

## ANNEXURE-1: SWITCHYARD ERECTION GUIDELINES

### 1.0 GENERAL

Loading / Unloading, verification, handling, shifting to & from stores, proper storage, assembly, installation, pre-commissioning test and commissioning tests (As per BHEL FQP) are included in the scope.

### 2.0 EARTHING

2.1 The earthing shall be done in accordance with requirements given hereunder and drawing titled 'Equipment Earthing Details' enclosed with the specification. The spacing for the main earthmat shall be as per the earthmat layout drawings..

Neutral points of systems of different voltages, metallic enclosures and frame works associated with all current carrying equipments and extraneous metal works associated with electric system shall be connected to a single earthing system unless stipulated otherwise.

Earthing and lightning protection system installation shall be in strict accordance with the latest editions of Indian Electricity Rules, relevant Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed.

- a) Code of practice for Earthing IS: 3043
- b) Code of practice for the protection of Building and allied structures against lightning IS: 2309.
- c) Indian Electricity Rules 1956 with latest amendments.
- d) National Electricity Safety code IEEE-80.

### 2.2 Details of Earthing System

Sl. No.	Item	Size	Material
a)	Main Earthing Conductor to be buried in ground	40mm dia	Mild Steel rod
b)	Conductor above ground & earthing leads (for equipment)	75x12mm GI flat	Galvanised Iron
c)	Trench Racks	50x6 mm GI Flat	Galvanised Iron
d)	Earthing of indoor LT panels, Control panels and out door marshalling boxes, MOM boxes, Junction boxes& Lighting Panels etc.	25x6 mm G.S. flat	Galvanised Steel
e)	Rod Earth Electrode	40mm dia, 3000mm long	Mild Steel
f)	Pipe Earth Electrode (in treated earth pit) as per IS.	40mm dia, 3000mm long	Galvanised Iron

The sizes of the earthing conductor indicated above are the minimum sizes.

## 2.3 **Earthing Conductor Layout**

- 2.3.1 Earthing conductors in outdoor areas shall be buried at least 600 mm below finished ground level unless stated otherwise.
- 2.3.2 Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks etc., it shall be laid minimum 300 mm below them and shall be circumvented in case it fouls with equipment/structure foundations.
- 2.3.2 Tap-connections from the earthing grid to the equipment/structure to be earthed shall be terminated on the earthing terminals of the equipment/structure as per "Equipment Earthing"

## 2.4 **Equipment and Structure Earthing**

- 2.4.1 Earthing pads shall be provided for the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by two short earthing leads (one direct and another through the support structure) free from kinks and splices. In case earthing pads are not provided on the item to be earthed, same shall be provided in consultation with Owner.
- 2.4.2 Whether specifically shown in drawings or not, steel/RCC columns, metallic stairs etc. shall be connected to the nearby earthing grid conductor by two earthing leads. Electrical continuity shall be ensured by bonding different sections of hand-rails and metallic stairs.
- 2.4.3 Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system.
- 2.4.4 Metallic conduits shall not be used as earth continuity conductor.
- 2.4.5 Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam conduits, etc. and steel reinforcement in concrete it shall be bonded to the same.
- 2.4.6 Light poles, junction boxes on the poles, cable and cable boxes/glands, lockout switches etc. shall be connected to the earthing conductor running alongwith the supply cable which inturn shall be connected to earthing grid conductor at a minimum two points whether specifically shown or not.
- 2.4.7 Railway tracks within switchyard area shall be earthed at a spacing of 30m and also at both ends.

## 2.5 **Jointing**

- 2.5.1 Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anti corrosive paint/compound.

- 2.5.2 Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded type. For rust protections, the welds should be treated with red lead and afterwards coated with two layers bitumen compound to prevent corrosion.
- 2.5.3 Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingress.
- 2.5.4 Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.
- 2.5.5 All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed.
- 2.5.6 Bending of earthing rod shall be done preferably by gas heating.
- 2.5.7 All arc welding with large dia. Conductors shall be done with low hydrogen content electrodes.
- 2.5.8 The 75x12mm GS flat shall be clamped with the equipment support structures at 1000 mm interval.

## 2.6 **Power Cable Earthing**

Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.

## 2.7 **Specific Requirement for Earthing Systems**

- 2.7.1 Each earthing lead from the neutral of the power transformer/Reactor shall be directly connected to two pipe electrodes in treated earth pit (as per IS) which in turn, shall be buried in Cement Concrete pit with a cast iron cover hinged to a cast iron frame to have an access to the joints. All accessories associated with transformer/reactor like cooling banks, radiators etc. Shall be connected to the earthing grid at minimum two points.
- 2.7.2 Earthing terminal of each lightning arrester & capacitor voltage transformer shall be directly connected to rod earth electrode which in turn, shall be connected to station earthing grid.
- 2.7.3 Auxiliary earthing mat comprising of 40mm dia M.S. rods closely spaced (300 mm x 300 mm) conductors shall be provided at depth of 300mm from ground level below the operating handles of the M.O.M. Box of the isolators. M.O.M. boxes shall be directly connected to the auxiliary earthing mat.

## 3.0 **Main Bus Bars (Applicable for Aluminium tube)**

The bus switching scheme, bus bar layout and equipment connection to be adopted are as per layout drawings.

4.0 **LIGHTNING PROTECTION**

4.1 Direct stroke lightning protection (DSLPP) shall be provided in the switchyard by lightning masts and shield wires. The DSLPP layout drawings enclosed indicate the arrangement.

5.0 **EQUIPMENT ERECTION DETAILS**

5.1 For equipment interconnection, the surfaces of equipment terminal pads, Aluminium tube, conductor & terminal clamps and connectors shall be properly cleaned. After cleaning, contact grease shall be applied on the contact surfaces

of equipment terminal pad, Aluminium tube/conductor and terminal clamps to avoid any air gap in between. Subsequently bolts of the terminal pad/terminal connectors shall be tightened and the surfaces shall be cleaned properly after equipment interconnection.

5.2 Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.

5.3 All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.

5.4 Bending of Aluminium tube and compressed air piping if any should be done by a Bending machine and through cold bending only. Bending shall be such that Inner diameter of pipe is not reduced.

5.5 Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.

5.6 Handling of equipment shall be done strictly as per manufacturer's/supplier's instructions/instruction manual.

5.7 Handling equipment, sling ropes etc. Should be tested periodically before erection for strength.

5.8 The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.

6.0 **STORAGE**

The Contractor shall properly store the equipments, where sensitive equipments shall be stored indoors. All equipments during storage shall be protected against damage due to acts of nature or accidents. The storage instructions of the equipment manufacturer/Owner shall be strictly adhered to.

7.0 **CABLING MATERIAL**

7.1 **CABLE TAGS AND MARKERS**

7.1.1 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

- 7.1.2 The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire conforming to IS:280. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.
- 7.1.3 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate.
- 7.1.4 Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable joints".
- 7.1.5 The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.
- 7.1.6 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry and at each end & turning point in cable tray/trench runs. Cable tags shall be provided inside the switchgear, motor control centres, control and relay panels etc., wherever required for cable identification, where a number of cables enter together through a gland plate.

## 7.2 **Cable Supports and Cable Tray Mounting Arrangements**

The Contractor shall weld the rack assembly on embedded steel inserts on concrete floors/walls to secure supports.

## 7.3 **Cable Termination and Connections**

- 7.3.1 The termination and connection of cables shall be done strictly in accordance with cable and termination kit manufacturer's instructions, drawing and/or as directed by the Owner.
- 7.3.2 The work shall include all clamping, fittings, fixing, plumbing, soldering, drilling, cutting, taping, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job.
- 7.3.3 Supply of all consumable material (Including cable glands) shall be in the scope of Contractor.
- 7.3.4 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for drilling of gland plates, painting and touching up. Holes shall not be made by gas cutting.
- 7.3.5 Control cable cores entering control panel/switchgear/MCCB/MCC/Miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap Or PVC perforated strap to keep them in position.
- 7.3.6 The Contractor shall tag/ferrule control cable cores at all terminations, as instructed by the Owner. In panels where a large number of cables are to

be terminated and cable identification may be difficult, each core ferrule may include the complete cable number as well.

- 7.3.7 Spare cores shall be similarly tagged with cable numbers and coiled up.
- 7.3.8 All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.
- 7.3.9 Double compression type nickel plated (coating thickness not less than 10 microns) brass cable glands shall be provided by the Contractor for all power and control cables to provide dust and weather proof terminations.
- 7.3.10 The cable glands shall conform to BIS: 6121. They shall comprise of heavy duty brass casting, machine finished and nickel plated, to avoid corrosion and oxidation. Rubber components used in cable glands shall be neoprene and of tested Quality. Cable glands shall be of approved/reputed make.
- 7.3.11 The cable glands shall also be suitable for dust proof and weather proof termination. The test procedure, if required, has to be discussed and agreed to between Owner and cable gland manufacturer.
- 7.3.12 If the cable-end box or terminal enclosure provided on the equipment is found unsuitable and requires modification, the same shall be carried out by the Contractor, as directed by the Owner.
- 7.3.13 Crimping tool used shall be of approved design and make.
- 7.3.14 Cable lugs shall be tinned copper solderless crimping type conforming to IS-8309 & 8394. Bimetallic lugs shall be used depending upon type of cables used.
- 7.3.15 Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided.

#### 7.4 **Storage and handling of Cable Drums**

Cable drums shall be unloaded, handled and stored in an approved manner and rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum.

#### 8.0 **DIRECTLY BURIED CABLES**

- 8.1 The Contractor shall construct the cable trenches required for directly buried cables. The scope of work shall include excavation, preparation of sand bedding, soil cover, supply and installation of brick or concrete protective covers, back filling and ramming, supply and installation of route markers and joint markers as per approved design. The Bidder shall ascertain the soil conditions prevailing at site, before submitting the bid.
- 8.2 Cable route and joint markers and RCC warning covers shall be provided wherever required. The voltage grade of cables shall be engraved

on the marker.

## 9.0 **INSTALLATION OF CABLES**

- 9.1 Cabling in the control room shall be done on perforated type cable trays while cabling in switchyard area shall be done on ladder type tray fixed on rack assembly at an interval of 1.5 m in the trench.
- 9.2 All cables from bay cable trench to equipments including and all inter pole cables (both power and control) for all equipment, shall be laid in GI pipes of 50 & 100 mm nominal outside diameter which shall be buried in the ground at a depth of 250mm below finish formation level. Separate GI pipes shall be laid for control and power cables. **Cable pull boxes of adequate size shall be provided if required.**
- 9.3 Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the floor. In the case of equipments located away from cable trench either pipe inserts shall be embedded in the floor connecting the cable trench and the equipment or in case the distance is small, notch/opening on the wall shall be provided. In all these cases necessary bending radius as recommended by the cable manufacturer shall be maintained.
- 9.4 Suitable arrangement should be used between fixed pipe / cable trays and equipment terminal boxes, where vibration is anticipated.
- 9.5 Power and control cables in the cable trench shall be laid in separate tiers. The order of laying of various cables shall be as follows, for cables other than directly buried.
- a) Power cables on top tiers.
  - b) Control instrumentation and other service cables in bottom tiers.
- 9.6 Power and control cables shall be securely fixed to the trays/supports with self locking type nylon ties with de interlocking facility at every 5 m interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminium strip clamps at every 3m.
- 9.7 Cables shall not be bent below the minimum permissible limit. The permissible limits will be as per approved GTP:
- 9.8 Where cables cross roads, drains and rail tracks, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one metre depth.
- 9.9 In each cable run some extra length shall be kept at a suitable point to enable one (for LT cables)/two (for H.T. cables) straight through joints to be made in case the cable develop fault at a later date.
- 9.10 Selection of cable drums for each run shall be so planned as to avoid using straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Owner. If straight through joints are required as per approved drg, the Contractor shall use the straight through joints kit of reputed make.

- 9.11 Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing.
- 9.12 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the Owner.
- 9.13 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.
- 9.14 Cable ends shall be kept sealed to prevent damage. In cable vault, fire resistant seal shall be provided underneath the panels.
- 9.15 Inspection on receipt, unloading and handling of cables shall generally be in accordance with IS:1255 and other Indian Standard Codes of practices.
- 9.16 Wherever cable pass through floor or through wall openings or other partitions, GI wall sleeves with bushes having a smooth curved internal surface so as not to damage the cable, shall be supplied, installed and properly sealed by the Contractor at no extra charges.
- 9.17 Contractor shall remove the RCC/Steel trench covers before taking up the work and shall replace all the trench covers after the erection-work in that particular area is completed or when further work is not likely to be taken up for some time.
- 9.18 Contractor shall furnish three copies of the report on work carried out in a particular week, indicating cable numbers, date on which laid, actual length and route, testing carried out, terminations carried out, along with the marked up copy of the cable schedule and interconnection drawing wherever any modifications are made.
- 9.19 Contractor shall paint the tray identification number on each run of trays at an Interval of 10 m.
- 9.20 In case the outer sheath of a cable is damaged during handling/installation, the Contractor shall repair it at his own cost to the satisfaction of the Owner. In case any other part of a cable is damaged, the same shall be replaced by a healthy cable at no extra cost to the Owner, i.e. the Contractor shall not be paid for installation and removal of the damaged cable.
- 9.21 All cable terminations shall be appropriately tightened to ensure secure and reliable connections. The Contractor shall cover the exposed part of all cable lugs whether supplied by him or not with insulating tape, sleeve or paint.
- 10.0 **Conduits, Pipes and Duct Installation**
- 10.1 Contractor shall install all rigid conduits, GI pipes, flexible conduits, hume pipes etc. including all necessary sundry materials such as tees, elbows, check nuts, bushing, reducers, enlargers, coupling cap, nipples, gland sealing fittings, pull boxes etc as specified and to be shown in detailed drawing. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion.

- 10.2 Contractor shall have his own facility for bending, cutting and threading the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any sharp edges. Anticorrosive paint shall be applied at all field threaded portions.
- 10.3 All conduit/pipes shall be extended on both sides of wall/floor openings. The fabrication and installation of supports and the clamping shall be included in the scope of work by Contractor.
- 10.4 When two lengths of conduits are joined together through a coupling, running threads equal to twice the length of coupling shall be provided on each conduit to facilitate easy dismantling of two conduits.
- 10.5 Conduit installation shall be permanently connected to earth by means of special approved type of earthing clamps. GI pull wire of adequate size shall be laid in all conduits before installation.
- 10.6 Each conduit run shall be painted with its designation as indicated on the drawings such that it can be identified at each end.
- 10.7 Embedded conduits shall have a minimum concrete cover of 50 mm.
- 10.8 Conduit run sleeves shall be provided with the bushings at each end.
- 10.9 Metallic conduit runs at termination shall have two locknuts and a bushing for connection. Flexible conduits shall also be suitably clamped at each end with the help of bushings. Bushings shall have rounded edges so as not to damage the cables.
- 10.10 Where embedded conduits turn upwards from a slab or fill, the termination dimensions shown on the drawings, if any, shall be taken to represent the position of the straight extension of the conduit external to and immediately following the bend. At least one half of the arc length of the bend shall be embedded.
- 10.11 All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign material.
- 10.12 For underground runs, Contractor shall excavate and back fill as necessary.
- 10.13 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls. Unnecessary bends and crossings shall be avoided to present a neat appearance.
- 10.14 Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U- bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonry or concrete for conduit support is not acceptable.
- 10.15 Embedded conduits shall be securely fixed in position to preclude any movement. In fixing embedded conduit, if welding or brazing is used, extreme care should be taken to avoid any injury to the inner surface of the

conduit.

- 10.16 Spacing of embedded conduits shall be such as to permit flow of concrete between them.
- 10.17 Where conduits are placed alongwith cable trays, they shall be clamped to supporting steel at an interval of 600mm.
- 10.18 For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.
- 10.19 Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.
- 10.20 Conduits joints and connections shall be made thoroughly water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.
- 10.21 The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.
- 10.22 After installation, the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.

#### 11.0 **TESTING AND COMMISSIONING**

11.1 An indicative list of tests for testing and commissioning is given below. Contractor shall perform any additional test based on specialities of the items as per the field Q.P./instructions of the equipment Contractor or Owner without any extra cost to the Owner. The Contractor shall arrange all equipments instruments and auxiliaries required for testing and commissioning of equipments along with calibration certificates and shall furnish the list of instruments to the Owner for approval.

#### 11.2 **GENERAL CHECKS**

- (a) Check for physical damage.
- (b) Visual examination of zinc coating/plating.
- (c) Check from name plate that all items are as per order/specification.
- (d) Check tightness of all bolts, clamps and connecting terminals using torque wrenches.
- (e) For oil filled equipment, check for oil leakage, if any. Also check oil level and top up wherever necessary.
- (f) Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanised surfaces.
- (g) Check cleanliness of insulator and bushings.

- (h) All checks and tests specified by the manufacturers in their drawings and manuals as well as all tests specified in the relevant code of erection.
- (i) Check for surface finish of grading rings (Corona control ring).
- (j) Pressure test on all pneumatic lines at 18.5 times the rated pressure shall be conducted.

11.3 **STATION EARTHING**

- a) Check continuity of grid wires
- c) Check earth resistance of the entire grid as well as various sections of the same.
- d) Check for weld joint and application of zinc rich paint on galvanised surfaces.
- e) Dip test on earth conductor prior to use.

11.4 **ACSR STRINGING WORK, TUBULAR BUS WORK AND POWER CONNECTORS**

- a) Physical check for finish
- b) Electrical clearance check
- c) Testing of torque by torque wrenches on all bus bar power connectors and other accessories.
- d) Millivolt drop test on all power connectors.
- e) Sag and tension check on conductors.

11.5 **ALUMINIUM TUBE WELDING**

- a) Physical check
- b) Millivolt drop test on all joints.
- c) Dye penetration test & Radiography test on 10% sample basis on weld joints.
- d) Test check on 5% sample joints after cutting the weld piece to observe any voids etc.

12 **All pre/commissioning activities and works work for substation equipment shall be carried out in accordance with owner's "Pre-Commissioning procedures and formats for substation bay equipments" by the contractor. This document shall be provided to the successful contractor during detailed engineering stage.**