SPECIFICATION NO. 12

SUBSTATION GROUNDING AND LIGHTNING PROTECTION SYSTEM

CONTENT

1 GENERAL CONDITIONS

1.1 Scope

The grounding system shall ensure the protection of personnel, electrical and electronic equipment, especially in relation to the major fault currents implied in electrical network, electromagnetic disturbances and over-voltage due to atmospheric conditions or switching operations.

1.2 Reference Standards

All equipment required within the scope of works shall comform as a basic requirement with the latest edition of the following standards:

IEC 60364-4-41	:	Electrical installations of buildings.-Part 4-41 : Protection for safety – Protection against electric shock
IEC 60364-5-54	:	Electrical installations of buildings – Part 5-54 : Selection and erection of electrical equipment - Earthing arrangements and protective conductors and protective bonding conductors
IEC 61024-1	:	Protection of structures against lightning – Part 1 : General principles
IEC 61089	:	Round wire concentric lay overhead electrical stranded conductors
IEEE 80	:	Guide for safety in AC substation grounding
IEEE 81	:	Guide for measuring earth resistivity ground impedance, and earth surface potentials of grounding Systems
TIS 64	:	Bare copper stranded conductor (Hard draw copper wires)
TIS 404	:	Galvanized steel stranded wire

The latest edition of each standard shall mean the edition available on the date of signing the Contract.

2 CHARACTERISTICS

2.1 Substation Grounding System (IEEE 80 and IEEE 81)

2.1.1 General

The grounding system shall consist of buried earthing mesh, with adequate number of electrodes, connectors, etc. to insure the above mentioned aims.

The design of the grounding system shall be based on the IEEE standard. 80 “Guide for Safety in AC Substation Grounding”

The Contractor shall submit the detailed design of the grounding system before the construction starts. This design, based on preliminary drawings, shall include calculations of the ground resistance, ground potential rise and current flows into or out of the ground.

2.1.2 Soil Resistivity

The soil resistivity measurement shall be performed by the Wenner' four-pin method and shall follow the IEEE Standard 81 "Guide for Measuring Earth Resistivity Ground Impedance, and Earth surface Potentials of a Ground System".

2.1.3 Design

2.1.3.1 General design

The design of the substation grounding system is based on the following principles and data:

a) The 22 or 33 kV systems are solidly grounded at the neutral point of the power transformer.

   Maximum earth fault: 31.5 kA – 0.6sec for substation or 40 kA – 0.6 sec for switching station (for main earthing conductor sizing, relevant to thermal capacity).

   Portion of the ground fault current flowing into the grid. (for touch and step voltages, relevant to earth potential rise).

b) The material used for the grounding system, in particular for jointing, shall be selected to prevent corrosion at the connection points as well as on the earthing material itself, both buried or exposed to air. If necessary, cathodic protection of an approved design shall be applied. In order to minimize the effect of seasonal variations of earth resistivity, all earthing equipment shall be designed for the worst dry and wet conditions.

c) The grounding system shall be safe for persons weighing 50 kg.

d) The resistance of the substation grounding system shall not be more than 1 ohm.

2.1.3.2 Building

For potential equalizing of the building, a grounding grid, of 95 mm^2 for 31.5 kA and 120 mm^2 for 40 kA short circuit current, suitably corrosion protected, shall be laid around the building. The connection points shall be exothermic welded.

Suitable connection points of the grounding grid shall be brought out of the concrete to allow connection of all metallic parts of equipment and building. These connecting points, when protruding from the concrete, shall be hot dip galvanized. The grounding grid shall be connected at 8 to 10 m on the periphery-distributed locations.

In building with a GIS switchgear, a grounding grid with a mesh size not greater than 3x3 m shall be implemented with stranded copper conductors of 95 mm^2 (31.5 kA) or 120 mm^2 (40 kA) and shall be laid below the bottom of GIS building.

To ensure that reinforcement grid is electrically continuously performed, a sufficient number of connection points will be brought out of the concrete. Together with the detailed building grounding system drawings, the grounding system design shall be checked before releasing for construction.

The connections to these parts shall be of copper material of adequate cross section of at least 32 x 4 mm. Further similar connection points shall be installed at judicious locations for portable earthing equipment.

Generally, each electrical device must be equipped with an earthing bus of sufficient diameter for connection to the grounding system. The same applies to all metallic parts such as panels, gates, rails, fences, etc.

For more information of lightning protection and building grounding system see specification No. 61.

2.1.3.3 Switchgear

High voltage equipment and switchgear shall be equipped with at least two terminal bolts or suitable grounding pads of adequate size to accommodate at least two fixing screws.

Control panels and desks, switchboards, etc. consisting of several individual sections or compartments shall each be connected to a common copper earth bar unless all panels are solidly welded together, or other approved means are applied ensuring solid earthing connection. In such a case, provisions for earthing must be made at one end at least.

2.1.3.4 Switchyard

All steel structures shall be earthed by applying welded connections at two different points of the grounding grid. A single structure shall be earthed at two points diagonally opposed from each other.

Grounding system shall be composed of grounding grid of buried copper electrodes. The grounding system drawings and calculations shall be provided by the Contractor.

- The mesh size under power transformer shall not be greater than 2x2 m. Stranded copper conductors of 95 mm^2 for 31.5 kA substation or 120 mm^2 for 40 kA switching station shall be used.

- The mesh size in switchyard shall not be greater than 10-x 10 m.

The switchyard surface shall be dressed to a depth of 100 mm with crushed rock and extending 1.50 m beyond station fence line.

For GIS substation, the switchyard surface shall be dressed to a depth of 150 mm around the building, and crushed rock extended 1.5 m beyond the fence. (If applicable)

2.1.4 Layings

All exposed ground conductors runs shall be fixed in a neat manner, horizontal, vertical and parallel to building walls or columns and shall not be laid haphazardly.

Grid conductors shall be arranged in parallel along the rows of structures and equipment, at intervals according to the recommendations of IEEE 80. A second set of parallel conductors shall be laid perpendicular.

At grid corners, the meshes shall be subdivided into smaller squares to prevent the higher potential gradients which would otherwise occur in these areas.

2.1.5 Connections

All metallic equipment structure shall be exothermic welded to the substation grounding grid by two separate links. If a metallic structure has more than two legs, only the two legs with the greatest space between them shall be chosen.

Earthing conductor to all stationary equipment; switchgear, transformers, panels, equipment enclosures, cable trays, distribution boards, shall be fastened by compression on terminal pad Moving metallic parts as gates and doors shall be connected to the metallic frames through flexible copper braid).

Cubicles for circuit breakers, disconnectors, earthing switches, junction boxes, etc. shall be earthed by a separated branch connected to each item of equipment.

2.1.6 Ratings

1. Type of Earthing Cable	Bare copper stranded conductor (Hard draw copper wires) according to TIS 64, not less than 95 mm^2
2. Step and Touch Voltage Criteria	As per calculation according to IEEE 80
3. Rod Electrode (copper clad-steel) minimum size: 1.6 x 300 cm	The number and the length to be calculated according to IEEE 80
4. Earthing Connections	Exothermic welding
5. Burial Depth of Grid Conductor	50 cm below the bottom of the backfilling or based on the calculated results according to IEEE 80
6. Fault Duration	0.6 sec. for 115-22 kV or 33 kV substation and for switching station
7. Grounding Grid Design Resistance with overhead earth wire connected	The calculation shall not take into account the overhead earth wire
8. Resistivity of crushed rock (Size No.2)	3000 ohm-m. (wetted with ground water)

2.2 Outer Station Grounding

As a minimum, a ring of 95mm^2 (for 31.5 kA substation) or, 120 mm^2 (for 40 kA switching station) conductor shall be laid at a distance of 1 m around each building and at a depth of 0.5 m according to calculation.

Grounding grid shall be extended 1m beyond the fence.

The connections of the building to the grounding system shall be made within the building. A grounding grid of sufficient size, defined by calculations and consisting of electrodes with a maximum mesh size of 2x2 m shall also be installed in the transformer bays.

All individual grounding grids shall be interconnected at periodic interval by not more than 10 meters through high conductivity hard drawn stranded copper wire of cross-section not less than 95 mm^2 (for 31.5 kA) or 120 mm^2 (for 40 kA)The grounding system shall be buried or supported on building structures, cable trenches, walls, etc. by means of copper alloy clamps with spacing of not more than 1.25 m.

Steel fences gate shall be connected to the grounding grid and the grid shall be extended beyond the fence gate at least 1m..

2.3 Lightning Protection (IEC 61024-1)

2.3.1 General

The Lightning Protection shall be provided to protect the substations against direct lighting strokes.

The shielding shall be designed with appropriate shielding angles and clearances to provide adequate lightning protection to all conductors and equipment in the switchyard in accordance with IEC 61024-1 standard.

The shield wire shall be terminated with strain clamp. The overhead shield wire shall be directly connected to substation gantries. The overhead shield wire connection to the steel structures shall be made with two-bolt connectors.

2.3.2 Ratings

The ratings and features of overhead shield wire shall be complied with IEC 61089 and TIS 404 standards.

1. Type of overhead shield wire	Galvanized steel stranded wire
2. Overall diameter (mm)	9.00 mm.
3. Failure rate of shielding from direct Lighting Strokes	$\leq$ 0.1% per annum
4. Protective angle • Outside a shielding • Between two shielding wires	 $\leq 30^{o}$ $\leq 60^{o}$
5. Cross section	50 mm2
6. Mass with grease	0.392 kg/m
7. Minimum breaking strength	32900 N
8. Modulus of elasticity	210 000 N/mm2