LIGHTNING PROTECTION AND EARTHING

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Engineering Department

WEST BENGAL STATE ELECTRICITY TRANSMISSION COMPANY LIMITED
পশ্চিমবঙ্গ রাজ্য বিদ্যুৎ সংবহন কোম্পানি লিমিটেড
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SUB-STATION LIGHTNING PROTECTION AND EARTHING

1. **SCOPE :**
   - The specification covers all detailed engineering activities like – design, calculations, preparation of drawings, schematics and other relevant documentations for approval.
   - Supply, delivery, installation, testing and successful commissioning of the substation lightning protection and earthing system is under scope of the bidder.

2. **DEVIATION :**

   Normally the offer should be as per Technical Specification without any deviation. If any modification felt necessary to improve performance, efficiency and quality of equipment, the same must be mentioned in the 'Modification schedule' with reasons duly supported by documentary evidences and advantages. Such modifications suggested may or may not be accepted, but the same must be submitted along with Pre-Bid Queries. The modifications not mentioned in Schedule will not be considered.

3. **LIGHTNING PROTECTION :**

   i) All buildings and equipment at the substation are to be protected from lightning at all times.

   ii) Lightning masts of suitable heights (if not provided by WBSETCL) shall be designed, fabricated, supplied so that the entire switchyard is protected from lightning stroke.

   iii) Location of lightning masts shall be finalised after approval of DSLP calculations.

   iv) For protection zone calculation, method followed by Prof. D.V. Rejevig can be adopted.

   v) Direct Stroke Lightning Protection of switchyard portion for new Sub-Stations shall be designed by considering Lightning masts.

   vi) In lightning mast, provision for fixing switchyard light fittings, platform and stairs for climbing at the top shall be kept.

   vii) Indicating light with all control and accessories for aviation if required shall also be provided.

   viii) Protection of Building and allied structures against lightning shall be done as per IS:2309.

   ix) For extension bays of existing Sub-Station, the height of Lightning Mast shall be identical to existing one.

   x) **At new Sub-Station, the entire switch-yard area (both present and future portion) shall be considered for lightning protection. For design at future area, the height of transformer under present scope is to be considered.**

   xi) **In new Sub-Station all lightning masts must be of same height.**

xii) Lightning masts must be connected by a dedicated conductor directly to the substation earth grid. The conductor must be supported to the tower/structure with the necessary clamps.

xiii) Any overhead transmission line earth wire or Optical Fibre Ground Wire (OPGW) must be terminated with a removal link at the base of structure/tower to solidly earth the overhead earth wire or OPGW to the ground mat.

xiv) All transmission line circuits exiting from and entering the substation must be effectively shielded with an earth wire or OPGW to prevent lightning strikes on phase conductors.

4. SUB-STATION EARTHING :

A. STANDARD :

The earthing grid for sub-station shall be designed in terms of IS:3043 and IEEE Standard Documents Number 80-1986.

B. DESIGN CRITERIA :

i) Earth mat design is to be done considering uniform spacing of main grid rods for both X and Y direction.

ii) The earthing system of sub-station shall be designed to ensure equipment safety, personnel safety and should facilitate proper operation of protection system during earth fault in the system.

iii) Neutral points of different voltages, metallic enclosures and frame work associated with all current carrying structures/metal works associated with electrical system shall be connected to single earthing system unless stipulated otherwise.

iv) The following particulars shall be taken into account for calculation & design of earthmat:

Sl. No	Description	Design input data for sub-station		
		For 400/220/132/33KV SS	For 220/132/33KV SS	For 132/33KV SS
(i)	Fault Current (KA)	50	40	31.5
(ii)	Fault duration (second) (for conductor sizing calculation of main earth grid)	1.0		
(iii)	Fault duration (second) (for calculation of attainable and tolerable step and touch potential)	1.0		
(iv)	Crushed-stone/gravel resistivity	2500 Ω-mtr		
(v)	Main (ground grid) earthmat conductor size and material	32mm Φ MS rod		
(vi)	Riser material (above ground) for equipment, columns and Aux. structures	50×10mm(minimum) GS Flat		
(vii)	Riser material (below ground)	32mm Φ MS rod		

(viii)	Pipe Earth Electrode (in treated earth pit) as per tech. spec.	40 mm. dia 3 metre long galvanized Iron pipe
(ix)	Earth electrode in non-treated pit	40 mm. Dia with 3 meter long MS Rod.
(x)	Depth of burial	600 mm (minimum) to 1000 mm. below finished ground level
(xi)	Current Diversity factor	1.0
(xii)	Earthing of indoor LT panels.	50 x 8 mm. GS Flat.
(xiii)	Control Panels & Outdoor Marshalling Boxes, MOM Boxes, Jn. Boxes & Lighting Panels etc.	50 x 8 mm. GS Flat.
(xiv)	Earthing conductor inside cable trenches.	50 x 8 mm. MS Flat.
(xv)	Thickness of crushed stone/gravel	100 mm.
(xvi)	Size of crushed stone/gravel	30mm to 50mm (Avg 40mm)
(xvii)	Soil resistivity (for main grid design)	30 Ω-mtr or actual measured value whichever is higher

N.B:-

(a) Consideration of current diversity factor may be changed for achieving safe touch & step voltage within the provision of IS-3043 , IEEE 80-1986/2000 & CBIP Manual on Earthing in case of very high soil resistivity of sub-station land.

(b) Design of earth mat based on non-uniform spacing method shall not be acceptable.

(c) In case of extremely high soil resistivity, particularly in hilly or plateau region, Bentonite Powder or Satellite Earthing concept may be used to bring down the resistivity.

v) For earth grid system design, the soil resistivity of 30 ohm-m or the actual measured value whichever is higher is to be considered.

vi) For the purpose of finding out actual soil resistivity, it is to be measured in dry season in presence of the representative of WBSETCL.

vii) Soil resistivity measurement shall be done with different number of electrode spacing, preferably in steps of 2, 5, 10, 15, 20/25 meters etc. by following Wenners four electrode method. The resistivity for these spacing shall be noted and taken as the resistivity for that particular direction. In a similar manner, resistivities for different locations (at least 6 locations), covering the entire switchyard area (including control room building), are to be measured. The average resistivity thus obtained shall be used for the design of the earthmat. If sufficient readings could not be taken then the design is to be done considering maximum measured earth resistivity reading.

viii) The design shall ensure that the grid resistance shall not be more than 0.5 ohm.

ix) Design shall ensure that potential gradient along the surface during short circuit is limited to a value considered safe for human being.

x) Supply and spreading of 100 mm. (min.) crushed stone / gravel comprising of avg 40mm (30mm to 50mm) size over 75mm average thick P.C.C (1:5:10) with jhama bricks to be done. The safe touch & step voltage shall be achieved considering crushed stone/gravel resistivity for Substation.

xi) Beside switchyard earthing system with main earth mat, its connections to different risers below and above ground upto equipment and different structures and other important installations are also within the scope of bidder.

xii) If Earth mat quantity is specifically mentioned in BOQ, then the quantity will be derived considering design value of main earth grid conductor, corner mesh and periphery as per approved document. For other items like auxiliary mat, bending length, overlapping length,

fencing earthing, gate earthing, riser above & below ground etc. shall have to be quoted as lumpsum / LOT price.

xiii) Control room building & integrated GIS building earthing shall have to be done.

C. **Structure and equipment Earthing**:

a) Two nos. riser directly from the main earthmat rod shall be used for equipment earthing. The same shall be connected at diagonally opposite direction.

b) Steel/RCC columns, metallic stairs etc shall be connected to the nearby main earthmat grid conductor by two earthing leads. Electrical continuity shall be ensured by bonding different sections of hand-rails and metallic stairs.

c) Railway tracks within switchyard area shall be earthed at a spacing of 30m and at both ends.

d) Lighting poles, junction boxes, BMK, CT/PT/CVT JB, cable boxes/glands etc shall be connected to earthing grid conductor at minimum two points.

D. **INSTALLATION OF EARTHING CONDUCTOR :**

(i) The grounding grid shall be constructed by use of corrosion resistant mild steel rod.

(ii) Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks etc. It shall be laid 300mm(min) below them and shall be circumvented in case it fouls with equipment/structure foundation.

(iii) All non-current carrying steel/metal parts, equipment in the switchyard shall be connected to the grounding grid.

(iv) Lightning arrestors, Reactors, Transformers, CVT/PT etc shall be earthed through earth electrode. This electrode shall in turn be connected to earthing grid through galvanised bolts and nut.

(v) Each earthing lead from the neutral of the transformer shall be directly connected to two galvanised pipe electrode treated earth pit which in turn shall be connected to station earth grid.

(vi) All points in steel earthing system shall be made by welding except the points with bolted connection which should be provided for separating the earthing grid for testing purpose. The point for testing purpose should be so placed that the earth grid can be frequently supervised.

(vii) Connection between equipment earthing lead & main earthing conductors and all joints at main earthing conductors shall be welded type.

(viii) For rust protection, the welded surface shall be treated with Barium Chromate. After treatment, the welded surface shall be painted with red lead and two layers of bitumen compound to prevent corrosion.

(ix) Size of earth pit (inner wall clear dimensions) –

a) Earth electrode without test link - at least 400x400 mm. in size and 375 mm. deep
b) Earth pit with test link - at least 700x700 mm. in size and 375 mm. deep.

(x) The earth pit shall be constructed with RCC (M-15) in surrounding wall and floor (minimum wall thickness 125 mm. and floor thickness 100 mm.) with a removable cover slab of 75 mm. thick

with RCC (M-15) (0.8% reinforcement by volume of concrete). Cover slab shall be plastered with cement mortar (1:4) on all sides.

(xi) To provide testing facility with Clip-on type earth resistance measuring meter one test link with ACSR panther conductor having compression type joint with socket of total length of about 300 mm. (combined) shall be incorporated.

(xii) Two earth pits shall be provided for transformer neutral to be connected through two nos. flat. One flat shall be directly connected to one earth electrode through welding and the other flat shall be connected with other earth pit through a testing link. All accessories associated with transformer/reactor like cooling banks, radiators etc shall be connected to the main earthing grid at minimum two points.

(xiii) The earthing conductor around control building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building and which in turn shall be connected to switchyard main earth grid conductor as per approved earthing lay out drawing for control room to be submitted separately.

(xiv) Steel to Copper connection if any shall be brazed type and shall be treated to prevent moisture ingression.

(xv) Bending of earthing rod shall be done preferably by gas heating.

(xvi) All ground connections shall be made by one welding except the point with bolted connection which should be provided for separating the earthing grid for testing purpose. The point for testing purpose should be so placed that the earth grid can be frequently supervised for rust protection. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load to it. Artificial cooling shall not be allowed.

(xvii) All C & R panels, Communication panels, Battery charger shall be earthed by 50×8 mm GS Flat (2nos flat one each on opposite side) to MS earth Bus of 50 x 8 mm.

(xviii) MS Flat runs on the top of the tier and all along the cable trenches shall be welded to each of the racks. Further this Flat shall be earthed at both ends and at an interval of 30 mtr. The MS Flat shall be finally painted with two coats of Red oxide primer and two coats of bitumen compound.

(xix) Earthing conductor for main ground grid in outdoor areas shall be buried at least 600 mm below finished ground level or more as per design consideration for green field Sub-Station. For existing substation it should be laid matching with existing earthmat grid level.

(xx) Earthing conductor or leads along their run on cable trench, ladder, wall, etc. shall be supported by suitable welding / cleaning at interval of 1200 mm. Wherever it passes through walls, floors, etc., galvanized steel sleeves shall be provided for passage of conductor and both end of sleeves shall be sealed to prevent passage of water through sleeves.

(xxi) Earthing conductor, i.e. grid perimeter ground conductor shall be buried 1000 mm (min.) outside the switchyard fence. All gates of every alternate post of fence shall be connected to earthing grid. Gravel / crushed stone spreading shall also be done 1000 mm (min.) outside the switchyard fence.

(xxii) Flexible earthing connectors shall be provided for moving parts.

(xxiii) Auxiliary earth mat of same dia of the main earth mat and total size1500×1500 mm with 500×500 mm closely spaced conductor shall be provided at a depth of 300 mm from the finished ground level below the operating handle of MOM box of all isolators. MOM box shall be directly connected to auxiliary mat which inturn shall be connected to main earth mat grid at two points.

(xxiv) The earth mat design shall be based on uniform spacing method. However closely spaced corner mesh shall be provided at all corners of the main earth mat in addition to main earth grid conductor to minimize ground potential rise and to control perimeter gradients and step potential, **two or more parallel conductor of same size of main earth mat shall be buried all along the perimeter.**

(xxv) Pipe and rod electrode shall be used as per following-

a) Pipe electrode in treated pit with test link (Test pit) :
Application: Reactor/Power Transformer's Neutral, Earthing Transformer/ Station Service Transformers' Neutral, Grid Corner, LA, CVT, PT.

b) Pipe electrode in treated pit without test link :
Application: Lightning Mast, Shield wire down comer, Control room building / Integrated GIS building corners.

c) Rod Earth electrode in non-treated pit :
Application: Coupling Capacitor, Grid periphery (other than grid corner).

(xxvi) Earthing conductors crossing the road shall be laid 300mm below road or at greater depth to suit site condition. Earthing conductors embedded in the concrete shall have approximately 50mm concrete cover

5. CONTRACT DRAWINGS AND DESIGN CALCULATIONS :

a) The contractor shall furnish design calculations, layout drawings & relevant documents of lightning protection and earthing system for approval.

b) Contractor shall submit detail equipment earthing drawing of all equipment, detail pipe electrode drawing in conjunction with treated pit with test link, treated pit without test link & non-treated pit and structure earthing drawings for approval of WBSETCL.

c) The software used to design the lightning protection system and for calculation of earthing system shall have to be provided for necessary checking and verification of submitted design.

d) Approved calculation and drawing both in hard and soft copy for each sub-station shall be submitted for record and distribution to site.

6. TEST :

All tests for earthing system shall be carried out by the contractor at site as stated below :

a) Earth resistance check of the entire grid as per approved earthmat design.
b) Continuity check of the earthmat grid.
c) Checking of all welded joint and coating of zinc rich paint.