7.1.12 Earthing Screen

Earthed screens shall be provided to protect the equipment from direct lightning strikes. The screens shall be of aluminum clad steel wires of not less than 50 sq.mm. total section, and connected to provide low impedance paths to earth.

The layout of the earth wires shall be such that equipment to be protected generally lies within areas bounded by two or more conductors, in which case the protected angle shall not exceed 45 degree centigrade. Where equipment is protected by a single earth wire, the protective angle shall not exceed 35 degree centigrade to the vertical.

The earth screens shall be suitable for extension to protect the switching station equipment to be installed in future stages of development.

Connections shall be made of copper strip of 30mm x 5mm cross section between the overhead earthed screen wire and the main switching station earthing system at each support unless the galvanized steel support structure has sufficient area and current carrying capacity.

Earth wires shall be held in clamps with free pin type joints between clamps and supports.

Connections shall be provided for the terminations of the earth wires of the overhead lines, including bimetal connectors where necessary.

The design of all structures shall generally comply with the specification and in addition is to ensure that in the event of breakage of one earth wire, the Factor of Safety is not less than 1.5.

7.1.13 Grounding Material

The grounding wire shall be 120 mm^2 stranded copper conductor. All nuts & bolts shall be cadmium plated. The washers shall be sine plated.

All clamps contort shall be of 25mmx 4mm copper.

All clamps connectors shall be of quality manufacturer such as Burnaby or equal.

Connector to equipment shall be by bare copper cable/flexible copper braid as required.

The grounding copper electrode shall be 16 mm Dia. And each 4 meter length.

7.1.14 H-Type Connectors

7.1.14.1 STANDARDS:

The H-Type Connectors as specified in this Section shall conform to the latest edition of the following standards for operation in overhead lines in air under local ambient conditions. Design, Manufacture, Testing and Performance of the H-Type Connector shall be in accordance with the BS-3288 Part-1 &BS-4579 Part 3 or equivalent International standards.

7.1.14.2 SPECIFICATIONS:

The H-Type Connectors will be used for connecting the ACSR Conductors to ACSR Conductors, AAC Conductors to AAC Conductors and Copper Conductors to AAC conductors. These should be Uni-metal or Bi-metal type according to the contractions and applications of such connectors.

These should be made from high conductivity Aluminium and pre-filled with oxide inhabiting compound. The design of the compression type connectors should be such that galvanic corrosion is minimized. Conductor rough & tooling shall be clearly joined on the connectors.

The connector must have at least the same conductance as the conductor for which it is intended to be used and shall carry the full continuous current rating of the conductor size they are designed for.

The original quality of contacts shall be maintained through out the service life of the connectors. Glow discharge and radio interference must be reduced to a minimum level. All compression type connectors shall be suitable for installation, using either manual or hydraulic compression tools.

The size of the connectors for different Conductors is as follows:

	Grove A		Grove B		
	Max (mm^2)	Min (mm^2)	Max (mm^2)	Min (mm^2)	Length in mm
Twin T ACSR 800/55 /ACSR GROSBEAK	871	350	400	350	150.00
Twin T ACSR /ACSR MARTIN	871	350	685	350	150.00
ACSR GROSBEAK/ACSR GROSBEAK	400	350	400	350	150.00
ACSR MERLIN/ACSR MERLIN	185	150	185	150	112.00

7.1.15 PG Clamp:

STANDARDS:

Item	Requirement
Type	Bolted Parallel Groove Clamp
Suitable Conductor	T-TACSR / TACSR 800/55 mm^2
Conductor Diameter	38.4 mm (Approx.)
Material	High Strength Aluminium Alloy
Bolts, Nuts & Washers	Hot Dip Galvanized Steel
Current Carrying Capacity	≥ Conductor Current Rating
Temperature Rise	Not exceeding conductor temperature rise
Short Circuit Withstand	As per IEC 61284
Mechanical Strength	Suitable for Jumper Application
Corrosion Protection	Hot Dip Galvanized Steel Parts
Standard	IEC 61284

The PG Clamps as specified in this Section shall conform to the latest edition of the following standards for operation in overhead lines in air under local ambient conditions. Design, Manufacture, Testing and Performance of the PG Clamp shall be in accordance with the BS-3288 Part-1 &BS-4579 Part 3 or equivalent International standards.

SPECIFICATIONS:

The PG Clamps will be used for connecting the ACSR Conductors to ACSR Conductors and AAC Conductors to AAC Conductors. Parallel Groove Clamp, a non tension bolted type connector, shall be made of Aluminum Alloy, massively designed body. The bolts are made of Galvanized Steel. For the insulated conductors, 0.80 mm thick PVC insulation cover is to be provided with full length clamp.

The clamps must have at least the same conductance as the conductor for which it is intended to be used and shall carry the full continuous current rating of the conductor size they are designed for.

The original quality of contacts shall be maintained through out the service life of the clamps. Glow discharge and radio interference must be reduced to a minimum level.

The size of the connectors for different Clamps is as follows:

	Conductor Size (sq. mm)	Conductor Diameter (mm)	Dimension		No. of Bolt
			L (mm)	W (mm)	
Twin T ACSR 800/55, either side	871	38.4	125	50	3
ACSR GROSBEAK, either side	370	25.15	125	50	3
ACSR MERLIN, either side	170	17.35	110	45	3

7.1.16 Dead End Clamp (Compression Type)

Item	Requirement
Type	Compression Full Tension
Suitable Conductor	Twin T-ACSR 800/55 mm^2
Material (Outer Sleeve)	Aluminium Alloy
Material (Inner Sleeve)	Galvanized Steel
Ultimate Strength	≥ 95% RTS of Conductor
Slip Strength	≥ 95% RTS
Standard	IEC 61284

a) Construction Requirements Aluminium Sleeve

- Seamless high-conductivity aluminium alloy.
- Compression type.
- Suitable for ACSR 800/55 mm^2 aluminium strands.

b) Steel Core Sleeve

- Galvanized steel compression sleeve.
- Designed to transfer full mechanical load of the steel core.

c) Anchor Assembly

- Forged steel construction.
- Hot-dip galvanized.
- Compatible with yoke plate and strain insulator hardware.

d) Type Tests

The Dead End Clamp shall have successfully passed:

1. Mechanical Tensile Test
2. Slip Strength Test
3. Temperature Rise Test
4. Corona Test
5. RIV Test
6. Short Circuit Current Test

7. Galvanization Test
8. Dimensional Verification Test

e) Routine Tests

- Visual Inspection
- Dimensional Check
- Material Verification
- Galvanization Check
- Assembly Check

f) Typical Design Data

Parameter	Value
Conductor Type	Twin T-ACSR 800/55 mm^2
Conductor Diameter	38.4 mm
RTS of Conductor	≈ 192 kN
Minimum Clamp Strength	≥ 182 kN (95% RTS)
Number of Dead End Assemblies per Phase	2 Nos. (Twin Bundle)

g) Supply per Twin Bundle Phase

- 2 Nos. Compression Dead End Clamps
- 1 Set Twin Bundle Yoke Plate
- Clevis, Eye, Socket, Shackle Pins
- Split Pins
- All Necessary Hardware

7.1.17 LV AC Distribution Panel with interlocking facilities.

Vermin and dust proof, completely metal enclosed by sheet steel (11 SWG) with necessary reinforcement, colour, Grey with appropriate spray painting, free standing type, compact in size, suitable for opening at the back by hinged door with locking device. The AC Panel shall have one Bus Coupler with proper Interlocking for independent operation of each AC System.

There shall be a 3 phase 400 A, 1 KV bus (Cu) arrangement with neutral. Bus being connected with the following MCCB's and instrument. :

Voltmeter with 6-position selector switch connected to the bus.

2 x400A, 4 pole MCCB being interlocked with each other, operative one at a time to bring the input Power to the Bus. Both these incoming feeders shall have 3 x ammeter (each).

2 x 100A, 3 pole MCCB as outgoing.

10 x 60A, 3 pole MCCB as outgoing.

10 x 30A, 3 pole MCCB as outgoing.

6A, 2 pole MCCB as outgoing as required.

The Short Circuit Current rating of each 3 phase MCB and MCCB shall be of at least 36 kA and that for 1 phase shall be at least 10 kA.

All MCCB's are provided with over load setting and short circuit tripping device. There shall be a 63.5-110/230-415V, 5(6)A, 3-φ 4-wire programmable energy meter of accuracy class 0.2s for recording the station use. Additionally 0.5 class 400/5 A ring type LT CT in each phase should be provided for metering purpose.

The AC distribution board shall be with 25% overall spare switches for future use.

Necessary terminal blocks and glands/openings shall be provided for the entry of suitable cables.

All equipment/instruments inside the panel shall be arranged neatly and sufficient space shall be provided for easy approach to each equipment/instrument.

Thermostat controlled panel heater, bulb for inside illumination of panel shall be provided. All other features as stated in the table of guaranteed data schedule shall applicable also.

7.1.18 DC Distribution Panel with interlocking facilities.

The switchboard shall comply with the requirements of BS 5468 (IEC 60439)

The DC distribution board shall be with 25% overall spare switches for future use.

The distribution switchboard shall be of the cubicle type or otherwise incorporated in the cubicles for battery chargers. Double pole switches and fuses or switch fuses (miniature circuit breakers to BS 4752 or IEC 60127 may only be used if it can be shown that there will be no discrimination problems with sub-circuits) shall be fitted to the DC switchboard as required by switching station services but, as a minimum requirement, that set out in the Schedule A of Requirements.

Distribution panels shall be mounted adjacent to the charger control panel and shall be of the cubicle type complying with the general requirements of cubicle type control panels. No equipment associated with the chargers shall be installed in the distribution board.

Distribution panels shall incorporate double-pole switches for each of the outgoing DC circuits and double-pole isolators for the incoming DC supplies. The panel shall be provided with a voltmeter and centre zero ammeter on each incoming circuit.

A double pole switch or contactor shall be provided for the purpose of sectionalizing the busbar.

A battery earth fault detecting relay, which will centre tap the system via a high resistance, shall be incorporated in the distribution panel.

A low voltage detecting device for the system shall be incorporated in the distribution panel. No-volt relays will not be accepted for these devices. The voltage setting shall be adjustable over an approved range.

In addition to any other requirements specified elsewhere, the battery earth fault detecting relays and low voltage devices shall each have three alarm contacts, one for local visual annunciation, one for the station control panel alarm indication and one for potential free contact for external supervisory alarms. A lamp test facility shall be provided.

Connections between the battery and the distribution cubicle shall be made in PVC insulated cable as required. Cable laid in runs where it may be subject to damage shall be protected by wire armouring, be sheathed overall and be cleated to walls as required.

Cable boxes or glands shall be provided as appropriate for all incoming and outgoing circuits of the distribution switchboard and associated battery chargers. Each circuit shall be suitably labelled at the front of the panel and at the cable termination where the terminals shall be additionally identified.

Charging and distribution switchboards shall be provided with an earthing bar of hard drawn high conductivity copper which shall be sized to carry the prospective earth fault current without damage or danger.

The cubicles for the chargers and distribution boards shall be of rigid, formed sheet metal construction, insect and vermin proof, having front facing doors allowing maximum access to the working parts, when open. The design of the cubicles for the chargers shall be such as to prevent the ingress of dust and minimise the spread of flames or ionised zones, shall be to IEC 60529 IP52, but at the same time shall provide all necessary ventilation and cooling. The design of the frames shall allow the clamping and holding of all chokes, transformers and similar sources of vibration, so that vibration will be minimised, satisfy relevant standards, and not limit the life of the equipment. The frame shall allow the fixing of lifting and so that the equipment remains properly mechanically supported whilst being transported, lifted and installed.

7.1.19 Switching-Station Steel Structure

7.1.19.1 GENERAL

The structural steel shall conform to the latest provision of ASTM A36/BS-4360 and all the parts shall be hot dip galvanized as per BS-729 after fabrication.

7.1.19.2 SCOPE

The work covered by these specifications shall include design, fabrication, marking, painting, galvanizing, supply of all materials, suitable for the location, sea worthy packing, transportation to S/S site, storage on the site, site visit needed to complete the sub-station structures, miscellaneous steel members, nuts, bolts, plates etc. according to specifications and drawings prepared by the bidder and approved by the Purchaser.

7.1.19.3 DESIGN DATA

Structure shall be designed on the basis of the following:

i) Buses, structures, conductors and shield wires shall be designed to withstand the force of a true wind velocity of 160 KM per hour (120 kg/m^2 on round surface, 200 KG/m^2 on flat surface). The over load capacity factor shall be 2.

ii) All connections between steel members shall be bolted, minor welds will be allowed for fabrication purposes before galvanization, but no welding will be permitted in the main legs of members of terminal structure. The diagonals and struts shall be bolted directly to the structure legs and to each other. Gasket plats shall not be used unless absolutely necessary.

Members shall be design to avoid depressions that can trap water, such depressions if unavoidable, shall have drain holes, and connections shall be designed so that all bolts can be tightened in the field using a flat erection wrench. The ends of connected members, shall, where necessary, be clipped or cut to allow free movement of the wrench.

The quantity of bolts, nuts and locking devices furnished shall include the number of each size required for erection plus an additional 5% of that number to cover loss and damages.

The bus supports shall be designed to withstand a momentary short circuit current equal to the momentary short circuit rating of the associated breakers.

All shield wires for the sub-station shall be 9.525 mm dia 7 strands with high strength steel galvanized wire.

The contractor must supply complete detailed drawings, bill of materials, composition of materials etc. all connectors, clamps, fittings, hardware, etc. with their range of adjustment. Detailed catalogues, printed literatures etc. showing all significant characteristics for all those things for which the contractor intends to offer must be supplied with the offer. Particular items proposed to be supplied, must be arrow marked in the catalogue.

7.1.19.4 Material

All materials used for the sub-station structures and buses shall be new and undamaged and shall conform to the requirements given below certified test reports for all steel materials shall be submitted to the Engineer before such materials shall be fabricated. The latest revisions to the specified American Society for Testing Materials (ASTM) and General Specifications ruling.

7.1.19.4.1 STEEL STRUCTURE MEMBER

The main steel structure shall be designed for the loading specified and separate additional structures as necessary shall be provided for overhead line terminations, disconnect switches, bus supports, potential devices lightning Arresters and other equipment.

The structures steel shall conform to the latest revision of ASTM for "Steel Bridge and Buildings" or equivalent and all parts shall be hot dip galvanized after packing for fabrication.

All structures shall be shipped completely unassembled unless other-wise specified. All S/S parts shall be plainly marked as aid in assembly and the marking shall agree with the identification on the erection drawings.

The structures shall be completed with all bolts, nuts and locking devices which are required for erection of the structures and for installation of equipment.

7.1.19.4.2 CONNECTION FASTENERS

All connections shall be made with hot dip galvanized, sodium carbon, heat treated, regular square head, bolts to meet Feb Spec FF-B-575. Type-1, Grade-5 or of equivalent standard with hot dip galvanized, heavy semi finished hexagonal nuts. Each fastener shall gave a locking devices by screw and bolt, length of which shall provide 3mm (minimum) to 12.5 mm (maximum) projection beyond nut when connection is tightened. Standard ASTM-A 394 or equivalent.

7.1.19.4.3 WELDING ELECTRODE

Where welding is permitted in Fabrication it shall be done in accordance with ASTM specification A233 using F-70 series low hydrogen electrode as recommended by American Welding Society (AWS) or equivalent for various grades of steel.

i) GALVANIZED COATING

All angles, channels, plates and other shaped or members required for these structures shall be galvanized in accordance with ASTM specification A123 or equivalent. Galvanizing is to be applied on after fabrication is competed as per BS-729 (1971) Galvanization shall be done when fabrication is complete.

ii) GROUND CONNECTION

Grounding will be done by placing a copper wire/bar Grid having cross section not less then 150 mm^2. Earthing rods/electrodes of copper having minimum diameter of 150 mm shall be inserted deep into soil and jointing/welding the rod with the grid as well as earthing electrodes shall be designed in such a way that Grounding resistance requirement is achieved as per IEEE 80 considering 50 kA fault current. All the joints within the grounding grid will be cad welding type. Existing grounding is to be upgraded in accordance with the new higher size power transformer.

The size/type of earthing leads for different equipment shall be as follows:

1.	Neutral of the station transformer, 33/0.4 KV	- not less than 120 mm^2 PVC LT cable
2.	Body of the station transformer,	- not less than 120 mm^2 Cu wire
3.	33 KV PT LV Neutral	- 16 mm^2 Cu. Wire.
4.	Steel mounting structure at the	- 120 mm^2 Cu wire
5.	Body of the 33 KV GIS switchgear Panel	- not less than 2x120 mm^2 Cu wire
6.	Body of the Indoor control relay panel - A.C. distribution panel. DC distribution panel, battery charger	- 120 mm^2 Cu wire
7.	other miscellaneous indoor	
8.	33 KV Lightning Arrestor Outdoor	- not less than 120 mm^2 Cu wire

The earthing leads with appropriate thimble shall be connected to the welded flat bar earth electrode, by bolts & nuts.

The other ends of the earthing leads shall be connected to the equipment/chassis at appropriate terminals by using thimbles/connectors etc and nuts & bolts.

iii) Earthing Device

Appropriate earthing devices and arrangement shall be provided for all 33KV switching panels having provision for operation from the front.

A. FABRICATION

The Purchaser/ Engineer shall be notified when fabrication of the materials is to begging so that Owner/ Engineer may, if desires, provide shop inspection.

Each steel component shall be completely fabricated and then galvanized in the shop. All workmanship and finishing shall be first class and equal to the best practices in modern steel fabricating shops. All angles and members shall be fabricated in accordance with the standard, specifications and details given in the edition of the "Steel Construction Hand- Book" issued by the American Institute of Steel Construction or its equivalent. Structural item as delivered to the job site shall have all members straight, free from warp, bends or local deformations, accurate, sot that when the structure is assembled, proper fit will be provided. All reaming of holes shall be done at the factory before galvanizing. Punching, drilling or reaming of holes after galvanizing will not be permitted. Holes, 18mm in diameter shall be provided in the steel for ground connection on each leg of each structure. Legs or members shall be drilled with 18 holes at 1.5m intervals, in all of members where ground conductors are to be installed for grounding of shield wires or equipment. These holes shall be made before galvanizing. Holes shall be drilled and attachment devices shall be furnished on the terminal structures for all overhead circuit conductors and shield wires.

The bolt holes shall not exceed the diameter of the bolt by more than 1.5mm. Leg angles and other members shall be lap spliced and the back of the inside angle shall be round to clear the fillet of the outside angles.

i) WELDING

All welding done in the shop on steel members shall be by the shield metal are processes using joints details performed in accordance with the American Welding Society (AWS) code or equivalent. All welding procedures and operators shall be qualified by an independent testing laboratory in accordance with AWS standard qualification procedures. Accurate records of operator and procedure qualifications shall be maintained by the contractor and shall be available to the owner or Engineer. All welds shall be continues and shall develop full strength of the least strength component unless otherwise shown on the drawings.

Components shall be thoroughly cleaned before welding and shall be accurately fitted and rightly secured in position during welding and weld surface shall be smooth and uniform and shall be thoroughly cleaned of all slag flux before galvanizing.

ii) MAKING

Each separate structure member shall be plainly stamped with a number. All like parts shall have the same number. The marking shall be stamped into the metal with figures at least 15mm high. Impression shall be made before galvanizing and have sufficient depth so that hey are plainly visible after galvanizing. The mark shall be placed as nearly as possible in the same relative position on each pieces so as to be seen plainly after assembly of the structure.

The mark numbers shall be composed of letters and numbers that will designate the S/S and type of structure. These markings shall the same as shown on the fabrication and erection drawings.

iii) GALVANIZING

All steel components of the structures shall be galvanized using the hot dip process. Fabrications shall be completed before galvanizing. All pieces to be galvanized shall be thoroughly cleaned to remove paint, grease, rust, scales or other materials that could interfere with the bonding of zinc with the steel. Galvanization shall be as per BS-729.

The contractor shall perform all works in accordance with the rules and requirements as specified under ASTM specifications A123, A153 and BS-729.

After galvanizing, steel members may be straightened, if necessary by being re-rolled or pressed only. No punching welding or any other work which may damage the protective cover shall be allowed after galvanizing, except the lapping of nuts. All holes shall be free from pelter

after galvanizing.

iv) DRAWINGS

The contractor shall furnish to the employer/ engineer complete fabrication and erection drawings along with the strength calculations on buses and loading on each structure foundation of each type of S/S structure for approval before fabrication. Drawings shall show outline, dimensions, drilling and details of fabrications.

B. STRUCTURE

All structures shall be designed, fabricated, galvanized etc. as specified and as described below :

i) TERMINAL STRUCTURES

The "Terminal Structure" is identified as the structure on which the 33 KV conductor are terminated. When designed to accept the cable termination, this shall be complete with all plates, bases and other fittings required for mounting the cable and box for 33 KV XLPE single core cable of appropriate size 3x1Cx800 Sq.mm cable per phase) with mounting switches etc.

For overload conductors and shield wires, the maximum tension per conductor shall be 450 Kg.

ii) BUS SUPPORT STRUCTURES

The bus support structures shall be pedestal type, steel columns used to support the strain ACSR S/S buses. These structures shall be designed to withstand the forces outlined herein without damage off deformation. All plates and bus support insulators shall be furnished.

C. STRUCTURE FOUNDATION

The contractors shall furnish the detail design for foundations of all steel structures considering soil pressure of <4880 Kg/m^2. A copy of calculations and design criteria for foundation along with complete bill of materials of sand, cement, reinforcing bar and concrete aggregate etc. shall be furnished after singing of the contract and at the time of drawing approval.

D. PACKING

i) Steel members shall be shipped unassembled only members with the same mark shall be bundled together.

ii) All packages shall be securely tied with heavy gauge annealed galvanized steel bands to withstand transportation handling.

iii) Parts shall be handled and loaded, without damaging the materials or galvanized coatings.

iv) The contractor shall replace, free charge all materials which has been damaged due to inadequate of faulty packing.

E. TAGGING

i) For erection purpose, each package or bundle shall be tagged to identify the number of pieces.

ii) For shipping purpose separate tagging shall be used for each package and bundle showing the name and number of the contract, gross weight, port of dispatch and the destination in Bangladesh.

7.1.20 Bus-Bar Conductor and Jumpers

1.	Installation	Sub-station, Outdoor.
2.	Type	Aluminum Conductor Steel Reinforced (ACSR)
3.	Code Name	Twin T-ACSR/TACSR (800/55 sq mm) for Bus-Bar and jumper
4.	Conductor Size	861 mm^2 for Twin T-ACSR/TACSR 800/55 sq mm
5.	Standard	Performance, design & testing shall be in accordance to the latest Editions of ASTM B-232.
6.	Shipment	On standard non-returnable wooden reels Gross weight shall not Exceed

7.	Standard	Design, Manufacture, Testing, Installation and Performance shall be in Accordance to the latest editions of the relevant IEC standards.

7.1.20.1 FEATURES

- Shall be of continuous length between supports.
- Conductors to be used for bus bars shall be stressed not more than 33% of their breaking strength.
- Overhead conductors carried by the S/S structures shall be erected with such a tension that when the conductors are subject to a transverse wind pressure of 640 Pascal's on the whole projected area, the factor of safety is not less than 2 (Two).
- When dissimilar metals are in contact, approved means shall be provided to prevent elector-chemical action and corrosion.
- Jumper wire current rating should be 3000 A.

7.1.20.2 Electrical Hardware for 33kV Switchyard

- All connectors shall be compression type and made of Aluminum alloy suitable for the conductor. Current rating of the connector should not be less than 3000A.
- Load support clamps shall be complete with bolts, nuts, lock washers etc. complete and of the appropriate size.
- Clamps and fittings made of steel or malleable iron shall be galvanized as per BS-729.
- Joints and connections shall be such as to permit easy dismantling. All necessary terminals and connections (bi-metallic) shall be provided for connection to the equipment. Suspension and tension conductor clamps shall be as light as possible and shall be of approved type.
- Tension conductor clamps shall be not permit slipping of or damage to or failure of the complete conductor or any part, thereof at a load less than 70% of the breaking load of the conductor.
- Catalogue with making on the catalogues of the hardware proposed shall be submitted with the offer.

7.1.21 Switching-Station Earthing

7.1.21.1 SCOPE

These Clauses describe the General Requirements for the Earthing and Lightning Protection and shall be read in conjunction with the Project Requirements and Schedules.

7.1.21.2 REFERENCES

American Standards

ANSI/IEEE std 80 : IEEE Guide for Safety in AC Switching station Grounding

ANSI/IEEE std 81 : IEEE Guide for Measuring Earth Resistivity, Ground and Earth Surface Potential of a Grounding System. Impedance,

German Standards

DIN VDE 0141 : Earthing Systems for Power Installations with Rated Voltages above 1 KV.

British Standards

BS 1432 : Specification for copper for electrical purposes; high conductivity copper rectangular conductors withdrawn or rolled edges.

BS 1433 : Specification for copper for electrical purposes; Rod and bars.

BS 2871	:	Specification for copper and copper alloys. Tubes.
BS 2874	:	Specification for copper and copper alloy rods and sections (other than forging stock).
BS 4360	:	Specification for weldable structural steel.
BS 6360	:	Specification for conductors in insulated cables and cords.
BS 6651	:	Protection of Structures against Lightning.
BS 6746	:	Specification for PVC insulation and sheath of electric cables.
BS 7430	:	Code of Practice for Earthing.

International Standards

ISO 427	:	Wrought copper-tin alloys - chemical composition and forms of wrought productions.
ISO 428	:	Wrought copper-aluminum alloys - chemical composition and forms of wrought productions.
ISO 11 87	:	Special wrought copper alloys - chemical composition and forms of wrought products.
ISO 1137	:	Wrought coppers having minimum copper contents of 99.85% - chemical composition and forms of wrought products.

7.1.21.3 GENERAL

An earthing System generally in accordance with the requirements of IEEE 80 and BS 7430 shall be designed under this contract. Installation and supply of all materials and equipment also included. The earthing system shall also be including earth electrodes 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 of all electrical equipment against lightning shall also be provided.

7.1.21.4 EXTENT OF WORK

The work under the clause **"SWITCHING-STATION EARTHING"** comprises the site testing, design, supply and installation including excavation, back filling and temporary reinforcement of earthing system and connections to electrical apparatus at the switching station. Also included the lightning protection scheme and the provision of portable earthing devices.

The contractor shall be required to undertake all necessary earth resistively tests at the sub-station sites and from the tests result to undertake the design of the earthing system. The design as well as providing safe passage to earth for the stated earth fault currents, shall also include calculation of step, touch and mesh potentials, which shall be within the allowable limits of the standards quoted in the specification.

The design calculations of step, touch and mesh potentials accompanied by full installation drawings and material requirement schedules, shall be submitted to and receive the approval of the Engineer before materials procurement or installation commences.

7.1.21.5 SOIL SURVEY

Actual soil resistance design based on a value of 100 ohm-m soil resistivity. Not later than one month after the site has been handed over for access, the Contractor shall carry out an earth resistivity survey of the sites and report in writing to the Engineer in accordance with the approved program. 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 proposal 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 deep rod electrodes.

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 program 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 Engineer before proceeding with the design of the earthing

7.1.21.6 FAULT CURRENT AND DURATION

Each site shall be provided with an earth grid of buried conductors designed for an earth fault current of 31.5 KA for 3 (three) second. The preliminary earthing, design shall be such that the potential rise shall not exceed kV.

7.1.21.7 EARTH ELECTRODE SYSTEM DESIGN

7.1.21.7.1 Design Calculations

The design of the earth electrode systems shall be based on the approved earth resistivity data and the system fault currents and their duration. **The design of the earthing system shall be based on a soil resistivity of 100 Ω·m or the actual soil resistivity measured during the dry season, whichever is greater.**

The design calculations in detail shall be submitted for approval of the Engineer and shall be based on the methods given in the standards listed. The calculations shall include the following parameters:-

(a) earth resistance of the whole system and 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

Earthing points shall be provided such that the combined resistance of the earth grid and all other earthing points does not exceed 0.5 ohm during the dry season.

The earth potential rises shall not exceed the CHIT 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 permitted limits calculated in accordance with the standards given in IEEE 80 for the proposed surface layer.

7.1.21.7.2 Earth Electrode

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

(a) a system of interconnected rods driven into the ground.

(b) a mesh system of bare conductors buried in the ground.

(c) structural metal work 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.

7.1.21.7.3 Mesh System

The mesh system shall be designed with above to limit touch, step and mesh 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 of hard drawn high conductivity copper strip with a minimum conductor size of 150 mm^2.

The conductor shall be installed in trenches excavated by the contractor to a depth of 500 mm. The system will be installed after all foundations have been laid and the site filled to 100 mm below finished level. When the earthing grid has been laid and back filled, bricks will be laid up to finished site level. Where the excavated material is rocky or may be difficult to consolidate, the back filling shall be carried out using other material to the approval of the Engineer. The cost of such material shall be deemed to be included in the Contract.

7.1.21.7.4 Interconnected Rods

If the design calculations show that a mesh alone is unable to limit 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 length, unless rating considerations determine otherwise). The copper rod electrodes of 15mm diameter shall be interconnected in groups of four to eight rods by insulated copper conductors and non-ferrous clamps 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 rod can be disconnected for testing.

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 70 mm^2.

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

7.1.21.7.5 Other Conductors

As an alternative to rods to supplement a mesh, additional bare copper conductors with a cross-section area of not less than 150mm^2 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.

7.1.21.7.6 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 Engineer. 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 approval of the Engineer.

7.1.21.7.7 Conductors Outside Perimeter Fence

If the design calculations show that the step and touch potentials outside the perimeter fence or wall exceed the limits, than 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 step and touch potentials are within the limits.

The minimum conductor size shall be 75mm^2 copper and shall be connected to the fence or the mesh with 75mm^2 conductors at each corner of the site and at intervals of not more than 100m. These conductors shall not be included in the calculations called for above.

7.1.21.8 DESIGN OF EARTH SYSTEM

7.1.21.8.1 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 or supports of electrical equipment
(d) the conductors between structural metalwork and non-electrical equipment 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, after allowing for the parallel paths through the earth system conductors, with any one conductor disconnected.

The design comprising all the above mentioned items shall be submitted to the Engineer for approval within three months of the award of contract.

7.1.21.8.2 Connection of the System Neutrals and Earth

The system neutral points within a switching station shall be arranged in two groups with a conductor from earthing point.

The earth electrodes of a neutral earthing point shall be arranged in two groups with a conductor from each group to a test link and there shall be duplicate bare copper conductors of cross sectional area not less than 150 mm^2 from each test link to the earth grid. The duplicate connection may be in the form of a ring.

Neutral earthing connections between the switching station system (transformer) neutral and the test links shall be of bare copper tape, secured and supported on stand-off insulators so

that there is no contact between copper tape and transformer tank.

Neutral earthing conductors shall normally be buried directly in the ground but where necessary, they may be cleared to walls, fixed to cable racks or laid in the cable trenches.

7.1.21.8.3 Main Earth Bar

The main earth bar shall be in the form of a ring or rings of bare conductors surrounding, 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 interconnections between earth bars and the earth electrode system shall not be less than 150 mm^2.

7.1.21.8.4 Electrical Equipment Tank and Structure Connections to Earth

Connections between: (a) all HV electrical equipment and (b) LV electrical equipment comprising substantial multi-cubicle switchboards and the main earth bar shall be duplicated. The bare copper conductor size shall have a minimum cross section area of 150 mm^2.

All switching station equipment, including disconnectors, earth switched, main transformer tanks, current and voltage transformer tanks, switchboards, electrical supporting steelwork and gantries etc. shall all be connected with the earth grid.

Surge Arresters installed for the protection of transformers and reactors shall be connected by low reactance paths both to the transformer tanks and to the earth grid.

Capacitor voltage transformers used in connection with line traps shall be connected by direct low reactance paths to a single earth rod for each Arrester, in addition to the earth grid.

An earth mat shall be installed at all operating positions for outdoor 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 minimum copper cross-section area of 75 mm^2.

Galvanized structures comprising bolted lattice components shall not be used as the sole earth connection path to post and strain insulators or to overhead line earth conductors.

Buildings containing electrical equipment shall be provided, at each level, with a ring of earthing conductors which shall have duplicate connections to the earth grid outside the building. The frames of all switchgear, control and relay panels and other electrical equipment and exposed structural metal work shall be connected by branches to a ring. The ring and branch conductors shall be of the same material as the earth grid. Strip run within buildings, inside cable trenches or above ground level on apparatus shall be neatly supported on non-ferrous clamps.

Fixed earthing connectors for use with portable earthing devices below shall be provided on each bus bar and on both sides of high voltage equipment is by tubular bus bars.

Rigid loops in the copper earthing strip branch bond between the equipment and the earthing grid shall be provided adjacent to each item of high voltage equipment for use with the portable earthing devices. The rigid loops shall be marked green.

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.

7.1.21.8.5 Connections to Non-Electrical Structural Metalwork and 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 150 mm^2.

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.

7.1.21.9 MATERIALS AND INSTALLATION

7.1.21.9.1 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 500 mm in an excavated trench. The back fill in the vicinity of the conductor shall be free of stones and the whole back fill 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 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 clear of the adjacent surface.

7.1.21.9.2 Earth Rods

Earth rods shall be driven to a depth below the ground water table level, to be determined by the Contractor during soil investigation and survey of site.

The earth rods shall be of hard-drawn high conductivity copper with a diameter of not less than 15mm 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 betonies 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 bounded high conductivity copper coating with a minimum radial thickness of not less than 0.25 mm. The overall diameter shall be not less than 12 mm. Rolled external screw threads shall be used on the rod for coupling and after rolling the thickness of the copper coating on the threaded portion shall be not less than 0.05 mm.

Rods, 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 Engineer.

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 C 101 or C102) for copper earth rods and to ISO 1337 Grade Cu-ETP (BS 28734 Grade C 101) 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/mm^2 to ISO 630, Grade Fe 430A (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% aluminum bronze to BS 2874, Grade CS 101 and BS 2871, Grade CA 102.

7.1.21.9.3 Fittings

Clips 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 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 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.

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

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

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

7.1.21.9.4 Joints

Permanent joints shall be made by **exothermic welding (Cad Welding)** below ground, or crimping for above ground connections.

Detachable joints shall be bolted and stranded conductors at bolted joints shall be terminated in exothermic welded lugs or a crimped cable socket. The diameter of any holes drilled in strip conductors shall not 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 Engineer.

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 the Engineer.

Bolted joints in metallic structures, including pipe work and which do not provide direct metallic contact, shall either 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 and 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 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.

7.1.21.9.5 EARTHING OF FENCES

7.1.21.9.5.1 Method

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

7.1.21.9.5.2 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, 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 center point of a 20m length of bare copper conductor buried in the ground at a depth of 500mm, running closely parallel 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 100m.

7.1.21.9.5.3 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 100m.

7.1.21.9.5.4 Bonding of Fence components

Fences made up bolted steel or other metallic component do not require bonding between components. Where such fences have non-metallic component, 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 component or for anti-climbing guards and the wires of chain link, shall be directly bonded to each electrode or to each bond to the main earthing system.

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

Wire fence component coated for anticorrosion protection shall be earthed inn accordance with this clause.

7.1.21.9.5.5 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.

7.1.21.9.5.6 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 100 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 100m. 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 bonded thereto, the fence and outer conductor rings shall but be connected to the main earthing system unless the approved design calculations show otherwise.

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

7.1.21.9.5.7 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 mm^2.

7.1.21.9.5.8 Portable earthing devices

Portable earthing devices for use with outdoor 33 KV apparatus in switching stations shall be supplied in the numbers stated in Schedule of Technical Requirements and shall comprise:

(a) Copper alloy earth end clamp for connection to the rigid loops in equipment earth bonding connections.

(b) Aluminum ally line and bus bar end clamp to suit the type supplied under the Contract.

(c) Flexible stranded aluminum alloy conductor with clear protective PVC sheath, size suitable for the specified fault level and duration.

(d) Telescopic operating pole of glass fibre or similar material, of sufficient length to reach the height of connections to high voltage equipment from ground, but retractable into a carrying length not exceeding 2.5m, and complete with non-slip hand grips.

7.1.21.9.6 SWITCHING-STATION EARTHING AND EARTHING ERECTION

General earthing of all equipment shall be in accordance with the IEC recommendation No. 80 :1976-Guide for safety in alternating current sub-station Grounding, the British standard code of practice CP-1013: 1965 or other approved standard.

7.1.21.9.6.1 Earthing System

Each site shall be provided with an earth grid of buried copper strip conductors designed for an earth fault current of 31.5 KA for 3 seconds for all S/S. For the purpose of preliminary design it shall be assumed that the distribution of the fault current will be such that the potential rise of each site will not exceed 5 KV.

Step and touch voltages both inside and outside the station must meet IEEE 80.

The design of earth grid over the area occupied by switchgear and associated apparatus shall be based on a maximum grid spacing of 5m x 5m. Conductors shall be buried at 800mm depth.

Earthing points will be provided so that the combined resistance of the earth grid and earthing points shall be less than 0.5 ohm under any climatic conditions.

The operating mechanisms of isolators, earth switches and circuit breaker kiosks not integral with the circuit breaker shall be connected to the earth system by a branch entirely separate from that employed to earth their bases. The branch is to be installed such that the connection would pass beneath where and operator would stand, so as to minimcize step potential.

Fences shall be earthed independently of the sub-station grid.

Connections to plant and equipment shall be made using the earthing terminals specified in the contract where a strip has to be drilled to fit an earth terminals the diameter of the hole shall not be greater than ½ the width of the strip.

Joints in earthing strip shall employ chemical welding or high compression joints or clamps.

7.1.21.9.6.2 Earthing Electrode

Each Earhting point shall consist of a group of copper rods drawn into undisturbed soil to a minimum depth of 4m. Each copper electrode shall be complete with approved non ferrous clamps for the connection of earthing conductors and with a hardened steel tip and cap for driving by means of a power hammer. The number of electrodes per group shall be not less than four and not more than eight, 16mm diameter rods and each copper electrode rod shall be 4 meter length and the number of rod groups per sub-station have been declared in the price schedule.

The electrodes of an earthing point will be arranged in two sub-groups with a conductor from each sub-group to the test link of the earth grid.

In addition to the above a single electrode is to be driven as close as possible and connected to the following :

i) Three phase set of surge diverts.

ii) Three phase set of voltage transformers.

iii) Three phase set of power transformers.

iv) The fence where an overhead line crosses at gates and at fence corners. The distance between electrodes is not to exceed 50 m.

7.1.21.9.6.3 Insulated Earthing Conductors

Conductors for interconnection between the electrodes in any group and between groups and the connections between the link chambers and sub-station earthing main grid shall have twin conductors with a combined rating of 31.5 KA for three seconds for all S/S . The neutral points of the 33 KV system shall be connected to the link chamber with twin conductors as above.

Earthing conductors shall be of annealed high conductivity copper and shall be stranded in accordance with IEC-228 table VII class-2. They shall be protected with an extruded PVC sheath of 100 volts grade.

7.1.21.9.6.4 Switching-station Earthing Screen

Approved earth screens shall be provided to protect the equipment from direct lightning strikes. The screens shall be of the steel corned aluminum wires of not less than 35 Sq.mm total cross section and connected to provide low impedance paths to earth.

The layout of the earth wires shall be such that generally equipment to be protected lie within areas bounded by lines drawn from the earth wire at 35 degree to the vertical in a plane perpendicular to the axes of the earth wire. The earth screen shall be suitable for extension to protect the sub-station equipment to be installed in suitable stages of development.

Connections shall be made of copper strip of 150 Sq.mm cross section between each support for the overhead earthed screen wire and the main sub-station earthing system. Earth wires shall

be held in clamps with free pin type joints between clamps and supports connections shall be provided for the terminations of the earth wires of the overhead lines including bimetal connectors where necessary.

The necessary stays, fittings, anchors, flying stays and additional masts shall ensure clearance of not less than 4600 mm over roadways for circuit breaker or transformer removal. The design of all structures shall ensure that in the event of breakage of either one earth wire or one stay wire the factor or safety is not less than 1.5.

7.1.21.9.7 REQUIREMENT EARTHING

7.1.21.9.7.1 Low Voltage Switchboards

Earth metal of switchboards fuse and distribution boards and distribution boards shall be bonded together and earthed to the main switching-station earthing system. Earthing connections shall be carried out in bare copper strip having a 3 second rating not less than 31.5 KA for all S/S

7.1.21.9.7.2 Control Panels

Each control panel shall be provided with a copper earth bar of not less than 80 Sq.mm cross-section and arranged so that the bars of adjacent panels can be joined together to from a common bus.

The common earthing bus bar of control and relay panels shall be connected to the main station earthing systems via a copper earthing connection of not less than 80 Sq.mm.

7.1.22 APPROVAL OF DRAWINGS

The successful bidder/tenderer shall submit the following drawings in AutoCAD format and in hard copy for the approval to the Engineer, Project Director, GPESDP, WZPDCL within within 15 days from the date of signing Contract.

a) Technical Specification and Guaranteed Technical Particular
b) Detailed dimensional drawings of 33KV Switchgear including foundation drawing. with cable slots showing all equipment mounted on them along with complete panel wise list of equipment and list of Name Plates. Weight of these panels with all the equipment mounted on these shall also be furnished in the Drawing.
c) Outlined drawings of internal wiring diagram of the instrument, relays, meters, annunciator and other equipment showing external terminal connections with the equipment terminal number.

Complete AC and DC Schematic diagram of 33KV Switchgear Panels to indicate the followings:

i) Annunciator circuit
ii) Protection and control circuit
iii) Indication and Supervision circuit
iv) Other circuits as necessary

These drawings shall show AC power connection and Secondary connections for relays, meters, terminal blocks with their number etc. interconnection diagram between PCM and circuit breaker, Power and Instrument Transformer and other equipment as necessary.

1. Cabling and wiring diagram of the cubicles and inter-connections between them. Ferrule numbers, device number and grouping for cable take off shall be distinctly shown. No work shall be performed in connection with the fabrication and manufacture of the testing equipment until the technical data and drawings have been approved.

2. Manufacturer's printed catalogue describing the type/model of offered 33KV Switchgear, Protective relays, Energy Meters

3. The Bidder shall have to submit 3 (three) sets of the same for Approval. The bidder shall also submit one set reproducible tracing of the above drawings in soft format.

No work shall be performed in connection with the fabrication and manufacture of the Testing Equipment until the technical data and drawings have been approved. The manufacturing of the equipment shall be strictly in accordance with the approved drawings and no deviation shall be permitted without the written approval of the purchaser. The cost of supplying drawings and specifications shall be borne by the supplier.

At the time of delivery of Equipment, the supplier shall supply three (3) sets of all approved technical data and drawings in bound book form along with manufacturer's original catalogue of the Equipment to the office of Project Director, GPESDP, WZPDCL, Khulna, Bangladesh.