5.1 GENERAL

The Contractor shall design the HVDC converter stations equipment's as per scope of work as required for achieving the reliability and availability design target figures given in section 11. The Contractor shall be responsible for the arrangement of the equipment's under the scope of the Contract. The Contractor shall be responsible for the arrangement and layout of the works under the scope.

The Contractor shall submit detailed single line diagrams, station general arrangements, and layout drawings, as applicable, to the Employer for approval and shall not commence the manufacture of any equipment or start the Works prior to approval by the Employer.

The complete installation shall be in strict accordance with the latest editions of Indian Electricity Rules/Act, Indian Standards, Codes of Practice and other Regulations existing in the locality where the system is installed.

5.2 AC SWITCHYARD

The Contractor shall design, arrange, lay to enable proper integration upon the re- commissioning of the HVDC Converters after refurbishment work in accordance with the Employer's Standards and practices and applicable local standards and codes.

The single line diagram for Vizag 400 kV ac substation to which the converter station shall be connected, are shown in Annexure_Vizag_AC SLD and existing DC SLD is given as Annexure_Vizag_HVDC SLD for the information of the Contractor.

5.2.1 GENERAL REQUIREMENTS

The Contractor shall design and supply the terminal connectors for terminations at all the interface points disconnected from the Employers existing equipment's/Switchyards isolated for the refurbishment works as defined in the TS.

For the main busses the Contractor may employ aluminum tubular buses supported on post insulators or strung ACSR or AAC conductor. The 400 kV ac bus and equipment terminals at first level, phase separation and gantry width shall be as per existing condition. Where safety clearances are not met, fence shall be provided. The existing PLC filter foundation may be used.

5.2.2 DESIGN CRITERIA: NOT USED

5.2.3 AC HARMONIC FILTERS

The ac harmonic filters details as existing are as follows:

Eastern side
6 Nos. 106 MVAR, 400 kV Double Damped (12/24th) filter
Nos. 106 MVAR, 400 kV C-Type (3rd) filter
Southern side
6 Nos. 106 MVAR, 400 kV Double Damped (12/24th)
filter 2 Nos. 106 MVAR, 400 kV C-Type (3rd) filter

For further details please refer Annexures-AC Harmonic Filters and SLD.

6.1 OTHER REQUIREMENTS

The Contractor's Scope of Work shall include the control and interlocking facilities required for the operation of all switches, disconnects/isolators and ground switches. Any interface/adaptive interfaces required shall be scope of supply & installation by the bidder**.** Interface with newly supplied equipment and interface to existing signals in the control room is in present scope. In addition, if any, existing signal is required by the new hardware, such interface is also in present scope.

All interlocking schemes shall be secure but shall be able to be overridden or bypassed in emergency under strictly controlled conditions by qualified personnel.

6.2 GENERAL PHYSICAL ARRANGEMENT

6.2.1 GENERAL

Existing converter station are in accordance with the requirements of these Specifications and the applicable requirements laid out in the Indian Electricity Rules and Act, as amended from time to time.

The Contractor shall utilize the existing converter station layouts.

6.2.2 EXISTING FEATURES

6.2.2.1 The existing converter station sites consist of the following features:

a) Two converter building housing the valve halls of both blocks, the station control centre and general services facilities.
b) Converter transformer area and HVAC switchyard.
c) Reactive compensation and ac filter areas.
d) PLC filtering areas.
e) Access and internal roads including access to Circuit Breaker

maintenance.

f) Rail tracks for the movement of the converter transformers
g) Electrical and mechanical station services.
h) Oil and water storage and other required areas.
i) Spare equipment and storage facilities.
j) An area for temporary construction facilities.
k) Fire walls.
l) Cable trenches.
m) Fencing/grounding/lightning protection/landscaping/ drainages etc.

6.2.2.2 The layout of the converter stations is designed considering the following:

(a) Reliable operation.
(b) Ease of maintenance and operation.
(c) Minimum effect of the failure of any component.
d) Separation of equipment.
(e) Minimum cable lengths within the physical constraints as prevailing at site.

6.2.2.3 Equipment associated with different poles to be installed is separated to provide for the following:

(a) Minimum effect of equipment failure:

It is necessary to guard against an equipment failure (e.g. due to fire, equipment explosion, water damage) affecting any equipment of another pole.

(b) Ease of maintenance:

The layout shall permit safe maintenance and full removal of any major item of equipment without requiring further reduction in power transfer capability.

(c) Construction of Working stages:

The Work shall be carried out in stages without affecting the operation of completed converter stations to the extent possible and without jeopardizing the safety of personnel.

6.2.2.4 The extent to which equipment separation is achieved and how much separation is practical shall be governed by the following:

(a) The block of power likely to be affected. As an example, a pole outage is more severe than an ac filter outage and thus deserves greater consideration.
(b) The mode and consequence of a failure. The time taken for the rectification of damage and the cost of the repair are to be taken into consideration.

6.2.2.5 Cables associated with different blocks are to be assigned to cable trenches, trays or ducts physically separated from each other. Similarly, power cables and control cables are to be segregated from each other. This shall be done to the extent possible within the work limits of the layout. Existing cables will not be separated. Whatever cable schedule details available with POWERGRID will be provided to the contractor and in case any further details are required the

same is included in the present scope of work.

6.2.2.6 Cooling equipment and valve control equipment is located outside the valve hall.
Internal roads are provided to enable proper operation and maintenance of the station.
Supplied equipment dimension and modified area layout shall ensure approachability of all equipment by adequately sized wheeled vehicle.

6.2.2.7 Equipment shall not be located on the roof of the converter building for reasons of seismic activity and the problem of sealing cable, pipe and duct entrances.

6.2.3 ELECTRICAL AND SAFETY CLEARANCES

The electrical and safety clearances for the equipment in present scope shall be determined by the Contractor and shall not be less than the clearances applicable for an ac switchyard at the equivalent BIL level nor than those given by the Contractor in his Bid. The minimum requirements for the HVAC side shall be as specified in Indian Electricity Rules'1956 or equivalent standards as approved by employer as amended up to the date of finalizing the switchyard layout.

6.2.4 ELECTRIC FIELD STRENGTH

The Contractor is to confirm and ensure adequacy of design in terms of corona performance as applicable for present scope of supply.
Ion current density shall be less than 20na/ sqm at ground level.
The Contractor shall furnish all calculations and documents in support of the above during detailed engineering.

6.2.5 KEY INTERLOCKING ARRANGEMENT

The layout shall be arranged, in consultation with Employer, such that the areas having restrictions on personnel movement are kept to a minimum as applicable for the present scope of supply. If any such areas are agreed to be necessary, fencing and electrical & mechanical key interlocking arrangements shall be provided for all these areas so that personnel can enter only after de-energization & grounding.

6.3 GROUNDING/ EARTHING

This section is employer standard grounding /earthing. Applicable clause for present scope of work may be referred.

6.3.1 GENERAL

The Contractor shall provide ground/earth inter-connections as required in the building/yard grounding system. The design of the grounding system is based on IEEE 80- 2000 "IEEE Guide for Safety in AC Substation Grounding" and shall be based on the ultimate short circuit levels given in Clause 2.4.5. The interconnections shall be made by the Contractor at the required points. If an inter connection is not made then the Contractor shall take this into account in the grounding design and meet all safety requirements as specified.

The Contractor shall submit drawings showing, in detail, the grounding system including all the required inter-connections from the existing ground mat to the equipment and ground conductor sizes. Conductor shall be oversized to allow for corrosion over a life of 50 years based on minimum resistivity.

The existing ground mat details are provided in Annexure-Earth mat.

6.3.2 GROUNDING DETAILS

6.3.2.1 GENERAL

a) All equipment and structures shall, in general, be grounded at least at two points at opposite corners and these shall be connected to different parts of the existing ground mat for security. Any part of any equipment which can be electrically separated shall be separately grounded. The equipment and structure shall be grounded separately.
b) Neutral points of systems of different voltages, metallic enclosures and frame works associated with all current carrying equipment, and extraneous metal works associated with the electrical system shall be connected to a single grounding system unless stipulated otherwise.

Standard drawing/details for earthing/grounding shall be referred from TS Section Switchyard Erection, Rev:10

6.3.2.2 Details of Grounding System (as applicable in present scope)

The parameters of the grounding conductor shall be determined by the Contractor, but they shall not be less than the following:

S.No.	ITEM	SIZE	MATERIAL
A	Main Grounding	40 mm dia rod	Mild Steel Conductor (buried) & riser
B	Conductor above ground	75 x 12 mm	Flat Galvanized level & grounding leads Steel (for equipment, structures etc.)
C	Rod Earth Electrode	40 mm dia.	Mild steel 3000 mm long rod
D	Pipe EarthElectrode (InTreated earthpit) As per IS	40 mm dia3000mm long	Galvanized Steel
E	Grounding Conductor	25 x 3 mm flat	Galvanized Steel for motors
F	Grounding Conductor	50 x 6 mm Flat	Galvanized for Cable trench, Control Steel Panels, LT Panels

Steel conductors above ground level shall be galvanized according to IS-2629. The minimum weight of the zinc coating shall be 618 gm/sq.m and the minimum thickness of coating shall be 85 microns. The galvanized steel shall be subject to four one-minute dips in copper sulphate solution as per IS-2633.

The galvanized surfaces shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surfaces of steel. The finished surface shall be clean and smooth and shall be free from defects like discolored patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel, globules, spiky deposits, blistered surfaces, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable for rejection.

6.3.2.3 Grounding Conductor Layout (as applicable in present scope)

a) Grounding conductors in outdoor areas shall be buried at least 600 mm below finished grade level unless stated/ calculated otherwise.
b) At least 6000 mm spacing between rod electrodes shall be provided

unless required/stipulated /calculated otherwise.

c) Wherever a grounding conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks, etc., it shall be laid at least 300 mm below them and shall be rerouted round equipment/structure foundations.

d) Tap connections from the ground grid to the equipment/ structure to be grounded, shall be terminated on the grounding terminals of the equipment/structure, if the equipment is available at the time of laying the grid. Otherwise, "ground insert" with temporary wooden cover or "ground riser" shall be provided near the equipment foundation/pedestal for future connection to the equipment grounding terminals.

e) Grounding conductors along their run on cable trench, ladder, columns, beams, walls, etc. shall be supported by suitable welding/cleating at intervals of 750 mm. Grounding conductors along the cable trenches shall be on the wall nearer to the equipment. In case mild steel angles are used for continuous edge protection of the cable trench, the same may be used for earthing purpose by providing suitable connections with the ground mat at intervals of 750mm. Wherever a grounding conductor passes through walls, floors, etc., galvanized iron sleeves shall be provided for the passage of the conductor. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.

f) Grounding conductor around the building shall be buried in ground at a minimum distance of 1500 mm from the outer boundary of the building. If high temperature is encountered at any location, the grounding conductor shall be laid at least 1500 mm away from such location.

g) Grounding conductors crossing roads shall be either installed in hume pipes or laid at greater depth to suit the site conditions. Grounding conductors embedded in concrete shall have approximately 50 mm concrete cover. If grounding conductor is required to be embedded in major foundations, then it shall be laid in a sleeve.

h) For grounding , where applicable Annexure Switchyard erection may be referred

6.3.2.4 Equipment and Structure Grounding

a) Grounding pads are required to be provided by the Supplier of apparatus/ equipment in accessible positions. The connection between grounding pads and the grounding grid shall be made by short and direct grounding leads free from kinks and splices. If grounding pads are not provided on the item to be grounded, they shall be provided and installed by the Contractor.

b) All steel columns, metallic stairs, etc. shall be connected to the nearest grounding conductor by two ground¬ing leads. Electrical continuity shall

be ensured by bonding the different sections of hand rails and metallic stairs.

c) Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to grounding conductor at not more than 10 m intervals. Apart from intermediate connections, both ends shall also be connected to the grounding system.
d) Metallic conduits and lattice structures shall not be used as ground continuity conductor.
e) A separate grounding conductor shall be provided for grounding lighting fixtures, receptacles, switches, junction boxes, lighting conduits, etc.
f) Wherever grounding conductor crosses or runs along metallic structures such as gas/water/steam conduit/ pipes etc. & steel reinforcement of concrete it shall be bonded to the same.
g) Lighting poles, junction boxes on the poles, cables boxes/glands, lockout switches etc. shall be connected to the grounding conductor running along with the supply cable which, in turn, shall be connected to the grounding grid conductor at least two points, whether specifically shown or not.
h) Railway tracks within the switchyard area shall be bonded across fish plates and connected to the ground grid at several locations. At the point where the track leaves the plant area, the rail section shall be provided with insulation joints at both ends.
i) A grounding conductor shall be buried 2000 mm outside the switchyard fence. All fences, including temporary fences, shall be grounded in order to ensure safety of personnel for all switching and fault events. Every alternate post of the fence and all gate posts shall be connected to the ground mat by one lead. Gates shall be connected to the gate post by at least two very flexible ground straps.
j) Flexible grounding connectors shall be provided where flexible conduits are connected to rigid conduits to ensure continuity.

6.3.2.5 Jointing

a) Ground connections to grounding pads of equipment shall be bolted type and joint faces shall be galvanized. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. At least two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anti-corrosive paint/compound or bitumen compound.
b) Connections between equipment grounding leads and main ground

conductors and between main ground conductors shall be welded/brazed type. For rust protection, the welds shall be treated with red primer and afterwards thickly coated with bitumen compound to prevent corrosion.

c) Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingression.
d) Resistance of the joint shall not be more than the resistance of a length of conductor equal to that of the joint.
e) All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on them. Artificial cooling shall not be allowed.
f) Bending of large diameter rod/thick conductor shall be done preferably by gas heating.
g) All arc welding of large diameter conductors shall be done with hydrogen content electrodes.
h) Some typical grounding details are shown in TS Section Switchyard erection, Rev:10

6.3.2.6 Cable Grounding

a) Metallic sheaths and armor of all multi core power cables shall be grounded at both equipment and switchgear ends. Sheath and armor of single core power cables shall be grounded at the switchgear end only.
b) The shield etc. of control cable shall be grounded at one end only and preferably at the panel (Kiosk and control room) end. Varistors of suitable ratings are to be provided at the control panels in case of suspected high voltage interference or voltage surge in the control cables.

6.3.2.7 Specific Requirements for Grounding Systems (as applicable in present scope)

a) Each ground lead from the neutral of power transformers, capacitor voltage transformers, filter neutral, capacitor neutral etc. shall be directly connected to the individual treated ground pit electrodes which, in turn, shall be connected to the station ground grid. All pipe (ground pit) electrodes shall have a cement concrete pit with a cast iron cover hinged to a cast iron frame to provide access to the joints.
b) Grounding terminals of each lightning arrester, and lightning down conductors shall be directly connected to individual rod electrodes which, in turn, shall be connected to the station ground grid.
c) An additional ground mat not less than 1500 mm x 1500 mm

comprising closely spaced (300 x 300 mm grid, 300 mm deep) conductors shall be provided below the operating handles of all disconnects, isolators and grounding switches and connected to station ground grid. Operating handles shall be directly connected to the ground mat and handles shall be provided with insulating material to avoid direct contact with operator during operation of ground switch.

6.4 DIRECT STROKE LIGHTNING PROTECTION

Not used

6.5 ELECTRICAL BUSWORK

The Contractor shall submit supporting calculations for the buswork to show adequacy of design parameters including calculations for:

i) Fibre-Stress
ii) Cantilever strength of post insulators
iii) Aeolian vibrations
iv) Vertical deflection of bus bars
v) Short circuit forces in bundle conductor and spacer location for each span offlexible conductor stringing as per layout drawings.
vi) Snap forces

6.5.1 RIGID ALUMINIUM BUS

The rigid busses shall be free of kinks and surface indentations. The surfaces of the buses shall be cleaned and polished after the buses have been freed of burrs and foreign matter. The number of joints in aluminium tube bars in one supports pan shall not exceed one.

6.5.2 FLEXIBLE STRAIN BUS

Joints, splices or repair sleeves in tension busses shall not be accepted. During installation particular care shall be taken to ensure that the conductors do not be come abraded. Any section of conductor damaged by the application of gripping attachments or otherwise shall be replaced.

6.5.3 BOLTED CONNECTIONS

Bolted connections shall be provided with a Belleville spring washer and a flat washer for tightening. The bolt shall protrude a minimum of two (2) threads but not more than 1/4inch beyond the nut. Bolts shall be tightened with a torque wrench to the bolt torque values specified in NEMA Standard No.CC1. All bolted connections shall be clamped firmly and locked securely.

An oxide inhibiting, corrosion resistant type paste shall be used in making connections. The paste shall be applied to the contact surfaces of the connector which shall then be wire brushed through the paste and additional paste applied if necessary to cover the contact area.