



**ODISHA POWER TRANSMISSION CORPORATION LIMITED**

**TECHNICAL SPECIFICATION**

**FOR**

**DESIGN CLAUSES FOR SUBSTATIONS**

**DESIGN CLAUSES FOR SUBSTATIONS**  
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## **1. 0 GENERAL**

The substation shall adopt switching scheme as shown on the attached single line diagrams. The Contractor shall propose the most economical substation layout that meets the desired degree of operational flexibility, reliability, service continuity and expandability. The contractor shall submit design considerations establishing the above and proposals for the Engg Incharge (Divisional Engr.) approval. The attached drawings are intended to show the basic requirements to be satisfied, i.e. switching arrangement, number of busbars, site location, available area, line termination etc. It is the responsibility of the Contractor to prepare a detailed layout showing the manner in which the various items of equipment offered can be accommodated to best advantage within the available area.

The arrangement shown on the attached drawings may be modified as necessary to accommodate the various items, e.g. different types of disconnector, provided the basic principles are maintained.

The Bidder is at liberty to offer substation arrangements based on significantly different principles where it is considered that these offer economies or technical advantages. It is emphasised, however, that the Bidder's main offer should comply with the principles shown in the attached drawings, other arrangements being submitted solely as alternatives to the main offer.

## **2. 0 DESIGN PARAMETERS - OPEN TERMINAL**

The substation design should be such as to minimise the number of levels of conductors and to ensure that the consequences of a failure of one set of high level conductors are limited to the loss of that circuit and a single busbar section. This principle shall also be applied with regard to earth wire conductors. All materials and equipment for use in the substation shall be suitably rated to meet the site conditions specified in the schedules.

All gantry type structures supporting conductors shall include facilities for ready access to all insulator sets. There shall be permanently attached climbing devices with guard-rails and access to high level beams shall not be possible without proper authorisation. Safety screens shall be provided between adjacent circuits to maintain the specified safety clearances and to prevent accidental access to live circuits.

Vehicle access to permit the transport of major switchgear equipment shall be provided. This shall be achieved without the need to de-energise circuits. Access for vehicles which require the de-energisation of circuits shall be kept to a minimum and avoided wherever possible.

Each substation shall be adequately protected against direct lightning strikes, either by the use of spikes or earth wires located on the substation structures, the use of spikes is preferred. The height, location, and number of spikes or earth wires shall be such as to protect all equipment installed within the substation to a failure rate of shielding from direct lightning strikes of not greater than 0.1 per cent per annum.

Where the connection to the substation is by overhead line, overhead line conductors will be terminated either at the substation gantry structures or to anchor blocks adjacent to the overhead line terminal towers. The overhead line conductors complete with tension insulators, line tee off clamps, and compression fittings (bi-metallic where necessary) shall be supplied and erected under a separate contract. The Contractor shall provide facilities on the gantry structure for the fixing of the tension insulators and arrange branching of conductors in to the sub-station from the transmission line conductors.

The overhead line earth wire will be extended into the substation and the substation gantry structure shall be arranged to receive this.

Where line traps are to be located within the substation, these should preferably be mounted integrally with the coupling capacitor. Should this be impracticable, then the use of post type insulators is preferred to suspension mounting.

Where disconnectors are of the pantograph type, the contact arrangements shall cater for conditions of maximum wind loading coincident with either the maximum or minimum ambient temperature and shall conform to the requirements of IEC 129. The Contractor shall also establish, through calculations, the length of arm of each pantograph isolator so that the contact is proper and robust. The Contractor shall also provide the required size and number of sag compensating springs where necessary.

Sub-station equipment, structures, roads, concrete cable troughs, drains etc.. shall be laid out in a neat and organised manner to meet the employers requirement, facilitate movement of vehicles and ensure safety of personnel and equipment.

Each substation shall be provided with safety grounding mat as per clause relevant clauses of this section. While designing the ampacity of the buried conductor suitable corrosion allowance shall be considered for thirty five (35) years. The conductors shall be buried at a depth of 700 mm from finished formation level. The conductors shall be welded suitably for maintaining a high degree of mechanical rigidity and electrical connectivity.

The substation earth mat shall be designed to provide a ground potential rise within safe limits of tolerable touch and step potential. The margins of limits shall confirm the international practices. The design of earthmat shall be in accordance with IEEE-80/1986 and shall be submitted for Engg Incharge (Divisional Engr.) approval.

### **3.0 BUSBAR CONSTRUCTION.**

Busbars shall be made of aluminium tubes in 400 KV side and connection from equipment to equipment & the top bus shall be twin ACSR Moose conductor. Bus bars of aluminium tube in 220 KV side (wherever specifically asked for) or ACSR conductor (**Main Buses shall be Twin Moose ACSR conductor and Reserve /Transfer Bus shall be single Moose ACSR conductor**) and aluminium tube for connection from equipment to equipment . The bus bar capacity shall be designed for maximum ambient temperature conditions and symmetrical short circuit condition of 63 KA for 400 KV side 40kA for 220 KV & 132 KV side. The continuous current rating shall be so designed that no portion of the bus bar is unduly loaded, or over heated. For EHV sub-stations, the bus bar and bus bar fittings shall be made corona free by the provision of corona rings or corona bells. There shall not be any harmful RIV from the constructed bus bars .

Tubular bus bars shall be mounted on support insulators of adequate strength, mounted on support structures above the ground in upright position, or hang from the structures depending upon the chosen lay out.

Strain bus bars shall be made bundled wherever necessary to carry the rated maximum continuous current. The bundle size shall be determined by the Contractor to make such that it is corona free, and fitted with spacers to limit the snatch forces such that no dangerous tensions are passed on to the structures.

Interconnections to equipment shall be made from aluminium tubes or suitable flexible ACSR conductors, through clamps and connectors only. Jumpers shall be made from flexible ACSR conductors only.

There shall be no conductor joints in a span of strung strain busbars. Tubular busbars shall have a maximum of one welded joint and shall be designed for thermal stresses and linear expansion, due to temperature, so as to relieve the support structure and busbar fittings from stress.

The Contractor shall submit design calculations in support of the various dimensions of the busbar for Engg Incharge (Divisional Engr.) approval.

The busbar deflection in respect of tubular busbars shall not exceed 50% of diameter. The stranded conductor sag shall not exceed 1/80th of conductor span.

### 3. 0 PROVISION OF EARTH SWITCHES

The earth switches shall be provided liberally in compliance to Indian Electricity Rules and as per latest recommendations of CBIP Manual on EHV substations.

However the Employer's practice is to provide earth switches with disconnecter on busbar side and feeder side of the circuit bay for all voltage class substations. For 400kV class substations earth switches shall also be provided with disconnectors on circuit breaker side. In case the Electrical Inspectorate requires provision of any further earth switches the same shall also be provided by the Contractor.

Additional cost payable on account of providing such earth switches shall be mutually agreed between the Contractor and the Employer on the basis of rates quoted by him for spare parts.

Each substation shall be provided with sufficient number of portable earth switches so as to carry out maintenance works for at least two circuit bays.

### 4. 0 INTERLOCKING

#### 4.1 General

The applicable recommended interlocking facilities of IEC 517 shall be provided. Padlocking to the requirements of this specification shall be provided for operational and maintenance security.

Earth switches on line circuits shall be capable of interrupting the current induced in the line at the voltage specified in the schedules. This current may arise by induction from a fully loaded line in parallel with the earthed line. If earth switches without the rated breaking capacity are provided, the interlocking arrangements shall ensure the interruption of this induced current by the circuit breaker before the earth switch is opened. Interlocking facilities shall be provided to release the circuit breaker for maintenance whilst maintaining the earthing of the incoming line.

#### 4.2 Philosophy

All disconnecting and earthing devices within the substation shall be interlocked in a manner that ensures that they always operate safely. The system employed shall satisfy two distinct categories:

- **Operational interlocking:** Interlocking associated with normal system operation and switching and intended to ensure that a predetermined switching sequence is satisfied. Such interlocking shall be achieved by electrical means in a manner that permits the equipment to perform any safe operation.
- **Maintenance Interlocking:** Interlocking associated with a series of switching operations to render the equipment or sections of the substation safe for access and maintenance by personnel. Such interlocking shall be achieved by mechanical interference type interlocks.

#### 4.3 Principles

The design of the interlocking scheme shall be based upon the following principles:

- a) Dis connectors are capable of switching the capacitive currents of associated connections.
- b) Circuit breakers shall not be used as a point of safety isolation, this is the function of a disconnecter.
- c) Dis connectors have neither load making nor breaking capacity.
- d) Dis connectors are not capable of making or breaking transformer magnetising current.
- e) Dis connectors are capable of the duty imposed when operated under parallel switching conditions.

- f) It shall not be possible to close or open any earth switch unless the point of application is disconnected from all possible sources of supply, and the power operating devices of such disconnectors are selected to the local control position.
- g) It shall not be possible to operate any disconnector unless its associated circuit breaker is open.
- h) It shall not be possible to operate any disconnector if an associated earth switch is already closed.
- i) Disconnectors concerned with supplies from a remote point cannot be fully interlocked and shall carry a warning notice to this effect. Similar notices shall be applied to earth switches.

## **5. 0 DESIGN PHILOSOPHY FOR PROTECTION, CONTROL AND METERING SYSTEM**

### **5.1 Protection Philosophy.**

The control and protection system shall be closely inter related in the sub-station.

The protection system shall be designed for the fault clearing time, so that it prevents or limits damage to primary equipment of the transmission system, and stability of the power system shall be protected. The main protective system shall be capable of tripping (excluding circuit breaker operating time ) within 10 - 50ms. However, in any case the fault clearing time from the instant of inception of fault to completion of the circuit breaker operation shall not exceed 100ms for 400kV and 220kV systems, 120ms for 132kV system and 150ms for 33kV system. Operating time of breakers to be provided by the Employer are 40ms for 400kV, 50ms for 220kV, 50 ms for 132kV and 60 to 85ms for 33kV.

The protection system shall generally be a dedicated system organised at bay level for lines, transformers etc., and at sub-station level for bus bar and breaker failure protection .

In the highest range of protection functions the protection unit and function shall be segregated as much as possible. The protection shall not be compromised in any way by the requirements of the other functions. The protection shall be permanently on line and shall be capable of tolerating faults in both the hardware and software at bay level and sub-station level. The system shall be so designed that in the event of loss of communication between the bay level and sub-station level, the continuity of protection function shall be ensured.

The protection sub-system (relays ) should communicate with control and monitoring system to provide information regarding operation, faulted phase, settings etc.. Information should also be available at station computer level and for transmission to LDC via SCADA.

The protection system may also include new designs of protective relays incorporated with features such as auto reclosing, fault recording , fault locating and synchronising check.

The recommended protection arrangement for different bays shall be in accordance with the protection single line diagrams attached to this Specification.

Busbar protection systems shall be designed to initiate immediate tripping of all circuit breakers connected to the faulted section of the busbar. In the event of non operation of a circuit breaker of a bay all the circuit breakers connected to the associated busbar shall trip under breaker failure protection.

### **5.2 Control Philosophy.**

The control function of the sub-station shall be the following:

- Control — Operation ( switching on or off or position change)
- Control — Monitoring ( alarms, annunciation, indication etc.)

The system shall efficiently perform the operation of circuit breakers, isolators, tap changers etc.. It shall also perform the interlocking at bay level as well as substation level. The control system shall be

suitable for operating manually, electrically (remote) and via SCADA system from a remote control centre.

Control shall be achieved at bay level, substation level and remote control centre level through conventional MMI or computer based automated system, as specified in this Specification.

The system shall be designed, along with the communication system so that there shall be high availability of bay protection associated with automatic functions such as auto reclosing. The systems shall function autonomously and independently of adjacent bays, substation functions and units etc.

## **6. 0 EARTHING SYSTEM**

Electrical measurements of the subsoil at various depths up to 20 metres shall be made at the site of each substation in order to determine the layered effects of the ground from which the effective ground resistivity and hence the expected resistance of the proposed earth grid system may be predicted. Wagner's 4 - Electrode method as per IEEE-Std 81 may be followed for measurement of earth resistivity.

The earthing system shall comprise a mesh grid formed by hot dip galvanised iron flat bar (GI flat) of 75 X 10 mm (for 220/132 KV & 132/33 KV) and 40 mm MS rod (for 400 KV) buried directly in the ground and arranged so as to utilise fully the available site area. A continuous conductor shall be laid outside the periphery of the substation site at a distance of two metres from the switchyard fence and at a depth of at least 0.7 metres (the earth mat top shall be at 700 mm below the finished ground level) below the surface. A mesh system shall be formed by interconnection at various points to the perimeter conductor. The distance between two buried earth mat (flat/rod) shall be maximum 5 meters both way. The mesh system shall be designed such that the grid potential rise limits the touch voltage to a value not greater than the maximum tolerable touch potential; the fault clearance time to be used in the earthing calculations shall be taken as one second.

The earthing system shall be designed to meet the requirements of this specification and shall be in accordance with IEEE 80 and IS 3043. The Contractor shall present calculations to show the earthing system meets these requirements and can be shown to be safe in terms of touch, step and transferred potentials. The calculations shall be carried out considering a layer of crushed metals of thickness 100mm and without the same; and if applicable recommend suitable site surfacing. The resistance of the earth mat shall not exceed  $0.5\Omega$ .

In the event of the substation resistance obtained with the foregoing installation being of a magnitude unacceptable to the Engg Incharge (Divisional Engr.), then where practicable, the ground area enclosed by the earth system should be increased by installing directly in the ground a GI flat /MS rod conductor in the form of a ring around the site at a significant distance from the boundary fence. Alternatively, earth conductors can be directly buried radially outside the substation perimeter fence. The use of earth plates as current carrying electrodes is not acceptable.

The earthing system shall be designed so as to include all overhead line terminal towers, which shall be earthed by extending the system so as to envelope all towers within the earth system. Each tower shall be bonded directly to the earth system from at least two locations. Structures and masts for lighting and security surveillance equipment shall also be within the perimeter of the earth grid. No fixed low voltage equipment, with the exception of a warning or alarm button and intruder alarms which shall be of the double insulation type, shall be erected outside the perimeter of the earth grid.

Where a metal substation fence is provided, this shall be bonded electrically to the earthing grid on each side at spacing not exceeding  $0.25r$  (where  $r$  is the equivalent circular plate radius), at points adjacent to each corner and immediately below any overhead line entering or leaving the Site. The location of the mesh conductors shall be such as to enable all items of equipment to be connected to the earth system via the shortest possible route.

Gate posts forming part of the substation fence shall be bonded together with below ground connections and the gates themselves shall be electrically bonded to the posts at two points through flexible braids.

The current density of the earth conductor shall be not greater than  $100\text{A/mm}^2$ . Single connections between equipment and the earth system shall carry the total short circuit current, but the cross sectional area of branch connections may be reduced to take account of current distribution in two or more conductors. A distribution of 60 per cent shall be assumed for this purpose, i.e. the cross sectional area of branch connections may be reduced to 60 per cent of the corresponding single conductor.

The earth conductor may be sized as per IEEE 80 and sufficient allowance for corrosion may be taken in to account.

The grid voltage rise under fault conditions shall not exceed 15 kV. If the calculated grid voltage rise exceeds 430V, the local Telephone Authority shall be advised, by the Contractor, of the grid voltage rise and the distance of the 650V contour from the substation grid periphery.

The alternative approach of independently earthing the fence and placing it outside the earth grid area shall only be adopted if the above mentioned procedures prove insufficient or impracticable. The Contractor shall provide calculations to show that this approach produces safe touch voltages at the fence and shall ensure that the fence is isolated from all other buried metalwork.

Metal parts of all equipment, other than those forming part of an electrical circuit, shall be connected directly to the main earth system at two points. For the same the size of the G.I flats shall also be 75X10mm. This is the raiser of the earth to the structures of column, beam and all equipment structures. The arrangement of the mesh earth system shall be such as to minimise the length of these connections.

A separate set of earth electrodes (at least two), GI pipe, perforated, 50mm dia, heavy duty having 3000mm long in a treated earth pit, shall be provided for the earthing for high frequency coupling equipment (CVT etc), surge arresters, IVT, each neutral of the transformers and reactors at a position immediately adjacent to the equipment being earthed in addition to the normal earth connection.

All main members of structural steelworks shall be earthed by GI flat (size 75X10mm) earthing connections being bonded to the steelworks. The Contractor shall be responsible for earthing of the transformers and circuit breakers installed on the substation site as per recommended.

Connections to apparatus and structures shall be made clear of ground level, preferably to a vertical face and protected against corrosion.

Earth bars installed directly into the ground should normally be laid bare and the trench back-filled with a fine top soil. Where the soil is of a hostile nature, precautions must be taken to protect the earth bar.

All exposed joints shall be at a minimum height of 150 mm above floor or ground level.

A facility shall be provided on the earth bar run between the equipment and the base of the structure, comprising a looped copper strip (test link), so as to permit the attachment of portable earth connections for maintenance purposes.

After installation of the earth system the Contractor shall measure the resistance of the substation. The method used shall preferably be the "fall of potential" method, requiring the availability of a local low voltage supply, but other methods using an earth resistance meter will be acceptable in the event of a local supply being unavailable.

The fencing of the switch yard also to be earthed by using G.I flats of size 75X10mm to each post and a continuous earth strip of size 50X6mm shall run all through the fence. The periphery of the switch yard shall be provided with non-treated earth pit at a distance of 5 mtrs all along the periphery. The size of the non-treated pit conductor shall be 40 mm dia MS rod of length 3000mm. The said earth MS Rod to be placed in earth pit as per standard practice and the pit shall be filled with Bentonite powder mixed with lomy soil at a ratio 1:10. There shall be provision of watering into the earth pits. A pipe of adequate size should run all along the periphery and outlets shall be provided to each pit. The pipe shall be connected to the overhead tank provided on the control room building and proper water control valve should be provided. Contractor shall prepare a detail earthing provision considering as per specification and shall obtain approval from OPTCL and the top of the MS rod shall be welded to the buried earth mats.