)</td>
<td>Ref IEC 61232</td>
<td>-</td>
</tr>
<tr>
<td>Aluminium type (AS wire)</td>
<td>-</td>
<td>20AS</td>
</tr>
<tr>
<td>Conductor Operating Temperature</td>
<td>5-80</td>
<td>-</td>
</tr>
<tr>
<td>Range(°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum mass of grease (kg/km)</td>
<td>51</td>
<td>-</td>
</tr>
<tr>
<td>Creep period of conductor to be considered (years)</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>No. and diameter of wire (No./mm)</td>
<td>Al. 30/4.135, St. 19/2.482</td>
<td>-</td>
</tr>
<tr>
<td>Overall diameter (mm)</td>
<td>28.95</td>
<td></td>
</tr>
<tr>
<td>Nominal breaking load (kN)</td>
<td>171.25</td>
<td></td>
</tr>
<tr>
<td>Weight (kg/km)</td>
<td>1,888</td>
<td></td>
</tr>
<tr>
<td>Direction of External Lay</td>
<td>Right hand</td>
<td>Right hand</td>
</tr>
</tbody>
</table>

Note:  

i. ACSR conductor shall be applied with grease in all layers for protection of steel from corrosion according to the relevant standard.  

ii. “A” Maximum diameter of OPGW must not exceed the diameter and mass of earthwire.
### APPENDIX 11.AI/2 – 132kV

#### CONDUCTOR - TYPES AND USES

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Phase</th>
<th>OPGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation (Code Name)</td>
<td>Grosbeak</td>
<td>7x3.25S earthwire equiv.</td>
</tr>
<tr>
<td>Type</td>
<td>ACSR</td>
<td>“A”</td>
</tr>
<tr>
<td>Reference standards</td>
<td>ASTM B232</td>
<td>IEC 61089</td>
</tr>
<tr>
<td>Aluminium Alloy Grade Steel Grade</td>
<td>-</td>
<td>as appropriate</td>
</tr>
<tr>
<td>Galvanising Thickness</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Aluminium class (AS wire)</td>
<td>Ref IEC 61232</td>
<td>-</td>
</tr>
<tr>
<td>Aluminium type (AS wire)</td>
<td>-</td>
<td>20AS</td>
</tr>
<tr>
<td>Conductor Operating Temperature Range(°C)</td>
<td>5-80</td>
<td>-</td>
</tr>
<tr>
<td>Minimum mass of grease (kg/km)</td>
<td>41</td>
<td>-</td>
</tr>
<tr>
<td>Creep period of conductor to be considered (years)</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>No. and diameter of wire (No./mm)</td>
<td>Al. 26/3.973 St. 7/3.089</td>
<td>-</td>
</tr>
<tr>
<td>Overall diameter (mm)</td>
<td>25.16</td>
<td>-</td>
</tr>
<tr>
<td>Nominal breaking load (kN)</td>
<td>112</td>
<td>-</td>
</tr>
<tr>
<td>Weight (kg/km)</td>
<td>1,303</td>
<td>-</td>
</tr>
<tr>
<td>Direction of External Lay</td>
<td>Right hand</td>
<td>Right hand</td>
</tr>
</tbody>
</table>

**Note:**

i. ACSR conductor shall be applied with grease in all layers for protection of steel from corrosion according to the relevant standard.

ii. “A” Maximum diameter of OPGW must not exceed the diameter and mass of earthwire.
## APPENDIX 11 Al/3 – 132kV

### Low Loss Thermal Conductor

#### CONDUCTOR - TYPES AND USES

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation (Code Name)</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Reference standards</td>
<td>ASTM/IEC</td>
</tr>
<tr>
<td>Aluminium Alloy Grade Steel Grade</td>
<td>-</td>
</tr>
<tr>
<td>Galvanising Thickness</td>
<td>-</td>
</tr>
<tr>
<td>Aluminium class (AS wire)</td>
<td>Ref IEC 61232</td>
</tr>
<tr>
<td>Aluminium type (AS wire)</td>
<td>-</td>
</tr>
<tr>
<td>Conductor Operating Temperature Range (°C)</td>
<td></td>
</tr>
<tr>
<td>Minimum mass of grease (kg/km)</td>
<td></td>
</tr>
<tr>
<td>Creep period of conductor to be considered (years)</td>
<td>20</td>
</tr>
<tr>
<td>No. and diameter of wire (No./mm)</td>
<td></td>
</tr>
<tr>
<td>Overall diameter (mm)</td>
<td>Equal or less than 25.15</td>
</tr>
<tr>
<td>Nominal breaking load (kN)</td>
<td>134±2%</td>
</tr>
<tr>
<td>Weight (kg/km)</td>
<td>Max 1,250</td>
</tr>
<tr>
<td>Direction of External Lay</td>
<td>Right hand</td>
</tr>
<tr>
<td>Current carrying capacity</td>
<td>Min 1220 amp at 120°C Operating temp.</td>
</tr>
<tr>
<td>Maximum DC Resistance at 20°C</td>
<td>0.068 ohm/km</td>
</tr>
</tbody>
</table>

**Note:**

i. Low Loss thermal conductor will be used for re-conductoring section only.

ii. All type test report shall be submitted at bidding stage.

## APPENDIX 11A2/1 - 230 kV

### SUB CONDUCTOR - CONFIGURATION

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Spacing (mm x mm)</th>
<th>Orientation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twin</td>
<td>450</td>
<td>Horizontal</td>
<td>230 kV</td>
</tr>
</tbody>
</table>
### CONDUCTOR SYSTEM LOADING

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Phase</th>
<th>Earthwire OPGW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Code name</strong></td>
<td>ACSR Mallard</td>
<td></td>
</tr>
<tr>
<td><strong>Maximum Working Tension</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum horizontal tension kN</td>
<td>50% of UTS</td>
<td>50% of B.L.</td>
</tr>
<tr>
<td>Wind pressure N/m²</td>
<td>1580</td>
<td>1800</td>
</tr>
<tr>
<td>Temperature °C</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Everyday condition</strong> (still air)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum horizontal tension kN</td>
<td>20% of UTS</td>
<td>20% of B.L.</td>
</tr>
<tr>
<td>Temperature °C</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td><strong>Erection Condition</strong> (still air)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum tangential tension kN</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Temperature °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sagging Limits of earthwire</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sagging Limits of earthwire as a percentage of conductor sag %</td>
<td>N/A</td>
<td>90</td>
</tr>
<tr>
<td>Conductor temperature °C</td>
<td>N/A</td>
<td>5</td>
</tr>
</tbody>
</table>

**Notes:**
1. Wind pressures stated above have been adjusted to take account of height and spatial effects.
2. B.L. is minimum breaking strength of OPGW.
3. OPGW to be sag matched to earthwire.
APPENDIX 11.A3/2 - 132 kV PORTION

CONDUCTOR SYSTEM LOADING

<table>
<thead>
<tr>
<th>Code name</th>
<th>Maximum Working Tension</th>
<th>Phase</th>
<th>50% of B.L.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Condition</strong></td>
<td></td>
<td>ACSR Grosbeak</td>
<td>2147</td>
</tr>
<tr>
<td>Maximum horizontal tension</td>
<td>kN</td>
<td>56</td>
<td>50% of B.L.</td>
</tr>
<tr>
<td>Wind pressure</td>
<td>N/m²</td>
<td>1952</td>
<td>2147</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Everyday condition (still air)</strong></td>
<td></td>
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<td><strong>Erection Condition (still air)</strong></td>
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<tr>
<td>Maximum tangential tension</td>
<td>kN</td>
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<tr>
<td>Temperature</td>
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<td>percentage of conductor sag</td>
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<td>Conductor temperature</td>
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**Notes:**
1. Wind pressures stated have been adjusted to take account of height and spatial effects.
2. B.L. is minimum breaking strength of OPGW.
3. OPGW to be sag matched to earthwire.
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<td>Maximum horizontal tension</td>
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<td><strong>Erection Condition</strong> (still air)</td>
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<td>Maximum tangential tension</td>
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<td><strong>Sagging Limits of earthwire</strong></td>
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<td>Sagging Limits of earthwire as a percentage of conductor sag</td>
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**Notes:**
1. Wind pressures stated have been adjusted to take account of height and spatial effects.
APPENDIX 11.BI

ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

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<td>Conductor Erection-Method Statement</td>
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<td>Inelastic Extension – Creep calculation</td>
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APPENDIX 11.DI

REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of the Specification are listed below:

IEC 60104: Aluminium-magnesium-silicon alloy wire for overhead line conductors
IEC 60888: Zinc coated steel wires for stranded conductors
IEC 60889: Hard drawn aluminium wire for overhead line conductors
IEC 61089: Round wire concentric lay overhead electrical stranded conductor
IEC 61232: Aluminium-clad steel wires for electrical purposes
IEC 61395: Creep test procedure for stranded conductors

Cigre Electra No. 75 'Permanent elongation of conductors. Predictor equation and evaluation method'. SC22 WG05.
ICAO - Aerodrome Annex 14 Volume 1 'Aerodrome Design and Operation'.
## SECTION 12  VIBRATION DAMPERS

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### APPENDIX
SECTION 12 VIBRATION DAMPERS

12.1 SCOPE

12.1.1 General

Vibration dampers shall be either of the Stockbridge type comprising two weights attached via a messenger cable to a conductor clamp, or spiral type (SVD) for installation on the conductor, OPGW or all dielectric self supporting (ADSS) optical fibre cable for which the damper is designed.

12.1.2 Types and Uses

Reference shall be made to Appendix 12.A1 for details of the specified requirements.

12.2 DESIGN

12.2.1 When installed in accordance with the manufacturer's recommendations the vibration damper(s) shall limit the aeolian vibration levels so that the conductor bending strain in the surface of the outer wires, determined in accordance with the Cigre/IEEE recommendations, shall not exceed 300 micro-strains peak to peak at the vibration damper clamp and at the adjacent suspension clamp or tension joint (dead end). This requirement shall be met for all frequencies up to \( f = \frac{1480}{d} \) Hz, where \( d \) is the conductor diameter in mm. The manufacturer shall provide either suitable laboratory test results, field test results or calculations to demonstrate to the Employer's satisfaction that this requirement is met for each damper/conductor combination.

12.2.2 The vibration damper shall be designed to perform satisfactorily under the environmental factors, including conductor temperature variations, ultra-violet radiation, ozone and atmospheric pollutants applicable to the Site. The vibration damper shall not damage or cause corrosion to the conductor or individual strands when installed or during service.

12.2.3 The weights for Stockbridge type dampers can be of equal or unequal weight and can have symmetrical or unsymmetrical shape. They can also be symmetrically or asymmetrically located on the messenger cable.

12.2.4 SVD's shall be manufactured from solid poly-vinyl-chloride (PVC) rod.

12.2.5 Vibration damper clamps shall be designed to ensure that it is not possible for the vibration damper to be removed from the conductor, without initially undoing the clamp bolt. The clamp design shall also ensure that after the bolt has been correctly tightened, no slackening of the clamp can occur in service.

The clamp bolt shall be suitably modified to prevent them being completely removed inadvertently. Any nut shall be captive.

12.2.6 For OPGW and ADSS optical fibre cable, the transmission properties of the optical fibres shall be unaffected by the vibration damper. During installation the interface between the clamp and the
conductor shall be filled with grease to exclude moisture and this fact shall be taken into account in the design.

12.2.7 The messenger cable shall comprise a suitable number of high tensile steel wire strands, (minimum number 19), shall be straight and sufficiently stiff to remain straight when the vibration damper is suspended by it's clamp. The attachment points of the cable to the clamp and to the weights shall be protected from water ingress. No relative movement shall be permitted between the clamp and the cable.

12.2.8 Damper weights shall be of a ferrous or zinc material and the design shall ensure that there is no contact between the weight and the conductor or the messenger cable when in service. Drain holes (minimum diameter 6mm) shall be provided where applicable to ensure that any water entering the weights can escape.

12.2.9 The active part length of SVD’s must capture one loop length of vibration.

12.2.10 Dampers shall be free from visible and audible corona discharge and radio interference at the voltage levels specified except those designed exclusively for use on earthwires.

12.2.11 No audible noise shall be induced by the wind under any weather conditions.

12.3 MATERIALS

12.3.1 Materials used in the manufacture of vibration dampers shall be of:

(a) Adequate strength for the intended application, service life requirements and free from defects which would affect their performance;

(b) Shall not be liable to intergranular or stress corrosion;

(c) Compatible with the conductor material, such that there can be no deleterious effects on the conductor or vibration damper resulting from their use;

(d) The material shall not adversely be affected in the long term by a coating applied for corrosion protection.

12.3.2 Vibration damper clamps shall be made from aluminium or aluminium alloy of a suitable grade complying with the requirements of BS EN 1559, 1676 and 1706.

12.3.3 Messenger wires shall be made from high tensile steel wire having a minimum tensile strength of 1220 N/mm².

12.3.4 Malleable cast iron weights shall be made of a suitable grade complying with either BS EN 1562 or BS EN 1563. Grey cast iron weights shall be made of a suitable grade complying with BS EN 1561.

12.3.5 Cast zinc weights shall be made of a suitable grade complying with BS EN 1774 and 12844.

12.3.6 Bolts and nuts shall be ISO Metric Precision Hexagon to BS 3692. Metal washers shall be ISO Metric to BS 4320 "Bright Series", and spring washers shall be ISO Metric to BS 4464.

12.3.7 Non-metallic materials used shall have:

(a) A good resistance to ageing;
(b) Capable of withstanding service temperatures and voltages without detrimental change of properties;

(c) Adequate resistance to the effects of nitrogen oxides, ozone, ultra-violet radiation and air pollution over the whole range of service temperatures.

12.4 WORKMANSHIP

12.4.1 General

The dimensions of the vibration dampers shall be shown on the contract drawings, together with material types and grades, protective treatment and any other pertinent information. Contract drawings shall be submitted to the Employer for approval. **This is a Hold Point.**

12.4.2 Identification

All vibration dampers shall be marked to ensure a system of traceability. Where practicable, and unless otherwise agreed between the Employer and the manufacturer, vibration dampers shall be clearly and indelibly marked with 3mm minimum high characters as follows:

(a) Identification of vibration damper (reference number);

(b) Manufacturer's identification;

(c) Date of manufacture (month and year);

(d) Conductor diameter range, or designation;

(e) Clamp bolt installation torque.

In the case of SVD's the information required above shall be provided on tear-off labels.

12.4.3 Installation Criteria

The supplier shall be responsible for determining (a) the exact number of vibration dampers required for each individual phase in each span of the transmission line, (b) distance of the vibration damper from the suspension clamp or mouth of the tension joint (dead end), (c) in-span separation and (d) clamp bolt installation torque. The rate for supply of vibration damper shall be quoted accordingly.

12.5 PROTECTIVE TREATMENT

12.5.1 Vibration dampers shall either be inherently resistant to atmospheric corrosion, or suitably protected against corrosion, such as may occur in transit, storage and in service. All ferrous parts which will be exposed to the atmosphere in service except steel wire, shall be protected by hot-dipped galvanising to comply with the requirements of BS ISO 1461.

12.5.2 Steel messenger wires shall be hot-dipped galvanised to comply with the requirements of BS EN 10244-2.

12.5.3 The ingot zinc used for galvanising shall comply with the requirements of BS EN 1179.
12.5.4 All external threads shall be cut or rolled before hot-dipped galvanising. Nuts to be galvanised shall be subsequently tapped 0.4 mm oversize and threads oiled.

12.5.5 All galvanised materials shall be stored on packing, clear of the ground and away from all material that might stain or corrode the galvanising. Black steel packing or bins shall not be used.

12.6 QUALITY CONTROL

12.6.1 General

Type and sample tests shall be undertaken on the vibration dampers in accordance with the requirements of this specification. Type tests specified in Clauses 12.6.2 to 12.6.8 shall be undertaken on a minimum of three samples which shall be identical in all essential details with the vibration dampers to be supplied.

Contract drawings previously submitted to the Employer shall be available at the time of testing.

The Contractor/Supplier shall give the Employer the requisite period of notice prior to undertaking the tests, and shall submit to the Employer a test program and procedures. **This is a Hold Point.**

12.6.2 Conductor Damage

An undamaged length of conductor shall be tensioned to approximately 20% of its nominal breaking load and the vibration damper clamp shall be installed using the recommended torque. The position of the clamp shall be marked and then removed from the conductors. No indentations in the outer strands of the conductor shall be present in the area of the clamp.

For vibration dampers used on fibre optic earthwire, to check for any degradation in the optical fibre signal strength, the above test set-up shall be reused, except that the clamp installation torque shall be twice the recommended value. The degradation of the optical fibre signal shall be measured using an optical power metre.

Using a similar test set-up to that described above a spiral vibration damper shall be installed. The position of the SVD shall be marked and then removed from the conductor. No indentations in the outer strands of the conductor shall be present in the area of contact of the SVD.

12.6.3 Clamp Grip

The axial grip of the clamp shall be measured on a 4m sample of greased conductor, Tensioned at 20% of its nominal breaking load. The end fixings of the tensioned Conductor shall be such as to prevent bird caging or slipping of the individual strands. With the vibration damper clamped at the recommended torque, a co-axial force of 2.5kN shall be applied to the clamp. The relative movement of the clamp shall not exceed 0.5mm after the 2.5kN has been held for one minute. The force shall then be increased until the manufacturer's design value has been reached, no additional movement should occur.

With a test set-up identical to that described above, the clamp bolt shall be tightened to twice the recommended installation torque. Where aluminium alloy shear head clamp bolts are used, they shall be replaced by high tensile steel bolts for this test. However, the aluminium alloy shear head
clamp bolts shall be capable of withstanding 1.5 times the recommended installation torque. No
damage shall occur to the clamp or its fasteners.

The axial grip of the SVD shall be measured using a similar test set-up described above. A co-axial
tension of 2.5kN shall be applied to the SVD, the relative movement of the SVD shall not exceed
0.5mm after the 2.5kN tensile force has been applied for one minute.

12.6.4 Slip Test

On an assembled vibration damper an axial tensile force of 10kN (for conductor diameters up to
25mm) or 15kN (for conductor diameters greater than 25mm) shall be applied between the weights
for one minute and the distance between the weights shall not increase by more than 2mm. The
force shall then be increased until the manufacturers design value has been reached, no additional
movement should occur.

12.6.5 Corona

All vibration dampers, other than those used exclusively for earthwire applications shall be erected
as in service (which may necessitate representation of the tower body) and subjected to a visible
corona test. Corona tests shall be undertaken in accordance with the recommendations of IEC
61284. The visible corona extinction voltage shall not be less than 0.8 times the nominal system
voltage plus 5%. One sample shall be retained for reference purposes.

12.6.6 Vibration Damper Characteristics

This test is required to establish the characteristics of the vibration dampers used in the Damping
Effectiveness test and the Fatigue test. Characteristics obtained before and after the Fatigue test shall
be used as one of the acceptance criteria for the Fatigue test.

The vibration damper shall be mounted vertically on a shaker table and driven with constant table
velocities of 0.05m/s and 0.10m/s over a given frequency range of 165/D to 1480/D where D is the
conductor diameter in mm. The frequency shall be varied either continuously with a maximum 0.2
decade per minute, or step by step with a maximum interval of 1 Hz. When measuring using the step
by step procedures the vibration must be stable at each step.

The following values shall be measured and plotted against frequency over the defined frequency
range:

(a) Reaction Force (F_v)
(b) Phase shift between the reaction force and the velocity (Q)
(c) Damper power absorption, $P_w = 0.5F_vV\cos Q$

where
F_v = reaction force (rms)
V = velocity (rms)
Q = phase shift
12.6.7 **Damping Effectiveness**

This test is intended to verify that the damping system i.e. the vibration damper installed on the conductor is efficient in protecting the conductor from fatigue damage. The test shall be carried out in accordance with IEC 61897 or equivalent standards.

The same damper which has been subjected to the test in accordance with Clause 12.6.6 shall be used.

This test shall also be undertaken using spiral vibration dampers.

The test shall be conducted on a laboratory span with a minimum length of 30 m. The test span shall be arranged in accordance with CIGRE guides Electra No. 62 and IEEE Std. 664. The conductor shall be tensioned to 20± 1 % of its nominal breaking load.

After the conductor has been tensioned, a square faced clamp shall be installed to rigidly support (but not to tension) the conductor at the same end of the span where the damper is to be rigidly installed. The vibration damper shall be installed on the conductor at the distance recommended by the Supplier from the clamp. If strain gauges are used they shall be mounted on the conductor outside of the square faced clamp and on either side of the vibration damper clamp or SVD. The strain gauges, at least two at each point, shall be mounted on the two uppermost strands, and within 2mm of the clamp to measure the highest stress at each point on the conductor. Alternatively, if bending amplitude of the conductor is measured this shall be undertaken at the same three points in span.

The test span shall be vibrated in steady waves within a given frequency range of 185/D, but not less than 8 Hz, to 1295/D, where D is the conductor diameter in mm. The power input for each tuneable harmonic shall be regulated to a strain of 150µm/m, peak-to-peak, at the most stressed point. Alternatively when bending amplitude is measured, the power input for each tuneable harmonic shall be regulated to a bending amplitude corresponding to a strain of 150µm/m, peak-to-peak, at the most stressed point. The bending amplitude at a distance of 89mm outside the last contact between the clamp and the conductor shall be determined in accordance with IEEE Standard 664.

The following values shall be measured at each tuneable harmonic:

(a) The power input from the shaker;

(b) The conductor antinode amplitude peak-to-peak in one of the first four loops nearest the vibration damper;

(c) The strain at the three measuring points of the test span or the bending amplitude at the same points.

The wind power input shall be calculated from the equation:

\[ P = D^4 F^3 \frac{f_{nc}}{f} (Y/D) L \]

where

- \( P \) = calculated wind input (Watts)
- \( D \) = conductor diameter (mm)
- \( F \) = tuneable harmonic frequency (Hz)
Y = conductor antinode amplitude peak-to-peak (metres)

\[ fnc \left( \frac{Y}{D} \right) = \text{a function of conductor antinode amplitude peak-to-peak, expressed in terms of conductor meter given in Figure 12-1.} \]

L = span length defined in Appendix 12.A1

Diagrams with the following data plotted against the frequency for each tuneable harmonic within the given frequency shall be presented:

(a) Strain at all three measuring points or, bending amplitude at all three measuring points;
(b) Conductor antinode amplitude peak-to-peak;
(c) Power input from the shaker;
(d) Calculated wind power input.

The acceptance criteria for this test, shall be that the measured input from the shaker must be greater than the calculated wind power input at all tuneable harmonics within the given frequency range.

12.6.8 Fatigue

The same vibration damper previously used for the Vibration Damper Characteristics and Damping Effectiveness tests shall be used.

The damper shall be attached to a shaker and driven in a vertical direction for \(10^7\) cycles. The frequency shall be the tuneable harmonic found in the damping effectiveness test, nearest to the frequency \(555/D\), where D is the conductor diameter in mm. The minimum peak-to-peak amplitude at the damper clamp shall be equal to the conductor antinode amplitude peak-to-peak measured at the corresponding harmonic.

After the fatigue test, the vibration damper shall again be subjected to the vibration damper characteristic test, to ensure that the dynamic behaviour of the vibration damper is maintained. The test shall be performed in an identical manner to that previously undertaken and the results shall be presented accordingly.

The acceptance criteria for this test, shall be that the characteristics of the vibration damper must not show any significant divergence's before and after the test. In addition a (destructive) examination of the messenger wires shall show none to be broken.

12.6.9 Sample Tests

The clamp grip and slip type tests shall be repeated as sample tests. In addition, verification of compliance with the "contract drawings" and that their shape and surface finish compares satisfactorily with the corona test reference sample shall also form part of the sample test.

The Supplier shall give the Employer the requisite period of notice prior to undertaking sample tests. **This is a Notification Point.**
The number of samples selected for test shall be in accordance with the following requirements, where "p" is the number of fittings to be tested, and "n" is the number of fittings produced in a batch:

\[
p = 4 \text{ when } n \leq 500 \\
p = 4 + \frac{1.5n}{1000} \text{ when } n > 500
\]

In addition to the sample tests defined above, a vibration damper characteristic test in accordance with Clause 12.6.6 shall be undertaken when requested by the Employer.

The reaction force and the phase angle between the reaction force and the velocity shall be measured and plotted against the frequency over the given frequency range. The corresponding curves for the type test shall also be plotted on the same graph.

If the randomly selected samples meet the test requirements, the batch(s) shall be deemed to comply with this Specification. In the event of any samples not meeting the requirements, a further set of "p" samples shall be tested. Should any further failure occur the whole batch(es) from which the samples have been selected shall be liable to rejection.

12.6.10 Galvanising

Tests for galvanised components of vibration dampers, shall be carried out at the works to ensure compliance with the requirements of BS ISO 1461 and BS EN 10244-2. Details of the test results shall be made available to the Employer.

Certificates relating to the ingot zinc used for galvanising shall also be made available to the Employer.

12.6.11 Test Certificates

All metallic materials used in the manufacture of vibration dampers shall be covered by test certificates stating their mechanical and chemical properties to show compliance with this Specification and IEC 61897, BS EN 1559, 1676, 1706, BS EN 1562, BS EN 1563, BS EN 1561, BS EN 1774, 12844 and BS EN 1676 as appropriate. Bolts and nuts shall be covered by the appropriate test certificate in respect of the test requirements of BS 3692.

Spiral vibration dampers shall be covered by the appropriate test certificate stating their mechanical and chemical properties. Test certificates for metallic, non-metallic materials and bolt and nuts shall be made available to the Employer. Test records, covering Type and Sample tests shall be made available to the Employer.
12.6.12 Certificate of Conformity

Copies of the following certificates/records shall also be forwarded:

(a) Metallic and non-metallic material test certificates
(b) Bolt and nut test certificates
(c) Galvanising test records
(d) Ingot zinc certificate
## APPENDIX 12.A1

### VIBRATION DAMPERS TYPES & USES

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REFERENCE STANDARDS

The reference standards and other documents referred to in this section of the specification are listed below:

IEC 61284: Overhead lines - Requirements and tests for fittings
IEC 61897: Overhead lines – Requirements and tests for Stockbridge dampers
BS EN 10244-2: Testing zinc coatings on steel wire for quality requirements
BS EN ISO 1461: Specification for hot-dipped galvanising coating on iron and steel articles
BS EN 1774: Specification for zinc alloys for die castings and zinc alloy die castings
BS EN 12844
BS EN 1561: Specification for flake graphite cast iron
BS EN 1559: Specification for aluminium and aluminium alloy ingots and castings for general engineering purposes
BS EN 1676
BS EN 1706
BS EN 1563: Specification for spherodical graphite cast iron
BS EN 1179: Specification for ingot zinc
BS 3692: Specification for ISO Metric hexagon bolts, screws and nuts
BS EN 1562: Specification for Malleable cast iron
BS EN 1676: Aluminium and aluminium alloys - Alloied ingots for remelting

## SECTION 13  SPACER DAMPERS

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### APPENDIX
SECTION 13 SPACER DAMPERS

13.1 SCOPE

13.1.1 General

The following definitions are used throughout the Specification:

‘Rigid bolted spacers’ for jumper and downlead applications, comprising bolted aluminium clamps which are rigidly connected to each other, both electrically and mechanically.

‘Spacer-dampers’ suitable for in-span application to control both aeolian vibration and sub-conductor oscillation.

13.1.2 Types & Uses

Reference shall be made to Appendix 13.A1 for details of the specified requirements.

13.2 DESIGN

13.2.1 All spacers and spacer dampers shall be designed so as to:

(a) Avoid damaging or cause corrosion to the conductor or individual strands under all service conditions;

(b) Maintain the sub-conductor spacing at spacer/spacer damper locations within the prescribed limits under all conditions of service apart from when fault currents are flowing. In sub-spans between spacer/spacer dampers the spacer/spacer dampers shall prevent physical contact between sub-conductors, but not necessarily during the passage of fault currents when the possibility of contact is accepted, provided that the specified spacing is restored immediately following fault clearance;

(c) Withstand the mechanical loads relevant to the installation, service (including wind induced conductor movements) and maintenance conditions, the design service current including short circuit effects, the service temperature and environmental effects;

(d) Be free from visible and audible corona discharge and radio interference at the voltage levels specified;

(e) Minimise the number of parts and the possibility of incorrect assembly and installation;

(f) Ensure that individual components are secured against becoming loose in service, and all threaded fasteners are locked;

(g) From materials which have sufficient strength, ductility and environmental resistance to withstand the static and dynamic loading.
13.2.2 The determination of the forces arising from the fault currents shall be based on the relationship given in IEEE Paper 31TP 65-707.

13.2.3 Spacer and spacer damper clamps shall be designed to ensure that they are capable of maintaining their effectiveness for the service life of the unit under the action of conductor tension variations, temperature variations and relative conductor movement with change in performance relative to time no greater than the prescribed range. The system must provide for resilient accommodation of change in the conductor diameter and change in the conditions of the clamp material. During installation the interface between the clamp and the conductor shall be filled with grease to exclude moisture and this fact shall be taken into account in the design, except those with elastomer-lined clamps.

13.2.4 Spacer and spacer damper clamps shall be designed to ensure that it is not possible for the unit to be removed from the conductor, without initially undoing the clamp bolt.

13.2.5 The clamp bolt shall be sufficiently modified to prevent them being completely removed inadvertently. Any nut shall be captive.

13.2.6 No audible noise shall be induced by the wind under any weather conditions.

13.2.7 When installed in accordance with the Supplier's recommendation the spacer dampers shall achieve the following performance criteria such as to adequately damp both aeolian and sub-span modes of oscillation to prevent sub-conductor clashing, fretting or fatigue, under all applicable frequencies:

(a) The conductor bending strains in the surface of the outer wires, determined in accordance with the CIGRE/IEEE recommendations; shall not exceed 300 microstrains peak-to-peak at the spacer damper clamp and at an adjacent suspension clamps or tension joints (deadends). This requirement shall be met for all frequencies up to \( f = 1480/d \) Hz, where \( d \) is the conductor diameter in mm;

(b) The system damping performance as measured by the logarithmic decrement of the fundamental wind induced anti-phase modes of the conductors shall not be less than 0.5.

Where the log decrement \( d = \frac{1}{n} \log_e \frac{A_o}{A_n} \)

\( A_o \) = peak to peak amplitude
\( A_n \) = peak to peak amplitude at nth cycle

13.2.8 Spacer dampers shall permit the following relative movements between sub conductors without
damage to the unit or to the conductor:

(a) Longitudinal movement of at least ± 25 mm;
(b) Vertical movement of at least 20 degrees;
(c) Conical movement of at least 20 degrees;

Horizontal movement perpendicular to the conductor of at least ± the diameter of the conductor.

13.2.9 The resistance between each conductor and the central frame shall be greater than 1 MΩ when the voltage between the frame and the conductor is 100 Volt, 50 Hz.

13.3 MATERIALS

13.3.1 Materials used in the manufacture of spacers and spacer dampers shall be of:

(a) Adequate strength for the intended application, service life requirements (including mechanical loads, vibration, electrical currents and environmental effects) and free from defects which would affect the performance of the fitting;
(b) Shall not be liable to intergranular or stress corrosion,
(c) The materials of compression components shall be capable of withstanding the cold working of the material due to compression;
(d) Compatible with the conductor material, such that there can be no deleterious effects, on the conductor, spacer or spacer damper resulting from their use;
(e) The material shall not be adversely affected in the long term by a coating applied for corrosion protection.

13.3.2 Spacer and spacer damper principal main components including clamps shall be made from a suitable grade of aluminium or aluminium alloy complying with the requirements of BS EN 1559, 1676, 1706 and/or BS EN 1676.

13.3.3 Bolts and nuts shall be ISO Metric Precision Hexagon to BS 3692. Metal washers shall be ISO Metric to BS 4320 'Bright series' and spring washers shall be ISO Metric to BS 4464.

13.3.4 If shear-head type bolts are used they shall be clearly marked, so after the correct torque has been applied the installed bolt may be clearly identifiable from the ground.

13.3.5 Non-metallic materials used shall have:

(a) A good resistance to ageing;
(b) Capable of withstanding service temperatures without detrimental changes of properties;
(c) Adequate resistance to the effects of nitrogen oxides, ozone, ultra-violet radiation and air pollution over the whole range of service temperatures;
(d) The resistance (or conductivity) of the various components shall be selected to ensure that, when correctly installed, potential differences between metallic components do not cause damaging discharges, and any current flowing between sub-conductors does not degrade any spacer or spacer damper materials.

13.4 WORKMANSHIP

13.4.1 General

The dimensions of the spacer or spacer damper shall be shown on the contract drawings, together with material types and grades, protective treatment and any other pertinent information. Contract drawings shall be submitted to the Employer. **This is a Hold Point.** All spacers and spacer dampers shall be free from sharp edges, burrs and sward.

13.4.2 Identification

All spacers and spacer dampers shall be marked to ensure a system of traceability. Where practicable and unless otherwise agreed between the Engineer and the manufacturer, spacers and spacer dampers shall be clearly marked with 3mm high characters as follows:

(a) Identification of spacer, spacer damper (reference number);

(b) Makers identification;

(c) Date of manufacture (month and year);

(d) Conductor diameter or designation;

(e) Conductor separation;

(f) Clamp bolt installation torque - if appropriate;

(g) Compression die size - if appropriate;

(h) Length to be compressed - if appropriate;

(i) Orientation of the spacer, spacer damper (as indicated by Up Arrows or by "Top"), shall also be indicated.

13.4.3 Installation Criteria

The supplier shall be responsible for determining (a) the exact number of spacer dampers required for each individual phase in each span of the transmission line, (b) distance of the spacer damper from suspension clamp or mouth of tension joint (dead end), (c) in-span separation, and (d) clamp bolt installation torque. The rate for supply of space dampers shall be quoted accordingly.

For spacers or spacer dampers with elastomer-lined clamps, details of any special tools required for installation shall be specified.
13.5 **PROTECTIVE TREATMENT**

Spacers and spacer dampers shall either be inherently resistant to atmospheric corrosion or suitably protected against corrosion, such as may occur in transit, storage and in service. All ferrous parts which will be exposed to the atmosphere in service shall be protected by hot-dipped galvanising to comply with the requirements of BS ISO 1461. All manufacturing processes shall be completed prior to galvanising.

The ingot zinc used for galvanising shall comply with the requirements of BS EN 1179.

All external threads shall be cut or rolled before hot-dipped galvanising. Nuts to be galvanised shall be subsequently tapped 0.4mm oversize and threads oiled.

---

13.6 **QUALITY CONTROL**

13.6.1 **General**

Type and sample tests shall be undertaken on spacers and spacer dampers in accordance with requirements of this Specification, Type tests specified in Clauses 13.6.2 to 13.6.13 shall be undertaken on a minimum of three samples, which shall be identical in all essential details with the spacers or spacer dampers to be supplied.

Contract drawings previously submitted to the Employer shall be available at the time of testing.

The Contractor/Supplier shall give the Employer the requisite period of notice prior to undertaking the tests, and shall submit to the Employer a test programme and procedures. **This is a Hold Point.**

13.6.2 **Conductor Damage**

An undamaged length of conductor shall be tensioned to approximately 20% of its nominal breaking load and the spacer or spacer damper clamp shall be installed using the recommended torque. The position of the clamp shall be marked and then removed from the conductor. No indentations in the outer strands of the conductor shall be present in the area of the clamp.

13.6.3 **Clamp Grip**

The axial grip of the clamp shall be measured on a greased portion of conductor, tensioned at 20% of its nominal breaking load. The end fixings of the tensioned conductor shall be such as to prevent bird-caging or slipping of the individual strands.

With the spacer or spacer damper clamped at the recommended torque, a co-axial force of 5kN (or 1kN for elastomer-lined clamps) shall be applied to the clamp. The relative movement of the clamp shall not exceed 0.5mm (1.0mm for elastomer-lined clamps) after the 5kN has been held for one minute. The force shall then be increased until the manufacturer's design value has been reached, no further movement should occur.

With a test set-up identical to that described above bolted spacers or spacer damper clamp bolts shall be tightened to twice the recommended installation torque. Where aluminium alloy shearhead clamp
bolts are used, they shall be replaced by high tensile steel bolts for this test. However, the aluminium
alloy shearhead clamp bolts shall be capable of withstanding 1.5 times the recommended installation
torque. No damage shall occur to the clamp or its fastener at less than the defined torque.

13.6.4 Visible Corona

Corona tests on spacers or spacer dampers shall be undertaken in accordance with the
recommendations of IEC 61284.

The visible corona extinction voltage shall not be less than 0.8 times the nominal system voltage
plus 5%. One sample shall be kept for reference purposes.

13.6.5 Strength (Spacer Dampers Only)

The loads arising from the fault conditions determined in accordance with Clause 13.2.2 shall be
applied simultaneously towards the geometric centre of the unit. The distance between the arms
shall be measured before and after the test. On completion of the load application and relaxation the
spacer damper shall be hand worked for three cycles and left for one minute before re-measuring.
The difference between measurements before and after the tests shall be less than 3% of the original
measurement.

13.6.7 Movement (Spacer Dampers Only)

Movement tests shall be undertaken to demonstrate compliance of the spacer damper to the
requirements of Clause 13.2.8 without damage to the unit or conductor. The conductor may be
represented by tubes or rods of the same diameter, one of which shall be fixed in position.

13.6.8 Log Decrement (Spacer Dampers Only)

The log decrement of the system shall be determined using the criteria specified in Clause 13.2.7
(b).

13.6.9 Damping/Flexible Element (Spacer Dampers Only)

The damping/flexible element shall be stressed to its end stops for $10^7$ cycles at a simulated
frequency of 1-5 Hz. Prior to the start of the test the damping/flexible element shall be subject to
accelerated environmental conditions similar to those specified in IEC 60507 Clause 8.4.1 artificial
pollution tests (salt fog method).

Measurement of the damping/flexible element stiffness shall be taken before and after the test, and
the stiffness of the element after the test shall not be less than 75% of an untested element.

13.6.10 Longitudinal (Spacer Dampers Only)

With one arm rigidly fixed to a parallel test rod of similar diameter to the conductor and with the
remaining arms free to move, the spacer damper shall be subject to $10^6$ Cycles without deterioration
or damage of the unit or individual components, with the greater of the two longitudinal movements
defined below:
The free arms shall be moved either:

(a) 75% of the permitted longitudinal movement as specified, or
(b) ± 12.5mm about the longitudinal centre line of the unit.

13.6.11 Sub-Conductor Oscillation (Spacer Damper Only)

One arm of the spacer damper shall be installed at the recommended torque on a greased portion of conductor, tensioned at 20% of its normal breaking load. The other arm forming a horizontal pair shall be rigidly attached to a horizontal tube simulating the other sub-conductor. The tube shall be subjected to oscillations perpendicular to the conductor, with a vertical displacement sufficient to ensure the stop limits are engaged, at a frequency of 1 - 5 Hz for $10^7$ cycles. At the end of the test there shall be no deterioration to the unit or damage to the conductor.

13.6.12 Aeolian Vibration (Spacer Dampers Only)

With a test-rig identical to that described above, the rod shall be subjected to a vibration force sufficient to produce a bending strain of 300 micro-strains peak-to-peak in the outer strands of the conductor determined in accordance with the CIGRE/IEEE recommendations for $10^8$ cycles. At the end of the test there shall be no deterioration to the unit or damage to the conductor.

13.6.13 Elastomeric Bushes Resistance (Spacer Dampers Only)

The resistance of the elastomeric bush(es) between each conductor and the spacer frames shall be determined by application of 100 Vrms (±10%) 50 Hz and the value determined from $V_{rms}/I_{rms}$ shall be in accordance with requirements of Clause 13.2.9.

13.6.14 Jumper Bonding Spacer Resistance

Rigid compression jumper bonding spacers shall be installed in sample lengths of conductor and the resistance measured using a digital micro-ohm-meter, between two points on the conductor on either side of, and immediately adjacent to the spacer and shall not exceed the equivalent length of conductor. The test shall be made with direct current, the current connections shall be at a distance from the spacer of not less than 50 times the diameter of the conductor.

13.6.15 Sample Tests

The clamp grip, strength and the electrical resistance of the bushes type tests shall be repeated as sample tests. In addition, verification of compliance with the 'contract' drawings and surface finish compatible with the reference spacer or spacer damper shall also form part of the sample test.

The Contractor/Supplier shall give the Employer the requisite period of notice prior to undertaking sample tests. This is a Notification Point.

The number of samples selected for test shall be in accordance with the following requirements, where ‘p’ is the number of fittings to be tested, and ‘n’ is the number of fittings produced in a batch:

$$p = 4 \text{ when } n \leq 500$$

$$p = 4 + 1.5 \frac{n}{1000} \text{ when } n > 500$$
If the randomly selected samples meet the test requirements, the batch(s) shall be deemed to comply with this Specification. In the event of any sample not meeting this requirement, a further set of ‘p’ samples shall be tested. Should any further failure occur the whole batch(s) from which the samples have been selected shall be liable to rejection.

13.6.16 Galvanising

Tests for galvanised components of spacers and spacer dampers shall be carried out at the works, to ensure compliance with the requirements of BS ISO 1461. Details of the test results shall be made available to the Employer.

Certificates relating to ingot zinc used for galvanising shall also be made available to the Employer.

13.6.17 Tests Certificates

All metallic materials used in the manufacture of spacers and spacer dampers shall be covered by test certificates stating their mechanical and chemical properties to show compliance with this Specification and BS EN 1559, 1676, 1706 and/or BS EN 1676.

Bolts and nuts shall be covered by the appropriate test certificate in respect of the test requirements of BS 3692.

Elastomeric bushes shall be covered by the appropriate test certificate stating their mechanical and chemical properties.

Test certificates for metallic, non-metallic, bolts and nuts shall be made available to the Employer.

Test records covering Type and Sample tests shall be made available to the Employer.

13.6.18 Certificate of Conformity

Copies of the following certificates/records shall also be forwarded:

(a) Metallic, non-metallic material test certificates;
(b) Bolt and nut test certificates-;
(c) Galvanising test records;
(d) The ingot zinc certificate.
### APPENDIX 13.A1

**SPACER & SPACER DAMPERS TYPES AND USES**

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<th>Spacer</th>
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**Note:** Spacers are only required to be fitted to jumper loops and downleads.
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### ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

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<td>13.6.15</td>
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<td>13.6.17</td>
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### NOTIFICATION AND HOLD POINTS

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REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of the Specification are listed below:

IEC 60507: Artificial pollution tests on high-voltage insulators to be used on ac system.
IEC 61854: Requirements and tests for spacers
BS ISO 1461: Specification for hot-dipped galvanising coatings on iron and steel articles
BS EN 1559: Specification for Aluminium and aluminium alloy ingots and castings for general engineering purposes

BS EN 1676
BS EN 1706
BS 3692: Specification for ISO Metric Precision Hexagon bolts, screws and nuts
BS 4320: Specification for Metal washers for general engineering purposes. Metric series
BS 4464: Specification for Spring washers for general engineering and automobile purposes. Metric series
BS EN 1676: Aluminium and aluminium alloys - Alloied ingots for remelting.
BS EN 1179: Specification for zinc and zinc alloys

## SECTION 14  OPTICAL FIBRE CABLE AND FITTINGS

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APPENDIX
SECTION 14  OPTICAL FIBRE CABLE AND FITTINGS

14.1  SCOPE

14.1.1  General

This section of the specification covers optical fibre cable suitable for incorporation into the earthwire (OPGW), associated fittings and non-metallic underground fibre optic cable. The OPGW must match with the optical properties of existing OPGW on existing line. Technical specifications of existing OPGW on existing line are enclosed (Enclosure-1) for reference purpose.

14.1.2  Types and Uses


14.2  DESIGN

14.2.1  Reliability

The overall system design of the fibre optic system shall meet the following minimum requirements:

(a)  Single failure or degradation in any optical fibre not more than one per year averaged over five years;

(b)  Failures or degradations affecting more than one optical fibre, not more than one in ten years;

(c)  Increase in optical system transmission attenuation due to accumulated ageing and other effects at the end of five years not more than 0.05 dB/km.

14.2.2  Fibre Optic Earthwire (OPGW)

The fibre optic earthwire to be supplied shall be suitable for installation on transmission lines, and shall be supplied complete with all necessary fittings and optical joint boxes. The earthwire, fittings and optical joint boxes shall be type approved.

The fibre optic earthwire shall comprise an optical sub-unit containing optical fibres, over which shall be laid aluminium, aluminium alloy or aluminium coated steel strands. Reference should be made to Section 11 for pertinent details of the overall earthwire.

The optical sub-unit shall withstand the temperature rise associated with the specified lightning fault current flowing in the earthwire without damage. The fibre optic earthwire shall be manufactured in continuous lengths of not less than 3km.

14.2.2  Optical Fibres

Optical fibres shall be single mode fibre. The fibres shall be coded for ready identification at each end. Single mode fibres shall conform to CCITT G652 or to IEC 60793-2-B1 and Appendix 14.A3.
The optical fibre coating material shall be mechanically strippable. The optical fibres shall be capable of being joined by fusion splicing techniques.

There shall be no measurable long term or short term optical attenuation change due to the temperature rise associated with a fault current flowing in an earthwire, or a lightning strike on the earthwire.

The optical fibres shall not be subjected to any critical stresses when the cable is at its maximum system loading, reference Appendix 11.A3/1.

After finalisation of the drum lengths, the Contractor/Supplier shall submit calculations for the expected overall attenuation and dispersion. This is a Hold Point. This will be compared with the actual values measured after a completion of the installation.

14.2.3 OPGW Fittings

The fibre optic earthwire shall be used with approved conductor fittings in accordance with Section 10 & 12 of the Specification. The application of these fittings shall not damage the earthwire or the fibres, either mechanically or optically.

At each support, a bypass device shall be provided to guide the cable around the earthwire fittings associated with the support.

Earthwire bonds similar to those specified in Section 10 of the specification shall be provided.

The cable run from the earthwire to the splice enclosure shall be secured to the support and suitable protection shall be provided to prevent damage from shotgun attack or other accidental means.

14.2.4 Optical Joint Boxes

Optical joint boxes shall be provided to protect the splice joints of optical fibres, either when individual lengths of fibre optic OPGW, are jointed, or between the fibre optic earthwire and the underground fibre optic cable. The optical joint boxes shall protect the splice joint from both mechanical and environmental damage.

The optical joint boxes shall preferably be of hood/dome type with single end plate in bottom and shall be fitted to the support immediately above the anti-climbing device.

The joint boxes shall consist of an external steel or die cast aluminium housing and provide protection to IEC 60529 IP447, and an internal die cast aluminium or high impact plastic ABS box to IEC 60529 IP54.

The external housing shall be designed so that rain water is directed-away from the door, and there shall be no water ingress when the door is opened.

The door of the box shall be fitted with captive hinges and shall be fastened shut by screw fixings. A hasp shall be provided on the door capable of taking a 10mm padlock.

The bottom of the box shall be fitted with two gland plates, each gland plate shall have two entry points. The gland plates shall be interchangeable, one style shall be used for fibre optic earthwire, the other for underground fibre optic cable. The joint boxes shall be supplied complete with all fittings to secure and seal the cable in the gland plates or blank the unused spigots. Cable cleats to
secure the fibre optic OPGW or underground cable shall be fitted inside the box. The cleats shall not have a detrimental effect on the performance of the optical fibres when tightened to the recommended torque.

The top and bottom of the joint box shall be vented, and the vents provided with vermin shields.

An M12 earthing boss complete with an M12 galvanised nut and lock washers shall be provided on the outside of the box.

The interior box shall be mounted on brackets inside the external housing and shall be capable of easy removal, complete with the optical fibre tails. The seal around the box shall be capable of withstanding specified temperatures.

The box shall be supplied complete with internal splice cassettes to accommodate the required number of splices. Glands shall be fitted to accommodate either the fibre optic OPGW, or underground fibre optic cable.

14.2.5 Fixing Clamps

A bolted clamping system shall be used to attach the OPGW to the inside of the support without drilling or modifications to the support steelwork. The clamping system shall be capable of use with galvanised steel angle sections varying between 40 and 200mm wide and accommodating either single, double or multiple lengths of OPGW.

The attachment clamps shall be capable of being attached and detached from the support, without affecting the OPGW.

14.2.6 Non-Metallic Underground Fibre Optic Cable

The fibre optic cable shall be circular in cross section and shall be designed so that any cable strain is not directly imported on the optical fibres. The cables shall not include any metallic components, to prevent high induced voltages when used in switching or substation compounds.

Optical fibres shall be in accordance with Clause 14.2.5 and shall match the OPGW, fibres in type and colour.

14.3 MATERIALS

14.3.1 Fibre Optic Earthwire

External aluminium, aluminium alloy or aluminium coated steel strands shall be in accordance with the requirements of Section 11 of the specification. OPGW of dissimilar materials such as stainless steel tube with aluminum-clad steel wire strands are not allowed.

14.3.2 Optical Joint Boxes

Optical joint boxes shall be made from either a suitable grade of aluminium alloy complying with the requirement of BS EN 1559, 1676, 1706 and/or BS EN 1676, or steel complying with requirements of BS 3100.
14.3.3 Fixing Clamps

Fixing clamps shall be made from a suitable grade of aluminium alloy comprising with the requirements of BS EN 1559, 1676, 1706 and/or BS EN 1676. Bolt quality shall be grade 4.6 according to ISO 898-1. Bolts and nuts shall be ISO Metric Black Hexagon to BS 4190, and shall unless otherwise specified be threaded ISO Metric Coarse Pitch to BS 3643: Part2, Tolerance Class 7h/8g.

14.4 WORKMANSHIP

14.4.1 Contract Drawings

Contract drawings for fixing clamps and optical joint boxes shall in addition to the dimension show material types and grades, protective treatment and any other pertinent information. Contract drawings shall be submitted to the Employer. This is a Hold Point.

14.5 PROTECTIVE TREATMENT

14.5.1 Fibre Optic Earthwire

Where two layers of wire strands are provided over the optical sub-unit, the external surface of the optical sub-unit and the inner strand layer shall be greased, using an approved conductor grease (Ref.: Section 11 of the Specification).

14.5.2 Ingress of Moisture

The cable shall be capped before shipment to prevent the ingress of water.

14.5.3 Optical Joint Boxes

Optical joint boxes (steel exterior housings) shall be hot dipped galvanised after manufacture to meet the requirements of BS ISO 1461. The boxes shall be sufficiently rigid so that there is no distortion of either the box or its door after galvanising.

14.6 INSTALLATION

14.6.1 General

The supplier of the OPGW, will be responsible for the supervision of installation by the Contractor, to ensure that overall system reliability requirements are met. To ensure that this is undertaken, the supplier will provide the services of a suitably qualified/experienced installation supervisor, who shall supervise the installation of the Works and shall advise the Engineer and the Contractor in matters of methods procedures and precautions to be followed and will be responsible for all matters pertaining to the quality of the installation. The supplier’s installation supervisor shall make at least four visits of 2(two) weeks each during progress of OPGW installation work for the purpose.

The Contractor shall provide the Employer with a method statement giving sequential details of the stripping procedure and the optical fibre jointing (splicing) procedure. The method statement shall
take full cognisance of the manufacturer's installation instructions.

The method statement shall be submitted to the Employer for acceptance the requisite period prior to stringing or optical fibre jointing commences. **This a Hold Point.**

### 14.6.2 Workmanship

The Contractor shall ensure that the fibre optic cables are not strained or damaged either mechanically or optically during stringing and/or jointing. If necessary the Contractor shall demonstrate the suitability of his proposed method, including the choice of running blocks prior to the commencement of stringing operations.

### 14.6.3 Optical Fibre Joints

Optical fibre joints either in the OPGW, or between the OPGW, and the non-metallic underground fibre optic cable shall be housed in optical joint boxes. The joint boxes shall be located immediately above the anti-climbing device for convenient access by technical personnel. All joint boxes shall be earthed to the support steelwork using approved multi-wire/multi-strand flexible aluminium earthing bonds.

### 14.7 QUALITY CONTROL

#### 14.7.1 General

Type, sample and routine tests shall be undertaken on OPGW, their associated fittings, non metalic underground fibre optic cable and the optical fibres in accordance with the requirements of this Specification, CCITT G652, IEC 60793 and IEC 60794 as appropriate. Contract drawings previously submitted to the Employer shall be available at the time of testing.

The Contractor/Supplier shall give the Employer the requisite period of notice prior to undertaking the tests, and shall submit to the Employer a test programme and procedures for approval. **This is a Hold Point.**

#### 14.7.2 OPGW

##### 14.7.2.1 Type Test

(a) **Stress-strain**

A sample of OPGW not less than 10m length, complete with the proposed end fittings shall be subject to a stress-strain test. The test shall be undertaken in accordance with IEC 61089 Annex B and the measuring techniques in accordance with IEC 60794-1 El. There shall be no visual change to the OPGW strands after the test and that the fibre strain must be less than 0.05% at 85% of the UTS of the cable.

(b) **Tensile Performance**

The test shall be undertaken in accordance with the load conditions specified in IEC 61089 Annex B and the measuring techniques in accordance with IEC 60794-1 El. There shall be no permanent change in the fibre attenuation at the specified wavelength after the test, while the
change in attenuation during the test shall be less than 0.05db/km from zero load to 85% of the UTS of the cable.

(c) **Crush and Impact**

The tests shall be undertaken in accordance with the recommendations of IEC 60794 - 1 -E3 and IEC-60794 - 1 -E4.

The crush test shall be undertaken by applying a 10kN load for 1min to the OPGW via two 50 x 50 mm flat plates. There shall be no measurable permanent change in the fibre attenuation at the specified wavelength, while any temporary change in attenuation shall be less than 0.1db.

The impact test shall be undertaken by dropping a 4kg weight from a height of 150mm onto the end of a 20mm diameter steel mandrel placed on the OPGW. After 20 repeated applications, there shall be no measurable change in fibre attenuation at the specified wavelength, while any temporary change in attenuation shall be less than 0.1db.

(d) **Temperature Cycling**

The optical performance under temperature cycling shall be tested in accordance with IEC 60794-1-F1 with $T_A$ and $T_B$ as specified in Appendix 14.A1 and the duration of 4 hours. The test should be undertaken twice.

(e) **Water Ingress**

The optical sub-unit shall be tested for water ingress in accordance with IEC 60794-1-F5.

(f) **Fault Current**

A sample of OPGW not less than 2m in length shall be subject to a fault current pulse. The fault current pulse specified in Appendix 14.A1 shall be supplied in less than 1s after the conductor has been raised to the specified initial temperature. During the test the temperature of the optical sub-unit shall be measured, the temperature immediately after the current pulse shall be less than the specified temperatures. The test shall be performed twice with an interval of 30min between tests. After the second impulse the OPGW shall be dismantled and the optical cable examined throughout its length for any signs of deterioration.

(i) **Lightning Strike**

The Contractor shall submit his proposals to the Employer to demonstrate the effectiveness of the OPGW to withstand the effects of a lightning strike. The test shall consider both an initial stroke and a power follow through. The initial peak current shall be as specified in Appendix 14.A1. The test shall be carried out on a sample of OPGW not less than 2m long. The acceptance criteria shall be that earthwire's calculated residual strength is not less than 90% of the original stated ultimate tensile strength. Any damaged strands shall be assumed to be broken.
14.7.2.2 Routine Test

OPGW on all drums shall be tested for mechanical Tests including measurement of dimensions of steel and aluminium (Al) wires and overall diameter of OPGW, measurements of thickness of Al on ACS wires, twist test of steel & Al wires, torsion test of steel wires, checking of lay length & lay ratio of layers, checking of lay directions, breaking load test of steel and Al wires and DC resistance measurement of Al and ACS wires at the factory by the manufacturer as routine tests.

In addition, attenuation shall be measured on each fibre of all OPGW with OTDR at the factory by the manufacturer as routine test.

The test results shall be available with the manufacturer and shall be submitted to the Employer, if requested.

14.7.2.3 Sample Test

Samples taken on random sampling basis from the OPGW drums ready for shipment against each batch shall be tested for mechanical tests including measurement of dimensions of steel and aluminium (Al) wires and overall diameter of OPGW, measurements of thickness of Al on ACS wires, twist test of steel & Al wires, torsion test of steel wires, checking of lay length & lay ratio of layers, checking of lay directions, breaking load test of steel and Al wires and DC resistance measurement of Al and ACS wires at the factory by the manufacturer which shall be witnessed by the Employer’s representative.

In addition, attenuation shall also be measured on each fibre of above mentioned sample drums of OPGW with OTDR.

14.7.3 Optical Fibres

Optical fibres shall be tested in accordance with the requirements of CCITT G652 and IEC 60793 as appropriate.

14.7.4 Optical Joint Boxes

Optical joint boxes shall be visually inspected to ensure they meet the specified requirements. If the external housing or its door shows any signs of distortion or any galvanising damage then the box shall be rejected. Details of the inspection shall be recorded and shall be made available to the Engineer upon request.

14.7.5 Non-metallic Underground Fibre Optic Cable

Non metallic underground fibre optic cable and the optical fibres shall be tested in accordance with the requirements of CCITT G652, IEC 60793 and IEC 60794 as appropriate.

14.7.6 Fibre Optic Cables

All fibre optic cables shall be tested prior to despatch using an OTDR on each fibre.

14.7.7 Test Certificates

Test records, covering Type and Sample tests shall be made available to the Employer.
14.7.8 Certificates of Conformity

When requested copies of the following certificates/records shall also be forwarded:

(a) Optical joint boxes visual inspection records;

(b) Routine test records;

(c) The records of the OTDR test results.

14.7.9 Installation

The following tests shall be undertaken by the Contractor:

(a) Prior to installation the fibre optic cable shall be tested with an OTDR on each fibre to ensure that no physical damage has occurred to the fibre during, delivery and shall be compared with the results prior to despatch;

(b) After installation the above test shall be repeated to ensure that no damage has occurred to the fibre during installation;

(c) An end to end attenuation measurement shall be taken in each direction on each fibre using an optical source and optical power meter.

The overall attenuation of the installed cable shall not exceed that calculated using the attenuation and splice loss values specified in Appendix 14.A3.

The Contractor shall give the Engineer the requisite period of notice prior to commencing the tests. This is a Notification Point. Details of the test results shall be submitted to the Employer.

The supplier of the OPGW is requested to co-operate with the Fibre Optic Terminal Equipment Supplier (if this is under a separate contract) and shall supply all technical data requested.

14.8 TEST EQUIPMENT

Reference should be made to Appendix 14.A4 for details of the test equipment required.
### APPENDIX 14.A1/1

**OPGW DESIGN REQUIREMENTS**

#### 230KV PORTION

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#### APPENDIX 14.A1/1

**OPGW DESIGN REQUIREMENTS**

#### 132KV PORTION (NOT USED)

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<tr>
<td>Leading Edge</td>
<td>40 (°C)</td>
</tr>
<tr>
<td>Lightning Initial Peak Current</td>
<td>1.2 (µs)</td>
</tr>
<tr>
<td>Tail</td>
<td>100 (kA)</td>
</tr>
<tr>
<td>Power Follow Through</td>
<td>50 (µs)</td>
</tr>
<tr>
<td>Temperature Cycling Test T_A</td>
<td>5 (°C)</td>
</tr>
<tr>
<td>Temperature Cycling Test T_B</td>
<td>40 (°C)</td>
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### APPENDIX 14.A2
NOT APPLICABLE
**APPENDIX 14.A3**

**SINGLE MODE OPTICAL FIBRE CABLE REQUIREMENTS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
<th>Unit 4</th>
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</thead>
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<tr>
<td>Coating diameter</td>
<td>µm</td>
<td></td>
<td></td>
<td>250 ± 15</td>
</tr>
<tr>
<td>Cladding diameter</td>
<td>µm</td>
<td></td>
<td></td>
<td>125 ± 3</td>
</tr>
<tr>
<td>Cladding non-circularity</td>
<td>%</td>
<td></td>
<td></td>
<td>≤ 2</td>
</tr>
<tr>
<td>Mode field diameter</td>
<td>µm</td>
<td></td>
<td></td>
<td>9 ± 1</td>
</tr>
<tr>
<td>Mode field concentricity error</td>
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</tr>
<tr>
<td>Cut off wave length</td>
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</tr>
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<td>Attenuation at 1285 nm (maximum average)</td>
<td>dB/km</td>
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<tr>
<td>Attenuation at 1550 nm (maximum average)</td>
<td>dB/km</td>
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<tr>
<td>Zero dispersion wave length</td>
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<tr>
<td>Chromatic dispersion at 1285 nm (maximum average)</td>
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<td>Chromatic dispersion at 1550 nm (maximum average)</td>
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<tr>
<td>Individual splice loss</td>
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<td>Mean splice loss</td>
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**APPENDIX 14.A4**

**TEST EQUIPMENT**

OTDR
## APPENDIX 14.B1

### ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

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<thead>
<tr>
<th>Clause Reference</th>
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<td>14.4.1</td>
<td>Optical Joint Boxes - Contract drawings Fixing clamps - contract drawings</td>
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<td>14.4.3</td>
<td>Installation instructions</td>
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<td>14.6.1</td>
<td>Method Statement</td>
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<td>OPGW fittings</td>
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<td>Non-metallic underground fibre optic cable and optical fibres</td>
<td>Documentary evidence</td>
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<td>- Type test certificates</td>
<td>Test proposals</td>
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<td>OPGW - Routine Tests</td>
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<td>OPGW fitting &amp; optical fibres - Routine test records</td>
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<td>Certificate of Conformity</td>
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### NOTIFICATION AND HOLD POINTS

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</table>
APPENDIX 14.D1

REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of the Specification are listed below:

IEC 60529: Classification of decrees of protection provided by enclosures
IEC 61089: Round wire concentric lay overhead electrical stranded conductors
IEC 60793-1: Optical Fibres Part 1: Generic Specification
IEC 60794-1: Optical Fibre Cable Part 1: Generic Specification
IEC 60794-2: Optical Fibre Cable Part 2: Product Specification

BS ISO 1461: Specification for hot dip galvanised coatings on iron and steel articles
BS EN 1559: Specification for Aluminium and aluminium alloy ingots and castings for general engineering purposes
BS EN 1676
BS EN 1706
BS 3100: Specification for steel castings for general engineering purposes
BS 3643: Ingot zinc
BS 4190: Specification for ISO Metric hexagon bolts, screws and nuts
BS EN 1676: Aluminium and aluminium alloys - Alloied ingots for remelting
BS EN 10025: Specification for hot rolled products of non-alloying structural steels and their technical delivery requirements.
ISO 898-1: Mechanical properties of fasteners made of carbon steel and alloy steel

CCITT G652: Characteristics of single mode optical fibre cable.
SECTION 15
AIRCRAFT NAVIGATION (OBSTRUCTION AIDS)

15.1 SCOPE

15.1.1 Types and Uses

The type and arrangement of all aircraft navigation (obstruction aids) i.e. aircraft warning lights (solar or LV powered), solar arrays, batteries and aircraft warning spheres shall be approved.

Reference shall be made to Appendix 15.A1 for details of the specific requirements.

15.2 DESIGN

15.2.1 General

All aircraft navigation (obstruction aids) shall be so designed as to:

(a) Withstand the mechanical loads relevant to the installation-service-maintenance conditions and environmental effects;

(b) Minimise the number of parts and the possibility of incorrect assembly and installation;

(c) Ensure that individual components are secured against becoming loose in service; all threaded fasteners shall be locked;

(d) Utilise materials which have sufficient strength, ductility and environmental resistance to withstand the static dynamic loading;

(e) Avoid damaging the earthwire under all service conditions;

(f) Comply with the requirements of ICAO Aerodromes Annex 14 Volume 1 Aerodrome Design and Operation and Aerodrome Design Manual Part 4 unless stated to the contrary.

15.2.2 Obstruction Lights (Solar powered)

The complete solar powered obstruction light system i.e. obstruction lights, photovoltaic cells, storage batteries and control equipment, shall be designed to ensure maximum unattended operation with minimal maintenance, i.e. maximum once per year.

The obstruction lights shall consist of one main and one stand-by low intensity omnidirectional red lamps in compliance with local aviation requirements.
The light shall be equipped with Neon discharge lamps having a luminous intensity of approximately 320 candelas, and a rated life of at least 20,000 hours. Neon discharge lamps shall be of the cold cathode type and fitted with RF screens.

The light shall be designed to allow it to be directly installed on any vertical or horizontal surface on the peak of the tower. In case the power adapter cannot be installed at the lamp locations, an extension cable assembly with lampholder shall be provided.

The operation of the lights during darkness or poor visibility shall be controlled by a photoelectric switch. The levels of illuminance falling on a vertical surface for activating the lights shall be agreed with the Engineer.

15.2.3 Obstruction Lights (LV powered)

Obstruction lights shall consist of one main and one standby low intensity omni-directional red lamps in compliance with ICAO requirements.

The luminous intensity shall be approximately 320 candelas and have the longest possible rated life, which should not be less than 10,000 hours.

The light shall be designed to allow it to be directly installed on any vertical or horizontal surface on the tower. The operation of the light during darkness or poor visibility shall be controlled by a photo-electric switch. The level of illuminance falling on a vertical surface for activating the lights shall be agreed with the Engineer.

At the base of the tower immediately above the A.C.D. level a termination box shall be provided complete with isolator and other control gear as necessary.

The termination box shall be manufactured from either steel or die cast aluminium to provide protection to IEC 60529 IP 55.

15.2.4 Photo-Voltaic Cells (Solar array)

The photo-voltaic cells in conjunction with the storage batteries shall be designed to have the maximum system reliability and battery life. Solar panels shall not be designed to provide maximum power during periods of peak solar radiation, but to provide power at an essentially constant rate over the annual solar cycle. The minimum charge state shall provide adequate reserve for weather anomalies which may comprise up to one month of continuous heavy cloud cover, whilst the maximum charge state achieved during favourable conditions shall not exceed the rated battery capacity to prevent the possibility of overcharging the battery causing electrolyte evaporation.

For protection of the solar array from reverse currents during darkness, a diode shall be placed in series with the array.

The complete solar panel shall be designed to ensure that the maximum electrical Output degradation shall not exceed 10 percent over a 10 year period.
The photo voltaic cells shall be redundantly interconnected and provided with integral bypass diodes to prevent cell overheating due to localised shading and system continuity in the event of cell circuit failure.

The complete solar panel shall be suitably sealed in an aluminium frame which effectively isolates the cells from thermal and mechanical shock and prevents the ingress of moisture.

15.2.5 Support Framework

The solar array support framework shall be designed to mount the complete solar panel at the optimum tilt angle, and to resist the imposed wind loading calculated in accordance with Section 8 of this Specification.

15.2.6 Storage Batteries

Vented lead acid electrolyte batteries of an extremely low self-discharging type shall be used in conjunction with photo voltaic cells. Catalytic recombinator caps shall be used to reduce water loss to very low levels. The batteries shall have proven cycling abilities in conjunction with photo voltaic operation and shall be designed to provide power during periods of low solar radiation, which shall not be less than a minimum of 5 days, reserve storage plus specified low solar storage calculated from the optimum storage array, size associated with the location.

A regulator shall be used to protect the battery from overcharging and a low voltage disconnecter from excessive discharge.

The batteries must have a stable voltage characteristic with less than 5 percent variation in nominal output voltage from fully charged to discharged.

15.2.7 Battery Enclosure

A suitably designed battery enclosure shall be provided for housing the batteries and control unit at the specified work platform level.

The enclosure shall have hinged access panels for ease of battery maintenance, vent holes in the base and ventilation at the top to provide adequate air through venting of gases from the batteries. Maximum and minimum electrolyte levels of all battery cells shall be clearly visible.

15.2.8 LV Cables
All LV cables and cabling shall be in accordance with the appropriate British Standards and local health and safety requirements.

15.2.9 Aircraft Warning Spheres

Aircraft warning spheres shall be a minimum of 600 mm diameter and shall be fitted to the earthwire.

Externally, the spheres shall be coloured red or orange to meet the local environmental conditions and installed alternatively with white spheres. All component bolts shall be captive and preference shall be given to use of shear-head clamp tightening bolts. Factory formed helical armour rods shall be fitted to protect the earthwire at aircraft warning sphere locations.

15.2.10 Tower Painting

Painting of towers to comply with the requirements of local aviation authorities, shall be undertaken when specified by the Engineer.

The paint system shall comprise an etch primer, under and gloss coat which shall be formulated to take into consideration the local environmental conditions. The paint shall not present a health hazard and shall conform to relevant current health and safety requirements.

Reference shall be made as appropriate to BS 5493. Details of the proposed painting system shall be submitted to the Engineer. **This is a Hold Point.**

For details of the extent of the painting requirements reference should be made to Appendix 15.Al.

In some areas where the tower may be under water during the rainy season, the tower (All members) shall be painted for navigation with reflecting paint upto 3 m from the ground level. The contractor has to submit the details specification of the reflecting paint and the location nos. of the towers which shall be painted, to the employer’s engineer for approval before start of the painting.

15.3 MATERIALS

15.3.1 Materials used in the manufacture of aircraft navigation (obstruction aids) shall be of:

(a) Adequate strength for the intended application and service life requirements (including mechanical loads, vibrations, electrical currents and environmental effects) and free from defects which would affect the performance of the equipment.
(b) Shall not be liable to intergranular or stress corrosion.
(c) The material shall not be adversely affected in the long term by a coating applied for corrosion protection.
15.3.2 Photo-voltaic cells shall comprise matched monocrystalline silicon cells enclosed by a glass front surface and a rear composite layer to provide the optimum thermal and electrical performance.

The glass front surface shall have similar thermal expansion characteristics to the photovoltaic cell, shall be resistant to impact and abrasion by wind blown materials and shall be self-cleaning under the action of rain.

15.3.3 All mild steel used in the manufacture of the support framework shall comply with the requirements of BS EN 10025 or BS EN 10210. Minimum steel grade shall be S275JR and S275JOH respectively.

15.3.4 Aluminium or aluminium alloy used in the manufacture of the complete solar panel frame shall comply with the requirements of BS 1474.

15.3.5 Cast aluminium and aluminium alloy fittings shall be made from aluminium or aluminium alloy of a suitable grade, complying with the requirements of BS 1490 and/or BS EN 1676.

15.3.6 Aircraft warning spheres shall be made from either glass reinforced polyester resin or aluminium sheet, having a minimum specified thickness. Aluminium sheet shall comply with the requirements of BS EN 485.

15.3.7 Bolts and nuts shall be either ISO Metric Black Hexagon to BS 4190 threaded ISO Metric Course Pitch to BS 3643 : Part 2 Tolerance Class 7H/8g, or ISO Metric Precision Hexagon to BS 3692. Metal washers shall be either to BS 4320, Form E, Grade 4.6 or 'bright series'. Spring Washers shall be ISO Metric to BS 4464.

If shear-head type bolts are used they shall be clearly marked so after the correct torque has been applied, the installed bolt may be clearly identifiable from the ground.

15.3.8 Non-metallic materials shall have good resistance to ageing and shall have adequate resistance to the effects of nitrogen oxide, ozone, ultra-violet radiation and air pollution.

Glass reinforced polyester resin mouldings for aircraft warning spheres shall be in accordance with BS 4549, Part 1.

15.3.9 All paints used shall be suitable for use with and not adversely effect galvanised steel.

15.4 WORKMANSHIP

15.4.1 The dimensions of all aircraft navigation (obstruction aids) equipment shall be shown on the contract drawings. Contract drawings including cabling layouts shall be submitted to the Engineer. This is a Hold Point.

All equipment shall be i-narked to ensure a system of traceability for each component of the equipment. Where practicable, and unless otherwise agreed
between the Engineer and the Contractor/Supplier, equipment shall be clearly and indelibly marked with 6 mm high characters as follows:

(a) Identification of equipment (reference number);
(b) Maker's identification;
(c) Date of manufacture (month and year);
(d) Cast code - if appropriate;
(e) Conductor diameter range - if appropriate;
(f) Fitting bolt installation torque - if appropriate.

15.5 PROTECTIVE TREATMENT

15.5.1 All parts of the aircraft navigation (obstruction aids) equipment shall either be inherently resistant to atmospheric corrosion or suitably protected against corrosion, such as may occur in transit, storage and service. All ferrous parts which will be exposed to the atmosphere in service shall be protected by hot-dipped galvanising to comply with the requirements of BS 729. All manufacturing processes shall be completed prior to galvanising.

15.5.2 The ingot zinc used for galvanising shall comply with the requirements of BS 3436.

15.5.3 All external threads shall be cut or rolled before hot-dipped galvanising. Nuts to be galvanised shall be subsequently tapped 0.4 mm oversize and the threads oiled.

15.6 INSTALLATION

15.6.1 Aircraft navigation (obstruction aids) shall be installed strictly in accordance with the Supplier's instructions.

15.6.2 The proposed means of paint application shall take full cognizance of local environmental requirements and shall be subject to the approval of the Engineer. This is a Hold Point.

15.7 QUALITY CONTROL

15.7.1 General

Type, sample and routine tests as appropriate shall be undertaken on both individual items and complete system, eg. obstruction lights, solar panels, storage batteries etc. in accordance with the requirements of this Specification. The test procedure must clearly demonstrate the suitability of the complete system to meet the environmental and operational conditions specified. The Contractor's proposals for these tests shall be submitted to the Engineer for approval before manufacture commences. This is a Hold Point.

Contract drawings previously submitted to the Engineer shall be available at the time of testing. The Contractor/Supplier shall give the Engineer the requisite period
of notice prior to undertaking the type and sample tests, and shall submit to the Engineer for approval a test programme and procedures. **This is a Hold Point.**

### 15.7.2 Galvanising

Tests for galvanised equipment shall be carried out at the works to ensure compliance with the requirements of BS 729. Details of the test results shall be made available to the Engineer upon request.

### 15.7.3 Test Certificates

All metallic materials used in the manufacture of the equipment shall be covered by test certificates stating their mechanical and chemical properties to prove compliance with requirements of this Specification and BS EN 10210, BS EN 10025, BS EN 485, BS 3100, BS 4190, BS 1474, BS 1470 as appropriate.

Bolts and nuts shall be covered by the appropriate test certificate in respect of either BS 4190 or BS 3692.

Tests certificates for metallic materials, bolts and nuts and where appropriate non-metallic materials shall be made available to the Engineer upon request.

Where Type and Sample tests are undertaken test certificates covering these tests shall be made available to the Engineer.

Where Routine tests are undertaken test certificates covering the tests shall be made available to the Engineer upon request.

### 15.7.4 Certificate of Conformity

Prior to despatch the Contractor/Supplier shall forward to the Engineer requisite copies of the completed Certificate of Conformity. The certificate shall be supported by copies of the appropriate test reports of any type and/or sample tests undertaken.

When requested copies of the following certificates/records shall also be forwarded:

- (a) Metallic material test certificates
- (b) Bolt and nut test certificates
- (c) Non-metallic material test certificates
- (d) Galvanising test records
- (e) Routine test records.

### 15.7.5 Site Tests

Prior to commissioning the Contractor shall submit to the Engineer his proposals for checking/testing the complete installation. This is a **Hold Point.** The Contractor shall give the Engineer the requisite period of notice prior to undertaking the agreed commissioning tests. This is a **Notification Point.**
15.7.6 Painting

Prior to the commencement of painting the Contractor shall submit to the Engineer his proposals for checking/testing the routine quality of the Painting. This is a Hold Point.
## APPENDIX 15.A1

### AIRCRAFT NAVIGATION (OBSTRUCTION AIDS)

<table>
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<th>Details</th>
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<tr>
<td>Tower Painting as per local requirements</td>
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<tr>
<td>Obstruction Lights</td>
<td>Solar Powered</td>
</tr>
<tr>
<td>L.V. powered &amp; supply voltage</td>
<td>V ---</td>
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</table>

**Solar powered:**
- **Number and position of lights per support**: 3*  
- **Height and position of work platform**: Top Crossarm  
- **Height and position of solar array**: Earthwire  
- **Diameter of aircraft warning spheres**: mm 600  
- **Spacing of aircraft warning spheres**: m 30 between adjacent spheres on opposite earthwires

* One at the top of the tower and one each on both transverse faces of the tower at bottom crossarm level.

### Tower Painting

All river crossings towers are to be painted in alternative bands of orange and white colour, starting from top of the chimney level to the top of the tower. Width of bands to be approximately 8 m, to conform to the requirements of ICACO.
APPENDIX 15.Bl

ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

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<th>Document Description</th>
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<td>Obstruction Aids – Contract drawing</td>
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<td>Test Proposals – type, sample, routine</td>
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<td>Galvanizing test results</td>
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NOTIFICATION AND HOLD POINTS

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APPENDIX 15.D1

REFERENCE STANDARDS

The reference standards and other documents referred to in this Specification are listed below:

IEC 60529: Classification of degrees of protection provided by enclosures.
BS 729: Specification for hot-dipped galvanising coating on iron and steel articles.
BS 1474: Specification for wrought aluminium and aluminium alloys for general engineering purposes bars, extruded round tubes and sections.
BS 1490: Aluminium and aluminium alloy ingots and castings for general engineering purposes.
BS 3463: Specification for ingot zinc.
BS 3643: ISO Metric threads.
Part 2: Limits and tolerances for course pitch series threads.
BS 3692: Specification for ISO Metric Precision hexagon bolts, screws and nuts.
BS 4190: Specification for ISO Metric hexagon bolts, screws and nuts.
BS 4320: Specification for metal washers for general engineering purposes Metric series.
BS 4549: Guide to quality control requirements for reinforced plastic moulding.
Part 1: Polyester resin mouldings reinforced with chopped strand mat or randomly deposited glass fibre.
BS 5493: Protective coatings of iron and steel structures.
BS EN 485: Aluminium and aluminium alloys sheet, strip and plate.
BS EN 1676: Aluminium and aluminium alloys - Alloyed ingots for remelting,
BS EN 10025: Specification for hot rolled products of non-alloy structural steels and their technical delivery requirements.
BS EN 10210: Hot finished structural hollow sections of non-alloy and fine grain structural steels.
### SECTION 16  MISCELLANEOUS

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SECTION 16 MISCELLANEOUS

16.1 TOOLS AND APPLIANCES

Each tool or appliance shall be clearly marked with its size and/or purpose and is not to be used for erection purposes by the Contractor.

The tools and appliances with the appropriate boxes are to be handed over to the Employer at the Employer's stores depot at the time of arrival at Site.

The Contractor shall, where required, by the Engineer, provide test certificates and die-stamp or indelible mark on each piece of equipment in an approved manner.

For details of the tools and appliances to be supplied reference should be made to Appendix 16.A1.
(a) Sets of temporary earthing equipment shall consist of one, telescopic, Fibre glass rod 3m total length, complete with a screwing head together with 6 PVC covered 8m lengths of 150mm$^2$ pure aluminium conductor. Each length of conductor shall be equipped with an earth end clamp which shall have a hardened steel threaded point capable of piercing a galvanised or corroded steel surface to provide a good earth connection. In addition an alloy line end clamp shall be provided which shall be spring loaded and capable of being further tightened around a conductor of up to 32.4mm diameter, to provide a good electrical connection. The line end clamp and the screwing head of the pole shall be such that the latter is capable of holding, fixing and tightening the end clamp onto the conductor when attached to the temporary earth lead.

The leads are expected to withstand a fault current of 2.5kA for 10s.

(b) Elcometer for measuring galvanisation thickness.
## SECTION 17

PACKING, PROTECTION AND DESPATCH MARKING

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SECTION 17

PACKING, PROTECTION AND DESPATCH MARKING

17.1 GENERAL

The following minimum packing methods shall be adopted for suppliers external to the country of the transmission line installation, unless otherwise specified.

The Supplier shall be entirely responsible for ensuring that the packing is suitable for transit and storage and will be held responsible for any shortages or damage during transit.

Wherever possible, the Supplier shall utilise shipping by container vessels in the containers of the correct type for the item being shipped to reduce the likelihood of damage to the items. If containerisation is not possible the requirements of the following Clauses shall be applicable.

All materials shall be carefully packed in a manner suitable for transport to and storage under the climatic conditions present. Items packed in cases or crates shall be so secured that they are not free to move, and cannot work loose in transit.

Woodwool is to be avoided as a packaging material as far as possible.

Waterproof paper and felt lining are to overlap at the seams by at least 12mm, and the seams secured together in an approved manner, but the enclosure is to be provided with vermin proof screened openings to permit ventilation.

A packing note in a weatherproof plastic envelope is to be securely attached to the right hand lower corner of one side of all cases or crates. A copy of the packing list shall also be included inside.

All packing cases or crates shall be marked on the outside to show the correct way up and where relevant, where the weight is bearing and the correct positions for slings.

Shipping mark, numbers and symbols will be provided by the Employer. These marks shall be applied to conductor drums and cases either by the use of a waterproof stencil, flo-pen or any other permanent method. The use of tie-on tags is not permitted. Cases shall be marked on two opposite sides.

ALL MARKS SHALL BE CLEARLY LEGIBLE AT THE TIME OF DESPATCH.

17.2 LATTICE TOWER AND ASSOCIATED STEELWORK

(a) Main Legs Steel Poles, Heavy Sections

As loose items, or as below.

(b) Angle Bracings and Large Plates

Bundled in packages of less than 5t and strap-bonded as follows:

Galvanised -Tensional Steel Stripping, either
i) Tension strapping 32mm x 0.8mm, minimum of two bands and at maximum centres of 2m; or

ii) Tension strapping 19mm x 0.8mm, minimum of three bands and at maximum centres of 1.25m.

Whichever method i) or ii) is adopted, bundles shall also have a layer of either hessian or polythene between the strap-bands and the galvanised steelwork.

One end of tie bundle shall also be wired in such a way as to prevent the removal of any single piece.

(c) Plates, Small Items

These shall be cased (maximum net mass 500kg).

Cases shall be of sturdy construction, made from new 25mm thick timber and constructed with annular (rag) nails. They shall have packing pieces on the underside to enable the use of fork-lift trucks.

(d) Bolts

Shall be double bagged and cased as above. A contents list shall be included in each bag.

(Cases used both (c) and (d) shall be stored in dry areas both before and after packing.

Where required, materials shall be colour flashed to aid recognition.

17.3 CONTAINERISATION

Where materials shipped by the use of containers, a reduced level of packing, is acceptable as follows:

(a) Strap-band centres may be increased to 3m for 32mm x 0.8mm bands and 2.5m for 19mm x 0.8mm bands.

(b) The use of wire through bundle ends is not required.

(c) Cases may be 20mm thick timber.

17.4 CONDUCTOR

Conductors shall be supplied on drums of sufficient sturdiness to withstand transport and shipment, and the drums shall be securely battened to prevent damage to the conductor. The drums shall become the property of the client.

All wooden components shall be manufactured from sound defect-free seasoned softwood and suitable for prolonged storage without deterioration. Wood shall be either planed or finely sawn to facilitate accuracy in assembly. The thickness of each ply or component part shall be of reasonable uniformity.

The flanges of drums shall be constructed from two ply of wood laminated in such a manner to be cross-grain to each other. The boards shall be close butted to provide maximum support. Fastenings
of the flanges shall be with suitable bright nails with the head countersunk on the inside flange. A flange conductor hole of sufficient diameter for the free passage of the conductor shall be cut in one flange. The exposed end of the conductor shall be protected by a suitable sheet metal plate.

Drainage holes shall be provided through each flange as close as possible to the underside of the barrel lagging. The inner checks of the drum shall be painted with an aluminium flake or bitumen based paint.

The spindle hole shall be round and cut through the centre of the centre board of each flange ply. The spindle holes, of not less than 80mm diameters, shall be reinforced by a 6mm mild steel plate bolted to each flange.

The drum barrel shall be of the segmented type, with supports and cross struts, with a diameter not less than 30 times the conductor diameter. The barrel lagging shall be closely butted and shall provide a smooth external finish to the conductor. The barrel and flanges shall be securely clamped together by not less than six M20 bolts.

The inner end of the conductor shall be brought through the drum flange and secured by staples. The outer end shall also be secured to the inner face of the flange in a similar manner painted with aluminium flake paint.

The outer layer of the conductor on the drum shall be covered by either a layer of sheet plastic or waxed paper secured immediately under the circumferential battens so that it is not in contact with the conductor.

Circumferential battens shall enclose the conductor space completely. They shall fit flush with the outer flanges and shall be securely fixed.

Drums shall be provided with a secure waterproof label displaying the maker's name, type, size and length of conductor on the drum. Drum serial number shall be either chiselled into one drum cheek or impressed onto a secure metallic label. Drums shall be painted on all outer surfaces in finishing colours to the option of the manufacturer.

Drums shall display an arrow and the words "Roll This Way" on each cheek to show the correct direction of rolling.

Steel conductor drums shall be used for any spare conductor supplied and shall comply with the requirements of the American Aluminium Association Standards or other equivalent National Standards.

17.5 INSULATORS

Insulators shall be crated, each crate shall contain insulators units of the same type. Crates shall be either hexagonal or rectangular cross section.

Crates shall be wooden and close boarded, manufactured from sound seasoned softwood a minimum of 20mm thick. They shall be tensioned strapped at not less than three positions along their length. All crates shall be marked with the batch number and insulator code number.

Special attention shall be paid to ensure that all insulators are complete with their security clip.
17.6  INSULATOR, CONDUCTOR AND ANCILLARY FITTINGS

Insulator, conductor and ancillary fittings shall be cased as per Clause 17.2(c).
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SECTION 18  METHOD OF MEASUREMENT & PAYMENT

18.1  INTRODUCTION

18.1.1  General

Payment will be made in accordance with the unit prices and total prices set against the items in the Price Schedules as amplified in this section and against the final quantities approved by the Employer. These unit prices and total prices shall include all of the work, temporary and permanent, necessary to comply with the Contract. Where non-quantified unit prices are required in the Bid submission, they shall be so provided. Measurement for the purposes of payment shall where appropriate be made jointly by the representative of the Employer and the Contractor.

The Contractor when requested shall attend for purposes of measurement, or otherwise accept measurements made by the Employer alone.

Where applicable the Contractor shall indicate on each invoice the identification number of each support to which items in the invoice refer.

Unit prices in the Schedule where applicable shall be deemed to include for all work on site irrespective of access conditions, including slope of ground, nature of subsoil, presence of water or other obstacles adjacent to or across the line of the route.

The unit prices shall include all incidental expenses which the Contractor or specialist Subcontractor may incur in the preparation and maintenance of access, in the provision of site services and of all transportation for labour whether skilled or unskilled.

The unit prices in the Schedules shall include all out allowances or other supplementary payment to skilled or unskilled labour, customary, authorised or required by regulations in force at the date of the Bid.

The unit prices shall be deemed to include payment to labour, or other expenses incurred for idle time during which work on site is interrupted by weather conditions or flooding by storm overflow or the like.

Whilst every assistance will be provided to facilitate line construction activities in sequence in accordance with the Contractor's agreed programme of work, there could be occasions when this may not be possible. No claims for additional costs to the Contractor will be accepted solely for such discontinuity of working.

Only those prices shown in the miscellaneous unit prices will be accepted as additional to the Contract price where the use of such unit prices is authorised by the Employer.

18.1.2  Surplus Material

Surplus quantity or waste material of Goods and materials if any, collected from the Purchaser's Stores, are to be returned to the Employer. Surplus or waste material supplied by the Contractor will
not be paid by the Employer.

18.1.3 Nominated Subcontractor/Supplier

NOT USED.

18.1.4 Specialist Subcontractors

NOT USED.

18.1.5 Quantities

The quantities set out in the schedules are unless otherwise defined estimated quantities of the Works. They are not to be assumed as the actual and correct quantities to be executed by the Contractor in fulfilment of his obligations under the Contract. The Contractor is presumed to have satisfied himself as to the relevance of the estimated quantities in the preparation of his Bid.

Final quantities shall be established and agreed upon between the Employer and Contractor immediately after the date of signing of the Contract.

18.1.6 CIF Price

The term CIF shall be governed by the rules prescribed in the Incoterms of current edition published by the International Chamber of Commerce, Paris.

18.1.7 Freight and Insurance Prices

NOT USED.

18.1.8 Ex-works (EXW) Price

The term EXW shall be governed by the rules prescribed in the Incoterms of current edition published by the International Chamber of Commerce, Paris.

18.1.9 Local Transportation & Erection Price

Not Used.

18.1.10 Drawings, Reference Standards and Records

The provision of all drawings, design calculations, records etc as specified in the Contract shall deemed to be included in the Contract price.
18.1.11 Witnessing of Tests by Employer

(i) Two Engineers of the Employer shall visit at manufacturer’s works/ testing station for witnessing proto-type load test for each type of 132kV kV double circuits towers and proto-assembly test for each type of 132kV double circuit and double circuit towers.

(ii) Two Engineers of the Employer shall visit at manufacturer’s works/ testing station for witnessing Acceptance/Sample Tests of Tower materials, Insulators, Conductor, insulator & conductor fittings with accessories, OPGW and OPGW fittings with accessories before each shipment of materials. In case of manufacturer’s works/ testing station outside Employer’s country, the cost of the air fare, hotel charges, laundry expenses, travelling expenses, fooding, health facilities and all other related cost shall be borne by the Contractor. Each visit must be minimum of 7 days or more than 7 days (if required) excluding travel time. In case of manufacturer’s works/ testing station within Employer’s country, travelling charges, hotel charges, fooding and all other related cost shall be borne by the Contractor. The visit period shall be determined as per requirement of test.

A per diem allowance of US$ 100 or equivalent shall be additionally given to the Employer’s Engineers per head including travel time by the Contractor for both test conducted at Employer’s country and outside Employer’s country. All costs for the above visits are deemed to be included in the contact price.

18.1.12 Overseas Training

Two (02) engineers of PGCB shall be given training on PLS-CADD and PLS TOWER Software at Power Line System (PLS), USA’s recognized training centre by the PLS authorized trainer,

Two (02) engineers of PGCB shall be given training on Operation & Maintenance on Transmission line from an internationally specialized training institute is also required and the duration of training shall be two weeks.

Two (02) HRD officers of PGCB shall be given on skill development from an internationally specialized training institute is also required and the duration of training shall be one weeks.

all related costs of which shall be borne by the Contractor.

The Contractor shall be responsible for bearing all costs for the above Engineers/officers including the air fare, hotel charges, travelling expenses, fooding, laundry, visa fees and health insurance to cover all medical costs that may be required during visit etc. together with a per diem allowance of USD 100 for each of the Employer’s trainees. All costs for the above visits are deemed to be included in the contract price.

18.1.13 Instruction of Employer’s Staff

During the erection period, when the Employer nominates those employees later intended to operate and maintain the Works supplied under this Contract, the Contractor, without additional cost, shall provide training on site for twenty (20) engineers of the Employer comprising a two week course on Design of Towers and Foundations. These “class-room” courses of training shall be carried out by manufacturers specialists who must be proficient in the use of the English language. Course notes
shall be issued to attendees in advance of the Course of Instruction. Completion of training shall be an essential requirement before a Taking Over Certificate is issued.

The cost of this training shall deemed to be included in the Contract Price.

18.2 SURVEY

Full precision profile survey undertaken by the Contractor on the Employer's instruction shall be paid for as per unit prices in the Price Schedule and shall be measured to the nearest metre along the centre-line of the route. The unit price shall include for the establishment or re-establishment of the line route from terminal points and other such fixed points the Employer may define, full ground survey, preparation and submission of route maps, mouza maps, profile drawings with tower plotting, SIMMs document, tree marking and tree schedule and pegging of tower locations. During check survey, the route might need to be changed due to field requirements. Cost involved in such changes shall deemed to be included in the price indicated in the price Schedule. Payment shall be done considering the final length of the line route.

18.3 ROUTE CLEARANCE & ACCESS

Route clearance undertaken by the Contractor on the Employer's instruction shall be paid for at Schedule 4 unit prices and shall be measured to the nearest metre along the centre line of the route. The prices of route clearance shall include payment of compensation for crops, trees, houses, etc. and all kinds of damage compensation.

18.4 FOUNDATIONS

18.4.1 General

The prices quoted in Price Schedule for the supply and installation of a foundation refers to a foundation required in accordance with the Specification and 'Method of Measurement and payment'. Where additional work is required over and above that provided for in the Specification and 'Method of measurement and Payment' this will be paid on a measured basis at miscellaneous unit prices or unit prices to be agreed.

The unit prices for foundations shall include all necessary geotechnical investigation and geotechnical studies as defined in the Specification or as required by relevant authorities.

The unit prices for all foundations shall include for site clearing, excavating in any material and by any means, manual or mechanical, and for ensuring, stability and natural drainage inside the working area, for all back filling, compacting and disposal of surplus material, routine testing, site restoration and for all necessary supports to sides of excavations.

The complete foundations for a tower shall be paid for at the appropriate Price Schedule unit prices.

The unit price shall include for all excavations, conventional pumping (including well-point de-watering), excavation supports, concrete work, formwork, reinforcing, stub steelwork, stub cutting, routine testing, backfilling, clearing up and all other work required to complete the foundation in accordance with the Specification.
The unit prices shall also include supply of weak-mix concrete or the importation of any back fill material necessary due to the excavated material being unsuitable as backfill.

The unit prices for foundations shall include the use of whichever type of cement is to be used and density of concrete necessary to meet the requirements of the Specification.

The unit prices for foundations shall include all stub steelwork installation and setting out including the use of templates, setting to any level and any excavation necessary for Setting out. The protective treatment to defined concrete faces or support steelwork and provision of site protection barriers shall be included in the rates for the foundations.

The unit prices for foundations shall include the cost for all earthing requirements.

Where site stabilisation outside the defined 'working area' is required this shall be undertaken at unit prices to be agreed.

Design tests on foundations to prove the foundation design shall be paid for at the unit prices quoted. The unit prices shall include for the removal of concrete and steel down to 1m below ground level where this is deemed necessary by the Employer.

All costs regarding making necessary arrangement for de-watering or whatsoever required starting the foundation inside river or water logged locations shall be included in the unit price of foundation.

18.4.2 Piled Foundations and Special Foundations

The complete foundations for each support shall be paid for at the appropriate Schedule B unit prices. The unit prices shall include for mobilisation and de-mobilisation of piling rig, setting out, cleaning, cutting, to length, reinforcement and pile cap connection, jointing of piles as necessary irrespective of number of piles, all excavations (including rock), conventional pumping (including well-point de-watering), excavation supports (including use of bentonite slurries), concrete work for piles, pile cap and tie beams, formwork, reinforcing stub steelwork, stub cutting, routine testing, backfilling, clearing up and all other work required to complete the foundation in accordance with the Specification.

The unit prices for piled foundations shall be based on the unit price for a complete tower foundation including piles, pile cap and tie beams etc.

18.4.3 Flood Protection Walls

NOT USED.

18.4.4 Miscellaneous Unit Prices

The miscellaneous unit price for additional excavation shall include for site clearing, excavating in any material and by any means manual or mechanical and for ensuring, stability and natural drainage, pumping, backfilling, compacting and disposal of surplus material, site restoration and for all necessary support to the sides of the excavation.

The miscellaneous unit price for additional concrete shall include for all design and preparation formwork and all other work necessary.
The miscellaneous unit price for reinforcement shall include for design and drawing preparation of bar bending schedules, cutting, bending, fixing and all other associated activities.

18.5 STEEL TOWERS

Steel towers normal extensions shall be paid for at Schedule B unit prices. The unit prices shall include for standard cross arms and shall include stub steelwork.

The unit prices for steel towers shall include for access facilities, anti-climbing devices, attachment plates, ancillary steelwork etc. used as standard fittings on the tower.

The unit prices shall include for all tower mounted notice plates.

Type tests, including prototype tests (if require by this specification) to structural failure, which shall be conducted at an independent testing facility or manufacturer’s own testing facility on the specified contractor-designed lattice steel towers, shall be paid for at the unit prices quoted in Schedule 8, but only if the test proves that the contractor-designed tower complies with the requirements of the specification (see Section 8).

The unit price of towers shall include all supplies and all works associated with the towers which are specified in this bid document.

18.6 INSULATOR SETS AND ASSOCIATED FITTINGS

All Insulator sets shall be paid for at Schedule B unit prices. The unit prices for insulator, sets shall include for all insulator units, links, sag adjusters, turnbuckles, weights, insulators protective devices (arc horns), tension joints (dead ends) and suspension clamps (Inclusive of helical armour rods), used as a standard between the support and the phase conductor and all others fittings specified to be supplied in this tender document.

Unit prices for earthwire tension and suspension sets shall where specified include for all earthwire bonding to the supports including all earthwire bonding clamps in accordance with the Specification and all others fittings specified to be supplied in this tender document.

All conductor tee-connectors and line termination fittings shall be paid for at Schedule B unit prices.

18.7 CONDUCTOR AND FITTINGS

Phase conductors and earthwires including OPGW shall be paid for at Schedule B unit prices, and shall be measured to the nearest metre after erection, along the centre of the route without allowance for sag jumpers or scrap. The supply and erection unit price shall include for all normal phase and earthwire jumpers including the jumpers at terminal supports between phase conductors or earthwires and downleads.

Downleads between terminal supports and anchorages and downdroppers between downleads and substation equipment shall be paid for at Schedule B unit prices. The unit prices shall include for conductors, jumpers and associated fittings.
The cost of fibre optic earthwire (OPGW) connections to the joint boxes, fixing clamps, joint boxes and fusion splicing of optical fibres shall be included in the erection unit price of OPGW.

The aforementioned erection unit prices shall include all joints, clamps and fittings other than insulator sets and their fittings, tension joints (dead ends) and/or earthwire, jumpers and downlead conductors.

All spacer dampers, vibration dampers and spacers including bonding and weighted jumper and/or spacer shall be paid for at Schedule unit prices.

18.8 AIRCRAFT NAVIGATION (OBSTRUCTION AIDS)

Aircraft warning light shall be paid for at Schedule B unit prices and shall be measured on a per support basis. The unit price shall include for the warning lights and as appropriate connection to the LV mains supply or solar panels, storage batteries etc., all power and control cables, solar light switches, support steel works as necessary.

The prices for aircraft warning lights shall include for all type, sample and routine tests.

18.9 MISCELLANEOUS

Tools and spares shall be paid for at the Schedule B unit prices.

18.10 PAYMENT FOR WORK CARRIED OUT AT TIME AND MATERIAL RATES

The Employer may, if in their opinion it is necessary or desirable, order that any additional or substituted work shall be executed on a Time and Material basis.

No work shall be carried out on a Time and Materials basis without written instructions of the Employer. All applications for payment for such work by the Contractor shall be accompanied by statements, authorising the undertaking of such work, duly signed by the Employer and shall be submitted within three months of completion of such work.

When the work is in progress the Contractor shall render daywork sheets in duplicate to the Employer showing the number of men so employed with the number of hours worked and detailed quantities of materials used. The Contractor shall obtain the Employer's certification of the daywork sheets at the end of each working week whilst the work is in progress and failure to do so shall render the Contractor liable to forfeiture of payment.

Where the Contractor is required to carry out work at the Time and Material unit prices, the Employer will furnish the Contractor with such particulars as necessary to enable the Contractor to prepare such drawings and schedules as required for such work. Unit prices for work executed on a Time and Material basis shall be agreed.
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List of Towers drawings are enclosed.

The following drawings are enclosed for tender purpose only. All types of 132 kV towers are already approved and the contractor shall manufacture the towers according to these drawings and as per the available drawings as mentioned in the bidding document.

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**TOWER TYPE 1QT6**

- **4** Route Map of 132 kV Keranigonj-Sreenagar TL
- **5** Route Map of four ckt LILO from Has-Amin to Kera. ss
- **6** Route Map of four ckt int connection line to KSS
- **7** Route Map of 132 kV LILO from Sirajgonj-Bogra to Sherpur(Bogra)ss
- **8** Re-route Map of 132 kV four ckt. line
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### TOWER TYPE 1Q30

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<td>1</td>
<td>Erection Drawing Tower Type 1DT6(ANGLE TOWER) for Bottom part of ±0M</td>
<td>PGCB/SC/02/ED/1DT6/47</td>
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<td>Erection Drawing Tower Type 1DT6(ANGLE TOWER) for Top part-1 of ±0M</td>
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<td>Erection Drawing Tower Type 1DT6(ANGLE TOWER) for Top part-2 of ±0M</td>
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<td>4</td>
<td>Erection Drawing Tower Type 1DT6(ANGLE TOWER) Cross - Arm plan</td>
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<td>Erection Drawing for Tie plan</td>
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**TOWER TYPE 1DT6 (Terminal) (Normal)**

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<td>Erection Drawing Tower Type 1DT6 (Terminal Tower) Cross Arm Plan With Aux Cross-Arm</td>
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<td>Erection Drawing Tower Type 1DT6 (Terminal Tower) Tie Plan with Aux-TIE</td>
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**TOWER TYPE 1DT6 (Angle/Terminal) (Normal)**

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<td>Erection Drawing of stub for pile foundation Tower Type: 1DT6 (ANGLE TOWER)</td>
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<td>Erection Drawing Tower Type 1DT6 (Terminal Tower) TIE PAN</td>
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### Accessories

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<td>Number plate</td>
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<td>5</td>
<td>132 kV heavy suspension set (120 kN)</td>
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<td>6</td>
<td>132 kV tension set (120 kN)</td>
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<td>132 kV upright low duty tension set (120 kN)</td>
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<td>132 kV inverted low duty tension set (70 kN)</td>
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<td>OPGW suspension set</td>
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<td>OPGW tension set</td>
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<td>11</td>
<td>Typical drawing for insulator showing zinc sleeve &amp; straight head</td>
<td>PGCB/TL/INS</td>
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<td>12</td>
<td>Step bolt</td>
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<td>14</td>
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### TOWER TYPE 1DL

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<td>T2005-1DL-01</td>
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<td>132kV Tower Type – 1DL, Bottom Part</td>
<td>T2005-1DL-02</td>
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<tr>
<td>3</td>
<td>132kV Tower Type – 1DL, E0 Body</td>
<td>T2005-1DL-03</td>
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<td>4</td>
<td>132kV Tower Type – 1DL, E1.5 Body</td>
<td>T2005-1DL-04</td>
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<td>132kV Tower Type – 1DL, E6 Body</td>
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<td>132kV Tower Type – 1DL, Stub (Except E9)</td>
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### TOWER TYPE 1D1

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<td>132kV Tower Type – 1D1, Bottom Part</td>
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### TOWER TYPE 1D25
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<td>132kV Tower Type – 1D25, Bottom Part</td>
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<td>132kV Tower Type – 1D25, E0 Body</td>
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<td>132kV Tower Type – 1D25, E1.5 Body</td>
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<td>132kV Tower Type – 1D25, E3 Body</td>
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### TOWER TYPE 1DT6
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### TOWER ERECTION DRAWING LIST FOR TYPE 2DT6

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<td>Erection Drawing for Bottom X-Arm Plan (without Aux-X-Arm)</td>
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<td>Erection Drawing for Middle X-Arm Plan (without Aux-X-Arm)</td>
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<td>Erection Drawing for ±6M Body Extn.</td>
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<td>Erection Drawing for ±6M Body Extn.(View 16-16 &amp; 17-17)</td>
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<td>Erection Drawing for ±3M Body Extn.</td>
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### SINGLE LINE DRAWING LIST FOR TOWER TYPE 2QT6

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<td>Details Tower Design for four circuit Angle/Terminal Tower Type “2QT6”(30˚-60˚)</td>
<td>HGPT/PGCB/2QT6/TD105</td>
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<td>Details Tower Design for four circuit Angle/Terminal Tower Type “2QT6”(30˚-60˚)</td>
<td>HGPT/PGCB/2QT6/TD105</td>
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Note: Soft copy of the above listed drawings are available in CD
Social Safeguards issues and management

This project triggers World Bank’s OP 4.12 (Involuntary Resettlement). Thus, the contractor will be responsible to ensure that all construction activities follow the policy
provisions specified in project’s “environment and social management framework (ESMF)” and the “resettlement policy framework (RPF)” to provide appropriate compensations and assistance to affected persons. Once awarded the contract, the contractor will review these documents carefully and work with PGCB and its resettlement consultant firm to implement the provisions mentioned in line with the World Bank policies. Depending on an affected person’s preference, BREB/PGCB may consider using both financial and material forms of compensation and assistance. Costs related to compensation as per the ESMF and RPF will be borne by the employer. The payment for compensation may have to be paid by the contractor to be reimbursed by the employer. The contractor will ensure delivery of the agreed compensation/assistance in a timely and transparent manner. Compensation for the affected assets will be according to the following principles:

• Replacement cost of houses/structures at the current prices of same building materials, plus the current cost of labor to build them. Depreciation and value of the salvageable building materials will not be deducted while computing the compensation.
• Current market prices of trees that are to be felled (owners will retain ownership of un-felled trees).
• Other acceptable in-kind compensation.
• Compensation in cash will be made in public.

Construction/ Rehabilitation of Transmission Line and Distribution Line: Impacts of sub-projects and corresponding mitigation and enhancement measures

<table>
<thead>
<tr>
<th>Activity/Issues</th>
<th>Potential Impacts</th>
<th>Proposed Measures</th>
<th>Mitigation and Enhancement Measures</th>
<th>Responsible Parties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction and operation of labor shed for workers</td>
<td>• Generation of sewage and solid waste; water/ environmental pollution</td>
<td>• Construction of sanitary latrine/ septic tank system.</td>
<td>• Erection of “no litter” sign, provision of waste bins/cans, where appropriate</td>
<td>Contractor (Monitoring by PGCB)</td>
</tr>
<tr>
<td></td>
<td>• Health of workers</td>
<td>• Raising awareness about hygiene practices among workers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Possible development of labor camp into permanent settlement</td>
<td>• Availability and access to first-aid equipment and medical supplies</td>
<td></td>
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<tr>
<td></td>
<td>• Outside labor force causing negative impact on health and social well-being of local people</td>
<td>• Contractor to remove labor camp at the completion of contract</td>
<td></td>
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</tr>
<tr>
<td>General construction works for sub-projects</td>
<td>• Drainage congestion and flooding</td>
<td>• Provision for adequate drainage of storm water</td>
<td>• Provision of adequate diversion channel, if required</td>
<td>Contractor (Monitoring by PGCB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Provision for pumping of congested water, if required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity/Issues</td>
<td>Potential Impacts</td>
<td>Proposed Mitigation and Enhancement Measures</td>
<td>Responsible Parties</td>
<td></td>
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<tr>
<td>---------------------------------</td>
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<td></td>
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<tr>
<td>• Air pollution</td>
<td>• Ensure that all project vehicles are in good operating condition.</td>
<td>• Spray water on dry surfaces/ unpaved roads regularly&lt;br&gt;• Maintain adequate moisture content of soil during transportation, compaction and handling.&lt;br&gt;• Sprinkle and cover stockpiles of loose materials (e.g., fine aggregates).&lt;br&gt;• Avoid use of equipment such as stone crushers at site, which produce significant amount of particulate matter.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Traffic congestion, obstruction to pedestrian movement</td>
<td>• Schedule deliveries of material/ equipment during off-peak hours.&lt;br&gt;• Depute flagman for traffic control&lt;br&gt;• Arrange for signal light at night</td>
<td></td>
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<td></td>
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<tr>
<td>• Noise pollution</td>
<td>• Use of noise suppressors and mufflers in heavy construction equipment.</td>
<td>• Avoid using of construction equipment producing excessive noise at night.&lt;br&gt;• Avoid prolonged exposure to noise (produced by equipment) by workers.&lt;br&gt;• Regulate use of horns and avoid use of hydraulic horns in project vehicles.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Water and soil pollution</td>
<td>• Prevent discharge of fuel, lubricants, chemicals, and wastes into adjacent rivers/ khals/ drains.&lt;br&gt;• Install sediment basins to trap sediments in storm water prior to discharge to surface water.&lt;br&gt;• Keep noise level (e.g., from equipment) to a minimum level, as certain fauna are very sensitive to loud noise (e.g., during transmission tower construction over river/wetlands)</td>
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<tr>
<td>• Destruction of aquatic habitat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Felling of trees, clearing of vegetation</td>
<td>• Replant vegetation when soils have been exposed or disturbed.&lt;br&gt;• Plantation to replace felled trees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Accidents</td>
<td>• Following standard safety protocol.&lt;br&gt;• Environmental health and safety briefing.&lt;br&gt;• Provision of protective gears as specified in ECoP.&lt;br&gt;• Provision of appropriate protective measures against accidental fall from elevated height (e.g. using body harness, waist belts, secured climbing devices, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity/Issues</td>
<td>Potential Impacts</td>
<td>Proposed Mitigation and Enhancement Measures</td>
<td>Responsible Parties</td>
<td></td>
</tr>
<tr>
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</tr>
</tbody>
</table>
| Spills and leaks of oil, toxic chemicals | - Good housekeeping.  
- Proper handling of lubricating oil and fuel.  
- Collection, proper treatment, and disposal of spills. | - A safety observer must be appointed at each subproject site by the contractor before the commencement of work.  
- Only allowing trained and certified workers to install, maintain, or repair electrical equipment;  
- Deactivating and properly grounding live power distribution lines before work is performed on, or in close proximity, to the lines;  
- Proper Personal Protective Equipment (PPE) for all workers and others associated with work  
- Where rehabilitation is required within minimum setback distances, specific training, safety measures, personal safety devices, and other precautions should be defined before work. | Contractor (Monitoring by PGCB) |

| Health and Safety | Exposure to physical hazards from use of heavy equipment and cranes; trip and fall hazards;  
- Exposure to dust and noise; falling objects; work in confined spaces;  
- Exposure to hazardous materials;  
- Exposure to electrical hazards from the use of tools and machinery. | - Not storing electric poles/transmission tower components over busy roads/highways  
- Following standard safety protocols while erecting poles and stretching cables  
- Taking appropriate protective measures against accidental fall from elevated height (e.g. using body harness, waist belts, secured climbing devices, etc.) as specified in ECoP. | |

| Installation of poles of transmission / distribution lines adjacent to roadways | Traffic congestion/traffic problems  
- Safety | Contractor (Monitoring by PGCB) |

| Construction of power line through natural habitat or tree plantation area | Impact on biodiversity, vegetation and habitat | Contractor (Monitoring by PGCB) |

| Tower Foundation in the Major River | Impact on Fisheries and Other Aquatic Life in the Major River  
- Collision with water vessels | Use a vibratory hammer for pile work  
- Installation of underwater enclosures to minimize sound  
- Use signage and construct fender( if necessary) | Contractor (Monitoring by PGCB) |
General Instructions:

Safety Directives for Protective Gears

1. The Contractor shall organize orientation to use of personal protective equipment. Workers shall be informed of all measures to be taken. Consultation and participation shall take place on the matters related to the use of the protective equipment. A partial list of protective gears to be worn by the workers at designated work areas is given below; Table 17 presents the list in tabular form.

2. Head Protection: Protective helmets will be put on at all times mainly at the building and bridge construction sites, under scaffolds, erection and stripping of formworks, etc., where there are possibilities of head injuries from falling/flying objects.

3. Hearing Protection: Ear plugs or ear muffs should be worn in areas where exposure to high noise level is expected. Examples of such activities include percussion drill, bolt driving, etc.

4. Eye and Face Protection: Spectacles, Goggles, Face Shield or Arc-welding Mask with Hand Masks, whichever is appropriate, should be worn at times when percussion drilling, spray painting, welding or similar activities are in progress at the field.

5. Respiratory Protection: In work areas such as septic tanks, dump sites, sewers etc., where exposure to harmful or toxic gases is likely the workers should wear gas masks, dust filters, or insulating appliances with air supply, whichever is appropriate.

6. Hand and Arm Protection: In the work involving piercing, cutting or vibration. For protection against toxic chemicals special chemical resistant gloves should be worn. Over sleeves must be worn to protect ones arms.

7. Foot Protection: In road and bridge constructions, working on or under scaffolds, roof works, formwork erection and dismantling safety shoes/boots are essential protective measures.

Safety and Health Signs

8. Safety signs, health signs, prohibition sign, warning sign, mandatory sign, emergency escape sign, first-aid sign, information sign, signboard, supplementary signboard, safety color, symbol, pictogram, illuminated sign, acoustic signal, verbal communication and hand signal are essential tools for preventing accidents by providing information in advance.

9. When working on or with overhead lines the provisions of the paragraphs shall be complied with:
   • Prior to climbing poles, ladders, scaffolds, or other elevated structures, an inspection shall be made to determine that the structures are capable of sustaining the additional or unbalanced stresses to which they will be subjected.
   • Where poles or structures may be unsafe for climbing, they shall not be climbed until made safe by guying, bracing, or other adequate means.
   • Before installing or removing wire or cable, strains to which poles and structures will be subjected shall be considered and necessary action taken to prevent failure of supporting structures.
   • When setting, moving, or removing poles using cranes, derricks, gin poles, A-frames, or other mechanized equipment near energized lines or equipment, precautions shall be taken to avoid contact with energized lines or equipment, except in bare-hand live-line work, or where barriers or protective devices are used.
   • Unless using suitable protective equipment for the voltage involved, employees standing on the ground shall avoid contacting equipment or machinery working adjacent to energized lines or equipment.
   • Lifting equipment shall be bonded to an effective ground or it shall be considered energized and barricaded when utilized near energized equipment or lines.
   • Pole holes shall not be left unattended or unguarded in areas where employees are currently working.
   • Tag lines shall be of a nonconductive type when used near energized lines.

Table 4.18: Brief list of protective gears to be worn during the use of some equipment

<table>
<thead>
<tr>
<th>Works / Equipment Use</th>
<th>Safety Measures for Workers and/or Work Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Construction Works</td>
<td>HH, STB, HG</td>
</tr>
<tr>
<td>Earth-works</td>
<td>HH, STB, HG</td>
</tr>
<tr>
<td>Electric-works</td>
<td>IB, HG</td>
</tr>
<tr>
<td>Cables and Wires</td>
<td>HG, EG, HH</td>
</tr>
<tr>
<td>Works/ Equipment Use</td>
<td>Safety Measures for Workers and/or Work Areas</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Wood-works</td>
<td>HH, STB, HG</td>
</tr>
<tr>
<td>Road Paving</td>
<td>HH, STB, HG, BP, FM</td>
</tr>
<tr>
<td>Cranes</td>
<td>HH, STB, HG, WB</td>
</tr>
<tr>
<td>Pile Driver</td>
<td>HH, STB, HG, EP, WB</td>
</tr>
<tr>
<td>Arc Welder</td>
<td>HH, WV, HG</td>
</tr>
<tr>
<td>Bull Dozer</td>
<td>HH, STB, WB</td>
</tr>
<tr>
<td>Auger Drill</td>
<td>HH, STB, HG, WB</td>
</tr>
<tr>
<td>Concrete Mixer</td>
<td>HH, STB, HG, WB</td>
</tr>
<tr>
<td>Fork Lift</td>
<td>HH, HG, STB, WB</td>
</tr>
<tr>
<td>Elbow Jack</td>
<td>HH, STB, HG</td>
</tr>
<tr>
<td>Sledge/Pick Hammer</td>
<td>HH, STB, HG, WB</td>
</tr>
<tr>
<td>Vibrator</td>
<td>HH, STB, HG, WB</td>
</tr>
<tr>
<td>Pick Axe</td>
<td>HH, STB, HG, WB</td>
</tr>
<tr>
<td>Electric Saw</td>
<td>HG, EG, EM</td>
</tr>
<tr>
<td>Working on Poles, Towers</td>
<td>HH, STB, HG, WB</td>
</tr>
</tbody>
</table>


10. For Metal Tower Construction:
   - When working in unstable material the excavation for pad- or pile-type footings in excess of 1.5m deep shall be either sloped to the angle of repose as required in design or shored if entry is required. Ladders shall be provided for access to pad- or pile-type footing excavations in excess of 1.33m.
   - When working in unstable material provision shall be made for cleaning out auger-type footings without requiring an employee to enter the footing unless shoring is used to protect the employee.
   - A designated employee shall be used in directing mobile equipment adjacent to footing excavations.
   - No one shall be permitted to remain in the footing while equipment is being spotted for placement.
   - Where necessary to assure the stability of mobile equipment the location of use for such equipment shall be graded and leveled.
   - Tower assembly shall be carried out with a minimum exposure of employees to falling objects when working at two or more levels on a tower.
   - Guy lines shall be used as necessary to maintain sections or parts of sections in position and to reduce the possibility of tipping.
   - Members and sections being assembled shall be adequately supported.

11. The construction of transmission towers and the erecting of poles, hoisting machinery, site preparation machinery, and other types of construction machinery shall conform to following applicable requirements:
   - No one shall be permitted under a tower which is in the process of erection or assembly, except as may be required to guide and secure the section being set.
   - When erecting towers using hoisting equipment adjacent to energized transmission lines, the lines shall be de-energized when practical. If the lines are not de-energized, extraordinary caution shall be exercised to maintain the minimum clearance distances required by PGCB.
   - Erection cranes shall be set on firm level foundations and when the cranes are so equipped outriggers shall be used.
   - Tag lines shall be utilized to maintain control of tower section being raised and positioned, except where the use of such lines would create a greater hazard.
   - The load-line shall not be detached from a tower section until the section is adequately secured.
   - Except during emergency restoration procedures erection shall be discontinued in the event of high wind or other adverse weather conditions which would make the work hazardous.
   - Equipment and rigging shall be regularly inspected and maintained in safe operating condition.
   - Adequate traffic control shall be maintained when crossing highways and railways with equipment as required.
   - A designated employee shall be utilized to determine that required clearance is maintained in moving equipment under or near energized lines.

12. For Stringing of Conductors: Conductors being strung in or removed shall be kept under positive control by the use of adequate tension reels, guard structures, tielines, or other means to prevent accidental contact with energized circuits.
   - Guard structure members shall be sound and of adequate dimension and strength, and adequately supported.
   - Catch-off anchors, rigging, and hoists shall be of ample capacity to prevent loss of the lines.
- The manufacturer's load rating shall not be exceeded for stringing lines, pulling lines, sock connections, and all load-bearing hardware and accessories.
- Pulling lines and accessories shall be inspected regularly and replaced or repaired when damaged or when dependability is doubtful.
- Conductor grips shall not be used on wire rope unless designed for this application.
- While the conductor or pulling line is being pulled (in motion) employees shall not be permitted directly under overhead operations, nor shall any employee be permitted on the cross-arm.
- A transmission clipping crew shall have a minimum of two structures clipped in between the crew and the conductor being sagged. When working on bare conductors, clipping and tying crews shall work between grounds at all times. The grounds shall remain intact until the conductors are clipped in, except on dead end structures.
- Except during emergency restoration procedures, work from structures shall be discontinued when adverse weather (such as high wind or strong rain or storm) makes the work hazardous.
- Stringing and clipping operations shall be discontinued during the progress of an electrical storm in the immediate vicinity.
- Reel handling equipment, including pulling and braking machines, shall have ample capacity, operate smoothly, and be leveled and aligned in accordance with the manufacturer's operating instructions.
- Reliable communications between the reel tender and pulling rig operator shall be provided.
- Each pull shall be snubbed or dead ended at both ends before subsequent pulls.

13. The Contractor will provide or ensure that appropriate safety and/or health signs are in place at their work sites where hazards cannot be avoided or reduced. Workers and their representatives must be informed of all the measures taken concerning health and safety signs at work and must be given suitable instruction about these signs.

Special Environmental Clauses (SECs):

14. These clauses are aimed at ensuring that the Contractor carries out his responsibility of implementing the EMP and other environmental and safety measures. Further, the special clause must be included for prohibiting the purchase and installation of transformers containing PCB.

15. To perform the work the contractor must hire at least one environment, health and safety supervisor for each subproject. Depending on the size of the subproject, REB/PGCB may recommend more than one supervisors in the bidding document.

16. Environmental Management Plan (EMP): The Contractor shall carry out all mitigation and enhancement measures (including those related to mitigation of air/noise/water pollution; drainage/traffic congestion) as specified in the Environmental Management Plan (EMP), annexed to this Contract.

17. Temporary Works: The Contractor shall make sure that all equipment and safeguards required for the construction work such as temporary stair, ladder, ramp, scaffold, hoist, run away, barricade, chute, lift, etc. are substantially constructed and erected, so as not to create any unsafe situation for the workmen using them or the workmen and general public passing under, on or near them.

18. Health and Safety: All contractors are responsible to:
  - Maintain standards of Health and Safety towards all of his employees not less than those laid down by the national standards or statutory regulations.
  - Be in compliant with all Health and Safety Terms and Conditions described in ECoP 20 and 21;
  - Ensure that all of its workers entering the worksite comply with the Occupational Health and Safety. The Contractor shall provide all appropriate protective clothing and equipment for the work to be done and ensure its proper use. Where required, safety nets, belts, harnesses and lines shall be provided by the contractor. The “safety directives for work equipment” and “safety directives for protective gears”, as specified in the Occupational Health and Safety Guidelines (attached) shall be followed.
  - The Contractor shall supply and install PCB free transformers so as to prevent possible exposure to hazardous chemicals.
  - Provide and maintain in prominent and well-marked positions all necessary first-aid equipment, medical supplies and other related facilities. A sufficient number of trained personnel will be required to be available at all times to render first aid.
  - Provide or ensure that appropriate safety and/or health signs are in place at their work sites where hazards cannot be avoided or reduced.
  - Report to the Engineer promptly and in writing particulars of any accident or unusual or unforeseen occurrences on the site, whether these are likely to affect progress of the work or not.
• Safety Orientation prior to working at the work-site;
• Unless otherwise agreed to in writing by the REB/PGCB/PBS Project Contact Person, supply all necessary equipment and tools, including but is not limited to ladders, scuffles, man-lifts, forklifts, and others required in completing the work;
• Ensure that all equipment and tools, including PPE, used on the work-site are in good working condition, properly maintained;
• Ensure that equipment is operated only by those workers who have been properly trained and are skilled in the operation of the equipment;
• Have available for reference a manufacturer’s operating manual for all the equipment and tools brought to the work-site;
• Use appropriate authorization to facilitate access to the project site as permitted.
• Ensure good accommodation, water supply and sanitation facilities for all workers.

19. Disposal and Pollution:
• The Contractor shall not dispose any waste, rubbish or offensive matter in any place not approved by the Engineer or Statutory Authority having jurisdiction. The Contractor shall not discharge into any watercourse oil, solids, noxious or floating materials.
• The Contractor shall, where required, treat PCB contained in old transformers available technologies; namely, super critical oxidation, electro-chemical oxidation, solvated electron technology, chemical reduction method, dehalogenation process, and thermal desorption using pyrolysis, catalyzed dehalogenation and vitrification before disposal.
• The Contractor shall take all reasonable precautions to keep public or private roads clean of any spillage or droppings from his vehicles or equipment. Any spillage or droppings which accrue shall be cleaned without delay to the satisfaction of the Engineer.
• The Contractor shall construct sanitary latrine or septic tank system or install portable cabin toilet for disposal of human waste in the site office and temporary labor sheds for workers/employees; the Contractor shall provide waste bins/cans for collection of solid waste at appropriate locations (as directed by the Engineer), and ensure proper transfer/disposal of solid waste.

Institutional Arrangement and Responsibility

Contractor:

20. In addition of Contractor’s general arrangement to continue the construction and rehabilitation work under the transmission line project, contractor must hire at least one environment, health and safety supervisor for each subproject before the commencement of work. The Contractor/Subcontractor shall abide by the rules of regulation of the Occupational health and safety as stipulated in the Labour Act-2006 and BNBC codes of Bangladesh. The contractor shall also abide by the clauses of health and safety in the clauses at General Condition and subsequent Particular Condition of the bid document.

21. Role of environment, health and safety supervisor: Primary role is to monitor the movement of people, workers and equipment, give timely warnings of any risk or non-compliance with safe work procedures and, where necessary, stop work if a risk situation escalates or cannot be minimized as well as look the potential environmental issues (air pollution, noise level, water quality, waste management etc.).

22. The tasks of environment and safety supervisor include the following:

• Ensure first aid facilities and personal protective equipment (PPE) for workers at the sites
• Provide orientation to workers before start of the subproject activities.
• Warn the workers of any imminent or deteriorating risk situation that could result in an accident, and instruct when it is safe to proceed
• Ensure restrain from undertaking any other tasks that may distract the workers focus on the work, mainly, work on or near live overhead conductors, work on transmission and communication towers.
• Stop the work, if necessary safety would not be ensured
• Pause the work while the safety observer changes position.
• Ensure special safety during elevated work platform work or crane operations on or near live conductors.
• Ensure proper collection and disposal of solid wastes within the construction site.
• Ensure proper infrastructure facilities, water supply and sanitation facilities for all workers.

23. The contractor will prepare a monitoring report on environment and safety for each subproject at every month during the construction/rehabilitation of transmission line or substation.

Environmental Code of Practice (ECoP)
The Environmental Code of Practice (ECoP) is a guideline for reducing or eliminating environmental risk due to various activities associated with the construction of substations, construction and rehabilitation of 132kV Transmission Lines of PGCBS and 33kV Distribution Lines of REB.

**ECoP 1.0: Planning and Design Phases of a Project**

1.1 General

This code of practice details the factors to be considered during project preparation to avoid/address environmental concerns through modifications in project design and incorporation of mitigation measures.

1.2 Compliance to Legal Requirements

The bid document shall include the various applicable clearances pertaining to environmental management and shall contain the necessary procedures for compliance of the same.

**ECoP 2.0: Route Selection**

2.1 Selection and Finalization of Alignment/Project Location

- Adequate consultations with the communities to identify the concerns and preferences need to be taken up during selection of the alignment of the Transmission/Distribution lines.
- Alignment shall conform to the natural topography as far as possible to avoid excessive cut and fill.
- Special care should be taken to align the routes along the hillside, which is stable and where cutting on hillside causes least disturbance.
- Consultations with the local communities are to be conducted to obtain their suggestions and incorporate their concerns to address the potential environmental impacts.
- Selection of site for substations should be done in consultation with the local communities addressing the environmental as well as social issues so as to cause least possible adverse impacts.
- In case of flood prone areas and/or areas with very flat slopes, hydrological surveys have to be conducted before alignment finalization.

**ECoP 3.0: Tower/Pole Erection**

3.1 General

Erection of poles/towers for installation of 33kV/132kV power distribution/transmission lines of the REB/PGCB involves:

1. Informing the local community about the installation schedule;
2. Marking and clearance of the designated locations for installation/replacement of SPC poles/Steel tower. Scope of this ECoP includes only the measures to address environmental concerns expected during the Pole erection process.

3.2 Pole/Tower Erection Activities by REB/PGCB

- Informing the community and local city/village councils about the likely schedule of erection;
- After obtaining the consent of the community REB/PGCB shall be responsible to stake out the designated locations.

3.3 Pole/Tower Erection Activities by the Contractor

- The contractor shall submit the schedules and methods of operations for various items during the Pole/Tower erection operations to the REB/PGCB for approval.
- The clearance of sites shall involve the removal of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, part of topsoil and rubbish. Towards this end, the Contractor shall adopt the following measures:
- To minimize the adverse impact on flora and vegetation, only ground cover/shrubs that impinge directly on the permanent works shall be removed.
- In locations where erosion or sedimentation is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion and sedimentation control features can follow immediately, if the project conditions permit.
- The disposal of wastes shall be in accordance with the provisions of ECoP 11.0, “Waste Management”.

**River Crossing Towers**

- All regulatory clearances shall be obtained before actual start of work. River Crossing Towers are very high electric towers specially designed to cross large rivers. Tower construction for river crossing will require proper protective measures against bank collapse. Sheet-Piling or Shore protection measures should be ensured while laying the foundation of the tower near the river bank or in the river bed. Pre-cast piles should be driven in with extreme care so as to expose the workers to the least possible danger.
- Foundation should be checked for damages or uneven settlement following construction.
- Proper safety measures should be ensured prior to River crossing jobs.
- The work plans should be submitted by the contractor/engineer prior to commencement of the erection work. The work plan should provide detailed steps of foundation works in the river. River traffic movement should not be obstructed at any stage.
- Proper protective measures should be adopted to prevent or minimize river water pollution.
- Use signage and construct fender (if necessary) to prevent collision with vessel.
ECOp 4.0: Overhead Power Cable Installation

4.1 General
Installation of 33kV/132kV power distribution/transmission lines of the REB/PGCB involves:

i. Informing the local community about the installation schedule;

ii. Marking and clearance of the designated routes for installation/rehabilitation of overhead power lines. Scope of this ECoP includes only the measures to address environmental concerns expected during the power cable installation process.

4.2 Overhead Distribution/Transmission Cable Installation Activities by REB/PGCB
- Informing the community and local city/village councils about the likely schedule of installation;
- After obtaining the consent of the community REB/PGCB shall be responsible to stake out the designated route.

4.3 Overhead Distribution/Transmission Cable Installation Activities by the Contractor
- The contractor shall submit the schedules and methods of operations for various items during the overhead power cable installation/rehabilitation operations to the REB/PGCB for approval.
- The clearance of sites shall involve the removal of all materials such as trees, bushes and rubbish. Towards this end, the Contractor shall adopt the following measures:
  - To minimize the adverse impact on flora and vegetation, only ground cover/shrubs that impinge directly on the permanent works, if any, shall be removed.
  - The disposal of wastes shall be in accordance with the provisions of ECoP 11.0, “Waste Management”.
  - All regulatory clearances shall be obtained before actual start of work.

ECOp 5.0: Installation of Transformers on H-Pole

5.1 General
Installation of Transformers on H-Poles along the route:

i. Informing the local community about the installation schedule;

ii. Marking and clearance of the designated locations for installation of transformers on H-poles Scope of this ECoP includes only the measures to address environmental concerns expected during the power cable installation process.

5.2 Activities Involved in Transformer Installation on H-Pole by REB/PGCB
- Informing the community and local city/village councils about the likely schedule of installation;
- After obtaining the consent of the community REB/PGCB shall be responsible to stake out the designated locations.

5.3 Activities Involved in Transformer Installation on H-Pole by the Contractor
- The contractor shall submit the schedules and methods of operations for various items during the installation operations of the transformers on H-Pole to the REB/PGCB for approval.
- The clearance of sites shall involve the removal of all materials such as trees, bushes and rubbish. Towards this end, the Contractor shall adopt the following measures:
  - To minimize the adverse impact on flora and vegetation, only ground cover/shrubs that impinge directly on the permanent works shall be removed.
  - The disposal of wastes shall be in accordance with the provisions of ECoP 11.0, “Waste Management”.
  - All regulatory clearances shall be obtained before actual start of work.

ECOp 6.0: Site Preparation for Substations

6.1 General
The preparation of site for construction of electrical substations involves:

i. Marking and clearance of the required project area of all encroachments by the REB/PGCB prior to mobilization of Contractor;

ii. Informing the local community about construction schedule; and

iii. Site preparation by the contractor prior to commencement of construction. Scope of this ECoP includes only the measures to address environmental concerns expected during the site preparation.

2.2 Site Preparation Activities by the REB/PGCB
- Informing the community and local village councils about the likely schedule of construction
- After obtaining the consent of the community the REB/PGCB shall be responsible to stake out the substation locations and boundary.

2.3 Site Preparation Activities by the Contractor
- The contractor shall submit the schedules and methods of operations for various items during the construction operations to the REB/PGCB for approval.
- The clearance of site shall involve the removal of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, part of topsoil and rubbish. Towards this end, the Contractor shall adopt the following measures:
  - To minimize the adverse impact on flora and vegetation, only ground cover/shrubs that impinge directly on the permanent works shall be removed.
  - In locations where erosion or sedimentation is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion and sedimentation control features can follow immediately, if the project conditions permit.
  - The disposal of wastes shall be in accordance with the provisions of ECoP 11.0, “Waste Management”.
All regulatory clearances shall be obtained before actual start of work.

**ECoP 7.0: Construction Camps**

**7.1 General**

ECoP 7.0 provides guidelines on the selection, development, maintenance and restoration of construction camp sites in order to avoid or to mitigate against significant adverse environmental effects, both transient and permanent.

**7.2 Construction Camp Siting**

During planning of the works consideration shall be given to the location of construction camps for the field implementation of the project. Construction camps and areas identified that may be suitable for the development of such camps shall be selected in consultation with the Engineer of the REB/PGCB. Areas which are not suitable for reasons such as environmental, cultural or social sensitivity shall also be identified. Wherever possible, construction camps shall be planned in areas that will have minimal adverse environmental effects. In identifying such areas particular care shall be taken to evaluate the adverse affects on water, noise and air pollution, which, although transient, will preclude the use of some areas as construction camp sites.

**7.3 Construction Camp Location**

Construction camp sites shall be located such that permanent adverse environmental effects can be avoided or mitigated against and transient adverse environmental effects are minimized. Camp sites shall not be located in areas identified during the planning stage as unsuitable for such use. The site or sites shall be selected such that mitigation measures stipulated in this ECoP can be implemented with reasonable facility.

**7.4 Private Land**

Where construction camps are to be located on land outside the road reserve the contractor shall obtain the approval of the landowner to establish the camp site on such land and pay agreed compensation as per the **Resettlement and Rehabilitation Framework**. Environmental protection measures established by this ECoP shall apply to all land regardless of ownership.

**7.5 Construction Camp Facilities**

The construction camp shall be provided with the following minimum facilities:

- A perimeter security fence at least 1.5m in height constructed from appropriate materials.
- Ablution block with a minimum of one water closet toilet or Pota-cabin, one urinal and one shower for personnel engaged either permanently or temporarily on the project. Pota-cabins or separate toilet and wash facilities shall be provided for male and female employees.
- A sickbay and first aid station.
- Areas for the storage of fuel or lubricants and for a maintenance workshop. Such an area shall be bounded and have a compacted/impervious floor to prevent the escape of accidental spillage of fuel and or lubricants from the site. Surface water drainage from bounded areas shall be discharged through purpose designed and constructed oil traps. Empty fuel or oil drums may not be stored on site.
- Storm water drainage system to discharge all surface run off from the camp site to a silt retention pond which shall be sized to provide a minimum of 20 minutes retention for storm water flow from the whole site that will be generated by a 20 year return period rainfall having a duration of at least 15 minutes. The run-off coefficient to be used in the calculation of the silt pond volume shall be 0.9. Silt ponds shall be maintained in an efficient condition for use throughout the construction period with trapped silt and soil particles being regularly removed and transported and placed in waste material disposal areas as per ECoP11.0.
- All discharge from the silt retention pond shall be channeled to discharge to natural water via a grassed swale at least 10 meters in length with suitable longitudinal gradient.
- All camp facilities shall be maintained in a safe clean and or appropriate condition throughout the construction period.

**7.5.1 Construction Camp Development Plan**

A development plan of the construction camp shall be prepared describing the following:

- Perimeter fence and lockable gates
- Workshop
- Accommodation
- Ablutions
- Water supply
- Wastewater disposal system
- Bounded fuel storage area
- Proposed power supply
- Proposed all weather-surfaced areas.

**7.6 Site Restoration**

At the completion of the construction work, all construction camp facilities shall be dismantled and removed from the site and the whole site restored to a similar condition to that prior to the commencement of the works or to a condition agreed to with the owner of the land. All oil or fuel contaminated soil shall be removed from the site and transported and buried in waste soil disposal areas.

**ECoP 8.0: Topsoil Salvage, Storage and Replacement**

**8.1 General**

Loss of topsoil will be a long-term impact along the process of construction of substations, installation or rehabilitation of the overhead power cables by the REB/PGCB due to,
i. Site clearance and excavation for temporary road, substation, protective embankment, etc.
ii. Development of borrow areas
iii. Temporary construction activities as material storage locations, diversion routes, etc.

Scope of this ECoP includes removal, conservation and replacement of topsoil.

8.2 Pre-construction Stage

The arrangements for temporary usage of land, borrowing of earth and materials by the Contractor with the land owner shall include the conservation/preservation of topsoil.

8.3 Construction Stage

- The stockpiles for storing the topsoil shall be designed such that the slope does not exceed 1:2 (vertical to horizontal), and the height of the pile is restricted to 2m.
- In cases where the topsoil has to be preserved for more than a month, the stockpile is to be stabilized within 7 days. The stabilization shall be carried out through temporary seeding. It consists of planting rapid-growing annual grasses or small grains, to provide initial, temporary cover for erosion control.
- After spreading the topsoil on disturbed areas, it must be ensured that topsoil is seeded, and mulched within 30 days of final grading.
- During construction, if erosion occurs from stockpiles due to their location in small drainage paths, the sediment-laden runoff should be prevented from entering nearby watercourses.
- The Contractor shall preserve the stockpile material for later use on slopes or shoulders.

8.4 Post-construction Stage

- The topsoil shall be re-laid on the area after taking the borrow earth to maintain fertility of the agricultural field, finishing it to the required levels and satisfaction of the farmer.
- All temporary arrangements made for stockpile preservation and erosion control are to be removed after reusing the stockpile material.

ECoP 9.0: Borrow Areas

9.1 General

In general transmission line will pass over the agricultural land, low lying area. A high level temporary access may be required for tower foundation or mobilization of equipment and vehicles. Embankment or filling material, if needed, is to be procured from borrow areas designated for the purpose. The scope of this ECoP extends to measures that need to be incorporated during borrow area identification, material extraction and rehabilitation with regard to environment management.

9.2 Pre-construction Stage

The contractor shall identify the borrow area locations in consultation with the owners, after assessing the suitability of the material. The suitable sites shall be selected and finalized in consultation with REB/PGCB.

9.3 Construction Stage

The contractor should adopt the following precautionary measures to minimize any adverse impacts on the environment:

i. Borrow pits situated less than 0.5 km (if unavoidable) from villages and settlements should not be dug for more than 30 cm after removing 15cm of topsoil and should be drained.
ii. The Contractor shall maintain erosion and drainage control in the vicinity of all borrow pits and make sure that surface drains do not affect the adjacent land or future reclamation.
iii. In case the borrow pit is on agricultural land, the depth of borrow pits shall not exceed 45 cm and may be dug out to a depth of not more than 30 cm after stripping the 15 cm top soil aside.
iv. In case of riverside, borrow pit should be located not less than 15m from the toe of the bank, distance depending on the magnitude and duration of flood to be withstood.

9.4 Post-construction Stage

It needs to be ensured that all reclamation has been carried out in accordance with the restoration plan. Certificate of Completion of Reclamation is to be obtained by the Contractor from the landowner that “the land is restored to his satisfaction”. The final payment shall be made after the verification by the REB/PGCB.

ECoP 10.0: Slope Stability and Erosion Control

10.1 General

- Stability of slopes is a major concern in hill areas and locations of high embankment.
- Soil erosion is consequent to high runoff on hill slopes, high wind velocities cause erosion of embankments made up of cohesion-less sandy soils.
- Embankments made up of silty and sandy soils are eroded, in the absence of vegetative cover, when the slopes are steep, say more than 20 degrees.
- Erosion control is provided to prevent soil damage done by moving water.
- The scope of this ECoP includes measures to minimize the adverse environmental impacts on slope stability and soil erosion due to the construction of embankments. The adverse environmental impact can be:
  i. damage to adjacent land,
  ii. silting of ponds and lakes disturbing the aquatic habitat
  iii. erosion of rich and top fertile top layer of soil
  iv. contamination of surface water bodies and
  v. reduction in road formation width due to erosion of shoulders/berms.

10.2 Pre-construction Stage

- Interceptor ditches are constructed in hill areas to protect the road bench and hillside slope from erosion due to heavy rainfall and runoff.
ECoP 11.0: Waste Management

11.1 General
This code of practice describes procedures for handling, reuse and disposal of waste materials during construction of the substations, rehabilitation of the existing substations/transmission or distribution lines. The waste materials generated can be classified into:

i. Construction Waste;
ii. Domestic waste;
iii. Discarded conductors from rehabilitated power lines; and
iv. Discarded switchboxes, bus-bars, transformers, etc. from rehabilitated substations.

11.2 Pre-construction Stage
- The contractor shall identify the activities during construction that have the potential to generate waste and work out measures for the same in the construction schedule.
- The Contractor shall educate his workforce on issues related to disposal of waste, the location of disposal site as well as the specific requirement for the management of these sites.

11.3 Construction Stage
- The contractor shall either re-use or dispose the waste generated during construction depending upon the nature of waste.
- The contractor shall dispose off wastes that could not be re-used safely.
- The waste management practices adopted by the Contractor shall be reviewed by REB/PGCB during the progress of construction.
- Discarded conductors resulting from the rehabilitation of power lines should be recycled under the guidance of REB/PGCB.
- Discarded transformers should be properly disposed of as per the guidelines of REB/PGCB so as to minimize environmental pollution.
- The old transformers may contain hazardous chemicals such as PCB which should be handled as per the national/international Hazardous Waste Management guidelines. However, the more recent transformers do not contain such hazardous oil. Therefore, such non-hazardous oil should be discarded following the waste disposal guidelines as stipulated in ECR ’97. Therefore, during the substation rehabilitation process the old transformers containing PCB should be discarded following available technologies; namely, super-critical oxidation, electro-chemical oxidation, solvated electron technology, chemical reduction method, dehalogenation process, and thermal desorption using pyrolysis, catalyzed dehalogenation and vitrification. (see also ECoP 22.0)
- The waste generated from the discarded switchgears, bus-bars, transformers, etc. following the rehabilitation process should be handled as per the guidelines for E-waste management specified in ECR ’97.

11.4 Post-construction Stage
- After decommissioning of construction sites, the Contractor shall hand over the site after clearing the site of all debris/wastes to REB/PGCB.
- In case of disposal of wastes on private land, certificate of Completion of Reclamation is to be obtained by the Contractor from the landowner that “the land is restored to his satisfaction”.

ECoP 12.0: Water Bodies

12.1 General
Water bodies may be impacted when the infrastructure development project activities are adjacent to it or the runoff to the water body is affected by change of drainage pattern due to construction of embankment. The following activities are likely to have an adverse impact on the ecology of the area:

i. Earth moving
ii. Removal of vegetation
iii. Waste disposal from construction works

12.2 Pre-Construction Stage
When there is interruption to regular activities of the inhabitants near water body due to construction or rehabilitation work, following are the Contractor’s responsibilities:

i. Restriction on use of water during construction, if any, should be intimated to the community in advance.
ii. Alternate access to the water body is to be provided in case there is interruption to use of exiting access.
iii. If the water body affected is a drinking water source for a habitation, alternate sources of water are to be provided to the users during the period for which its use is affected.

- Interceptor ditches are very effective in the areas of high intensity rainfall and where the slopes are exposed.
- The vegetative cover should be planted in the region where the soil has the capacity to support the plantation and at locations where meteorological conditions favors vegetative growth.
- On side slopes in hills, immediately after cutting is completed and debris is removed, vegetative growth has to be initiated by planting fast growing species of grass.
- In regions of intensive rainfall, locations of steep slopes, regions of high soil erosion potential and regions of short growing seasons, erosion control matting should be provided.
- Adequacy of drainage for erosion control

10.4 Post-construction Stage
All the exposed slopes shall preferably be covered with vegetation using grasses, bushes etc. Locally available species possessing the properties of (i) good growth (ii) dense ground cover and (iii) deep root shall be used for stabilization.

- The waste generated from the discarded switchgears, bus-bars, transformers, etc. following the rehabilitation process in substations, rehabilitation of the existing substations/transmission or distribution lines containing PCB should be discarded following available technologies; namely, super-critical oxidation, electro-chemical oxidation, solvated electron technology, chemical reduction method, dehalogenation process, and thermal desorption using pyrolysis, catalyzed dehalogenation and vitrification. (see also ECoP 22.0)
- The waste generated from the discarded switchgears, bus-bars, transformers, etc. following the rehabilitation process should be handled as per the guidelines for E-waste management specified in ECR ’97.
12.3 Construction Stage
- It should be ensured by the contractor that the runoff from construction site entering the water body is generally free from sediments.
- Silt/sediment should be collected and stockpiled for possible reuse as surfacing of slopes where they have to be re-vegetated.
- Cutting of embankment reduces the water retention capacity and also weakens it, hence:
  i. The contractor should ensure that the decrease in water retention should not lead to flooding of the construction site and surroundings causing submergence and interruption to construction activities.
  ii. Any perceived risks of embankment failure and consequent loss/damage to the property shall be assessed and the contractor should undertake necessary precautions as provision of toe protection, erosion protection, sealing of cracks in embankments. Failure to do so and consequences arising out of embankment failure shall be the responsibility of the contractor. The REB/PGCB shall monitor regularly whether safe construction practices near water bodies are being followed.
- Alternate drain inlets and outlets shall be provided in the event of closure of existing drainage channels of the water body.
- Movement of workforce shall be restricted around the water body, and no waste from construction sites shall be disposed into it.

12.4 Post-construction Stage
- The zones of the water body have to be left clean and tidy with the completion of construction.
- Engineers of REB/PGCB will check if drainage channels of adequate capacity have been provided for the impacted water body.

ECoP 13.0: Water Qualities
13.1 General
- Construction of the substations, small-scale access road construction and small-scale embankment construction may affect the aquatic environment, by lowering or raising water levels, and decreasing water quality.
- Deterioration of water quality and disturbance of aquatic environment by lowering or rising of water levels.

13.2 Pre-construction Stage
Following measures are to be undertaken by the contractor prior to the commencement of construction:
- Base line data of the water quality is necessary.
- In addition, the availability of enough water during the lean season needs to be assessed as part of the baseline data collection.

13.3 Construction Phase
- Improper disposal of solid and liquid waste including excreta generate from sites will pollute the water quality and proper prevention measure should be taken.
- Wastewater and toxic chemicals disposal, sanitation/latrines may have positive cumulative effects on human health, but if not properly implemented may affect ground and surface and ground water quality; the contractor should give proper attention on it during construction stage.
- Protect water bodies from sediment loads by silt screen or bubble curtains or other barriers.

13.4 Post-construction Phase
- Inspection of water quality shall be done regularly.

ECoP 14.0: Drainage
14.1 General
- Drainage is designed for temporary access roads to direct surface or subsurface flow away to a safe outfall without damage to the structure, adjoining property or agricultural fields.

14.2 Pre-construction Stage
Following measures are to be undertaken by the contractor prior to the commencement of construction:
- The downstream as well as upstream user shall be informed one month in advance
- The contractor shall schedule the activities based on the nature of flow in the stream while constructing the substations and access roads.
- The contractor should inform the concerned departments about the scheduling of work. This shall form part of the overall scheduling of the civil works to be approved by REB/PGCB.
- All the safety/warning signs are to be installed by the contractor before start of construction
- In case of utilization of water from the stream, for the construction, the contractor has to take the consent from the concerned department.

14.3 Construction Phase
- Temporary drainage at construction site shall be provided at the earliest to ensure proper compaction
- In hill areas sub-surface drains, if required, shall be provided immediately after cutting the slopes and forming the roadbed (sub grade).
- Safety devises and flood warning signs to be erected while working over streams and canals.

14.4 Post-construction Phase
- Inspection and cleaning of drain shall be done regularly to remove any debris or vegetative growth that may interrupt the flow.
- Temporary structures constructed during construction shall be removed before handing over to ensure free flow through the channels.

ECoP 15.0: Electromagnetic Field (EMF)
15.1 General
Electromagnetic Field during the rehabilitation of the existing transmission or distribution lines may be a cause of concern. Thus, appropriate protective measures should be adopted during the implementation phase.

Electric and magnetic fields (EMF) are invisible lines of force emitted by and surrounding any electrical device (e.g., power lines and electrical equipment). Electric fields are produced by voltage and increase in strength as the voltage increases. Electric field strength is measured in volts per meter (V/m). Magnetic fields result from the flow of electric current and increase in strength as the current increases. Magnetic fields are measured in units of gauss (G) or tesla (T), where 1T equals 10,000G. Electric fields are shielded by materials that conduct electricity, and other materials, such as trees and building materials. Magnetic fields pass through most materials and are difficult to shield. Both electric and magnetic fields decrease rapidly with distance. Power frequency EMF typically has a frequency in the range of 50 – 60 Hertz (Hz), and is considered Extremely Low Frequency (ELF). Although there is public and scientific concern over the potential health effects associated with exposure to EMF (not only high voltage power lines and substations, but also from everyday household uses of electricity), there is no empirical data demonstrating adverse health effects from exposure to typical EMF levels from power transmissions lines and equipment. However, while the evidence of adverse health risks is weak, it is still sufficient to warrant limited concern. Recommendations applicable to the management of EMF exposures include: Evaluating potential exposure to the public against the reference levels developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Average and peak exposure levels should remain below the ICNIRP recommendation for General Public Exposure. Considering siting new facilities so as to avoid or minimize exposure to the public. Installation of transmission lines or other high voltage equipment above or adjacent to residential properties or other locations intended for highly frequent human occupancy, (e.g., schools or offices), should be avoided. If EMF levels are confirmed or expected to be above the recommended exposure limits, application of engineering techniques should be considered to reduce the EMF produced by power lines, substations, or transformers. Examples of these techniques include:
- Shielding with specific metal alloys
- Burying transmission lines
- Increasing height of transmission towers
- Modifications to size, spacing, and configuration of conductors

15.2 Post Construction:
- During the Post-construction phase REB/PGCB should monitor the EMF around the substations and under the Distribution/Transmission lines on a regular basis.
- Construction of residential buildings and/or small households should only be allowed ensuring the safe distance as specified in the Code.

ECoP 16.0: Public Health and Safety
16.1 General
The safety and health of the public is impacted due to the hazards created during the construction period. This code of practice describes the measures that need to be taken to mitigate the impacts.

16.2 Pre-construction Phase
- In order to incorporate public health and safety concerns, REB/PGCB and the Contractor shall disseminate the following information to the community:
  i. Location of project activities,
  ii. Borrow areas,
  iii. Extent of work
  iv. Time of construction
  v. Involvement of local labors in the construction
  vi. Health issues - exposure to dust, communicable diseases etc.

16.3 Construction Phase
- The Contractor shall schedule the construction activities, such as:
  i. Sowing of crops
  ii. Harvesting
  iii. Local hindrances such as festivals, etc.
  iv. Availability of labor during particular periods

- Proper safety/warning signs are to be installed by the contractor to inform the public of potential health and safety hazard situations during the construction phase in the vicinity of the project.
- The REB/PGCB shall carry out periodic inspections in order to ensure that all the measures are being undertaken as per this ECoP.

16.3 Post-construction Phase
The construction site shall be cleaned of all debris, scrap materials and machinery on completion of construction for the safety of public and users. During operation phase (especially during regular maintenance) following issues should be addressed:
- Regular patrolling along the power lines to identify the need for regular and immediate maintenance operation.
- Inspection immediately after a major storm/rainfall event
- Regular cutting and trimming of trees around power lines.
- Provision for shutting down of line in case of snapping of line.
- Regular monitoring of power lines to prevent electricity pilferage especially when Axially Bundled Cables (ABC) are used which may lead to accident.
- No temporary/permanent shops underneath the H-pole to be allowed
- No Dumpster to be allowed underneath the H-Pole.

**ECOp 17.0: Material Storage, Transport and Handling**

17.1 General

Activities related to materials storage, handling, and transfer that are considered to potentially have negative environmental effects include:

- Transportation, storage, handling and of construction materials;
- Storage, handling, and transfer of petroleum, oil, and lubricant (POL) products;
- Application of asphaltic concrete and asphalt binder;
- Storage and handling of hazardous materials other than POL products; and
- Storage and application of transformer oil.

Some materials used during implementation of projects may have potentially hazardous effects on the environment if not properly stored and handled.

17.2 Transportation, Handling and Storage of Cement and Aggregates

- The Contractor shall be responsible for ensuring that all trucks and carriers are clean and dry prior to loading them with cement or aggregates. All trucks and carriers for transporting cement/aggregates shall be equipped with weather proof closures on all openings.
- All cement/aggregates that will be brought to the site shall be kept free from contact with deleterious matter.
- All cement/aggregates shall be placed on impervious mat spread over the storage area to prevent direct contamination of top soil in the storage area. Stockpiling of cement/aggregates should be limited to minimum space and should be covered with weatherproof closures.
- Stockpiles shall be built up in horizontal or gently sloping layers. Overlap of different materials shall be prevented by suitable walls of ample distance between stockpiles.
- The Engineer shall approve the site for the storage of all aggregates.
- The Engineer shall approve the methods of handling aggregates and the equipment used.

17.3 Environmental Concerns with Materials used for Construction and Maintenance of Infrastructure Development Projects. Concerns are related to accidental releases into the environment, such as spills, refueling losses, and leakage from equipment that could result in contamination of soil, groundwater, or surface waters.

Groundwater may transport the contaminants off-site to down-gradient aquifers or water supplies, or discharge them into surface waters. Therefore, release of potential contaminants on the ground surface could have significant environmental impacts that could ruin groundwater (well supplies).

17.3.1 Petroleum, Oil, Lubricants and Transformer Oil

The toxic effect of a petroleum product in the aquatic environment varies considerably due to the different chemical composition of each petroleum product. The toxicity of petroleum products is related largely to its solubility in water. Petroleum pollution from accidental spills may affect aquatic birds, fish and vegetation. The effect of oil on birds’ feathers (loss of insulation) is an important cause of death. Oil polluting the water may also be toxic to birds if they ingest it. Plants in marshes or in wetlands (haor, baor, ponds and others) and steams may die off for short periods. Long-term impacts of spilled petroleum products are associated with the portion, which sinks and becomes incorporated into bottom sediments. This causes the petroleum products to degrade very slowly and they may persist for many years.

Petroleum products can stick to the gills of fish and interfere with normal respiration. Under relatively mild pollution, fish may produce mucus as a defensive mechanism to remove the oil. However, in heavy pollution, this mechanism is inefficient and the oil tends to accumulate on the gills and smother the fish. Petroleum products contain soluble materials, which can be ingested by fish. The flavor of the fish flesh may, therefore, become tainted, or if ingested in enough quantity, may become lethal. Groundwater sources contaminated with petroleum products may have potentially toxic effects on consumers.

17.3.2 Asphalt Products

Environmental concerns with tack asphalt binder, and asphaltic concrete are also related to the hydrocarbon components, which are toxic to aquatic life, wildlife, and humans. As mentioned above, if these materials sink to the bottom, they may destroy the fish’s source of food supply and smother the eggs or emerging fry.

17.3.3 Other Hazardous Materials

The following hazardous materials are likely to be generated in construction, rehabilitation or maintenance activities of substation and power lines and have potential environmental concerns:

- Paints;
- Solvents;
- Transformer Oil; and
- Fresh concrete and admixtures.

Paint materials, which are lead – or oil-based, may affect aquatic life if significant amounts enter a watercourse. Specific concern exists with lead, as this compound may have a direct toxic effect on young fish. Toxins can accumulate over time in aquatic fish, bugs, and plants. Upon consumption by animals such as birds and small mammals, some metals could be transferred to the consumer and affect their health.

Some solvents used for cleaning purposes may contain components, which are toxic to aquatic life, wildlife, and humans. If solvents enter a watercourse/water supply, and significant concentrations occur in the water, this could be harmful to users.

Concrete, which is typically made up of aggregates, cement, water, and possibly admixtures, is very alkaline because of its calcium (lime) content. If concrete enters a watercourse in significant amounts, the pH of the water may be affected locally over the short-term. If the pH of the receiving water is altered, this may cause physiological stress in fish, which may result in death.
When a power line (Transmission and/or Distribution) is re-conducted the old conductors are discarded. Recycling of these metal conductors should be practiced to reduce waste generation.

The old transformers contained transformer oil which is hazardous to the human and environment.

17.4 Storage, Transport and Handling of POL Products

Care must be taken with the storage, transfer, handling of POL products to prevent potential environmental damage. All empty containers and drums shall be returned to the maintenance depot. It shall be ensured that all drums and containers are closed and not tipped over and all waste oil, lubricants, and solvents shall be stored in closed containers.

17.4.1 Storage

Any container, drum, or tank that is dented, cracked, or rusted will probably eventually leak. Make sure all containers, drums, and tanks that are used for storage are in good condition. Check for leakage regularly to identify potential problems before they occur.

The proper storage of materials will greatly reduce the risk of accidental spills or discharges into the environment.

For temporary outdoor storage, put containers and drums in clearly marked areas, where they will not be run over by vehicles or heavy machinery. The area should preferably slope or drain to a safe collection area in the event of a spill.

Tanks should have appropriate secondary containment (i.e. double-walled or surrounded by a dyke) that will collect spilled material in case of a leak. Permanent storage areas for containers or drums should be on an impermeable floor that slopes to a safe collection area in the event of a spill or leak.

17.4.2 Transport and Handling

At all times when products are being handled or transported, care must be taken to prevent any product from being spilled, misplaced, or lost and possibly entering and contaminating the soil or a natural waterway. When equipment and vehicle maintenance or repair is required in the field, it should be undertaken at least 30 m away from any watercourse.

Minimize the potential for entry of hydraulic fluids or oil into a watercourse by using sorbent materials to collect spilled petroleum products. Return all used sorbent materials to the appropriate storage yards for safe disposal.

Return all diesel or fuel used to wash asphalt emulsion pumps to the maintenance depot for safe storage or disposal. Also return all solvents used to wash spray-painting or other equipment to the appropriate storage yards for safe disposal.

Wash equipment in maintenance areas equipped with oil/water separators so that any petroleum products can be removed prior to discharge of the wastewater. Oil/water separators are only effective if they are properly maintained. At sites without oil/water separators, minimize the amount of wash water used and wash in areas where the potential for entry of wash water into a waterway is minimized by proper grading or curbing.

Tankers should not be washed near watercourses. Wash out should be done in places where proper grading or curbing minimizes the potential for entry of wash water into a waterway. Re-fuelling or servicing of equipment and vehicles to be done at least 30 m away from any watercourse. Re-fuelling over liner material with an absorbent pad (e.g. sand bed) will help to contain potential spills. If re-fuelling is done from a bulk tanker, the hose/nozzle assembly should be replaced to its proper position upon completion.

17.5 Spills and Spill Cleanup

Quick action in the event of a spill of hazardous materials is important in order to prevent environmental damage.

Things to do when a spill occurs:

1. Identify the material Involved and make a quick assessment:
   - How extensive is the spill?
   - Are there any watercourses nearby?
   - Are the watercourses down gradient from the spill?
   - Are there drainage systems down gradient from the spill, which lead to a nearby watercourse?
2. Stop the flow of product, if it can be done safely.
3. Notify the Engineer and Authorities immediately.
4. Control and contain spilled product until expert help arrives, if it can be done safely.

17.5.1 How to Control and Contain a Spill

When a limited oil spill occurs on level land, scoop up the affected soil and dispose at a site approved by the Engineer and the Department of Environment. When an extensive oil spill occurs on level land, dig sump hole and pump excess oil into a temporary container. The remaining contaminated soil must be scooped up and disposed of at a site approved by the Engineer and the Department of Environment.

When an extensive spill occurs on a slope or hillside, a trench can be dug downhill from the spill to intercept the spill material.

Should petroleum products reach a watercourse, several temporary spill containment measures can be used to help stop the spreading of products.

17.6 Storage and Handling of Dangerous Materials

Workers may be at risk from exposure to dust particles or toxic fumes from chemicals used in road works and materials testing.

Specific measures to reduce risks include limiting time of exposure to dust particles, chemicals and noise; enhancing safety and inspection procedures; and improving materials safe handling.

**ECoP 18.0: Vegetation Management**

18.1 General

- Besides improving aesthetics and ecology of the area, the vegetation provide fuel wood, act as noise barriers, provide visual screen for sensitive areas and also generate revenue by sale of its produce.
- This code of practice elaborates on the approach towards planting trees. Emphasis has been laid on a greater involvement of communities in planting and maintenance of trees.

18.2 Project Planning and Design Phase
During alignment of transmission line finalization, due consideration shall be given to minimize the loss of existing tree cover.

Tree felling, if unavoidable, shall be done only after compensatory plantation of at least two saplings for every tree cut is done.

The species shall be identified in consultation with officials of forest department/local community, giving due importance to local flora, preferably same species as cut. It is recommended to plant mixed species in case of both avenue or cluster plantation.

Design of plantation of fruit bearing trees and other suitable trees.

It should be ensured that plantation is carried out only in areas where water can be made available during dry seasons and the plant can be protected during the initial stages of their growth.

18.3 Post-construction Phase

During the operational phase regular trimming of trees along the route REB/PGCB personnel may become essential to prevent accidents due to over-growth onto the power lines. However, his activity should be conducted with minimal damage to the existing vegetation.

The project proponents would take up the planting of fruit bearing and other suitable trees, on both sides of the roads or other infrastructure development projects location from their own funds.

ECoP 19.0: Natural Habitats

19.1 General

The activities associated with construction a transmission line through or along the edge of Natural habitat areas may destroy and degrade the habitat. The activities can have impacts on the number, health, and survival of interior Native Plant and animal species, many of which are rare.

The code of practice envisages measures to be undertaken during implementation of the proposed subprojects by the REB/PGCB near natural habitats. These measures shall be undertaken in addition to the measures laid down in the other ECoPs.

As per the World Bank OP 4.04, the conservation of natural habitats, like other measures that protect and enhance the environment, is essential for long-term sustainable development. A precautionary approach to natural resource management to ensure opportunities for environmentally sustainable development has been adopted for the project.

19.2 Main features of the Bank’s Natural Habitats Policy (OP 4.04)

The policy on natural habitats contains two major provisions with respect to biodiversity conservation and EA. Firstly, it prohibits Bank involvement in projects, which involve significant conversion or degradation of critical natural habitats. These include: existing protected areas and adjoining or linked areas or resources (such as water sources) on which the protected areas depend; and sites identified as meriting protection. Secondly, where natural habitats out-side protected areas are within a project’s area of influence, the project must not convert them significantly unless:

- There are no feasible alternatives
- The EA demonstrates that benefits substantially outweigh the costs
- Mitigation measures acceptable to the Bank are implemented, which would normally include support for one or more compensatory protected areas that are ecologically similar to, and no smaller than, the natural habitats adversely affected by the project.

19.3 Project Planning and Design

Proper line route selection, appropriate timing of operations and proper construction and maintenance of the development of the transmission line can ensure that terrestrial, riparian and aquatic habitat values and fish and wildlife populations are protected from the adverse impacts. Following issues should be considered in Project Planning and Design stage.

- A detailed inventory of ecological features along the proposed rural road shall be prepared with the help of experts and the nature and type of impact on natural habitats shall be identified.
- Avoid concentrations of wildlife, areas of high value wildlife habitat and/or rare plant communities, when determining locations and routes for transmission line. A biologist or ecologist specialized in the discipline of concerns must be retained to identified and asses such areas of concern.
- In areas of continuous high value habitat, consider not developing the project or determine an alternative routing, if feasible.
- Adjusting pole placement and span length to minimize the impacts;

19.4 Pre-construction Phase

- Contractor in consultation with local expert or any other concerned authority shall prepare a schedule of construction within the natural habitat. Due consideration shall be given to the time of migration, time of crossing, breeding habits and any other special phenomena taking place in the area for the concerned flora or fauna.
- No Construction Camps, Stockyards, Concrete Batching or Hot Mix Plants shall be located within the natural habitat or within 500m from its boundary.

19.5 Construction Phase
Collection of any kind of construction material from within the natural habitat shall be strictly prohibited.

In the event that concentrations of wildlife species are present in the proposed construction area, consider re-scheduling construction and maintenance activities until such time when the numbers of animals present are reduced or absent from the worksite.

When removing vegetation from right of ways, workspaces etc., featheredge the cut to ensure that line of site and cover (both security and thermal protection) issues are addressed.

No water resources within the natural habitat shall be disturbed.

During construction, prevent human disturbance and ecosystem impacts on sensitive areas adjacent to projects by using temporary fencing or flag off area to restrict travel to construction zones, right of ways and workspaces.

Disposal of construction waste within the natural habitat shall be strictly prohibited.

19.6 Post-construction Phase

- The infrastructure development projects near the natural habitat shall be declared as a silence zone.
- Allowing tree and shrub species that reach heights of 12 to 15 feet to grow within the ROW, which may control trespassing and vandalism;
- Compensatory tree plantation within the project area shall be done.
- The REB/PGCB must ensure maintenance of drainage structure as per ECoP 14.0.

ECOp 20.0: Occupational Health and Safety

Most occupational health and safety issues during the construction, operation, maintenance, and decommissioning of electric power distribution projects are common to those of large industrial facilities, and their prevention and control is discussed in the General EHS Guidelines. These impacts include, among others, exposure to physical hazards from use of heavy equipment and cranes; trip and fall hazards; exposure to dust and noise; falling objects; work in confined spaces; exposure to hazardous materials; and exposure to electrical hazards from the use of tools and machinery.

Occupational health and safety hazards specific to electric power transmission and distribution projects primarily include:

- Live power lines
- Working at height
- Electric and magnetic fields
- Exposure to chemicals

Live Power Lines

Workers may be exposed to occupational hazards from contact with live power lines during construction, maintenance, and operation activities. Prevention and control measures associated with live power lines include:

- Only allowing trained and certified workers to install, maintain, or repair electrical equipment;
- Deactivating and properly grounding live power distribution lines before work is performed on, or in close proximity, to the lines;
- Ensuring that live-wire work is conducted by trained workers with strict adherence to specific safety and insulation standards. Qualified or trained employees working on transmission or distribution systems should be able to achieve the following:
  - Distinguish live parts from other parts of the electrical system
  - Determine the voltage of live parts
  - Understand the minimum approach distances outlined for specific live line voltages
  - Ensure proper use of special safety equipment and procedures when working near or on exposed energized parts of an electrical system
- Workers should not approach an exposed energized or conductive part even if properly trained unless:
  - The worker is properly insulated from the energized part with gloves or other approved insulation; or,
  - The energized part is properly insulated from the worker and any other conductive object; or,
  - The worker is properly isolated and insulated from any other conductive object (live-line work).
- Where maintenance and operation is required within minimum setback distances, specific training, safety measures, personal safety devices, and other precautions should be defined in a health and safety plan.
- Workers not directly associated with power transmission and distribution activities who are operating around power lines or power substations should adhere to local legislation, standards, and guidelines relating to minimum approach distances for excavations, tools, vehicles, pruning, and other activities;

1IFC Environmental, Health and Safety Guidelines for Electric Power Transmission and Distribution
Minimum hot stick distances may only be reduced provided that the distance remaining is greater than the distance between the energized part and a grounded surface.

Working at height on poles and structures

Workers may be exposed to occupational hazards when working at elevation during construction, maintenance, and operation activities. Prevention and control measures for working at height include:

- Testing structures for integrity prior to undertaking work;
- Implementation of a fall protection program that includes training in climbing techniques and use of fall protection measures; inspection, maintenance, and replacement of fall protection equipment; and rescue of fall-arrested workers, among others;
- Establishment of criteria for use of 100 percent fall protection (typically when working over 2 meters above the working surface, but sometimes extended to 7 meters, depending on the activity). The fall protection system should be appropriate for the tower structure and necessary movements, including ascent, descent, and moving from point to point;
- Installation of fixtures on tower components to facilitate the use of fall protection systems;
- Provision of an adequate work-positioning device system for workers. Connectors on positioning systems should be compatible with the tower components to which they are attached;
- Hoisting equipment should be properly rated and maintained and hoist operators properly trained;
- Safety belts should be of not less than 16 millimeters (mm) (5/8 inch) two-in-one nylon or material of equivalent strength. Rope safety belts should be replaced before signs of aging or fraying of fibers become evident;
- When operating power tools at height, workers should use a second (backup) safety strap;
- Signs and other obstructions should be removed from poles or structures prior to undertaking work;
- An approved tool bag should be used for raising or lowering tools or materials to workers on structures.

Electric and magnetic fields

Electric and magnetic fields (EMF) are described earlier. Electric utility workers typically have a higher exposure to EMF than the general public due to working in proximity to electric power lines. Occupational EMF exposure should be prevented or minimized through the preparation and implementation of an EMF safety program including the following components:

- Identification of potential exposure levels in the workplace, including surveys of exposure levels in new projects and the use of personal monitors during working activities; A 1994 study estimated the average exposure of electrical workers (including jobs in electric utilities and other industries) in Los Angeles, California to be 9.6 milligauss (mG), compared to 1.7 mG for workers in other fields (S. J. London et al., 1994). Although detailed studies of workplace exposure to EMF in the United States, Canada, France, England, and several Northern European countries have found no conclusive link or correlation between typical occupational EMF exposure and adverse health effects, some studies have identified a possible association between occupational exposure to EMF and cancer, such as brain cancer (U.S. National Institute of Environmental Health Sciences 2002) indicating there is evidence to warrant limited concern.
- Training of workers in the identification of occupational EMF levels and hazards;
- Establishment and identification of safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public exposure, limiting access to properly trained workers;
- Implementation of action plans to address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and the Institute of Electrical and Electronics Engineers (IEEE). Personal exposure monitoring equipment should be set to warn of exposure levels that are below occupational exposure reference levels (e.g. 50 percent). Action plans to address occupational exposure may include limiting exposure time through work rotation, increasing the distance between the source and the worker, when feasible, or the use of shielding materials.

ECoP 21.0: Community Health and Safety

Community health and safety impacts during the construction and decommissioning of transmission and distribution power lines are common and in addition to occupational health and safety standards code of practices, the operation of live power distribution lines and substations may generate the following industry-specific impacts:

- Electrocution
- Electromagnetic interference
- Visual amenity
- Noise and Ozone
- Aircraft Navigation Safety

Electrocution

Hazards most directly related to power transmission and distribution lines and facilities occur as a result of electrocution from direct contact with high-voltage electricity or from contact with tools, vehicles, ladders, or other devices that are in contact with high-voltage electricity. Recommended techniques to prevent these hazards include:


- Use of signs, barriers (e.g. locks on doors, use of gates, use of steel posts surrounding transmission towers, particularly in urban areas), and education / public outreach to prevent public contact with potentially dangerous equipment;
- Grounding conducting objects (e.g. fences or other metallic structures) installed near power lines, to prevent shock.

**Electromagnetic Interference**

The corona of overhead transmission line conductors and high frequency currents of overhead transmission lines may result in the creation of radio noise. Typically, transmission line rights-of-way and conductor bundles are created to ensure radio reception at the outside limits remains normal. However, periods of rain, sleet or freezing rain sharply increases the streaming corona on conductors and may affect radio reception in residential areas near transmission lines.

**Visual Amenity**

Power transmission and distribution are necessary to transport energy from power facilities to residential communities, but may be visually intrusive and undesirable to local residents. To mitigate the visual impact of power distribution projects, the following mitigation measures should be implemented:
- Extensive public consultation during the planning of power line and power line right-of-way locations;
- Accurate assessment of changes in property values due to power line proximity;
- Siting power lines, and designing substations, with due consideration to landscape views and important environmental and community features;
- Location of high-voltage transmission and distribution lines in less populated areas, where possible;
- Burying transmission or distribution lines when power must be transported through dense residential or commercial areas.

**Noise and Ozone**

Noise in the form of buzzing or humming can often be heard around transformers or high voltage power lines producing corona. Ozone, a colorless gas with a pungent odor, may also be produced. Neither the noise nor ozone produced by power distribution lines or transformers carries any known health risks. The acoustic noise produced by transmission lines is greater with high voltage power lines (400-800 kilo volts [kV]) and even greater with ultra-high voltage lines (1000 kV and higher). Noise from transmission lines reaches its maximum during periods of precipitation, including rain, sleet, snow or hail, or as the result of fog. The sound of rain typically masks the increase in noise produced by the transmission lines, but during other forms of precipitation (e.g. snow and sleet) and fog, the noise from overhead power lines can be troubling to nearby residents. Measures to mitigate this impact may be addressed during project planning stages to locate rights-of-way away from human receptors, to the extent possible. Use of noise barriers or noise canceling acoustic devices should be considered as necessary.

**Aircraft Navigation Safety**

Power transmission towers, if located near an airport or known flight paths, can impact aircraft safety directly through collision or indirectly through radar interference. Aircraft collision impacts may be mitigated by:
- Avoiding the siting of transmission lines and towers close to airports and outside of known flight path envelopes;
- Consultation with regulatory air traffic authorities prior to installation;
- Adherence to regional or national air traffic safety regulations;
- Use of buried lines when installation is required in flight sensitive areas.

**ECoP 22.0: Polychlorinated biphenyl (PCB)**

**General**

Polychlorinated biphenyl, otherwise known as PCB, is a synthetic chemical that is widely used for industrial and commercial use as dielectric fluid in transformers and capacitors because of its high resistance to decomposition, low electrical conductivity, low flammability and high heat capacity. Extensive scientific researches have shown that these substances are toxic, bio accumulative and persistent, thus, posing risks to health and the environment. PCBs are linked to chronic reproductive effects, gastric disorders, and skin lesions in laboratory animals and are suspected human carcinogen. Direct exposure to PCBs such as inhalation and skin contact could lead to serious headaches, drowsiness and skin irritation. The most common signs of exposure to PCBs are chlor-acne and elevation of liver enzymes Increasing concern over health risks posed by PCBs and their undesirable environmental effects has resulted in the banning of the manufacture, processing, and distribution in commerce. Thus, PCBs is one of the initial twelve chemical substances or groups classified as POPs under the Stockholm Convention.

Transformer repair, reconditioning and retro-filling facilities are the major industry sectors that contributes to the spread of PCB contamination. The retro-filling of transformer involves draining of oil, rewinding of the transformer coil and refilling of dielectric fluid. The dielectric fluid may either be the same oil, which was from the transformer but filtered or it may be substitute dielectric oil, such as silicones, synthetic hydrocarbons, and ester-based materials.
With the wider recognition of the perceived risks and hazards associated with PCBs, the use of PCB-contaminated equipment is diminishing but PCB wastes will continue to be generated for many years from the gradual phase-out of existing PCB-contaminated and retro-filled equipment.

Types of PCB Wastes
PCB wastes are discarded materials that contain PCB or have been contaminated with PCBs and that are without any commercial, industrial, or economic use. For the purpose of this Code of Practice, PCB wastes are classified as follows:

- **Liquid PCB wastes**
  - PCB-based dielectric fluids removed from transformers and other equipment
  - PCB-based heat transfer and hydraulic fluids
  - PCB-contaminated solvents
  - Leakages, spillages and splashes of PCB-based fluids due to mishandling or accidents.
  - Laboratory wastes with PCBs

- **Non-metallic solid wastes**
  - Material used in cleaning PCB equipment or absorbing the spillages such as rags, sawdust, clothing, gloves, gaskets, etc.

- **Metallic solid wastes**
  - PCB equipment such as capacitors, transformers, switchgears, circuit breakers, heat transfer systems, etc.
  - Contaminated components removed from electrical equipment such as windings; PCB-contaminated containers and equipment such as metal drums, tanks, pumps, metal filters, etc.

Packaging and Labeling of PCB Wastes
The generator is required to maintain an inventory of registered equipment with reference to the location of each item. PCB waste generators, transporters, and owners of TSD facilities should ensure proper packaging, labeling, and storage of PCB waste prior to transportation to disposal facilities. PCB equipment should have distinct markings on the intended use and the corresponding PCB content.

A. Packaging
1. Containers of PCB wastes should be durable, corrosion resistant, leak-free, in good condition and free from damage and shall follow the UN standard drums.
2. PCB liquid from transformers should be drained prior to any transport activity. Liquid PCB wastes should be stored in sealed, new or in good condition 200-litre steel drums or high density polyethylene (HDPE) drums, and fitted with double bung fixed ends. The steel drum should be treated or painted to prevent oxidation and rusting. There should be 7 to 10 cm airspace left at the top of the drum to allow liquid expansion. The liquid PCB wastes should be placed in heavy duty steel or HDPE drums, with removable lids and a gasket made of PCB resistant material such as nitrile rubber, cork, or Teflon. The drum should have a clear and visible label, in compliance with this Code of Practice.
3. Combustible PCB contaminated solid wastes such as materials used for cleaning PCB equipment; cleaning or absorbing of spillage such as sawdust, rags, etc.; PCB contaminated PPEs such as gloves, gaskets or clothing; and used PCB test kits should be packed in heavy duty and leak-proof polyethylene bags. The bags should then be placed in steel or HDPE drums in good condition and fitted with removable lids. The drum should also have a clear and visible label, in compliance with this Code of Practice.
4. The drum should be packed with absorbent material so that any leaks would be absorbed.

B. Labeling of PCB Equipment
The following label marking are prescribed:

- Transformers and capacitors containing concentration of PCBs ≥ 50 ppm
- Electric motors using PCB-containing coolants
- Hydraulic systems using PCB-containing fluids
- Heat transfer systems using PCBs
- PCB packaging stored for treatment or disposal
- Vehicles that carry PCB equipment and wastes
- Equipment removed from service containing total concentration of PCBs ≥2 ppm
- PCB-articles and containers
- PCB storage tanks, filter presses, tools and equipment used to service electrical articles
- Discarded bushings, insulator caps, and cables.

Further to include the following information in the label is recommended:

- CCO registration number
- serial number of the unit
- other identifying information
- total weight and volume of PCB waste
- name and address of the waste generator
- contact person and telephone number.
Storage
1. Storage facility should have good ventilation, dry surfaces, and has impermeable floor made of chemical resistant epoxies or resins.
2. All drummed wastes and PCB contaminated equipment should be kept in a bonded area adequate to contain any spill or leak.
3. PCB equipment and PCB waste materials should be stored separately from other chemicals. In cases that PCBs are to be stored with other materials, a partition must be installed or sufficient space separation must be ensured to prevent mixing of chemicals in case of leak or spill. For solvents or flammable materials, these chemicals should be separated by a fire-proof barrier, or separated adequately.
4. Roof-water drainage should be directed away from the inside of the containment facility to prevent a build-up and possible runoff of contaminated water. Drain spouts should not be incorporated into the base of concrete curbing to drain PCB oil collected inside the containment area as these spouts can leak and will certainly allow spillage onto the ground during drainage.
5. PCB handling equipment such as pumps, hoses, and tools intended for future use should be stored separately from waste and must be stored with spares until they expire or are discarded.
6. Drummed PCB waste should be placed on pallets. Drums should be stored in rows, maximum of four (4) drums on a pallet, with a minimum of four (4) feet aisle space between rows for inspection, response to leaks and fire control. The storage area should have sufficient space for internal access i.e., access for forklifts and other machineries and movement of large equipment.
7. Other provisions to be observed in the storage area or warehouse are as follows:
   - Place or provide metal drip trays under drain spouts of transformers.
   - Keep first aid and safety equipment handy.
   - Keep spill clean-up kits handy and display emergency cleanup procedures.
   - Provide appropriate fire-fighting equipment and install smoke detectors to warn of fire.
   - Keep a record of all materials entering and leaving the storage area.

Transport of PCB Wastes
1. Transport of PCB wastes must be done carefully with the required permit from REB/PGCB
2. Transport of PCB wastes should be under the supervision of trained and experienced personnel that have undergone the training required for the registration of PCB waste transporters.
3. Transport vehicles should have drop-side on both sides, with a canopy.
4. Transport vehicles should have hazard warning panels clearly marked with black indelible ink against yellow retro-reflective background. The panels should be displayed at the front and rear of the vehicle in a position that does not conceal any lights, license plates or other legally required signs or markings.
5. The Manifest must be kept on the driver's cabin or in the driver's side door compartment at all times.
6. Transport Vehicles must be equipped with safety equipment, including appropriate fire extinguisher(s) for emergency use, and a spill cleanup kit
7. The precautions to be observed during the transport shall include the following:
   - All materials to be transported shall be packaged and labeled in accordance to this Code of Practice
   - All liquid wastes shall be transported in closed transport vehicle or van
   - All loading and unloading operations should be carried out with care to avoid any damage which may result in leakage and spillage.
   - The drums or the PCB contaminated equipment must be loaded and fastened securely so that they are in an upright position and do not move about or fall off the vehicle.

Health And Safety Requirements And Procedures
A. Personal Protective Equipment (PPE)
Workers should eliminate risk of exposure to PCBs by utilizing the following personal protective equipment or proven equivalent measures.
   - Coveralls (Tyvek jumpsuit) with hood
   - Protective boot covers
   - Full-face respirator
   - Protective gloves
   - Heavy duty gauntlets or ductile taping of pant’s ankles to boot covers, and wrists to gloves
   - Hard hat for overhead dangers and head protection
   - Goggles for eye protection
The main danger when handling liquids with high PCB concentrations is skin absorption. Careful consideration must be given to the selection of protective clothing including coveralls, boots or boot covers, gloves and eye protection. Clothing and footwear must be resistant against splash and spills. For major spill clean-up operations, a full suit of non-porous material is appropriate. Disposable coveralls and PCB resistant knee length safety boots shall be used. Eye protection against liquid splashes is necessary. Goggles are adequate for this purpose. Chemical safety goggles face shield, or safety glasses with side shields are satisfactory. Working with hot fluid must be avoided since fumes may be generated when PCB fluids are heated above 55°C. Protective equipment must also be worn to prevent inhalation of fumes. A full-face respirator fitted with a cartridge suitable for PCBs shall be used and ventilation of the working area must be sufficient to dispose the generated vapors. If the respirator becomes slightly contaminated or clogged, wipe the
respirator with a paper towel and kerosene. If the respirator becomes heavily contaminated, it shall be disposed of in accordance with this code of practice. PCBs will penetrate most materials, but certain materials including natural rubber are particularly permeable to PCBs and are thus unsuitable for use as protective clothing. Chemical resistant fluorinated rubbers or elastomers are more suitable and laminated materials offer the best protection against PCBs. For continuous handling of PCB, resistant Viton, polyethylene, butyl rubber, nitrile rubber or neoprene gloves shall be used. No material is completely impervious to PCBs and therefore it is necessary to make certain that arrangements are in place to regularly change all PPE. The equipment supplier will normally provide details on the rate at which PCBs permeate protective equipment. This information will be useful in estimating, for each task, the time it takes for PCBs to penetrate through the protective equipment. This is known as the breakthrough time. This will depend on the frequency and duration of contact of the protective equipment and clothing with PCBs and may vary from one task to the next. The supplier should be able to provide typical breakthrough times for the different applications and advise if there is a need to reduce this time to allow for other factors such as abrasion. If rubber boots are used, the boots need to be regularly discarded. The foot protection reinforced by the use of disposable boot covers. For laboratory work, laboratory coats and suitable disposable gloves are necessary for protection against skin contact. If there is a danger of dust or fume formation (for example by heating) then the use of a fume hood is recommended. It will be necessary to treat all potentially contaminated protective equipment as PCB waste and dispose of it accordingly and decontamination and reuse is not allowed.

Safety Procedures
Preference should be given to the use of disposable protective clothing due to difficulty in decontamination. Contaminated protective clothing should be promptly removed and the area of skin contaminated with PCBs should be washed with or rinsed immediately. Level C PPE respirators must be worn. For work at normal temperatures, a suitable type is a full face-piece respirator with an appropriate cartridge. For high temperature or work in confined space, Level B PPE that includes a self contained breathing apparatus (SCBA) is required. Workers should be trained before they are allowed to use this type of breathing apparatus. If the respirators do not have eye protection, the chemical type goggles must be worn. Hands must be washed after handling PCBs (even if wearing full protection) before eating, drinking, smoking or using toilet facilities initially with waterless hand cleaners and paper towels, which shall then be disposed of in accordance with this code of practice.

Management of Spills and Contingency Plans
The Emergency Contingency Plan to be prepared and implemented by generators, transporters and TSD facilities as prescribed in the Implementing Rules and Regulations of RA 6969 shall include the following:
1. If a spill or leakage occurred during transport, emergency response procedures must be carried out immediately.
2. As soon as it is practical to do so, the driver’s supervisor or responsible official from the generator and TSD facility should be notified.
3. The vehicle should not be left unattended until the spill or leak is contained.
4. If the operator of the vehicle is incapacitated, the emergency services must rely on the (Manifest) shipping papers to identify the type of quantities of PCB material being transported.
5. Cleanup must be initiated immediately.
6. All personnel engaged in the cleanup must be properly trained.
7. All trained personnel handling the PCB or engaged in the cleanup must wear required PPEs to avoid contamination of garments and skin exposure.
8. PCB articles and PCB containers and their contents must be transferred immediately and must be properly marked.
9. The PCB containing equipment should be contained and cleaned up immediately.
10. PCB liquid must be prevented from reaching storm drains, sewers, drainage systems and other water bodies. Every available option must be employed to contain the spill, including temporary diversion or bunding (use of retaining walls).
Flow of water to the contaminated area should be prevented from sources such as sprinkler systems, rain, and street gutter runoff.
11. If in case the PCB liquid reach flowing water, storm sewers or any inaccessible area, the first employee arriving at the spill area should initiate notification procedures immediately and initiate measures to prevent additional PCB liquid reaching the water bodies or lands.
12. Barricades, caution tape, and signs should be put up around the contaminated area to prevent pedestrians, animals and vehicles from entering until the spill material is cleaned up and removed. Strict security of the area must be ensured and admittance to the site should be only upon authorization.
13. In most cases, oil absorptive material is a useful cleanup tool. It should be spread on the contaminated area and should be left in place for at least one hour, or as long as necessary to ensure that all PCB fluids have been absorbed. The absorbent may need to be physically scrubbed or pressed into the contaminated surfaces.
14. The common sorbent materials for spill clean-ups are the following:
• Activated charcoal
• Absorbent pads
• Local indigenous adsorbent materials such as coco coir
15. After the spilled liquids have been absorbed, the absorptive material, along with any contaminated soils, should be placed in steel containers provided for disposal purposes. If PCB penetration or permeation cannot be determined, at least 15 cm of soil depth should be removed.
16. All surfaces exposed to the spilled liquid should be decontaminated with swabs containing an efficient solvent.
17. Any contaminated steel structures, wood racks, cable trays (all types), and contaminated items such as tools, boots, full face respirator (unless severely contaminated) and other equipment should be washed down with perchloroethylene.
All equipment on these structures that may be contaminated by a PCB spill, but will not be removed, must also be similarly cleaned. Use perchloroethylene with caution to prevent further contamination of equipment, vehicles etc. in the spill area.

18. Large spills in populated areas, the spill area will be continuously manned until the spilled PCB oil and all clean-up materials have been removed from the site, secured in drums, or treated.

19. In case of fire, the fire department should be notified immediately and informed that the fire involves PCBs. Foam or dry chemicals must be used to extinguish the fire, rather than water to minimize contaminated runoff.

20. PCB contaminated soil need to be remediated to background levels (i.e., detection limits), where practically attainable, of any PCB spill.

21. Spills into small pools of water may be cleaned up by bailing or pumping the contaminated water and sediment into secured drums.

22. Spills into water bodies could pose a difficult clean-up and require special consideration. Since PCBs are heavier than water, it will settle to the bottom and dredging of contaminated sediment will be necessary in the area of the spill.

23. For Transporters, Spill report shall be submitted to the PGCB/REB, Concerned Government Agencies.

24. The spill report shall contain the following information:
   - Source of the PCBs
   - Quantity of waste involved
   - Time and duration of the incident.
   - Cause of the spill.
   - Estimated size and location of the affected area.
   - Nature or visible effects e.g., fish kill, toxic cloud, discoloration of receiving water.
   - Corrective measures taken or planned and the implementation schedule of such activities.
   - Spill Prevention Control and Countermeasures (SPCC), or contingency plans in effect.
   - Persons notified (including name, organization, date, and time)
   - Name(s) of cleanup personnel
   - Description of medium affected by release (porous/non-porous surface, drains, soil, water, air)

**Disposal**

The expired transformer (if found during upgradation work) should be cleaned and dried with careful protection with proper clothing including coveralls, boots or boot covers, gloves, eye protection etc. The above code should be followed to eliminate risk of exposure to PCBs. Dry-type transformers need not be considered as potential sources of PCB contamination. These expired transformers will be shifted in REB/PGCB designated area for proper recycling. The various metallic components of the transformers have high value in the current market. These metallic and other components will be cleaned properly and prepared for shipment to the authorized smelter.

In normal circumstances, decontaminated residual components could be accepted at landfill sites. Notification has to be given to REB/PGCB which will issue the appropriate directions for disposal.