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الهيئة الاتحادية للكهرباء والماء

Federal Electricity & Water Authority

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TECHNICAL SPECIFICATION
EARTHING AND LIGHTNING PROTECTION

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6. EARTHING AND LIGHTING PROTECTION

6.1. GENERAL

An earthing system for each new site and for new works at existing sites shall be designed and installed under this contract which shall include the supply of all materials and equipment. The earthing system shall include the earth electrodes to provide the connection to the general body of the earth and all conductors and connections to all electrical equipment and metallic structures on the site. The earth electrodes shall limit the potential rise under fault conditions and buried conductors shall be provided to limit potential differences on the site and adjacent to the site to ensure safety to people and animals.

Protection against lightning shall also be provided.

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

6.2. SOIL SURVEY

The preliminary tender design shall be based on earth resistivity which shall be determined by the Tenderer.

The Contractor shall carry out an earth resistivity survey on each site and report in writing to the Authority in accordance with the approved programme. The report shall detail the methods and instruments used and the results of the surveys. Based on the results the Contractor shall include in the report his proposals for the resistivities to be used in the design of the earthing system.

The surveys shall show the variation of resistivity across the site and with the depth below the site. The Contractor shall consider if there is a need to model the resistivity in two layers and if there is any advantage in the use of long rods. The surveys shall also determine the depth and nature of any underlying rock, which may limit the depth for driving earth rods or if boring will be necessary for installing earth rods.

The weather conditions prior to and at the time of the surveys shall be recorded in the report and an assessment made of the seasonal variations in resistivity based on meteorological data for the area. The programme for the project should, as far as possible, time the resistivity surveys to take place during a dry season.

The report should also state if there are any indications that the ground is corrosive to bare copper.

The report shall be approved by the Authority before proceeding with the design of the earthing system.

6.3. FAULT CURRENT AND DURATION

The Contractor is deemed to have visited the site and general area where the substation is to be located prior to submitting his tender to obtain soil reports or make observations in order that he can assess the quantities required for earth electrodes to satisfy the specification requirements. The Contractor shall have no claim for extra cost in connection with the earthing system should he be required to provide more copper than allowed for in his tender due to his failure to make a detailed analysis of the requirements at the time of tendering.

After award of the Contract the Contractor shall, in conjunction with the soil investigation specified for the civil works, carry out soil resistivity measurements at the substation site. A detailed earthing design shall be submitted for approval based upon the results of these tests and the System Prospective Fault Levels for a min. earth fault duration of 1 seconds.

To cater for the future growth of the System the design shall be based upon the maximum system prospective fault levels and shall be taken as 40 kA.

6.4. EARTH ELECTRODE SYSTEM DESIGN

6.4.1. DESIGN CALCULATIONS

The design of the earth electrode system shall be based on the approved earth resistivity data and the systems fault currents and their duration.

The design calculations shall be to the approval of the Authority and shall be based on the methods given in the standards listed. The calculation shall include the following parameters:-

a) earth resistance of the whole system of its components

b) earth potential rise

c) Step, touch and mesh potentials inside and outside the perimeter fence

d) requirements for a high resistance surface layer

e) conductor ratings

The earth potential rises shall not exceed the CCITT limits appropriate to the classification of the system unless special precautions are taken to cater for transferred potentials.

Step, touch and mesh potentials shall be within the limits calculated in accordance with the standards given in IEEE80 for the proposed surface layer.

The total resistance of the substation earth electrode shall be less than 1 ohm, where due to extremely high resistivity soil this is not easily obtainable the Contractor may propose artificial means of reducing the resistance using well proven, lasting and stable methods such as bentonite clay. However unless the Contractor can demonstrate that the artificial means can yield significant improvements it shall not be used and reliance shall be placed upon natural means such as utilizing deeper electrodes to reach lower resistivity soil strata.

6.4.2. EARTH ELECTRODE

The earth electrode shall comprise a system of bare conductors forming a mesh buried near the surface of the ground supplemented, if required, by one or more of the following electrodes:

a) a system of interconnected rods driven in the ground

b) a system of bare conductors buried in the ground

c) structural metalwork in direct contact with the ground

d) reinforcing steel in buried concrete

e) a system of bare conductors buried near the surface of the ground outside the perimeter fence

6.4.3. MESH SYSTEM

The mesh system shall be designed in accordance with sub-clause 6.4.1 to limit touch, step potentials taking into account the combined length of the mesh conductors, other buried conductors and rods but excluding any buried conductors outside the perimeter fence. Due regard shall be given to non-linear distribution of the fault current giving rise to the highest potentials at mesh corners.

The rating of the mesh conductors shall be compatible with the fault currents after allowing for parallel paths with a minimum conductor size of 150 mm2.

6.4.4. INTERCONNECTED RODS

If the design calculations show that a mesh alone is unable to limit the potentials to the required values, then the mesh shall be supplemented by the use of interconnected earthing rods driven into the ground or installed in bored holes.

Rods shall be installed inside the perimeter fence to enclose the maximum possible area compatible with the earthing of any metallic fence. (The spacing between rods shall not be less than their lengths, unless rating considerations determine otherwise). The rods shall be interconnected in groups of four to ten rods by insulated copper conductors to form a ring. Each group shall be connected to the mesh by duplicate insulated copper conductor via disconnecting test links.

Individual rods may be connected directly to the mesh provided the conductor to the rod can be disconnected for testing the rod.

Rods installed in bored holes may be used to reach lower resistivity ground strata at depths beyond the reach of driven rods or where rock is encountered and it is not possible to drive rods. After installing the rod the bored hole shall be back- filled with a low resistivity liquid mixture which shall not shrink after pouring to ensure good contact between the rod and the ground for the life of the installation.

The resistance and rating of individual rods and the combined resistance of the groups of rods in the proposed design shall be calculated and the rating of the interconnecting conductors shall not be less than that of the group of rods with a minimum conductor size of 150 mm2.

The calculation of potentials in the design of the complete installation called for in sub-clause 6.4.1 shall be made without the group of rods with the lowest estimated resistance to simulate the condition with the disconnected for testing.

6.4.5. OTHER CONDUCTORS

As an alternative to rods to supplement a mesh, additional bare copper conductors with a cross-section of not less than 300 sqmm may be used. They shall be buried in the ground within the perimeter fence to enclose the maximum possible area compatible with the earthing of any metallic fence. Such conductors may be laid below the mesh, below foundations or in areas where there is no plant. It shall be shown by calculation that the step potentials are low in such areas.

The conductor shall be in a ring or a part of a ring with at least two widely separated connections to the mesh or other parts of the earthing system.

6.4.6. Reinforcing Steel

The reinforcing steel in the foundations of buildings containing the primary electrical equipment may be used as auxiliary electrodes subject to the approval of the Authority. The Contractor shall show in the design calculations that the fault currents and d.c. stray currents will not damage the structure.

Steel reinforcing mesh in the floors of the building may also be used for the control of step and touch potentials within the building subject to the approval of the Authority.

6.4.7. Conductors Outside Perimeter Fence

If the design calculations show that the step and touch potentials outside the perimeter fence or wall exceed the limits then additional bare conductors shall be buried in the ground outside the fence in the form of rings encircling the whole site.

The distance of the conductors from the fence and the depth shall be determined in the design to ensure that steps and touch potentials are within the limits.

The minimum conductor size shall be 70 mm2 and shall be connected to the fence or the mesh in accordance with clause 6.7.4 with 70 mm2 conductors at each corner of the site and at intervals of not more than 40 m. These conductors shall not be included in the calculations called for in sub-clause 6.4.1.

6.4.8. Gas Insulated Switchgear

Gas insulated switchgear (GIS) installation shall be subject to special consideration in accordance with the standards listed.

6.5. DESIGN OF EARTH SYSTEM

6.5.1. Earth System

An earth system shall comprise the following components:-

a) the conductors between the earth electrode system and the main earth bar
b) the main earth bar
c) the conductors between the main earth bar and the metallic frames, enclosures supports of electrical equipment
d) the conductors between structural metalwork and non-electrical equipments and the main earth bar

The rating of earth system conductors connected between an item of electrical plant and the earth electrode system shall be sufficient to withstand the fault currents and duration, obtained as specified in Clause 6.3, after allowing for the remaining parallel paths through the earth system conductors with any one conductor disconnected.

The design of earth system shall take into account the corrosive- ness of the soil based on the soil survey.

6.5.2. Main Earth Bar

The main earth bar shall be in the form of a ring or rings of bare conductors surroundings or within an area in which items to be earthed are located. Where two or more rings are installed they shall be interconnected by at least two conductors which shall be widely separated.

The main earth bar or parts thereof may also form part of the earth electrode system providing this is bare conductor.

Each main earth bar shall be connected by at least two widely separated conductors to the earth electrode system.

The minimum conductor size for the main earth and inter- connections between earth bars and the earth electrode system shall not be less than 150 mm2 and the actual size required shall be decided based on the calculation for the criterion mentioned under clause 10.3.

6.5.3. 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 150 mm2.

Connections between other LV electrical equipment and the earth bar need not be duplicated. The single conductor shall be rated to withstand the fault rating of the equipment. The conductor size shall not be less than 150mm2/70mm2 as required.

An earth mat shall be installed at all operating positions for HV equipment manual operating mechanism boxes and local electrical control cubicles to ensure the safety of the operator. The 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 70mm2 or equivalent.

Earth connections to transformer neutral points which are solidly earthed shall be made utilising 1000V grade extruded PVC sheathed 150 sq.mm copper conductors direct to the groups of earth rods or the grid and also interconnected to the main substation earth bars. The transformer neutral points which are resistance earthed shall be connected to the NER utilizing the XLPE cables rated for full system voltage (as for phase connection) and as stated above.

6.5.4. CONNECTIONS TO STRUCTURAL METALWORK AND NON-ELECTRICAL EQUIPMENT

All metalwork 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 150mm2. Adequate provisions shall be made to prevent electrolytic corrosion between copper and galvanised surfaces.

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.

6.6. MATERIALS AND INSTALLATION

6.6.1. CONDUCTORS

Conductors shall be of high conductivity copper in the form of circular conductors stranded to IEC.228 (BS 6360) or solid rods or bars to BS.1433.

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

Buried conductors which are not part of the earth electrode system shall be PVC sheathed circular stranded cable.

Bare strip conductors only shall be used for earth electrodes or voltage control meshes.

Conductors buried in the ground shall normally be laid at a depth of 1000mm 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 mesh shall be laid at the depth required by the approved design, and, in the case of a PVC sheathed conductor, at the same depth as any auxiliary power or control cables following the same route.

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

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

6.6.2. EARTH RODS

The earth rods shall be of hard-drawn high conductivity copper with a diameter of not less than 15 mm with hardened steel driving caps and tips. The rods should 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 a 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 0.25mm. The overall diameter shall be not less than 12mm. 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, rods and driving caps and tips shall about 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 the Authority.

High conductivity copper for earth rods shall have a minimum copper content (including silver) of 99.90% to ISO 1337, Cu-ETP or Cu-FRHS (BS 2894 Grade C101 or C102) for copper earth rods and to ISO 1337 Grade Cu-ETP (BS 28734 Grade C101) for the molecular bonded copper coating of steel rods.

The steel for copper-clad steel rods shall be low carbon steel with a tensile strength of not less than 570 N/mm2 to ISO 630, Grade Fe 430 A (BS 4360, Grade 43A) or better.

Couplings for copper rods shall be of 5% phosphor bronze (copper-tin-phosphorous) to ISO 427, CU Sn4 (BS 2874, Grade PB 102M and for copper bonded steel rods of 3% silicon or 7% aluminium bronze to (BS 2874, Grade CS 101) and BS 2871, Grade CA 102.

6.6.3. 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.

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 bolt 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.

Sheathed conductor support fittings may be of silicon aluminium, glass-filled nylon or other tough non-hygroscopic material for indoor installations.

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

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

6.6.4. JOINTS

Permanent joints shall be made by brazing, exothermic welding or by crimping.

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 the Authority.

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 compression/tinning and 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 the Authority.

Bolted joints in metallic structures including pipework, 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 surfaces 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 throughout the reinforcing.

No connections shall be made to reinforcing bars and other steelwork which do not form part of the earthing system and are completely encased in concrete. Foundation bolts shall not be used for connecting to the earthing system.

6.6.5. GUARDS

Where earthing conductors are exposed to mechanical damage steel guards shall be provided to protect them.

6.7. EARTHING OF FENCES

6.7.1. METHOD

Metallic fences shall be separately earthed unless they come within 1.8m of any equipment or structure above the surface of the ground which is connected to the main earthing system. If the separation of 1.8m cannot be obtained the fence shall be bonded to the earthing system.

6.7.2. SEPARATELY EARTHED FENCES

The earthing of a fence shall be provided by connecting certain metallic fence posts to an earth rod by a copper conductor. The earth rod shall be driven adjacent to the posts inside the fence line to a depth of not less than 3.0m. Where no metallic posts are provided the earth rods shall be connected directly to the metal wires, mesh or other components of the fence.

If owing to the nature of the ground it is not possible to drive earth rods, then fence posts shall be connected to the centre point of a 20 m length of bare copper conductor buried in the ground at a depth of 500mm running parallel to and close to, the inside of the fence.

The earth rods or bare conductor electrodes shall be installed at each corner post, below the outer phase conductors of overhead line connections, passing over the fence at each gate and at intervals of not more than 100 m.

6.7.3. BONDED FENCES

Fences which need to be bonded to the main earthing system of the installation shall be connected by copper conductors to the nearest accessible point on the main earthing system at each point where the fence comes within 1.8 m of any electrical equipment. Bonds shall also be made to each corner post, below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 40 m.

6.7.4. BONDING OF FENCE COMPONENTS

Fences made up of bolted steel or other metallic components do not require bonding between components. Where such fences have non-metallic components bonds shall be installed to maintain continuity between metallic components. Reinforced concrete components shall be treated as being non-metallic.

Longitudinal wires for supporting other fence components or for anti-climbing guards and the wires of chain link shall be directly bonded to each fence earth electrode or to each bond to the main earthing system.

Metallic components on masonry, brick, concrete or similar boundary wall shall be treated in the same manner as metallic fences.

Wire fence components coated for anti-corrosion protection shall be earthed in accordance with this Clause.

6.7.5. GATES

The fixed metallic components on both sides of the gate shall be directly bonded together by a copper conductor installed under the surface of the access way. Flexible conductors shall be installed to bond the moving parts of the gates to the metallic fixed parts. An earth rod or a bond to the main earthing system shall be installed at each gate.

6.7.6. POTENTIAL CONTROL OUTSIDE FENCES

Where the approved design calculations show that the touch or step potentials outside the fence or boundary wall would otherwise be excessive, bare copper conductors shall be buried in the ground outside the fence or boundary wall at such depths and spacing as are shown in the approved design calculations to give acceptable touch and step potentials. The conductors shall form complete rings surrounding the installation and each ring shall be bonded to the adjacent ring and to the fence at each corner. Below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 40 m. In this case separate earth electrodes are not required for the fences.

If the boundary fence or wall is substantially non-metallic the rings of conductors shall be bonded to the main earth system at each corner of the site and at intervals of not more than 40 m. Any metallic components on such boundary fences or walls shall be bonded to the earthing system in accordance with this Specification.

If the boundary fence is metallic and is not within 1.8 m of any part of the main earthing system or equipment thereto the fence and outer conductor rings shall not be connected to the main earthing system unless the approved design calculations show otherwise.

Any meshes formed by bonding the outer conductors to the main earthing system shall be sub-divided by additional conductors, if required, to give acceptable touch, step and mesh potentials.

6.7.7. CONDUCTORS

All conductors used for earthing and bonding the fences and components and for outer rings shall have a cross-sectional area of not less than 70 mm2.

6.8. EARTHING CONDUCTOR CONNECTIONS

Connections between the branch earth connections and the main substation earth bars shall be tinned and riveted to the main earth bars.

Connections between earthing electrodes and earthing conductors, earthing conductors and earthwire masts and between the indoor and outdoor sites, shall be made with bolted non-ferrous links arranged for easy connection and disconnection to facilitate testing.

Stranded earthing conductors shall be in one continuous length and straight through jointing is prohibited except for the earth grid type electrode.

Connections to plant and equipment shall be made using the earthing terminals specified in the Contract.

Joints in earthing strip shall have the surface cleaned and tinned and shall be rivetted with copper rivets (not less than four 3 mm rivets per joint) and soldered.

Non-corrosive flux shall be used in all soldered joints.

Alternative methods, explosive welding or high compression joints or clamps, may be permitted, providing full details are submitted and approval is obtained from the Authority.

6.9. TESTS AT SITE

The Contractor shall provide all necessary test equipment for soil resistivity testing and for proving that the earthing systems comply with this Specification. The Contract shall also be responsible for measuring the resistance of each electrode installation and of each complete earthing system to the general body of earth without additional charge.

6.10. CIVIL WORKS

This contract includes all necessary excavation and reinstatement for the complete earthing installation.

6.11. ANTI-CORROSION PROTECTION

Earth conductors laid in exposed positions outdoors or buried in ground which is chemically corrosive shall be painted with two coats of bitumastic paint or other means of protection after installation and before covering to the approval of the Authority. Earth conductors run inside building battery rooms etc., shall be painted with two coats of anti-corrosive paint during erection.

6.12. LIGHTNING PROTECTION SYSTEM

GENERAL

This Specification shall cover: Design, Manufacturing, Factory Testing, Marking and Packing, Shipping, Transport to the site, Installation and Site Testing and Commissioning of Lightning Protection System for Low Voltage, Medium Voltage, High Voltage Extra High Voltage Substations and any combination of them.

The earthing & lightning system to be offered shall be complete in all respects necessary for its effective and trouble free operation.

6.12.1. TECHNICAL DESCRIPTION

GENERAL

In order to avoid/minimize damages due to lightning that may occur in buildings, structures, tanks, equipment, etc. the Bidder/Contractor shall provide all preventive equipment/systems and measures in accordance with the relevant IEC standards and the local safety regulations.

The Bidder/Contractor shall supply, install and commission all required systems for lightning protection including conductors, earth rods, protection devices and all kinds of fixing material to form a complete, safe and reliable system.

The Lightning Protection Systems shall consist of the outer protection system (i.e. catching rods, down conductors, sub-soil earthing system, etc.) and the inner protection system, which is required to cater for voltage differences that may damage electrical and/ or electronic equipment. Lightning catching rods and down conductors shall be of copper.

OUTER PROTECTION SYSTEMS

GENERAL

The following specific conditions shall be considered for the outdoor protection system:

a) Each outdoor steel tank shall be connected to 3 earthing electrodes evenly distributed around the circumference if it is not connected to the main earthing system.

b) Each building roof, civil work, outdoor structure under the responsibility of the Bidder/Contractor, shall have a lightning protection system, composed of roof lightning catching rods, down conductors of adequate sizes and sufficient spacing, which shall be connected to the main earthing system.

c) All connections and joints shall be installed mechanically and electrically effective (clamped, screwed, riveted or welded) in order to suit the local climatic conditions.

d) For every building, at least one ring of ground conductors shall be installed and interconnected, reinforced by an adequate number of potential equalization bars.

e) Air termination shall be of copper of not less than 8mm in diameter.

f) The earth termination shall be of copper of not less than 8 mm in diameter.

g) Potential equalization bar shall be of Tinned Copper.

h) All supports and connections shall be made of best suitable materials.

AIR TERMINATION

A complete air termination network shall be installed on the surfaces of the roofs. No part of the roofs shall be more than 10 m away from the nearest horizontal protective conductor.

Salient points of the structure shall be incorporated. All metallic projections such as air conditioning cabins, vent pipes, railings, gutters, steel constructions, antenna, etc. on or above the surfaces of the roofs shall be connected to the above mentioned network, or shall be used as part of the protective system.

Down conductors shall be distributed on the surface of the outside walls of the buildings with a spacing distance of not more than 20 metres and all main metal parts near the down conductors shall be connected thereto. Each down conductor shall be provided with a at least 3000mm long earth guard (copper-clad steel rod) of not less than 19 mm in diameter with test joints placed in a positions that results in easy testing.

INNER PROTECTION SYSTEM

PRIMARY CIRCUITS

The measures listed below are necessary to protect HV equipment besides its useful effect on interference to secondary circuits.

- Protection against lightning strokes
- Protection by lightning arrests
- Configuration of earthing systems
- Use of VT and CT with acceptable transient response.

SECONDARY CIRCUITS

In case of secondary circuits, the following are the minimum measures to be adopted to reduce EMI.

- Separation of the various circuits connected with devices having different degrees of interference level (e.g. power supplies, input and output network circuits, earth connections)
- Galvanic separation of the I/O signal circuits
- Each piece of equipment shall be earthed by means of radial connections
- Screens of cables should be interconnected at the inlet to the cabinet and connected to the earthing bar.
- It is preferable to have power supplies circuit filters with inductive input and low-

Further following measures are to be considered in the installation:

i) Separation between power circuits (e.g. ac. power supply cables) and control cables, by either spacing out or by following different routes.

ii) Equipment grounding connection to earthing mat should be kept as short as possible. For HV equipment at least two connections are necessary.

iii) Earthing mat meshes where the occurrence of high transient current is more likely (lightning arresters, spare gaps, VT and CT) to take place shall be crowded.

iv) frequency electric and magnetic fields for control cables shall be provided.

v) Earthing of the screen should have a very low impedance with adequate section, minimum length and optimum contact arrangements.

vi) Upper ends of metal structures or concrete reinforcing rods should be connected with lightning rods at the top and with the earthing ring at the bottom.

SURGE PROTECTION

The equipment manufacturer shall provide adequate surge protection on all input and output leads connected to the equipment in order to mitigate induced voltages and currents and prevent equipment malfunction or damage.

In the severe situation that the surges cause damage to the equipment, such damage shall be “fail-safe”. Logic designs shall be such as to minimize the possibility of false or improper operation of substation equipment. Partial failures, which do not disable the equipment but can reduce or eliminate security features, such as error checking in communication circuits, shall be detected and cause the blocking of control outputs to prevent false operations of the substation equipment.

6.12.2. TESTING AND INSPECTION

GENERAL

All lightning protection elements/devices shall be tested in the Manufacturer’s work. The Bidder/Contractor may be required to carry out any one or all of the tests stated in this Specification under witness of FEWA or his representatives.

FEWA reserves the right to perform checks during manufacturing process at any time or all the times. It shall be at the discretion of FEWA to witness tests on 100%, or any percentage quantity of each lot for routine tests, apart from the type tests, wherever called for.

Tests of lightning systems shall comprise factory and site tests.

6.12.3. FACTORY TESTS

A) TYPE TESTS

Evidence shall be given that the proposed lightning protection systems under this Specification shall have been subject to all type tests at an internationally recognised testing station, like KEMA or equivalent. If deemed necessary, FEWA will decide whether additional tests are necessary to be performed by the Bidder/Contractor.

An internationally recognised laboratory shall certify the type test reports.

The Bidder/Contractor shall submit certified copies of type test certificates covering the proposed lightning components.

Type tests certificates/reports shall be considered acceptable if they are in compliance with the relevant Standards and the following:

1. Type Tests conducted at an internationally recognised laboratory acceptable to FEWA.
2. Type Tests conducted at the manufacturer’s laboratory and witnessed by representatives from an internationally recognised laboratory acceptable to FEWA.

If the presented type test reports are not in accordance with the above requirements, FEWA may decide to ask for the type tests to be carried out in the manufacturer’s premises or other places subject to the approval of FEWA and at no additional cost. These tests shall be performed in the presence of an internationally recognised laboratory, which should issue the relevant type test certificates upon successful test.

SAMPLE TESTS

Sample Tests shall be performed, comprising as a minimum the following tests:

- Visual checks and measurements of dimensions
- Lightning components labeling as per this specification.

ROUTINE TESTS

Lightning equipment shall be subjected to routine tests as per the relevant IEC recommendations.

Routine test certificates shall be submitted for FEWA’s review and approval before shipment of the lightning systems.

6.12.4. SITE TEST

The site tests, of lightning protection systems/components shall be generally visual inspection. The visual inspection of the lightning systems, in order to ensure that all components are mechanically assembled and fixed properly and that there are no imperfections shall be performed

However, electrical tests related to lightning systems such resistance measurements and insulation/shielding shall be also carried. The test results shall be submitted immediately following the completion of tests, as computer print out or alternatively hand written.

Site test reports shall illustrate all test details, as well as details of all applied testing equipment and their calibration validity.

The complete lightning protection systems shall be tested at site as follows:

- Visual inspection of exposed elements

- Measurement of the earth voltage U_E by the voltmeter/ ammeter method, test current 100 - 300 A or an equivalent, approved method if above will be proved to be not feasible
- Measurement of the touch voltage U_B.

6.13. LIST OF STANDARDS

The latest Revision or Edition of the following Standards shall be applicable:

6.13.1. EARTHING

ANSI/UL	467	-	Grounding and Bonding Equipment
IEC	60621-2	-	Electrical installations for outdoor sites under heavy duty conditions
IEC	60634	-	
IEC	61936-1	-	Power installations exceeding 1 kVac – Common Rules
ANSI/IEEE	80-2000	-	Guide for safety in AC substation earthing
ANSI/IEEE	81	-	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
ANSI/IEEE	837	-	Standard for Qualifying Permanent Connections used in Substation Grounding
ANSI/IEEE	C37.122	-	Standard for Gas-Insulated Substations
VDE	0100	-	Installation of power systems with nominal voltages to 1000 V
VDE	0101	-	Power installations exceeding AC 1 kV
VDE	0151	-	Materials and minimum dimensions of earth electrodes with reference to corrosion
CIGRE	23.10	-	Earthing of GIS – An Application Guide
BS	5345	-	Earthing and safe working
BS	6651	-	Earthing in Hazardous Areas
BS	7430	-	Code of Practice for Earthing
WENNER		-	A method of measuring earth resistivity (Bull. of the American Bureau of Standards, Report 25B-1116)
TAGG		-	Earth Resistances (Tower House, London 1964)

6.13.2. LIGHTNING

IEC	61024	-	Protection of structures against lightning
IEC	61312	-	Protection against lightning electromagnetic impulse (LEMP)
IEC	61643	-	Surge Protective Devices
IEC	61662	-	Assessment of the risk of damage due to lightning
IEC	61663	-	Lightning protection – Telecommunication lines
IEC	61936-1	-	Power installations exceeding 1 kVac – Common Rules
IEC	62305	-	Protection against Lightning
VDE	0101	-	Power installations exceeding AC 1 kV
VDE	0185	-	Lightning system equipment
BS	6651	-	Code of Practice for Protection of Structure against Lightning

6.13.3. ALTERNATIVE CODES AND STANDARDS

The Bidder/Contractor may propose alternative Codes and Standards provided they are proven to give equivalent degree of quality as the referenced Codes and Standards. Acceptance of any alternative Codes or Standard is at the discretion of FEWA.

6.13.4. PRECEDENCE OF CODES AND STANDARDS

In case of discrepancy between these Specifications and any of the applicable Codes and Standards, the following order of precedence shall apply:

- This specification
- Applicable Codes and Standards
- Acceptable Alternative Codes and Standards.