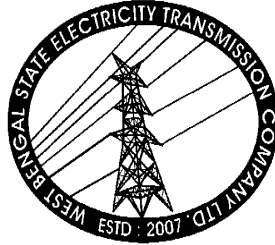


# LIGHTNING PROTECTION AND EARTHING

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*Engineering Department*

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## **TECHNICAL SPECIFICATION FOR SUB-STATION LIGHTNING PROTECTION AND SUB-STATION EARTHING**

### **1. LIGHTNING PROTECTION :**

#### **SCOPE :**

- i) Lightning masts of suitable heights (if not provided by WBSETCL) shall be designed, fabricated, supplied and erected at 400/220/132/33KV, 220/132/33KV & 132/33KV green field Sub-Station for all voltage classes so that the entire switchyard to be constructed under the scope of this tender is protected from lightning stroke. Location of lightning masts shall be finalised after approval of DSLP calculations.
- ii) In calculation of protection zone of a lightning mast method followed by Prof. D.V. Rejevig can be adopted.
- iii) Provision for fixing switchyard light fittings in lightning mast shall be kept and stairs and platform shall be provided for climbing at the top for fixing of light fittings and maintenance purpose also.
- iv) Indicating light with all control and accessories for aviation if required shall also be provided. Erection of aviation light and related control and accessories shall also be within the scope of contractor if the same is required.
- v) Protection of Building and allied structures against lightning shall be as per IS:2309.
- vi) Lightning protection is also to be achieved for the bay / bays to be extended under the scope of contract for existing 400KV, 220KV, 132KV & 33KV switchyard either by Lightning Mast or Shield wire as per existing arrangement at different existing substation. Bidder is to assess total involvement of work through site visit. Scope of work shall be guided by different schedule of works, and as per Technical Specification requirement and approved design document / drawings.
- vii) For extension bay / bays under scope of contract for existing Sub-Station, the height of Lightning Mast shall be identical to existing one.
- viii) In case of GIS Sub-Station, the entire switch-yard portion (both present scope as well as future extension portion), shall have to be covered under DSLP protection by Lightning Mast.

### **2. SUB-STATION EARTHING :**

#### **SCOPE: The scope of work is inclusive of but not limited to the followings:**

- i) Design and engineering of earthing mat and earthing system for complete 400/220/132/33KV, 220/132/33KV & 132/33KV sub-station and supply, delivery, installation, testing and successful commissioning of the same.

- ii) 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.
- iii) Both supply and spreading of crushed stone/gravel shall be within the scope of the contractor for all 400/ 220/132/33KV, 220/132/33KV & 132/33KV green field new sub-station and that shall be guided by Supply & Erection schedules.
- iv) For existing 400KV, 220KV & 132KV Substation main earthmat conductor shall be extended for bay/bays under scope of contract for its connection to different equipment, equipment structures, substation structures etc through risers (below and above ground) to make a complete earthing system. The diameter of main earthmat conductor and risers for extended portion shall be identical to the existing one.
- v) Requirement of earthing material, supply & spreading of crushed stone/gravel for the bay/bays for existing substation under scope of contract shall be assessed through site visit & to be guided by supply & Erection schedule.

### **3. STANDARD :**

This specification covers, Design, Engineering of sub-station earthing grid & supply, delivery, installation, testing & commissioning of the same. The earthing grid for sub-station shall be designed in terms of IS:3043 and IEEE Standard Documents Number 80-1986. However Earth mat design based on uniform spacing method is to be submitted for approval.

### **4. I) DEVIATION :**

Normally the offer should be as per Technical Specification without any deviation.

### **II) MODIFICATION :**

If any modification felt necessary to improve performance, efficiency and utility 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.

### **5. DESIGN CRITERIA :**

- i) 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 due to stipulated fault current for specified duration.
- ii) 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.
- iii) The following particulars shall be taken into account for calculation & design of earthmat:

Sl. No	Description	Design input datas for new 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 earthgrid)	1.0		
(iii)	Fault duration (second) (for calculation of attainable and tolerable step and touch potential)	1.0		
(iv)	Crushed-stone/gravel resistivity	2500 $\Omega$ -mtr		
(v)	Main (ground grid) earthmat conductor size and material	32mm $\Phi$ MS rod		
(vi)	Riser material (above ground) for equipment, columns and Aux. structures	50x10mm(minimum) GS Flat		
(vii)	Riser material (below ground)	32mm $\Phi$ 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)		

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. However design of earth mat based on non-uniform spacing method shall not be acceptable.

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

- iv) For the purpose of finding out actual soil resistivity, it is to be measured in dry season by the successful contractor in presence of the representative of WBSETCL. On the basis of actual soil resistivity of the substation earth mat shall be designed accordingly and as per approved earth mat design and approved layout drawing, the substation earth mat shall be laid accordingly.

To get the actual soil resistivity of the entire Sub-Station area, to arrive the designed average 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 widders four electrode method in line with guide line as laid down. The resistivity for these spacing shall be noted and taken as the resistivity for that particular direction. In a similar manner, resistivities for at least ten 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.

- Length of main earth mat conductors, pipe/rod earth electrode and auxiliary mat shall be considered for design purpose of Earthing system.
- The design shall ensure that the grid resistance shall not be more than 0.5  $\Omega$ .
- Design shall ensure that potential gradient along the surface during short circuit is limited to a value considered safe for human being. The potential gradient to be achieved shall be less than the safe touch and step voltage.

- v) Supply and spreading of 100 mm. (min.) Crushed stone/gravel comprising of avg 40mm (30mm to 50mm) normal size crushed stone/gravel over the entire switchyard area over 75mm average thick P.C.C (1:5:10) with jhama bricks to be constructed by the contractor for new 400/220/132/33KV, 220/132/33KV & 132/33KV new sub-stations as stipulated in the relevant price schedule. In case of existing sub-station the vendor shall follow the existing norms as per site requirement or as stipulated in the relevant price schedule.. The safe touch & step voltage shall be achieved considering crushed stone/gravel resistivity for Substation. Beside this if any extension of earth mat outside switchyard/Sub-Station area is required to achieve safe earth mat design, the same shall be within the scope of the Contractor.
- vi) Price for extra MT of main earth grid conductor, considering the design length of main earth grid conductor as per approved document, w.r.t the MT of main earth grid conductor indicated in the price schedules will be paid to the contractor as per quoted unit rate. On the other hand, pro-rate deduction of price as per quoted unit rate will be made if requirement of main earth grid conductor as per approved design document, converted to MT is less than the MT of main earth grid conductor indicated in the price schedules.

Except the above, no extra payment shall be made to the contractor for any other items including requirement of main earth grid conductor other than main grid, to be supplied & erected as per technical specification requirement.

Requirement of Supply & Erection of main earth grid conductor other than main mat considering bending length, overlapping length, fencing / barbed wire / gate earthing purpose, Control room building & integrated GIS building earthing purpose etc shall have to be quoted as lumpsum / LOT price.

vii) **Structure and equipment Earthing:**

- a) Two nos. riser flat (above ground) upto apparatus/equipment base directly from the main earthmat rod shall be used for equipment earthing and the same shall run parallel but in opposite direction including loops bonding across structural joints.
- 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 also at both ends.
- d) Lighting poles, junction boxes on poles and Sub-station, BMK, CT/PT/CVT JB, Cable and cable boxes/glands, lockout switches etc shall be connected to earthing grid conductor at minimum two points.

**6. INSTALLATION OF EARTHING CONDUCTOR LAY OUT :**

- (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 in the switchyard shall be connected to the grounding grid including equipment except lightning arrestors, Reactors, power transformers, CVT/PT etc which shall be earthed directly through earth electrode. This electrode shall in turn be connected to earthing grid through galvanised bolts and nut. 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. Contractor shall submit detail equipment earthing drawing of all equipment along with detail pipe electrode drawing to be used in conjunction with treated pit with test link, treated pit without test link and non-treated pit and structure earthing drawings for approval of WBSETCL.

- (iv) 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.
- (v) Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded type. For rust protection, the welded surface shall be treated with Barium Chromate and then Welded surface shall be painted with red lead and coated with two layers of bitumen compound to prevent corrosion.
- (vi) Earth pit of earth electrode without having any test link shall be at least 400x400 mm. in size and 375 mm. deep and earth pit with test link shall be at least 700x700 mm. in size and 375 mm. deep. 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.
- (vii) 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 between earth pit and neutral of the Reactor/transformer, CVT/PT/LA, Grid corners etc. which in turn shall be connected to main earth mat. The socket shall be connected with the flat through bimetallic strip. 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.
- (viii) 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.
- (ix) Steel to Copper connection if any shall be brazed type and shall be treated to prevent moisture ingress.
- (x) Bending of earthing rod shall be done preferably by gas heating.
- (xi) 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, the welded surface shall be protected with bitumen paint riser (M.S.Flat) above ground shall be painted with Zinc rich paint above anti Oxide primer. 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.
- (xii) All C & R panels, PLCC and its Battery charger shall be earthed by 50x8 mm GS Flat ( 2nos flat one each on opposite side ) to MS earth Bus of 50 x 8 mm. MS Flat runs on the top of the tier and all along the cable trenches and the same shall be welded to each of the racks. Further this Flat shall be earthed at both ends 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.
- (xiii) 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.
- (xiv) 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.
- (xv) 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. However criterion of gravel / crushed stone spreading shall be followed in line with requirement of approved drawing & schedule of works.

- (xvi) Flexible earthing connectors shall be provided for moving parts.
- (xvii) Tap connection from earthing grid to equipment /structures to be earthed shall be terminated on the earthing terminal of the equipment/structures as per approved drawings.
- (xviii) Auxiliary earth mat of same dia of the main earth mat and total size 1500×1500 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 in turn shall be connected to main earth mat grid at two points.
- (xix) As stated in clause 5.0 above, 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 dia of main earth mat shall be buried all along the perimeter.
- (xx) All above ground conductive metal parts that might accidentally energized shall be connected to main earth mat.
- (xxi) Pipe electrode shall be used in the following area (application wise) :
  - 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 corner, Control room building / Integrated GIS building corners.
  - c) Rod Earth electrode in non-treated pit :  
Application: Coupling Capacitor, Grid periphery (other than grid corner).
- (xxii) The crushed stone/gravel spreading shall be restricted to main earthmat area of the switchyard.
- (xxiii) Earthing conductors crossing the road shall be laid 300mm below road or at greater depth to suit site condition.
- (xxiv) Earthing conductors embedded in the concrete shall have approximately 50mm concrete cover.

## **7. CONTRACT DRAWINGS AND DESIGN CALCULATIONS :**

After placement of Letter of Award (LOA) the contractor shall furnish 6(six) copies of design calculations of lightning protection and earthing mat and earth mat layout drawings showing connection of different equipment/structures to earthing pit as well as to earthing mat to the Chief Engineer, Engg. Deptt., Vidyut Bhawan (9<sup>th</sup> floor), Salt Lake, Kolkata - 700 091.

Ten (10) copies of approved design calculation and drawing for each sub-station shall be submitted for our record and distribution to site. Ten(10) copies of approved design calculation of lightning protection and its layout drawings as well as ten (10) copies of earth mat layout drawing showing connection of different equipment/structure to earthing pit/earthing mat shall be submitted to the Chief Engineer, Engg. Deptt., Vidyut Bhawan (9<sup>th</sup> floor), Salt Lake, Kolkata - 700 091 for our record and distribution to site.

**8. TEST :**

All tests as required for successful commissioning of the 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 document.
- b) Continuity check of the earthmat grid.
- c) Checking for all weld joint and application of zinc rich paint.