

FEWA-PL-SS-E-0066 REV.0

**TECHNICAL SPECIFICATION
EARTHING SYSTEM**

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EARTHING SYSTEM

1. INTENT OF SPECIFICATION AND SCOPE OF SUPPLY

The intent of this specification is to cover the complete design, supply, installation and testing of grounding system including all necessary supervision, labour, tools, miscellaneous materials, accessories etc. required for new substations and extended part of existing substations.

The earthing system for any new extension shall be suitably connected to the existing system.

All the materials used for earthing shall be as per relevant IEC/BS/ISO standard and from countries in Western Europe, Japan or USA only. However earthing risers/cables from reputed manufacturer from GCC Countries is also acceptable.

All civil works associated with this section of works shall be deemed to be included in the scope of work. No additional payment will be made for such works.

The design and installation of below ground main earth mat, Auxiliary earth mat in switchgear and transformer rooms are excluded from the Scope of erection contract.

However, all equipment earthing connections to main earth mat/auxiliary earth mat etc are included in the scope of work of substation erection contractor. The erection contractor shall co-ordinate with the OHL/cable contractor and substation civil contractor for earthing of cables and other accessories.

2. GAS INSULATED SWITCHGEAR

The earthing of gas insulated switchgear (GIS) installations shall be subject to special considerations regarding step and touch potentials in accordance with the manufacturers recommendations. However, the earthing conductor to auxiliary earth mat in the basement shall be yellow-green coloured PVC insulated stranded copper conductor with minimum conductor size 2 runs of 150 sq.mm. The connection shall be at multiple points for each bay. The erection contractor shall design the method of earthing the gas insulated switchgear in co-ordination with the GIS manufacturer.

3. CONNECTIONS TO ELECTRICAL EQUIPMENT

Connections between HV electrical equipment and the main earth bar and between LV electrical equipment comprising substantial multi-cubicle switchboards and the main earth bar shall be duplicated. The minimum conductor size shall be 300 sq.mm and shall be yellow- green coloured PVC insulated stranded copper conductor.

For other auxiliary items the single conductor shall be rated to withstand the fault rating of the equipment. The conductor size shall not be less than 185sq.mm and shall be yellow-green coloured PVC insulated stranded copper conductor.

The auxiliary mat shall be directly bonded to the cubicle and the conductors forming the mat and the bonding connection shall have a copper cross-section area of 185 sq.mm or equivalent.

All the connection between equipments and auxiliary earth mat (above ground) shall be carried out by erection contractor.

4. CONNECTIONS TO STRUCTURAL METALWORK AND NON-ELECTRICAL EQUIPMENT

All metal work within the project area which does not form part of the electrical equipment shall be bonded to the main earth bar except where otherwise specified. The bonding conductor size shall be not less than 185 sq.mm yellow/green PVC insulated. Individual components of metallic structures of plant shall be bonded to adjacent components to form an electrically continuous metallic path to the bonding conductor.

Small electrically isolated metallic components mounted on non-conducting building fabric need not be bonded to the main earth bar.

5. MATERIALS AND INSTALLATION

5.1. Conductors

Conductors shall be of high conductivity copper in the form of circular conductors stranded to IEC 228 (BS 6360).

Conductor sheaths shall be of yellow-green coloured PVC to meet the requirements of BS 6746 grade TM1 or IEC 502 Grade ST1 with a minimum thickness of 1.5 mm.

Earth risers which are not part of the earth electrode mesh system shall be PVC sheathed yellow/green circular stranded cable.

Bare conductors only shall be used for earth electrodes meshes buried below the ground.

Conductors buried in the ground shall normally be laid at a depth of 1m below the ground in an excavated trench. The backfill in the vicinity of the conductor shall be free of stones and the whole backfill shall be well consolidated. Conductors not forming part of a voltage control mesh shall be laid at the depth required by the approved design and, in the case of a yellow-green coloured PVC sheathed conductor, at the same depth as any auxiliary power or control cables following the same route.

All conductors not buried in the ground shall be straightened immediately prior to installation and supported clearly of the adjacent surface.

5.2. Earth Rods

The earth rods shall be of hard-drawn high conductivity copper with a diameter of not less than 19mm with hardened steel driving caps and tips. The rods shall be as long as possible but couplings may be used to obtain the overall depth of driving required by the design.

The rods shall be installed by driving into the ground with a power hammer of suitable design to ensure the minimum of distortion to the rod. Where it is not possible to drive rods to the full depth required due to the presence of strata of rock, then holes shall be drilled or blasted in the rock. The holes shall be filled with bentonite or other approved material prior to inserting the rod.

If difficult driving conditions arising from hard or rocky ground are encountered or are anticipated or there is a need for deep rods, then high tensile steel rods shall be used. High tensile steel rods shall have a molecularly bonded high conductivity copper coating with a

minimum radial thickness of not less than 0.25 mm. The overall diameter shall be not less than 19 mm. Rolled external screw threads shall be used on the rods for coupling and after rolling the thickness of the copper coating on the threaded portion shall be not less than 0.05 mm.

Rods, and driving caps and tips shall treat at couplings to ensure that the couplings and screw threads are not subject to driving forces. All screw threads shall be fully shrouded at the couplings. Alternatively, conical couplings may be used to the approval of FEWA.

High conductivity copper for earth rods shall have a minimum copper content (including silver) of 99.90%.

The steel for copper-clad steel rods shall be low carbon steel with a tensile strength of not less than 570 N/sq.mm.

Couplings for copper rods shall be 5% phosphor bronze (copper-tin-phosphorous) and for copper bonded steel rods of 3% silicon or 7% aluminium bronze.

5.3. Fittings

Clips for supporting strip conductors not buried in the ground shall be of the direct contact type and clips for circular conductors shall be of the cable saddle type. The clips shall support the conductors clear of the structure.

Conductors shall be connected to earth rods by a bolted clamp to facilitate removal of the conductor for testing the rod. The number and location of links shall be agreed during design.

Disconnecting links shall comprise a high conductivity copper link supported on two insulators mounted on a galvanized steel base for bolting to the supporting structure. The two conductors shall be in direct contact with the link and shall not be disturbed by the removal of the link. Links for mounting at ground level shall be mounted on bolts embedded in a concrete base.

Disconnecting links mounted at ground level and the connections at the earth rods shall be enclosed in concrete inspection pits, with concrete lids, installed flush with the ground level.

All conductor fittings shall be manufactured from high strength copper alloys with phosphor bronze nuts, bolts, washers and screws. Binary brass copper alloys will not be acceptable. All fittings shall be designed for the specific application and shall not be permanently deformed when correctly installed.

Fittings not in direct contact with bare or sheathed conductors may be of hot dipped galvanized steel.

Bi-metallic connectors shall be used between conductors of dissimilar materials and insulating material shall be interposed between metallic fittings and structures of dissimilar materials to prevent corrosion.

5.4. Joints

Permanent joints shall be made by brazing, exothermic welding or by crimping. Joints for conductors forming part of mesh system shall be exothermic welding by suitable moulds.

Detachable joints shall be bolted and stranded conductors at bolted joints shall be terminated in exothermically welded lugs or a crimped cable socket. The diameter of any holes drilled in strip conductors shall not be greater than half the width of the strip.

Connections to electrical equipment shall be detachable and made at the earthing studs or bolts provided on the equipment by the manufacturer. When an earthing point is not provided the point and method of connection shall be agreed with FEWA.

Connections to metallic structures for earthing conductors and bonding conductors between electrically separate parts of a structure shall be either by direct exothermic welding or by bolting using a stud welded to the structure. Drilling of a structural member for a directly bolted connection shall only be carried out to the approval of FEWA.

Bolted joints in metallic structures including pipe work, which do not provide direct metallic contact shall be bridged by a bonding conductor or both sides of the joint shall be separately bonded to earth unless the joint is intended to be an insulated joint for cathodic protection or other purposes.

When the reinforcing in concrete is used as a part of the earthing system the fittings used to provide a connection point at the surface of the concrete shall be exothermically welded to a reinforcing bar. This fitting shall be provided with a bolted connection for an earthing conductor. The main bars in the reinforcing shall be welded together at intervals to ensure electrical continuity through out the reinforcing.

5.5. Measurement of Earth Resistance

The resistance of the complete earth system shall be measured before installation of outgoing cables by the contractor and with OHL termination towers disconnected from the earth mat with an approved form of earth resistance tester. The measured value shall be submitted for approval and shall not exceed 1 ohm when measured between the earth system and the surrounding earth.

On completion of the earth mat system, the step and touch potentials shall be measured in accordance with IEEE/BS/DIN/IEC etc.

6. DRAWING/DOCUMENTS REQUIRED

- 6.1 Equipment earthing connections details
- 6.2 Catalogues for all Earthing materials, moulds, joints, conductors, earth rods, fittings and accessories etc.

7. EARTH RISERS

Earth risers shall be of high quality stranded copper conductor, yellow-green coloured PVC insulated. All earth risers for the entire substations including but not limited to the following earth risers shall be provided.

S.No.	Description	Minimum size of riser from equipment to Earth mat(Erection Contractor)
1.	132kV GIS	2 runs of 150 sq.mm stranded, PVC insulated Y/G copper conductor

2.	33kV Switchgear (GIS)	300 sq.mm stranded, PVC insulated Y/G copper conductor
3.	11kV switchgear	300 sq.mm stranded, PVC insulated Y/G copper conductor
4.	Power transformer	300 sq.mm stranded, PVC insulated Y/G copper conductor
5.	Auxiliary transformer	300 sq.mm stranded, PVC insulated Y/G copper conductor
6.	NER/NES Equipments	300 sq.mm stranded, PVC insulated Y/G copper conductor
7.	Other S/S equipments including control room, LVAC/DC equipments, AC & Ventilation roof equipments etc.	185 sq.mm stranded, PVC insulated Y/G copper conductor
8.	All other equipments as per site layout	185 sq.mm stranded, PVC insulated Y/G copper conductor

In addition to the above, the following risers supplied by the civil contractor shall be connected to equipments by erection contractor.

1.	Power transformer	300 sq.mm stranded PVC insulated Y/G, Cu. Conductor for earthing neutral.
2.	Auxiliary transformer	300 sq.mm stranded PVC insulated Y/G, copper conductor for earthing LV neutral.
3.	Any other equipments as per site layout	185 sq.mm stranded PVC insulated Y/G, copper conductor.

The number of risers for each equipment shall be as per FEWA's standard practice and subjected to approval of FEWA. The earth mat copper strips/risers shall be clamped to wall by using saddle clips at spacing not more than 1.5 meter.

8. LIST OF STANDARDS

IEEE - 80	IEEE Guide for safety in AC substation grounding.
ANSI/IEEE/std 81	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Grounding System.
BS 7430	Code of Practice for Earthing.
BS 6651	Protection of Structures against Lightning.