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7.1 GENERAL

7.1.1 SCOPE

The Works to which this section shall apply include all mechanical auxiliary systems for the converter stations. The main systems to be provided are:

- a) Water distribution within the station from a point of supply of raw water at the terminal station fence.
- b) Cooling systems for HVDC converter equipment.
- c) Environmental control in buildings wherever required.
- d) Fire detection and protection systems.
- e) Permanent handling and processing facilities for insulating oil for transformers, reactors and other oil filled equipment.
- f) Emergency diesel generator sets.
- g) Valve module handling equipment.
- h) Water distribution system for sanitary services.
- i) Building Management System.
- j) Motor/hydraulic operated man lift upto about 25 m or as suitable for maintenance of outdoor equipment.

The further details are specified in the following clauses.

7.1.2 GENERAL REQUIREMENTS

All mechanical works shall satisfy the general technical requirements specified in Section 3 and shall be designed to operate in the ambient/system conditions specified in Section 2.

The following requirements shall be met by the equipment supplied by the Contractor:

The equipment shall be designed and constructed for safe, proper and continuous operation under all conditions described or implied in the Specification, without undue strain, vibration, corrosion or other operating difficulties.

Parts shall be designed and supported to permit free expansion and contraction without causing leakage, distortion or excessive strain on the equipment.

Parts subject to wear, corrosion or other deterioration or requiring adjustment, inspection or repair shall be readily accessible and

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capable of easy removal for repair or replacement.

All heavy components shall be provided with convenient means for slinging or handling during installation and maintenance.

No auxiliary system shall be common to both poles. Emergency connections between poles shall be provided but the two systems shall be separated in the normal mode of operation. This principle of pole separation shall apply to all systems including water supply. However common fire fighting pumps can be used.

Within a system, stand-by and/or duplicate equipment shall be provided with a minimum of two for each major component such as, pumps, heaters, strainers, fans or operationally separate cells of cooling towers or heat exchangers. Thus, loss of a single element of auxiliary plant shall not result in any loss of converter rating under any combination of load and ambient conditions. Loss of a second element of auxiliary plant of the same type and duty shall not reduce the station capability by more than the equivalent of the output of one pole.

Duplicate and/or stand-by equipment shall automatically, based on a predetermined cycle, be brought on the system such as to allow an equal wear and tear.

Unless otherwise specified, all equipment serviced by a duplicate or stand-by shall, on detection of failure, get automatically isolated. The corresponding duplicate or stand-by equipment shall automatically take over the failed equipment.

Loss of any equipment or system shall automatically be alarmed at operation control centre with display of events in SCADA system.

The principles detailed above need not be applied to systems upon which the conversion equipment does not depend for operation.

No mechanical equipment shall be installed on the roof of the converter building, i.e. valve halls and service building.

7.1.3 ELECTRICAL POWER SUPPLY FREQUENCY/VOLTAGE VARIATIONS

The power supplies to mechanical auxiliaries may experience transient, over and/or under frequency and voltage conditions which may cause over-speeding or slowing down of motors and driven equipment.

All mechanical equipment supplied for the works shall be capable of operating satisfactorily through those disturbances. No reduction of

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the HVDC power transmission capability shall result during these disturbances.

7.2 WATER SUPPLY AND DISTRIBUTION

The water supply and distribution system shall include the supply, distribution and storage of water to the stations for at least the following purposes.

- a) Water supply to the station shall be provided by the Contractor within HVDC terminal fencing area. The source of water shall be borewells to be installed by the Employer. The Contractor shall make necessary arrangements of pumps, valves, piping etc., as required, to supply the water to the main storage system & regulate its filling/makeup automatically.
- b) Treatment facilities shall be provided for water suitable for the station cooling system and to meet other station requirements including that of drinking water. The water treatment shall inhibit scaling, minimize biological growth and corrosion in the piping and equipment;
- c) distribution from source to points of consumption;
- d) storage of water for the fire fighting system;
- e) storage of water sufficient for 24 hours of continuous operation of HVDC converter in the event of interruption of water supply to the tanks;
- f) equipment for analysis of water which shall be adequate for monitoring the quality of the water supply and to check the effectiveness of the water treatment system;
- g) The equipment for water analysis shall be installed on the water treatment plant. The equipment shall monitor flow, Hardness and pH value and generate alarm for values beyond design limits. The measured value & alarm shall be wired to the Station SCADA System.
- h) water supply for the valve cooling system;
- i) water supply for sanitary services; The daily water consumption for sanitary services at each converter station is estimated to be about 2000 litres

Two nos. 100% capacity water storage RCC tanks shall be provided. Each tank shall be constructed in such a way that there shall be

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segregation between requirement for fire water storage and water for other purposes. Both the tanks shall have interconnection piping with isolation valves for both tanks. Separate piping for fire fighting, valve cooling and other purposes shall be provided from the tanks.

7.3 VALVE COOLING SYSTEMS

7.3.1 GENERAL

The Contractor shall provide reliable and efficient cooling systems for the HVDC converter valves. The design of valve cooling system shall be reviewed by the Employer and / or by its consultants and the Contractor shall provide all relevant information as required for the review of the design. For cooling of valves, the Contractor shall use a closed water cooling system. Operation of Valve cooling system and its subsystems shall be fully automatic with facility for manual operation also. The control and protection cubicles for valve cooling system shall be located in clean air conditioned environment. The valve cooling control system shall be protected against external electromagnetic interference.

7.3.2 RELIABILITY CRITERIA

The following general requirements shall apply to the design of the cooling system:

- a) The primary valve cooling system including control and protection shall be designed and developed on a pole basis. Thus, each pole shall have its own cooling system independent of all other cooling systems.
- b) Cooling towers or closed circuit evaporative coolers for valve cooling shall be on a pole basis. Storage for make up water to cooling towers or closed circuit evaporative coolers shall be on a pole basis.
- c) Make up water for cooling tower or evaporative cooler systems shall be supplied on a pole basis with facilities to supply both poles from one system in emergency or during maintenance.
- d) Storage shall be provided so that failure of a feeder pipe or piece of equipment shall not lead to loss of capacity, if the pipe or equipment is repaired within 24 hours.
- e) Where a number of units (e.g. fans) serve a multiplicity of other units (e.g. valve assemblies) via a common header or plenum chamber, the Contractor shall demonstrate to the satisfaction of

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Employer by model tests or other means that, with any likely selection of units operating, satisfactory flow and/or cooling conditions shall be provided for all the units so served.

- f) The system shall be so designed that in case of auxiliary power failure up to two minutes, no shutdown of plant or power transmission would be required. For this purpose a UPS shall be provided which should be capable of running the valve cooling system for at least two minutes. With UPS in service, the converter should not trip or reduce the transmission capability upon loss of auxiliary power supply for the duration the changeover to redundant power supply.

7.3.3 DESCRIPTION OF COOLING SYSTEM

7.3.3.1 FINE WATER CIRCUIT

The fine water circuit shall consist of a main circuit and a water treatment circuit.

The cooling medium in the fine water circuit shall be deionised water with low conductivity.

7.3.3.2 MAIN WATER CIRCUIT

The main cooling circuit shall consist of water within the thyristor valves, a de-aeration vessel, pumps and filters.

The main circuit shall be provided with an expansion vessel with level transducers and pressurised with nitrogen if required. The level transducers shall be used for control of the make up water for the system and for detection of leakages.

One of the two water pumps shall circulate the water through the main cooling circuit and the water treatment circuit. The other pump shall be included for redundancy purpose. The operation shall be automated and arranged into alternative days between these two pumps. Upon failure of the unit in service, the redundant shall be automatically activated.

7.3.3.3 WATER TREATMENT CIRCUIT

A part of the main flow shall be circulated in the water treatment circuit. The water treatment circuit shall consist of oxygen removers (if required), ion exchangers and mechanical filter. Sensors shall be provided for measuring conductivity of the water, both in the main cooling circuit and in the treatment circuit at the exit side of the ion-exchanger.

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The water treatment circuit shall be provided with a make up pump and associated valves and strainers.

The water pipe for fine water make up shall be connected to main fine water circuit through the water treatment circuit.

7.3.3.4 AIR COOLED LIQUID COOLERS

The air cooled liquid coolers shall cool the water from the thyristor valves. One redundant unit shall be provided by the Contractor over and above the quantity required to achieve the operating temperatures for rated power.

Each cooler shall consist of cooling fans with separated air channels. Each cooler shall be equipped with facility for spraying water on the cooling fins whenever the ambient temperature exceeds 40°C. Suitable protection against corrosion, oxidation etc. shall be provided for all cooling equipments. The water for use in the air cooled liquid coolers shall be provided with a suitable water softening system to prevent any scale formation.

7.3.3.5 MECHANICAL DESIGN

The cooling system shall be pre-fabricated. There shall be three main parts:

- fine water pump unit;
- air cooled liquid coolers;
- piping.

The fine water pump unit shall be mounted on a frame and shall be placed in the valve cooling room.

The air cooled liquid coolers shall be placed outdoors, near to the valve cooling rooms.

The piping shall be especially designed stainless steel and adapted to the station building.

7.3.3.6 CONTROL EQUIPMENT

The valve cooling control equipment shall be specially designed for application to the cooling system for thyristor valves. There shall be two computer based control systems such that either both are in ACTIVE mode, or when one system is in ACTIVE mode the other system shall be in ACTIVE STANDBY mode. Each computer based system shall be self checking and an automatic changeover to the

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other system shall take place automatically in the case of failure of the active system.

The control cubicle shall be tested along the main water cooling circuit, excluding air cooled liquid cooler, at manufacturer's plant.

7.3.3.7 DESIGN CRITERIA FOR THE COOLING SYSTEM

Features to ensure high reliability, proper function and prolonged life time for the cooling system and thyristor valves shall be included. The following main components shall be supplied with redundancy in order to increase the availability:

- main circulation water pump
- one air cooled liquid cooler (N + 1 Coolers, totally)
- bypass valves
- transducers
- nitrogen bottles if applicable

7.3.3.8 DESIGN COOLING REQUIREMENTS

The cooling system shall be designed to cool the heat generated in one 12-pulse group of thyristor valves for converter stations.

Cooling system shall be capable to operate and guarantee the design temperature range of cooling water for two hours and five seconds overload conditions, up to max specified design dry bulb ambient temperature.

7.3.3.9 AMBIENT CONDITIONS

Ambient Conditions are specified in Section 2 of the specification.

7.3.3.10 MATERIALS

The materials in contact with the cooling water as well as for manufacturing of the air cooled liquid cooler shall be selected in order to minimize the risk of corrosion. All frames, covers and tubes shall be of stainless steel and the cooling fins shall be of aluminium.

7.3.3.11 MEASURE AGAINST WATER LEAKAGE

The design of the valve cooling system shall be made to minimise leakages. The following precautions shall be taken to minimize the risk of water leakage from the system.

- choice of water pipe joint

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- number of water pipe joints in the system shall be kept as low as possible, particularly in the thyristor valves;
- velocity of deionised water in the pipes and in the thyristor heat sinks shall be kept low
- water circulation within the pipes shall be free from trapped air bubbles

7.3.3.12 VALVE COOLING CONTROL AND MONITORING

The valve cooling control systems shall be redundant and be equipped with an integrated data collecting unit that is connected by serial links to the station sequential event recorder system.

7.3.3.13 COOLING CAPACITY CONTROL

The water temperature to and from the thyristor valves are used as an input to the cooling capacity control.

In order to avoid condensation at the pipe lines within the thyristor valves the inlet fine water temperature shall be kept in an appropriate range. Dew point monitoring inside the valve hall shall be provided and alarm/trip shall be initiated in case of risk of condensation in the valve Hall.

7.3.3.14 PROTECTIONS

The following protections/monitoring shall be included:

- Temperature of the water from the valves
- Temperature of the water to the valves
- Water flow to the valves
- Water flow from the valves
- Water level in the expansion vessel
- Conductivity of the water from the water processing unit
- Conductivity of the water in the main circuit
- Pressure in the expansion vessel
- Pressure in the nitrogen bottle, if provided
- Position of bypass valve

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7.3.3.15 LEAKAGE DETECTION

There shall be three leakage detection methods used in parallel by the cooling control system. These methods can, depending on the nature of the leakage, generate trip of the converter and cooling system. However one of the methods of leakage detection shall generate a leakage alarm if volume of leakage exceeds the reference volume, during the last 24 hours.

Besides these detection methods alarms for frequent make up and for long make up, generated by the cooling control programme shall be provided. The total schematic of valve cooling system with valve position, flow, temperature, make up details, conductivity, pump running etc shall be made available to the SCADA system of HVDC terminal.

7.4 ENVIRONMENT CONTROL

7.4.1 GENERAL

Air conditioning and/or other environmental control systems shall be provided for all buildings, indoor DC yard and process areas to ensure satisfactory operation of the HVDC system under the range of climatic conditions to which the station may be subjected. These systems shall provide for personnel comfort and equipment operational reliability. Areas requiring environment control shall at least include:

- valve halls;
- control rooms;
- Bay Marshalling Kiosks
- offices, conference room, documentation room;
- first aid room;
- valve module workshop and storage room;
- control and protection workshop;
- electrical room;
- pump house
- battery rooms
- staircases
- valve cooling etc

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- Indoor DC yard

The systems shall consist of all necessary component parts including, but not limited to:

- Ventilation equipment including instrumentation, centrifugal fans, axial flow fans, filters, exhaust fans, dampers, etc.
- Air conditioning units
- Ductwork including dampers, louvers, diffusers, grilles, filters, insulation and all required accessories, etc.

7.4.2 DESIGN CONDITIONS

All air conditioned Spaces shall be designed

- To achieve an inside temperature of $24 \pm 1^{\circ}\text{C}$ (Dry Bulb) & relative humidity of $47 \pm 5\%$.
- Ventilation rate for a/c areas shall be 1.5 air changes per hour or 15 CFM per person; whichever is higher.

Ventilated systems shall be designed for the following:

Sanitary Facilities: 12 air changes per hour

Valve Hall: To be determined by the bidder

Other areas: 4.5°C above outdoor ambient temperature and air changes per hour shall not be less than 10.

7.4.3 DESCRIPTION OF THE SYSTEMS

7.4.3.1 VENTILATION SYSTEM

7.4.3.1.1 Ventilation system for valve hall

Each valve hall shall have an independent ventilation system. Each ventilation system shall consist of two 100% capacity systems, one operating and one stand-by.

The total air volume in the valve hall shall be re-circulated through the main filters at least once every hour. The ventilation system shall be a closed cycle with fresh air intake limited to a minimum. To ensure that the air being supplied to the valve hall is free from dust

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particles, a minimum three stage dust filtration process shall be supplied. This shall consist of at least the following:

1. Pre Filters: To remove dust particles down to 10 micron in size with at least 95% efficiency.
2. Fine Filters: To remove dust particles down to 5 microns in size with at least 99% efficiency.
3. Absolute Filters: To remove dust particles down to 0.3 microns in size with at least 99.5% efficiency.

All the filters shall be panel type. Easy access should be available to the filters for replacement/cleaning.

The ventilation of the valve hall shall be of a positive pressure type. Fresh outdoor air shall be filtered and dehydrated before being blown into the valve hall by the air fans to avoid dust accumulation and condensation on components present in the valve hall. Suitable measures shall be taken to minimise stagnant air. Each valve hall shall be provided with remotely operated motorized exhaust dampers.

It shall be possible to maintain specified conditions continuously inside the valve hall, both automatically and manually controllable from the station service panel (located in the control room) as well as from the local control panel.

In addition to the alarms for particular parameters like pressure, temperature & relative humidity etc, indicating instruments shall be provided for each valve hall. These parameters shall be integrated with station VPS system also.

The valve hall shall be kept at a pressure above the atmospheric pressure under all conditions. The test shall be conducted at site to measure the pressure inside the valve hall for 48 hours. The pressure inside valve hall shall be at least 7 mm of water Column over the pressure outside the valve hall for total duration of test.

7.4.3.1.2 Ventilation system for indoor DC yard

The indoor DC yard shall have an independent ventilation system and the inside pressure shall be above the atmospheric pressure under all conditions. Each ventilation system shall consist of two 100% capacity systems, one operating and one stand-by.

The total air volume in the indoor DC yard shall be re-circulated through the main filters at least once every hour. To ensure that the

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air being supplied to the valve hall is free from dust particles, a suitable dust filtration process in at least two stages shall be supplied. All the filters shall be panel type. Easy access should be available to the filters for replacement/cleaning. Alarms and Instrumentation as specified for the valve hall ventilation system shall be provided for indoor DC yard also. The indoor DC yard shall be kept at a pressure above the atmospheric pressure under all conditions. The test shall be conducted at site to measure the pressure inside the DC yard hall for 48 hours. The inside pressure shall be at least 2 mm of water Column over the pressure outside the DC Yard for total duration of test. The humidity inside the indoor dc yard shall be maintained less than 60% under all operating condition irrespective of outdoor temperature and humidity condition.

7.4.3.2 AIR CONDITIONING SYSTEM

Air conditioning shall be provided on a continuous basis to the control room, bay marshalling kiosks, valve module workshop & storage rooms, control & protection workshops, offices, first aid room, conference room, entrance halls, corridors etc. and all rooms containing electronic equipment.

The air conditioning system for the control room shall consist of two (2), each 100% capacity, chilled water type air conditioning units; one operating and one stand-by. The units shall be factory-assembled, factory-tested Microprocessor Controlled packaged Air Cooled Water Chilling Units with Unit Mounted Starter.

If valve base electronics and/or valve cooling control cubicles are located at places other than in the station control room, these areas can be cooled by using split Air Conditioning units of appropriate capacity. At least two units shall be provided, one operating and one stand-by with the facility of automatic changeover after operator assigned time period.

Both units shall be interconnected so that, in the event of breakdown of one unit, the stand-by unit can be placed into service. Stand-by and operating units shall be alternated monthly for regular operation. The operation of the units shall be automatically controlled including sequential start and stop with single command.

A separate air conditioning system shall be provided for other areas of the service building. This shall also consist of two (2), each 100% capacity, chilled water units; one operating and one stand-by. These units shall also be chilled water type as stated above.

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Each A/C unit shall be complete with all the relevant appurtenances including compressor, air handling unit, condenser, fans, casing, filters, piping, valve, controls, instruments, MCC control panel, chilled water pumps, ducting, diffuser, grills, insulation, etc.

7.4.3.3 AIR CONDITIONING UNIT DETAILS

.1 Compressors

The compressor shall be hermetic or semi-hermetic reciprocating/scroll type complete with drive package, oil heater, safety controls, shut off valves, purge valve, by-pass safety valve etc. It shall be complete with oil level port, oil drain plug with magnet and adequately sized inspection covers and oil level sight glass. The lubrication system shall be Forced Feed complete with reversible gear oil pump adequately sized oil filters, oil coolers etc. as required. Electrically operated crank case oil heater suitable for specified power supply shall be provided. Heater shall be automatically actuated when the compressor is stopped, either by a relay or by means of auxiliary contacts on the compressor motor starter. The compressor shall be equipped with automatic unloading device, to ensure for partial load starting of the compressor as well as multi-step capacity control.

Compressor shall be complete with required accessories, such as shut off valves, pipe flanges, suction strainer, pressure gauge and following controls:-

- Anti Freeze Thermostat
- Solid state operating Thermostat
- Liquid Line strainer
- Water flow switches at the outlet of cooler
- H.P., L.P. Oil pressure cut outs and pressure gauges.
- TX-valve or valves as required.
- Refrigerant solenoid valve or valves as required.
- Fan control Thermostat
- Inherent motor protectors.

The condenser Casing shall be heavy gauge, Zinc coated steel, backed on enamel weatherised for outdoor installation; Panel shall be easily removable for complete accessibility. Condenser Coils shall be seamless copper tubes in staggered formation and shall be expanded into aluminium fins. A Sub-cooling coil circuit shall be integral part of condenser. The fans shall be propeller type direct drive by independent motors and shall be positioned for vertical air discharge. The blades shall be dynamically and statically balanced

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and provided with heavy gauge anodised guards. Fan motors shall be permanent - split capacitor induction type and provided with permanently lubricated drive. The motors shall be isolated from the unit by resilient rubber mounts.

The Chiller shall be shell and tube, multi-pass, direct expansion type. The shell shall be of welded construction fitted with steel sheets on either side. The tubes shall be supported in the shell by adequate stiff supports to eliminate vibration and noise. The tube ends shall be properly expanded in the tube sheet to prevent leakage of refrigerant.

The refrigerant heads shall be made of cast iron and the faces ground to close tolerances to prevent leakage of refrigerant between passes and between the circuits in case of a multi-circuit cooler. The cooler shall be factory insulated to avoid condensation on coil. The cooler shall be complete in all respect and shall include:-

- Filter drier
- Relief valve, charging connection with valve and drain valve, sight glass, moisture liquid indicator.
- Water inlet and outlet connections with stem type thermometer and dial type pressure gauges.
- Supports for mounting.
- Steel sockets between each baffle complete with removable plug to drain entrapped water from chiller shell.

The refrigerant piping between Compressors, Chiller and Condenser shall be of heavy gauge copper with brazed joints. The circuit shall include sight glass, moisture indicator, solenoid valves, thermostatic expansion valves, filter dryers and necessary shut off valves with charging connections.

.2 Air Handling Unit

The air handling units shall be Double skin, draw through/ blow through type, modular construction and shall include filter section, fan section, coil section and mixing box (wherever required). The AHU shall be made of Double skin design with main structure made of 16G GI powder coated/ extruded Aluminium frame work. The panels shall be double skin sandwich type with minimum 24G GI powder coated external sheet and 24G GI powder coated internal sheet with 25mm thick insulation material in between. All sections shall be bolted to each other with neoprene rubber gasket.

The fan shall be double inlet, double width type. The wheel & housing shall be fabricated from heavy gauge galvanised steel. The

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impeller & fan shaft shall be statically and dynamically balanced. Fan housing with motor shall be mounted on a common steel base mounted inside the air handling housing on anti-vibration springs mounts. The fan outlet shall be connected to casing with the help of fire retardant flexible canvass. The fan shall be complete with multi V belt drive, belt guard and adjustable motor mounting base.

The cooling coil shall be of seamless copper tubes, with aluminium fins. The tubes shall be staggered in the direction of air flow. The headers shall be complete with water in/out connections. Air velocity across the cooling coil shall not exceed 2.5 m/sec.

Each system shall have washable pre-filter of 90% efficiency down to 10 microns at the inlet of AHU and a micro-vee filter of 99% efficiency down to 5 microns at the inlet of AHU.

The drain pan of AHU shall be double skin internally insulated with 25mm expanded polystyrene. The drain pan shall be constructed of 0.8mm thick CRCA sheet power coated on outside and 0.63 mm GI sheet on inside with 25 mm thick insulation in between. The cooling coil and condensate pan shall be assembly mounted on slides such that cooling coil and condensate pan can be wholly removed for maintenance.

The cooling coils, standard filters, etc., shall all be housed in a separate enclosure of suitable size and length. The inspection doors shall have double synthetic rubber seals doors and locking arrangements.

Each unit shall be provided with factory assembled humidifier section to accommodate hot dipped galvanised pan humidifier complete with immersion heater of suitable capacity, low level cut-out, float valve, sight glass. The humidifier section shall be coated with heat hardened polyester based power paint.

.3 CHILLED WATER PUMPS

The chilled water pump sets shall be split casing type with suction and discharge flange connections and drip proof squirrel cage induction motor. Pump set shall be as per IS: 1520-1960, IS: 5120, IS-9079, and IS-325. Drive ratings, at 50oC ambient, shall be 10% in excess of maximum BHP of Pump plus transmission losses

.4 MCC & Controls

Each unit shall be capable of being controlled locally and remotely from the station control room. Additional contacts shall be provided to effect interlocking of each unit with the fire detection system.

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The locally mounted control panel shall be installed in the casing of the unit and wired complete with magnetic starters for both fans and motors, high and low pressure cut outs, oil pressure safety switch, and motor winding protectors.

The remote control panel shall provide central control of cooling and shall be installed in the control room. Indication lights for unit functions shall be provided including system "COOL-AUTO-OFF" and fan "ON-OFF-TRIP". The main thermostat shall be located in the control room.

All conduit and wiring between controls and operating units shall be provided.

7.4.3.4 DUCTWORK AND RELATED ACCESSORIES

All ductwork including accessories required for the proper distribution of air for the air conditioning system and for the ventilation system shall be provided. The valve hall and indoor dc yard ventilation system shall also have ducts for complete air circulation, air inlet and air outlet along with all accessories. No part of the housing/room/civil construction shall be used as supply and/or return air path of ventilation system.

Duct and fittings shall be made of galvanized cold rolled steel sheets. Ductwork connections to units shall be made with fireproof flexible material. Supply, return and outdoor air ductwork and mixing sections with manual dampers, and by pass damper arrangement shall be shop or field fabricated.

Under deck insulation of at least 50 mm thickness shall be provided to all the air conditioned rooms where the ceiling is exposed to direct sunlight.(Isolation of noise from AHU, etc.)

The air velocity in the supply section shall not be more than 460 m/min. The air velocity in the return section shall not be more than 180 m/min. The minimum thickness of GI sheets shall be as follows:

Dimension of the duct:	Gauge
up to 750 mm:	24G
from 751 - 1500 mm:	22G
from 1501 - 2250 mm:	20G
above 2250 mm:	18G

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.1 Dampers

The dampers shall be provided in every main branch so arranged that they can be adjusted with a quadrant on the outside of the duct and can be permanently fixed in position after the system is properly balanced.

Damper regulator sets shall be cadmium plated stamped steel and shall be mounted directly on the ducts without insulation. Spacer studs shall be provided for insulated ducts.

.2 Louver Dampers

Louver dampers shall be provided where required and shall be carefully made to ensure tight shut-off and accurate positioning, manually or by damper motors. They shall be constructed with opposed blades, and shafts shall be fitted in "Oiltite" or approved equal bearings.

.3 Louvers

Louvers in walls for ventilating units shall be provided.

Louvers shall be extruded aluminium, with interlocking mullions, integral caulking slots and reinforced corners. Louvers shall be at least 100 mm wide and complete with 50 mm diamond galvanized bird screens.

.4 Hangers

Ducts shall be permanently hung from rigid supports with the horizontal runs level and the vertical runs plumb. Additional hangers shall be installed at all bends, transformations and take-off connections. Hanger rods shall be sway-braced by means of crossed rods at not more than 6 m spacing.

.5 Vibration Isolation

Floor mounted equipment having a frequency of vibration of 1200 cycles per minute or less, shall be mounted on spring isolators with sound absorbing pads.

.6 Sleeves

Where ducts pass through walls or partitions, suitable sleeves of a gauge not less than that of the duct shall be provided.

Ducts through plenum chambers shall be made air tight by caulking with asbestos rope between the duct and sleeve.

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.7 Thermal Insulation

Anti-sweating insulation material shall be supplied and installed on all air conditioning (supply as well as return) ductwork. The insulation shall have a fire retarding vapour barrier jacketing and shall be covered with aluminium jacketing. Insulation thickness shall not be less than 25 mm. Fibre glass insulation shall have a normal density of 24kg/cub.metre.

7.4.3.5 AIR CONDITIONING FOR BAY MARSHALLING KIOSK

Each bay marshalling kiosk shall be equipped with two units of air-cooled self contained package air-conditioning system. The two units shall work in conjunction through a Micro-processor based controller for desired operation. The system shall be designed for 24hours, 365 days of the year operation to maintain the specified temperature ($24\pm 1^{\circ}\text{C}$). One of the air-conditioners shall be running at a time and on failure of the same or as described hereunder, the other unit shall start automatically. To ensure longer life of the system, the redundant units shall also be running in cyclic operation through the controller. However, during running of one air-conditioning unit if the inside temperature of the kiosk reaches to a predefined value (i.e. 35°C), the other unit shall start running to maintain the inside temperature to specified 24°C and also give an alarm for such situation. After achieving this temperature, the other unit shall again shut off.

The air-conditioning unit shall be completely self-contained. All components of the units shall be enclosed in a powder coated cabinet. The colour of the cabinet shall be finalised during detail engineering.

The unit shall be assembled, wired, piped, charged with refrigerant, and fully factory tested as a system, to ensure trouble free installation and operation. Suitable isolation or other by-passing arrangement shall be provided such that any unit /components i.e. compressor or any other item etc. could be maintained/repaired without affecting the running of the standby unit.

The compressor shall be hermetically sealed Scroll type of reputed make suitable for operation on R-22 and shall be CFC free. Compressor should be installed on vibration isolated mountings or manufacturers recommended approved mounting. Valve shall be provided for charging/topping up of the refrigerant. The Contractor shall also furnish details of all accessories i.e. refrigeration system,

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evaporator coil, condenser coil, evaporator blower, filter, cabinet, indoor supply and return grills etc.

The micro processor based controller system shall be supplied with the controls for the two units and shall have at least the following features:

a)	Power Supply	180 – 270 Volts
b)	Working Mode	Run, Test & Standby
c)	Temperature Setting	16°C to 30°C with 1°C resolution.
d)	Kiosk temperature variation from set temperature	± 3°C
e)	On/Off differential	1°C to 10°C with 1°C steps
f)	Cycle Time, Duty Changeover	2, 4, 6, 8, 10, 12, 16 & 24 Hours.
g)	Memory	Set temp., working hours & ON / OFF Status.
h)	Temperature Sensors	Two Nos
i)	Alarms	Potential Free contacts for generating following alarms in the SCADA system. <ul style="list-style-type: none">• Unit Fail.• High Temp. Alarm inside shelter.• Power Fail Alarm.• Compressor fail

7.5 FIRE DETECTION AND PROTECTIONS SYSTEMS

7.5.1 GENERAL

A comprehensive fire detection and protection system covering all areas of the station shall be provided for all equipment which is critical to station operation and also for equipment having a significant fire hazard because of its construction or content e.g. oil filled equipment. The system shall conform to Indian Rules & Regulations.

All the system shall be designed to meet the requirement of Tariff Advisory Committee (TAC) of India and this section of the specification.

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The Contractor shall be responsible for getting approval from the Loss Prevention Association of India (LPAI) for the fire fighting system. Any other additional equipment not specifically mentioned above but found necessary to meet the requirements of T.A.C. and also for safe and sound operation of the plant shall be provided by the Contractor at no extra cost to the Employer.

7.5.2 SCOPE

The following specific equipment and areas of the converter station shall be protected against fire. Depending on the design and layout of the station other areas not included specifically but requiring fire protection shall also be provided with fire protection system by the Bidder/Contractor at no extra cost:

- converter transformers;
- 400/220/33 kV Transformers
- insulating oil storage and handling equipment;
- all buildings including indoor DC yard ;
- diesel generator;
- cable galleries and vaults;
- outdoor AC and DC yards
- Bay controller Kiosk

7.5.3 DESIGN CRITERIA

7.5.3.1 The main fire protection system shall consist of a fire water system serving the whole station. It shall be designed to cater for the provision of water at flow rates to suit large transformer and other deluge systems, and also to provide for the fighting of a maximum credible fire on any equipment, not protected by deluge. The system shall be designed as defined in TAC rules.

7.5.3.2 In the areas of the station containing electronic equipment, relays and switchgear; the use of water shall not be permitted. These areas include, but are not limited to the following:

- control rooms;
- control equipment rooms;
- valve halls
- auxiliary power switchgear areas;
- electronic and electrical equipment storage areas;

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- electronic and electrical equipment workshops;
- cable vault
- Bay controller kiosk.

For the above areas alternative fire extinguishing system shall be provided using media as specified in this section.

For situations covered by the Standards, the level of protection specified therein shall be regarded as the minimum acceptable and, where the situation so requires, protection systems of greater capabilities shall be provided. For situations which are not covered by the standards, the system shall be supplied and installed to ensure effective protection.

- 7.5.3.3 Steel work design shall be such that the effects of a major equipment fire shall be minimised in order to reduce the amount of consequential damage which may be caused and to reduce risk of further failures being caused.
- 7.5.3.4 As far as possible suitable fire compartmentalisation shall be done in case of cable galleries, cable vaults, and cable rooms, electrical equipment rooms etc. Also, wherever cables pass through walls/floors, they shall be sealed. Requirements specified under electrical specifications shall also be complied with. Fire proofing shall be provided on structures where high fire hazards are involved.

7.5.4 FIRE DETECTION & ALARM SYSTEM

7.5.4.1 GENERAL

The Contractor shall supply a fire detection and alarm system, which has to be completely independent from the fire protection system, consisting of manual break glass alarms, automatic fire detectors and all necessary equipment to complete the system, which shall initiate alarms on the station fire alarm control panel installed in the control room. This system shall be electrically supervised against failure on the detection and alarm circuits. In case of failure of an alarm circuit, a visual and audible alarm, different from those for fire detection, shall indicate on the station fire alarm control panel.

Operation of any manual alarm or automatic detector shall cause the following:

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- Initiating of the visual and audible alarm on the station fire alarm control panel, indicating the area or the location of the originating alarm.
- Automatic shut down of the air conditioning and ventilation and opening of the exhaust systems.
- Annunciation of the fire alarm in the station alarm monitoring reporting system.
- Operation of fire bells throughout the station.

7.5.4.2 VALVE HALL FIRE DETECTION SYSTEM

An independent VESDA (or equivalent) System shall be installed in each valve hall for early detection of incipient fire/smoke. For faster response the air sampling points shall be of sufficient numbers and well distributed over each multiple valve structure and inside the ventilation air ducts. The VESDA remote control unit shall be located inside the control room. The VESDA detectors shall be located such that there is no condensation due to temperature difference between the sampled air and the outside temperature. All necessary ground clearance and precautions shall be taken so as to avoid risk of flashover or corona inside the valve hall due to the installation of the pipes for air sampling.

The design of the VESDA detectors and control shall be such that it shall prevent any possible alteration in the smoke detectors sensitivity when installed in ventilation air duct. Suitably graded fire annunciation shall be provided with at least two levels of alarm before reaching a level at which a significant level of combustion products is present. At the lowest levels an alarm shall be sounded. At the next level an alarm shall be sounded and a period of several minutes shall be allowed before any automatic action is taken. At higher levels the time before automatic action shall be reduced, eventually becomes instantaneous. In the event of automatic action being taken the valve hall ventilation system shall be tripped and the exhaust dampers shall be opened. In addition the Valve hall shall be de-energised and the fire audible alarm system in the station shall be actuated.

In case VESDA sampling pipes are routed through air conditioned areas, suitable measures shall be taken to prevent condensation. If so required the detection system shall be suitably compensated to take care of the existing ambient pollution levels.

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In addition, a secondary fire detector using UV sensors to detect electrical arcs shall also be installed within the valve hall. These will be integrated in the fire control panel and BMS. The UV detectors shall be sufficient to provide complete visibility to all sections of each valve stack and provide necessary redundancy.

7.5.4.3 SMOKE DETECTORS

All indoor areas, other than valve hall, shall be provided with smoke detectors except areas normally having products of combustion present such as welding shops and loading bays, diesel engine room, etc. Smoke detectors shall be provided in bay marshalling kiosks also.

The smoke detectors shall be plug-in type, with two ionization chambers and shall have no moving internal components. The chambers shall be of stainless steel construction giving maximum corrosion resistance.

The base of each detector shall have a signal lamp to indicate operation of the detector.

When the detector is in the alarm state the indicator shall come on and it shall latch until reset, however, after each operation, the detectors shall be able to operate again without requiring removal or refitting of any internal components.

The amplification circuit of the detector shall use solid state circuitry.

The spacing and location of smoke detectors shall be in accordance with NFPA-72-E standards and shall consider the conditions such as air velocity, average ambient temperature, particle size etc, the number of detectors required for a complete coverage and the location of detectors with respect to ventilation and air conditioning facilities.

The indoor DC yard at inverter station shall have fire detection using UV sensors to detect electrical arcs within the indoor DC yard. These will be integrated in the fire control panel and BMS. The UV detectors shall be provided for complete coverage to all sections of the yard and provide necessary redundancy.

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7.5.4.4 THERMAL DETECTORS

The following areas shall be provided with both smoke and thermal detectors:

- Loading bays
- Welding workshops
- Auxiliary Transformers rooms
- Diesel engine rooms.

The thermal detector shall be plug-in type, combined rate-of-rise and fixed-temperature detectors.

The base of each detector shall have a lamp to indicate healthiness and operation of the detector. When the detector is in the alarm state the indicator shall come on and shall latch in this state until reset. Healthiness of the detector shall be indicated by intermittent flashing of the lamp.

The spacing and location of the thermal detector shall be in accordance with NFPA standard 72-E.

7.5.4.5 AIR DUCT DETECTORS

Detectors shall be designed for detection of combustible gases, fire and smoke in air conditioning and ventilation ducts.

Each detector shall consist of an ionisation type plug-in detector with self-contained control, complete with a red LED alarm indicator, local and remote reset switches, and alarm and system trouble contacts. In addition, the detectors shall be capable of extending the tripping command to the air conditioning units in the event of detection of smoke.

Detectors and related controls shall be supplied in weatherproof enclosures, suitable for outdoor installation.

7.5.4.6 MANUAL BREAKGLASS BOX ALARMS

Manual break glass box alarms shall be provided adjacent to the automatically protected areas and equipment and at strategic and prominent positions throughout the installation and near all room exits.

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7.5.4.7 AUDIBLE DEVICES

Audible devices shall be supplied and installed in strategic locations at the stations such as station control room, lobbies etc. The audible devices shall be suitable for operation on dc circuit supply.

The sound Level of the audible devices shall be determined suitably based on standard norms/background noise level.

7.5.4.8 FIRE ALARM CONTROL PANEL

The design of the fire alarm system shall balance high sensitivity with good stability. The control panel shall reduce the unwanted alarms and increase the speed of detection of smouldering or slow burning fires.

The fire alarm control panel shall be located in the station control room. This system shall monitor the entire plant area for fires and shall display and report occurrences visually & audibly both locally at the applicable areas and centrally at the control room. In addition these alarms shall also be incorporated into the station alarm, monitoring and reporting system. The fire alarm control panel shall have redundancy in accepting alarms from valve halls, converter transformer, indoor reactor, ac & dc auxiliary system of Employer's future expansion project where parallel converter of 3000MW shall be added to the existing system. The system, as installed, shall include, but not be limited, to the following:

- a) The Fire Alarm Control Panel shall be micro processor based fully Analogue Addressable Analogue Control Unit which shall control all Analogue Addressable detectors, Manual Call Stations and Switching Systems (for disconnecting AHU and power supply) connected to it.

All addressable units shall be connected to the Panel through the Loop Cards and shall be addressed through individualised numbers. The Panel shall be able to obtain analogue value for all detectors in the circuit through a pulsed digitalised current data. The Panel shall be able to analyse all analogue inputs from all addressable units, and through its own software and ambient level screening the Panel shall be able to Identify Fire, possible Fire or Fault conditions. The Unit supervision shall be dynamic and continuous.

- b) The Fire Alarm Panel shall itself have all Zone Cards in it. Each Loop shall be able to access a 127 addressable detector with a total of 200 addressable devices per Loop.

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The Panel shall also give adequate warning signal whenever there is dust accumulation in detectors, and up to the point of its replacement it should be possible to change the level of ambient alarm calibration condition either by the use of software programme operable by the Employer or by resetting the detector. This is especially so for the Basement where there is possibility of false Fire Signals for the Smoke Detectors.

- c) Short circuit, loose wiring or missing units shall also be reported at the Panel with pin point or segment wise location. In such cases, the System through the use of Fault Isolators shall be able to isolate that segment between the two fault isolators.

The Panel shall have a Liquid Crystal Display Alpha - Numeric type on it to indicate immediately at all conditions. The display should be high resolution, 40 characters x 8 lines graphical. In case of testing of the system from the Panel, the Display shall be able to give readouts of analogue value of all detectors being tested. The Panel shall also be able to carry out continuous self monitoring when in normal condition.

- d) The Panel shall have either an in-built or external printer coupled to the Panel which shall log all events with time. The printout shall clearly indicate the event- Fire/Pre Alarm/Fault etc., the Unit address and time. The Panel shall also be able to discriminate between false alarms and fire conditions, as well as priority selection of alarm in case alarm activates in two or more remotely located Units simultaneously. In such cases, the Mutual Call Box shall be reported first, group of sequentially laid detectors 9 in one room for example second and a detector with the greatest obscuration over a period of time third.
- e) The Panel shall also be able to actuate switches automatically in case of Fire condition that of AHUs and Power Supply or other Systems such as piped pressurised gas supply. The Contractor shall be required to design and install the System in operation in co-ordination with the relevant Contractors. The Contractor shall not be allowed to charge extra on this account, and such charges shall be included in his package.

In this respect the Contractor is required to take note of Clause relating to switching of AHUs given above. The Contractor shall indicate in his Bid what facilities shall need to be provided by the Client for completion this mechanism.

- f) The System shall be failed safe and adequate safe guards

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should be undertaken that in the event of a failure of a part of the System it shall not handicap the complete System. The Mother Board shall be of Modular Construction.

The Contractor shall undertake the responsibility of the complete installation. Commissioning interfacing, user trails, training and maintenance of the System as required. The Contractor shall take all responsibility for preparation and installation of System Software into the Panel. The Software shall be such so as to be easily operated by the Employer's Personnel, is secured against Software errors, ability to be upgraded so as to incorporate Detector Unit or replacement/changing of Detector Units, can incorporate more features at a later date such as illumination Control, Security etc.

The Panel shall have an extra Zone/Loop Card to serve as standby in case of burnout or malfunctioning of any operating Zone/Loop Cards.

- g) The following protection system shall be connected to the alarm system.
 - i) Hydrant system
 - ii) Break glass alarm boxes
 - iii) High velocity water spray system
 - iv) Fire detection system
- h) All panels shall be provided with a stand-by power supply from a dc battery and a battery charger. On the loss of alternating current, the stand-by battery system shall provide for electrical supervision and support to the normal system for a minimum of 24 hours with sufficient reserve capable of sounding at least one alarm signal of not less than 5 minutes duration, or a complete four rounds of coded signal. An acknowledgement switch or push-button to silence the audible alarm, shall be provided.

A battery charger/transfer module shall be provided to recharge the batteries to their full capacity. The loss of main operating power to the system shall automatically cause the system to transfer to battery power. After the main power has been restored and the batteries fully recharged, the system shall continue to float charge the batteries automatically. Fuses shall be provided for protection against over current and

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accidental reversal of polarities.

- i) All the relay contacts shall run to identified terminal blocks.
- j) The terminal blocks shall be provided with at least 20 percent spares with a minimum of 6 Nos terminals.
- k) Complete interconnecting cabling between various fire detector junction boxes and panels shall be included.

In addition to the control room monitoring station an annunciation panel shall also be provided in the fire water pump house. This panel shall indicate the status of pumps, system pressure, hydrant system in operation, and water spray system in operation.

- l) For the oil filled transformers and reactors deluge systems, the control panel shall be provided with, at least, the following audible and visual alarms, indicating the location of the originating alarm :
 - i) Deluge valve open.
 - ii) Low water level in the storage water tank.
 - iii) Strainer shut-off valve closed.
 - iv) Low air pressure in the deluge system (if applicable).
 - v) Trouble on the fire pump or on the driver.
 - vi) Failure of the jockey pump.

7.5.5 FIRE PROTECTION SYSTEM

7.5.5.1 WATER SYSTEMS

The fire protection system shall include:

- Fire water storage
- Fire pumps
- Deluge systems
- Portable extinguishers
- Fire hose reels and fire hydrants
- All components and appurtenances required to complete the system

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7.5.5.1.1 *Fire Water Distribution Criteria*

Water for fire fighting duties shall be distributed on the site such that, if a fault forces a section of main to be out of service, all users except those on the affected section of main shall remain operational at full capacity. The main shall be sub-divided into isolatable sections so that damaged sections shall be arranged to minimize the consequences on station operation of a fire occurring in an area served by an unserviceable section of main. The water system for fire fighting shall be independent of the other water systems.

The Contractor shall provide an automatically controlled jockey pumps (2 Nos.) to maintain system pressure and make up leakage so as to avoid continuous operation of the main fire pumps.

A hydrant ring shall be provided for outside & inside of the converter building located to reach, with the aid of the hose stations, all major apparatus not directly protected. The hydrant system shall be extensively provided to cover all areas such as transformer area, reactor area, outdoor & indoor stores, valve hall, service building, valve cooling, valve hall ventilation, pump houses, etc.

7.5.5.1.2 *Fire Water Storage*

The fire water storage tanks shall be duplicated. The size of the storage tanks shall be as per TAC guide lines. The capacity of each tank shall be 100% of the water requirement for the fire fighting system.

The tank shall be of RCC construction and equipped with all necessary components in accordance with the Standards. Provision shall be made for maintenance/cleaning of the tank.

7.5.5.1.3 *Fire Water Pumping System*

The fire water pumps shall take water from the storage tank and deliver it to a distribution system designed to convey water under pressure to:

- i) deluge systems for transformers and other deluge systems, as applicable;
- ii) hydrants;

Two 100% capacity pumps shall be provided for hydrant service, one driven by electric motor and one by a diesel engine. Hydrant pumps shall be sized as per TAC guidelines. For the High Velocity Water Spray (deluge) System, two 100% capacity pumps, one

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driven by an electric motor and one by a diesel engine shall be provided. Pumps shall be sized for the largest risk. Pressurization shall be through the jockey pump and a hydro-pneumatic tank.

The pumps and driver shall be provided to protect simultaneously the largest and most remote items of equipment with a flow rate not less than 10.2 litres per minute per square meter of protected surface of the equipment.

The pumps shall also be provided with manual switches located on a panel at the pump house.

Pumps shall be direct coupled. The parts of the pumps shall be of non-corrosive metal, preferably of brass or bronze.

The pumps shall be controlled and protected in accordance with NFPA Standards.

7.5.5.1.4 Deluge System

Each oil filled transformers and reactors, oil storage tank shall be equipped with an automatic water deluge type of fire extinguishing system in accordance with NFPA-13 having a water flow rate not less than 10.2 litres per minute per square meter of protected surface.

In the event of a fire occurring on a converter transformer the auxiliaries at that transformer and other transformers associated with the same valve group shall be shut-down.

The deluge system shall consist of all necessary component parts and appurtenances including, but not limited to, the following:

- i) Isolating valves
- ii) Deluge valves
- iii) Sprinkler piping & nozzles around the transformer/ reactor, its cooler bank & conservator, complete with supports & all necessary hardware.
- iv) Fire detection devices
- v) Alarm and control devices
- vi) Pressure gauges

The system shall be fully automatic. The operation of the deluge valves and fire pumps shall be controlled by fire detection devices.

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However it shall be possible to operate the system manually from control room as well as locally.

Operation of the deluge systems shall be initiated by means of heat detectors located around the equipment. Design of the detectors and their circuits shall meet NFPA-72E requirements.

A local control panel shall be provided with each deluge system to control the deluge valve as required. The following shall be monitored:

- Deluge valve open
- Low water pressure
- Stop valve partly closed
- Detector circuit fault
- Water flow
- Detector circuit operated

Remote annunciation of deluge valve alarms shall be provided in the control room.

7.5.5.2 VALVE HALL FIRE PROTECTION SYSTEM

The valve hall fire protection system shall consist of a portable CO₂ fire extinguisher system

The portable CO₂ fire extinguisher system shall consists of all equipment required for directing the CO₂ gas discharge at a fire including, but not limited to, a wheel carriage loaded with CO₂ cylinders and necessary piping and instrumentation system and a flexible hose along with a jet nozzle. The effective reach of CO₂ gas jet release shall be sufficient to fight small fires that could develop in a valve structure (Up to top level). Alternatively equivalent extinguishers with adequate range can be provided. This system shall be located close to the valve hall entrance.

7.5.5.3 CONTROL ROOMS, BAY KIOSK & COMMUNICATION ROOMS

These rooms shall be protected by portable CO₂ fire extinguisher system. The system shall consist of all equipment required for directing the CO₂ gas discharge at a fire including, but not limited to, a wheel carriage loaded with CO₂ cylinders and necessary piping and instrumentation system and a flexible hose along with a jet nozzle. The effective reach of CO₂ gas jet release shall be sufficient to fight small fires that could develop in a control room area. One

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portable CO₂ fire extinguisher system shall be provided at each station. This system shall be located on the control room floor. In addition CO₂ fire extinguishers shall be placed at strategic locations in these areas.

7.5.5.4 FIRE PROTECTION FOR OTHER AREAS

7.5.5.4.1 *Auxiliary Equipment Areas*

Auxiliary equipment areas including those areas containing valve cooling, station water supply and treatment, pumps, air conditioning and power supply equipment shall be supplied with hand held extinguishers in accordance with TAC guidelines.

7.5.5.4.2 *Workshop Maintenance Areas*

All maintenance and workshop areas shall, in general, be equipped with hose cabinets connected in the fire water main and spaced according to the standards of NFPA. For areas in which electrical equipment requires protection, dry powder type hand held extinguishers shall be provided in accordance with TAC.

7.5.5.4.3 *Cable Distribution Areas*

Cable distribution areas shall be supplied with hand held CO₂ extinguishers and hose cabinets.

7.5.5.4.4 *Insulating Oil Storage*

The insulating oil storage, if located less than 30 meters from any building and/or energized area, shall be effectively protected against fire by a deluge system. If the insulating oil storage area is located more than 30 meters from any building or equipment it shall be served by hydrants and hose systems to permit fire fighting using fog water nozzles. In addition the storage area shall be accessible by road to permit the fire to be tackled from any side, depending on wind direction.

Indoor and/or trailer mounted oil pumping and/or oil treatment equipment shall be provided with hand held CO₂ or dry powder fire extinguishers.

7.6 BUILDING MANAGEMENT SYSTEM

7.6.1. GENERAL

A fully computerized and automatic Building Management System (BMS) shall control the operation of the mechanical systems serving

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the valve hall and service building and other systems as detailed later in this section.

The Building management System shall cover the following services:

- Air-conditioning System
- Fire fighting
- Station water storage and supply
- Access Control
- Illumination system
- Closed circuit Camera in indoor DC yard
- Detection of RF generation inside the indoor DC Yard

7.6.2 SCOPE OF WORKS

- i) The scope of work shall cover all necessary system provisions (including hardware and software) for synchronizing/integrating the BMS with the control panels of Air Conditioning system, Valve hall ventilation system and Fire Detection & Fire Alarm System.
- ii) The Control and Monitoring of all Air-conditioning Systems including Chillers, Condensers, Chilled Water Pumps, AHU's, valve hall pressurisation Fans, motorized dampers, etc. shall be by use of Allen-Bradley PowerFlex® 400 (Rockwell Automation) or better
- iii) Monitoring of Fire Fighting Systems including Fire Spray and Hydrant systems, water level in Fire Water Tanks etc.
- iv) Control and Monitoring of Utility Services i.e. Water Storage and Supply,
- v) Access Control including Motorised Gate at the entrance to the station and for all entrance doors for the control room building including provision of electromagnetic door locks, card readers etc. The main gate shall be motorised and it should be possible to operate the gate from the control room and from the inside of the gate and by using access control cards. Colour Cameras for CCTV surveillance would be located at the main entrance gate and all entrance doors for the service building, other buildings, indoor and outdoor DC yard, valve halls. The operation of the cameras shall be integrated with the BMS and VPS (Specified in section 4). The CCTV data shall be recorded (minimum for 30 days) and stored, followed by transfer of the data to a juke box.
- vi) Control and Monitoring of Fire Detection and Alarm System.

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vii) Control and Monitoring of Illumination systems

7.6.3 REQUIREMENTS OF BMS

- i) The Building Management System shall be fully computerised, user friendly, modular, flexible and expandable. The BMS software shall cover the following:
 - Building Layout and Floor plans
 - System topology, piping and duct work layout, plant symbols.
 - Line diagrams, bar charts, pie charts of consumption trends of auxiliaries.
- ii) The integration of the fire Alarm System with BMS shall include at least the following:
 - Monitoring of status of each detector by super imposing the same building layout.
 - Alarm/Malfunctioning conditions reported at fire system control panel shall be repeated at BMS control panel.
 - In the event of fire alarm. BMS would automatically shutdown AHU's in the fire floors and control other floors to minimise smoke hazard by closing the relevant Duct Dampers.
 - In the event of fire, Secured doors would be disarmed to help in evacuation and also to avoid intruder alarms on these doors.
- iii) The Contractor shall be responsible for supply, installation and commissioning with all interconnecting wirings/cablings of:
 - a) A Central processing unit (CPU) located in the control room shall provide a user interface with the control, monitoring and other information from the MCC's/panels located in various areas covered in the BMS. The Central processing unit (CPU) of the central operator's control shall provide for overall building data acquisition and transfer, report generation, historical data storage and retrieval, and operator interface. The central operators control shall include the latest Pentium PC (min 3.2 GHZ, 2GB RAM, 120 GB hard disk) with latest configuration available in the market along with:
 - Coloured TFT 22" monitor, coloured Laser printer, External USB 2.0 DVD writer and A4 Scanner
 - Windows XP Prof. operating system latest version with

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license

- Multimedia software and hardware.
- Two sets of Anti- virus Software

b) BMS outstations at the various locations:

This outstation shall provide the interface between the operation of the plant and the control parameter dictated via the central station CPU. Each outstation shall be capable of stand alone operation in the event of a BMS communications failure. The Field Controllers shall perform remote data acquisition and process control. These shall be locally mounted completely self-contained, field programmable, real-time microprocessor based controllers capable of stand alone operation.

iv) Data communications necessary to affect a BMS data transmission system.

v) Complete operating and maintenance manuals and training of O&M personnel.

vi) System commissioning and acceptance tests as specified.

vii) Full documentation for all software provided.

viii) The BMS shall provide stable control of all connected systems with a closed loop control accuracy not to be worse than:

Temperature	2 percent of sensor span
Humidity	4 percent of sensor span
Pressure	2 percent of sensor span
Flow	3 percent of sensor span

The Contractor shall submit a detailed acceptance test procedure designed to demonstrate compliance with contract requirements.

7.6.4 I/O POINT SUMMARY FOR BMS

The minimum control & monitoring required for the BMS is summarized in the I/O list below:

A.	AIR-CONDITIONING SYSTEM	
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	CHILLERS	<ul style="list-style-type: none"> • Chiller - Enable • Chiller Run Status • Chiller Refrigerant Leak Alarm • Fault Alarms • Capacity Control • Chilled Water Reset • Chiller Compressor Current Monitoring • Individual Chiller' Supply Temperature • Differential Pressure Across Chiller In & out
	CHILLED WATER PUMPS	<p>Primary Chilled Water Pumps</p> <p>Primary Chilled Water Pump Start/Stop</p> <p>Primary Chilled Water Pump Status</p> <p>Pump Manual Operation Status</p>
	HEADER CIRCUIT	<p>Common Chilled Water Supply Temperature</p> <p>Common Chilled Water Return Temperature</p> <p>Chilled Water Flow Meter</p> <p>Differential Pressure Chiller In and Out</p> <p>Outside Air Temperature and RH</p>
	AIR HANDLING UNITS	<p>AHU Start/stop Low Speed</p> <p>AHU Start/Stop High Speed</p> <p>AHU Blower Status</p> <p>AHU Manual Operation Status</p> <p>AHU Filter Status</p> <p>AHU Return Air Temperature & RH</p> <p>AHU modulate Chilled Water Valve</p> <p>AHU supply air temperature</p> <p>AHU supply air humidity</p>

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	EXPANSION TANK	Chilled Water Low Level Monitoring
B.	VENTILATION SYSTEM FOR VALVE HALL	Fan start/stop Fan Manual Operation Status Heaters ON/OFF Valve Hall differential Pressure(w.r.t atmosphere) Temperature & Humidity Motorised damper open/close Filter dirty alarm
C.	FIRE FIGHTING	Electrical Fire Fighting Pumps Pumps status Jockey Pumps Pump status Diesel fire fighting pump Pump status Others Pressure in Hydrant line Sprinkler line flow status FIRE ALARM SYSTEM
D.	OTHER SERVICES	Tube well Pumps Pump status Pump ON/OFF Manual Operation Status Domestic Raw water pumps Pump status All water storage tanks 2-step level indication HSD storage tank 2-step level indication HSD service tank (DG Set) 2-step level indication

7.6.5 ILLUMINATION SYSTEM

All controls and commands for the illumination system shall be incorporated centrally integrated with the building management system. Commands for the lighting of station building, yard lighting area etc. should be given according to time of the day and also

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according to weather conditions and brightness outside.

7.6.6 *CCTV*

A closed circuit television (CCTV) system shall also be provided as part of the BMS and fully integrated with the BMS computer/server.

Colour Cameras (about 13nos at each rectifier station and 19 nos at inverter station) for CCTV surveillance would be located at the main entrance gate and all entrance doors for the service building, other buildings, indoor and outdoor DC yard, valve halls. The operation of the cameras shall be integrated with the BMS and VPS (Specified in section 4). The CCTV data shall be recorded (minimum for 30 days) and stored, followed by transfer of the data to a juke box.

The CCTV system shall be an integrated system with IP network centric functional and management architecture aimed at providing high-speed manual/automatic operation for best performance. The system should facilitate viewing of live and recorded images and controlling of all cameras by the authorized users. The system shall use video signals from various types of indoor/outdoor CCD colour cameras installed at different locations, process them for viewing on workstations/monitors in the control Room and simultaneously record all the cameras after compression using MPEG 4 or better standard. Mouse-Keyboard controllers shall be used for Pan, Tilt, Zoom, and other functions of desired cameras. The System shall provide sufficient storage of all the camera recordings for a period of 30 days or more @ 25 FPS, at 4 CIF or better quality using necessary compression techniques for all cameras. It shall be ensured that data once recorded shall not be altered by any means. The recording resolution and frame rate for each camera shall be user programmable.

The surveillance CCTV System shall operate on 230 V, 50 Hz single-phase power supply.

7.6.6.1 SYSTEM REQUIREMENTS:

- a) Camera with external encoder shall be used for image capture.
- b) Indoor cameras shall be either with fixed focal length lens or with Pan/Tilt & Zoom lens as per site requirement. All outdoor Cameras shall be Day/Night cameras.

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- c) Housing of cameras meant for indoor use shall be of IP 42 rating whereas outdoor camera housing shall be of IP 66 or better rating.
- d) System must provide built-in facility of watermarking or Digital certificate to ensure tamperproof recording.
- e) All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password.
- f) Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system.
- g) Facility of Camera recording in CIF, 4 CIF, VGA, CIF as well as in any combination i.e. any camera can be recorded in any quality.
- h) System to have facility of additional camera installation beyond the originally planned capacity.
- i) In order to optimize the memory, while recording, video shall be compressed using MPEG-4 or better standard and streamed over the IP network.
- j) System shall be triplex i.e. it should provide facility of Viewing, Recording & Replay simultaneously.
- k) The offered system shall have facility to export the desired portion of clipping (from a desired date/time to another desired date/time) on CD or DVD. Viewing of this recording shall be possible on standard PC using standard software like windows media player etc.
- l) System shall have provision of WAN connectivity for remote monitoring.

7.6.6.2 VIDEO SURVEILLANCE APPLICATION SOFTWARE

- a) Digital video surveillance control software should be capable to display and manage the entire surveillance system. It should be capable of supporting variety of devices such as cameras, video encoder, Servers, NAS boxes/Raid backup device etc.
- b) The software should have inbuilt facility to store configuration of encoders and cameras.

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- c) The software should Support flexible 1/2/4 Windows Split screen display mode or scroll mode on the PC monitor or on preview monitor as per site requirement.
- d) The software should be able to control all cameras i.e. PTZ control, Iris control, auto / manual focus, and color balance of camera, Selection of presets, Video tour selection etc.
- e) There must be a single encoder for each camera.
- f) The software should have user access authority configurable on per device or per device group basis. The user shall have the facility to request the access and control of any camera for a pre determined time period. Control of camera shall be released automatically after expiry of the pre determined time period.
- g) The system shall provide user activity log with user ID, time stamp, action performed, etc.
- h) The users should be on a hierarchical basis as assigned by the administrator. The higher priority person can take control of cameras, which are already being controlled by a lower priority user.
- i) It should have recording modes viz. continuous, manual, or programmed modes on date, time and camera-wise. All modes should be disabled and enabled using scheduled configuration. It should also be possible to search and replay the recorded images on date, time and camera-wise. It should provide onscreen controls for remote operation of PTZ cameras. It should have the facility for scheduled recording. Different recording speeds (fps) and resolution for each recording mode for each camera should be possible.
- j) The software for clients should also be working on a browser based system for remote users. This will allow any authorized user to display the video of any desired camera on the monitor with full PTZ and associated controls.
- k) Retrieval: The CCTV application should allow retrieval of data instantaneously or any date / time interval chosen through search functionality of the application software. In case data is older than 30 days and available, the retrieval should be possible. The system should also allow for backup of specific data on any drives like DVD's or any other device in a format which can be replayed through a standard PC based software. Log of any such activity should be maintained by the system.

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7.6.6.3 DIGITAL VIDEO RECORDER

The digital video recorder shall conform to the following requirements:

1.	Recording Frame Rate	Realtime 240 frames per second total, 30 frames per second per camera
2.	FPS Display Frame Rate	Realtime 240 frames per second total, 30 frames per second per camera
3.	Recording Resolution	(NTSC): 704(H) x 480(V) / (PAL): 704(H) x 586(V) It should be possible to select lower resolutions
4.	Operating System	MPEG4 Hardware RTOS (realtime operating system)
5.	Compression Method	MPEG-4
6.	Video Motion Detection Capable	Standard and built-in (selectable in menu)
7.	Video Motion Detection Options	Masking, sensitivity adjustment
8.	Monitoring Options	Split screen 1, 4 or 8 cameras
9.	Playback Options	Search, still image capture
10.	Alarm/Event Recording Capable	To be provided with built-in external alarm input/output ports (8 in, 2 out)

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11.	Network Operation Capable	To be provided by using WAN or LAN router
12.	Remote Internet Viewing Capable	Using WAN or LAN router
13.	Ethernet/Modem Built-in	Ethernet standard and built-in
14.	Standard HDD Capacity	500 GB Expandable
15.	HDD Storage Consumption	80 ~ 350 MB per hour / channel variable based on frame speed and resolution settings, as well as compression
16.	HDD Speed	7200 R.P.M + 8 MB buffer
17.	Includes Remote Controller	Wireless IR remote controller
18.	Operation	Triplex operation (simultaneous recording, playback, network operation)
19.	Number of Video Inputs	Eight (8) video inputs for eight (8) cameras total
20.	Audio Recording Capable	Eight (8) audio inputs for eight (8) microphones total
21.	Number of Video Outputs	Two (2) A/V outputs, one (1) VGA output
22.	Pan / Tilt / Zoom Protocol Drivers Built-in	Yes
23.	Input Voltage	230v AC

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7.6.6.4 CCTV CAMERA

The CCTV camera shall be suitable for wall mounting and ceiling mounting. The CCTV camera should be high resolution, superHAD, Weatherproof Pan / Tilt / 220x Zoom Dome Camera.

1.	Image sensor	Color High Resolution
2.	Resolution(TV lines)	480 horizontal TV lines
3.	Effective Pixels	(PAL): 752(H) x 582(V) pixels
4.	Total Pixels	(PAL): 795(H) x 596(V) pixels
5.	Signal System	50 Hz
6.	S/N (signal to noise) Ratio	More than 45 dB (AGC off)
7.	Gamma Correction	$\gamma = 0.45$
8.	Electronic Shutter	1/60 ~ 1/100,000 sec. automatic
9.	Back Light Compensation (BLC)	Adjustable / Automatic and built-in
10.	Automatic Gain Control (AGC)	Automatic ([0 ~ 30 dB] / 41) dB and built-in
11.	White Balance Control (WBC)	Adjustable / Automatic (2,100° ~ 8,000°K) and built-in
12.	Low Light Sensitivity (lux)	0.01 lux
13.	Lens	270x (27x optical /10x digital) IR-corrected aspherical power zoom lens
14.	Lens Aperture	F1.6 ~ 3.7
15.	Pan / Tilt / Zoom Protocol Languages Supported	Yes
16.	PTZ Data Transfer Baud Rates	Selectable 2400 bps / 4800 bps / 9600 bps

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	Supported	
17.	PTZ Data Transfer Interface	Two wire RS-485 (RS-485+ / RS-485-)
18.	Panning Range	Complete 360 degrees (horizontal)
19.	Pan Speed	Adjustable 0.3 degrees / second ~ 240 degrees / second
20.	Tilting Range	180 degrees (vertical) with automatic camera flip
21.	Tilt Speed	Adjustable 0.3 degrees / second ~ 240 degrees / second

7.6.6.5 PTZ-KEYBOARDS

The features of PTZ shall include:

- Fully functional dynamic keyboard controllers with joystick
- Controls all pan / tilt and zoom functions
- Control up to 255 units from a single keyboard
- Many preset options and advanced tour programming
- Compatible with DN-PTZ camera / DVR-RT series recorders

1.	Key Application	wired keyboard control operation of PTZ functions for weatherproof dome cameras
2.	Pan / Tilt / Zoom Protocol Languages Supported	Selectable
3.	PTZ Data Transfer Baud Rates Supported	selectable 1200 bps / 2400 bps / 4800 bps / 9600 bps

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4.	Additional Features	dynamic joystick for smooth camera movements, preset location option for quick access to frequently monitored areas
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7.7 OIL HANDLING SYSTEM

7.7.1 GENERAL

The Contractor shall provide, at each converter station a mobile oil treatment facility for treating and testing insulating oil for use in the power transformers and other oil insulated equipment.

7.7.2 MOBILE OIL TREATMENT PLANT

The oil treatment plant shall be designed to process oil to the quality required for the equipment installed in the stations. It shall be capable of processing oil for transformers and other equipment at a minimum rate of 6000 ltrs/hr. The following shall be regarded as minimum requirements for this equipment.

The plant shall be used for vacuum filling of the converter transformers and reactors. Vacuum filling requires the recirculation of hot degasified and dehydrated oil through the transformer. Filling of a transformer requires vacuum drying of the windings of the transformer and shall require the filling of the unit under vacuum with degasified, filtered and dehydrated oil. One additional vacuum measuring instrument with all accessories shall be supplied separately.

The plant shall also be able to supply the necessary dry air for purging the tanks, releasing vacuum and performing tests on the tanks to check for leaks.

The plants shall be capable of operating in ambient temperatures of 0°C to 50°C.

The equipment shall be in a sheet steel enclosure and mounted on a trailer so designed that it can be moved on any roadway within the station. The plant shall be fully automatic and suitable for continuous operation.

An indicating panel with indicating lights showing which equipment is running shall be provided.

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After the commissioning of the station the mobile oil treatment plant shall be completely refurbished by the Contractor for future use by the Employer.

The Contractor shall supply a 10 kL mobile tank with partition for loading/unloading of oil from drums.

A laboratory shall be provided as part of the mobile treatment plant to permit testing and monitoring of the oil quality during equipment processing/operation.

The treatment plant shall be supplied with suitable lengths of vacuum and oil hose of sufficient length to reach between the oil system and transformer connections; and a power cable to reach the power points installed for this purpose on or adjacent to the transformers and other units requiring treatment.

The trailer shall be capable of accommodating these hoses and cables during transport in the station.

7.7.3 DRY AIR GENERATOR

The dry air generator plant shall be mobile, automatic and designed to generate dry air to feed under pressure as heatless dryer. The dryer capacity shall be 70 CFM and inlet pressure should not be below 5.5 kg/cm^2 at max inlet temp of 40 deg C and outlet dew point at atmospheric pressure should be better than -40 deg C. Supply voltage shall be $230\text{V} \pm 15\%$, 1 phase, 50 Hz or $415\text{V} \pm 15\%$, 3 ph, 50Hz. Suitable instrument along with accessories shall be provided along with dry air generator to measure the dew point.

7.8 OIL STORAGE

The Contractor shall provide 2 nos of oil storage tanks of minimum capacity of 60% oil quantity of the largest transformer.

The internal and external paint of the tanks will be similar to that for the converter transformers.

7.9 VALVE MODULE HANDLING AND TRANSPORTING EQUIPMENT

The Contractor shall supply suitable handling and transporting equipment for erection and maintenance of the valve modules. These shall include electrically operated hoists, collapsible elevating platforms or similar equipment as appropriate for the design of the valve, to remove, install or service modules in the valve and to transport modules to the maintenance areas and storage areas.

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7.10 WATER SYSTEM FOR SANITARY SERVICES

7.10.1 GENERAL

The Contractor shall supply a complete water system for sanitary services consisting of, but not limited to, the following:

1. Storage system
2. Water treatment equipment
3. Pumping system
4. Fixtures
5. Distribution system, piping, valves and fittings

7.10.2 DESCRIPTION

The water shall be treated by a suitable water treatment system before being distributed into the station water distribution system. The water shall be distributed inside all the buildings and drained through the sewage system.

7.10.3 STORAGE SYSTEM

The storage system shall have a minimum capacity to supply water for the sanitary services for one (1) month of normal use. The storage tank shall be of RCC construction.

Additional storage tank of suitable capacity of Sintex or equivalent make for daily use shall also be provided.

7.10.4 WATER TREATMENT PLANT

The water treatment system shall consist of all necessary component parts, accessories and appurtenances including, but not limited to:

1. A compact, self-contained, factory built water treatment system. Potable water shall be as per WHO standards. PH values shall be in the range 7.5 to 8.5.
2. Pumps including motors and starters.
3. Valves, piping and fittings.
4. Controls and instruments.
5. Connections for water inlet supply, discharge, backwash, waste and sludge.

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6. Chemical feed system including chemicals for one (1) year of service.
7. Potable water analysis kit.
8. All interconnecting electrical wiring, conduit and accessories complete with terminal blocks for connection of power supply cables and remote alarm cables.

7.10.5 PUMPING SYSTEM

The pumps shall take the water from the water treatment plant/main storage tank. Pumps shall be automatically controlled (start/ stop) by an electrical signal from the level switch located in the tank. Remote indication of storage tank levels and two low and one high level alarm shall be provided.

7.11 ADDITIONAL GENERAL REQUIREMENTS

7.11.1 TESTS

The Contractor shall perform all tests and inspection necessary to ensure that the material and workmanship conform to the approved design drawings and that such tests are adequate to demonstrate that the equipment shall comply with the requirements of the Specification & relevant standards. The Contractor shall test the component parts at his plant or his Sub-Contractor's plant, prior to packaging and shipping, to determine that the performance requirements have been met. All testing shall be in accordance with the Standards related to the piece of work.

7.11.2 PUMPS

7.11.2.1 GENERAL

Where pumps are supplied as part of the Equipment covered by the Specification they shall comply with the following requirements unless otherwise specified/ approved by the Employer.

- a) Each pump and motor shall be mounted on a hot dipped galvanised steel base with drip rim and tapped drain connection.
- b) All pumps shall be provided with air cocks.
- c) Each pump shall be connected to its motors with a flexible coupling. All couplings shall be protected with guards.

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- d) Rotating parts of all pumps and drivers shall be statically and dynamically balanced.
- e) A centrifugal pump shall have an impeller with a diameter not greater than 90% of the maximum that could be installed.
- f) The materials of pumps shall be selected with due regard to operating conditions. Higher grade materials than specified may be proposed by the Contractor if considered more suitable.
- g) Pump rotation shall be as indicated on approved shop drawings.
- h) All motors shall be selected to handle the run out conditions of the pump at a service factor equal to or greater than 1.0.
- i) The equipment code number shall be shown on the nameplate of the equipment.
- j) All pumps shall have metallic seals between housing and pump shaft to prevent leakage.

7.11.3 PIPING

7.11.3.1 GENERAL

The Contractor shall supply the piping for all the station systems wherever required. The main piping systems shall include, but not be limited to, the following:

- Fire protection systems
- Water distribution systems and sewage system
- Cooling systems
- Oil handling and storage systems

Piping shall be defined as pipe, valves, fittings, bolting and jointing materials and thermo-welds, pipe hangers & supports and other related material. In case of bends (90°) only prefabricated bends shall be used.

7.11.4 HOISTS & LIFTING ARRANGEMENTS

A provision for a permanent motorised hoist shall be made inside each valve hall. The hoist shall be mounted on a monorail placed just above the valve structures and positioned in such a way so as

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to enable its use for lifting valve modules, surge arresters, etc. The minimum lifting capacity of the hoist shall be 250kgs. The controls for the hoist shall be at the ground level in the valve hall and shall be of hand held type. A man carrying cage shall also be supplied with the hoists – one for each valve hall.

7.11.5 TYRE MOUNTED HYDRAULIC OPERATED TELESCOPIC BOOM CRANE

Hydraulic operated, tyre mounted crane with telescopic boom, suitable for erection of at least the following equipment shall be supplied by the Contractor at all the converter stations (one for each converter station).

- Transformer bushings
- All AC & DC yard equipments excluding smoothing reactor

The Hydraulic Mobile Crane shall be self propelled with a lifting capacity of at-least 15 MT. The general technical specifications for the crane for guidance of the bidders are given below. However the exact details shall be finalised during detailed engineering.

Sl No.	Name of Parts	Description
01	Super Structure Frame	All welded rigid structure
02	Telescopic boom	3/4 part, 1 base and 2/3 telescopic element with synchronized movement fully powered over length retraced 6 meter, extended 15 meters
03	Hoisting Gear	Gear motor, hoisting gear drum with built in hydraulically controlled spring loaded multiple disk break.
04	Ring Gear Assembly	For continuous infinite rotation through 360 degree.
05	Driver's Cabin	One man revolving cab, sheet metal structure, large sized safe glass windows, adjustable driver's seat, top glass lifting type rear emergency exit window, sliding door, wipers ventilating fan cab light, instrument panel with

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		rpm/hour meter, fuel gauge, water temperature gauge, hydraulic pressure gauge, speed selector, crane control safe load system with audio visual indication of safe/over load starter switch with key, combination switch for head light horn, crane levelling gauge, parking break lever, foot break and throttle , dual rear view mirror, tyre inflation Kit.
06	Slewing gear drive assembly	Hydraulically driven planetary gear box including spring loaded hydraulically released multiple disc brakes, slewing speed unladen 0-2 rpm (approx).
07	Safety devices	Safety valves for protection against pipe or hose rupture, which over hoist limit switch, automatic hydraulic cut off in case of over loading, slew locking during travel, auto steer reversal, safety – latch in hook.
08	Chassis	Torsion resistant and rigid steel structure of side member construction.
09	Out riggers	4 nos. out riggers operated through hydraulic cylinders fitted with dual pilot lock valves for total safety, with inverted jacks. All steel fabricated, quick releases type out trigger.
10	Engine	Suitable water cooled diesel engine of adequate hp.
11	Gear box	Power shift gear box with adequate forward and reverse speed
12	Drive Configuration	4x4 or 4x2 depending on requirement.
13	Electrical system	Two 12 volt maintenance free batteries. Batteries shall be suitable for starting of engine and lighting of crane.
14	Axle	Front : Non-drive, Non Steer. Rear : Drive steer

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15	Axle Suspension	Front: Centrally suspended and with lateral oscillation, hydraulic axle locking assembly. Rear: Bolted to the frame.
16	Hydraulic System	Hydraulic system using double gear pump driven through transmission steer pump through engine.
17	Control valves	Should be provided in sufficient Nos
18	Brake	Service – foot operated air assisted. Parking – Hand operated air assisted, fail safe on rear wheels.
19	Steering	Fully independent power steering. Fully hydrostatic two wheel steering.
20	Tyres	4 Nos. of suitable size and strength, PR Earth mover and tubeless type.
21	Safe load indicator	Automatic safe load indicator giving display of actual and maximum safe working load (at a particular radius) along with audible and visual warnings on approach to over load and cut off.
22	Gradient	1 in 5 (un laden) approx. 1 in 8 in laden condition approx.
23	Dimensions	Length (wheel to wheel) – 3.0m (Max.) Width – 2.5 m (Max,) Height (top of Driver Cabin) – 3.5 m (Max.)
24	Lighting	Full lighting including turn indicator, head, trail, brake and suitable for hazardous condition.

SECTION 8: CIVIL WORKS

8.1 GENERAL

The civil works to be provided by the Contractor, in accordance with the Specification, shall include the design & construction of all the items required, in each of the converter stations, including site and general services; buildings; foundations; structures; noise, fire and blast walls etc. The supply of steel and cement required for the civil works shall also be in the scope of the Contractor.

All civil works shall satisfy the requirements specified in other Sections of this Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification and implied as per national/international Standards.

All civil works shall be carried out as per applicable Indian Laws, Standards and Codes. The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and directions of the Employer.

All the Works shall be carried out according to the design/drawings to be developed by the Contractor, and approved by the Employer. For all buildings, structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the plant and facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this Specification for guidance purpose only; however, the Contractor shall provide according to the complete requirements.

All quality standards, fabrication and erection check lists, welding standards and other technical requirements as covered in the Specification shall be strictly adhered to by the Contractor.

8.2 CIVIL WORKS DESIGN BASIS

8.2.1 GENERAL

The Contractor shall design and construct all civil works to meet the requirements of the Specification and to be suitable for the intended use at the specified locations. In particular the Contractor shall be responsible for obtaining all data not specifically detailed herein which is required to ensure compliance with the Specification.

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The foundations and structures shall be designed to ensure that relative movement over the specified life of the installation does not result in stresses in any part of the Works which exceed the maximum design levels.

A design intent memorandum (DIM) to the effect shall be submitted by the Contractor for the Employer's specific approval giving details regarding his assumed data, loading for all civil design.

Any variation in design data shall not constitute a valid reason for any additional cost & shall not affect the terms & condition of the Contract. No extra payment what so ever, shall be paid to the Contractor on account of any variation in soil properties/conditions.

8.2.2 GEOTECHNICAL INVESTIGATION

Levelled site shall be handed over to the Contractor. The finished ground level shall be the finished formation level furnished by the Employer. The compaction of finish formation shall be approx 95% on proctor scale. In case it is found to be lower, then the Contractor shall redo the job without any additional cost to the Employer. The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the Site in order that the foundation of the various structures can be designed and constructed safely and rationally.

A report to the effect shall be submitted by the Contractor for Employer's specific approval giving details regarding data proposed to be utilised for civil structures design.

8.2.3 SCOPE OF WORK

This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out field investigation as well as, laboratory investigation, analysis and interpretation of data and results, preparation of detailed Geo-technical report including specific recommendations for the type of foundations and the allowable safe bearing capacity for different sizes of foundations at different founding strata for the various structures of the substation. The Contractor shall make his own arrangement for locating the co-ordinates and various test positions in field as per the information supplied to him and also for determining the

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reduced level of these locations with respect to the benchmark indicated by the Employer.

All the work shall be carried out as per latest edition of the corresponding Indian Standard Codes.

8.2.3.1 BORE HOLES

Bore holes of 150 mm diameter in accordance with the provisions of IS: 1892 at the rate of minimum one number bore hole per hectare up to 10 meter depth into virgin soil or to refusal whichever occurs earlier shall be drilled. In any case number of boreholes shall not be less than five. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. Number of boreholes may be increased in case soil strata are varying from borehole to borehole in order to have fair idea of soil profile. In case of pile foundations soil investigation is to be carried out up to 25 m depth from virgin ground level or refusal whichever is earlier. In case rock is encountered, coring in all the boreholes shall be carried out up to 3 meter in rock.

The Contractor shall carry out Standard Penetration Tests at approximately 1.5 m interval in the borehole starting from 1.5 m below ground level onwards and at every change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests.

The Contractor shall collect undisturbed samples of 100/75 mm diameter 450 mm long from the bore holes at intervals of 2.5 m and every change of stratum starting from 1.0 m below ground level onwards in clayey strata.

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor's laboratory without any damage or loss.

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The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-charge.

8.2.3.2 TRIAL PITS

Trial pits shall be carried out at minimum one location per hectare as directed by the Employer. The trial pits shall be 2 m x 2 m in size extending to 4 m depths, or as specified by the Employer. Undisturbed samples shall be taken from the trial pits as per the direction of the Employer.

8.2.3.3 ELECTRICAL RESISTIVITY TEST

This test shall be conducted to determine the Electrical resistivity of soil required for designing safety-grounding system for the entire station area. The specifications for the equipments and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to IS: 3043. The test shall be conducted using Wagner's four electrode method as specified in IS: 1892, Appendix-B2. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.2 m up to a distance of 50.0 m.

8.2.3.4 PLATE LOAD TEST

Plate load test shall be conducted to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to IS: 1888. Modulus of sub grade reaction shall be conducted as per IS: 9214. The location and depth of the test shall be at the Converter Building location at the proposed foundation depth below finished ground level for determining the bearing capacity.

Undisturbed tube samples shall be collected at 1.0 m and 2.5m depths from natural ground level for carrying out laboratory tests.

SECTION 8: CIVIL WORKS

The size of the pit in plate load test shall not be less than five times the plate size and shall be taken up to the specified depth. All provisions regarding excavation and visual examination of pit shall apply here.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs. Settlement shall be kept as specified in IS: 1888.

Backfilling of the pit shall be carried out as per the directions of the Employer. Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

8.2.3.5 WATER SAMPLE

Representative samples of ground water shall be taken when ground water is first encountered before the addition of water to aid drilling of boreholes. The samples shall be of sufficient quantity for chemical analysis to be carried out and shall be stored in air-tight containers.

8.2.3.6 BACK FILLING OF BORE HOLES

On completion of each hole, the Contractor shall backfill all bore holes as directed by the Employer. The backfill material can be the excavated material.

8.2.3.7 LABORATORY TEST

1. The laboratory tests shall be carried out progressively during the field work after sufficient number of samples has reached the laboratory in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.
2. All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant I.S. Codes.

The following laboratory tests shall be carried out

- a) Visual and Engineering Classification
- b) Liquid limit, plastic limit and shrinkage limit for C-Ø soils.

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- c) Natural moisture content, bulk density and specific gravity.
- d) Grain size distribution.
- e) Swell pressure and free swell index determination.
- f) California bearing ratio.
- g) Consolidated drained test with pore pressure measurement.
- h) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic matter and any other chemical harmful to the concrete foundation.
- i) In case of rock samples following tests shall also be conducted:
 - Rock quality designation (RQD), RMR.
 - UCC test.
 - Point load index test.

8.2.3.8 TEST RESULTS AND REPORTS

- i) The Contractor shall submit the detailed report in four (4) copies wherein information regarding the geological detail of the site, summarised observations and test data, bore logs, and conclusions and recommendations on the type of foundations with supporting calculations for the recommendations. Initially the Contractor shall submit draft report and after the draft report is approved, the final report in four (4) copies shall be submitted. The test data shall bear the signatures of the Investigation Agency, Vendor and also site representative of Employer.
- ii) The report shall include, but not limited to the following:-
 - a) A plan showing the locations of the exploration work i.e. bore holes, dynamic cone penetration tests, trial pits, Plate load test etc.
 - b) Bore Logs: Bore logs of each bore holes clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected at various depths shall be clearly shown against that particular stratum.

Test results of field and laboratory tests shall be summarised strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference

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calculations for settlement, bearing capacity, pile capacity shall be enclosed.

- c) The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from the Employer. The observations and recommendations shall include but not limited to the following:
 - i) Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.
 - ii) Recommended type of foundations for various structures. If piles are recommended the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.
 - iii) Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 3.0 (three). Recommendation of liquefaction characteristics of soil shall be provided.
 - iv) Recommendations regarding slope of excavations and dewatering schemes, if required.
 - v) Comments on the Chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.
 - vi) If expansive soil is met with, recommendations on removal or detainment of the same under the structure, road, drains, etc. shall be given. In the latter case detailed specification of any special treatment required including specification of materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.
 - vii) Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.

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- viii) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given.

8.3 SITE PREPARATION

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by the Employer. The Contractor shall give all help in instruments, materials and personnel to the Employer for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

8.3.1 SCOPE

This clause covers the design and execution of the work for site preparation, such as clearing of the site, the supply and compaction of fill material, excavation and compaction of backfill for foundation, road construction, drainage, trenches and final topping by stone (broken hard stone).

8.3.2 GENERAL

- .1 The Contractor shall develop the site area to meet the requirement of the intended purpose. The site preparation shall conform to the requirements of relevant sections of this specification or as per stipulations of standard specifications.
- .2 If fill material is required, the fill material shall be suitable for the above requirement. The fill shall be such a material and the site so designed as to prevent the erosion by wind and water of material from its final compacted position or the in-situ position of undisturbed soil.
- .3 Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted to the density described under Compaction. Excavated material not suitable or not required for backfill shall be disposed off in areas as directed by Employer upto a maximum lead of 2 km.

8.3.3 EXCAVATION AND BACKFILL

- .1 Excavation and backfill for foundations shall be in accordance with the relevant code.
- .2 Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom

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of the excavation level during excavation, concreting and backfilling.

- .3 When embankments are to be constructed on slopes of 15% or greater, benches or steps with horizontal and vertical faces shall be cut in the original slope prior to placement of embankment material. Vertical faces shall measure not more than 1 m in height.
- .4 Embankments adjacent to abutments, culverts, retaining walls and similar structures shall be constructed by compacting the material in successive uniform horizontal layers (not exceeding 15 cm in thickness). (of Loose material before compaction). Each layer shall be compacted as required by means of mechanical tampers approved by the Employer. Rocks larger than 10 cm in any direction shall not be placed in embankment adjacent to structures.
- .5 Earth embankments of roadways and site areas adjacent to buildings shall be placed in successive uniform horizontal layers not exceeding 20 cm in thickness in loose stage measurement and compacted to the full width specified. The upper surface of the embankment shall be shaped so as to provide complete drainage of surface water at all times.

8.3.4 COMPACTION

- .1 The density to which fill materials shall be compacted shall be as per relevant IS and as per direction of Employer. All compacted sand filling shall be confined as far as practicable. Backfilled earth shall be compacted to minimum 95% of the Standard Proctor's density at OMC. The sub grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Cohesion less material sub grade shall be compacted to 70% relative density (minimum).
- .2 At all times unfinished construction shall have adequate drainage. Upon completion of the road's surface course, adjacent shoulders shall be given a final shaping, true alignment and grade.
- .3 Each layer of earth embankment when compacted shall be as close to optimum moisture content as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains any excess moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlapping half the width of the roller each time and progress to the centre of the road or

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towards the building as applicable. Rolling shall also be required on rock-fills. No compaction shall be carried out in rainy weather.

8.3.5 ANTIWEED TREATMENT & STONE SPREADING

8.3.5.1 SCOPE OF WORK

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification and direction of the Employer.

Stone spreading along with cement concrete layer shall be done in the areas of the switchyard under present scope of work within fenced area. Outside the fenced area where no equipment is envisaged, the Employer may carryout landscaping in those areas. Landscaping shall not be in the Contractors scope.

GENERAL REQUIREMENT

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the Employer.

- .1 The material to be used for stone filling/site surfacing shall be uncrushed/crushed/broken stone of 40mm nominal size (ungraded single size) conforming to Table 2 of IS:383 – 1970. Hardness, flakiness shall be as required for wearing courses are given below:

a) Sieve Analysis limits (Gradation)

(IS: 383 – Table – 2)

Sieve Size	% passing by weight
63mm	100
40mm	85-100
20mm	0-20
10mm	0-5

“One Test” shall be conducted for every 500 cu.m.

b) Hardness

Abrasion value (IS: 2386 Part-IV) – not more than 40%

Impact value (IS: 2386 Part-IV) – not more than 30% and frequency shall be one test per 500 cu.m. (With a minimum of one test per source).

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c) Flakiness Index:

One test shall be conducted per 500 cu.m. of aggregate as per IS:2386 Part – I and maximum value is 25%.

- .2 After all the structures/equipments are erected, anti-weed treatment shall be applied in the switchyard where ever stone spreading along with cement concrete is to be done and the area shall be thoroughly de-weeded including removal of roots. The recommendation of local agriculture or horticulture department may be sought where ever feasible while choosing the type of chemical to be used. The anti-weed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be strictly done as per manufacturer's recommendation. Nevertheless the effectiveness of the chemical shall be demonstrated by the Contractor in a test area of 10MX10M (approx) and shall be sprinkled with water at least once in the afternoon everyday after forty eight hours of application of chemical. The treated area shall be monitored over a period of two to three weeks for any growth of weeds by the Engineer – in- charge. The final approval shall be given by Engineer – in –charge based on the results.

Engineer-in-charge shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.

After anti-weed treatment is complete, the surface of the switchyard area shall be maintained, rolled/compacted to the lines and grades as decided by Engineer-in-charge. The sub grade shall be consolidated by using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass. In areas that are considered by the Engineer-in-Charge to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted by plate compactors. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.

The sub grade shall be in moist condition at the time the cement concrete is placed. If necessary, it should be saturated with water for not less than 6 hours but not exceeding 20 hours before placing of cement concrete. If it becomes dry prior to the

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actual placing of cement concrete, it shall be sprinkled with water and it shall be ensured that no pools of water or soft patches are formed on the surface.

Over the prepared sub grade, 75mm thick base layer of cement concrete in 1:4:8 (1 cement :4 fine sand : 8 burnt brick aggregate/ stone aggregate) shall be provided in the area excluding roads, drains, cable trenches as per detailed engineering drawing. For easy drainage of water, the slope of 1:1000 is to be provided from the ridge to the nearest drain. The ridge shall be suitably located at the centre of the area between the nearest drains. The above slope shall be provided at the top of base layer of cement concrete in 24 hours after laying of the cement concrete. The cement concrete shall be laid over a saturated sub-grade to ensure avoiding of leaching of slurry. A layer of cement slurry of mix 1:6 (1 cement: 6 fine sand) shall be laid uniformly over cement concrete layer. The cement consumption for cement slurry shall not be less than 150 kg. Per 100 sq.m.

A final layer of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size (ungraded size) shall be spread uniformly over cement concrete layer after curing is complete.

The filter areas shall be finished with Plain Cement Concrete (PCC) of grade 1:3:6 which shall be at least 100mm thick.

8.3.6 SEWAGE SYSTEM

- a) Sewage system (including collection, treatment and disposal) shall be provided for all utility buildings including the converter buildings, the relay building, and other auxiliary buildings.
- b) For treating the effluents the Contractor shall provide septic tank and soak pit system of suitable size within the stations.
- c) The sewage system shall consist of all necessary piping, pumps (if required), fittings, manholes, clean-outs, piping connections and all other materials required for a safe and efficient sewage system. Sewer pipes and fittings shall conform to the relevant Indian Standards.
- d) Sewers shall be designed for a minimum self cleansing velocity of 0.75 m/sec and the maximum velocity shall not exceed 2.4 m/sec.
- e) Cement concrete pipes or Cast Iron pipes shall be used below ground level. However, salt glazed stoneware pipes can be used

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in localized areas not subject to any traffic load. However, all vertical pipes from the building shall only be cast iron.

- f) Manholes shall be provided at every 30 m along the length, and at connection points, and at every change of alignment, gradient or diameter of a sewer pipeline.

8.3.7 DRAINAGE

8.3.7.1 SITE DRAINAGE

The Contractor shall provide rain water drainage system within the switchyard fencing. Connection at one or more locations to the outfall points located outside the station boundary wall is in the scope of the Contractor. Invert level of drainage system at outfall points shall be decided in such a way that the water can easily be discharged outside the station boundary wall. In case outfall point is more than 50M away from boundary wall, only 50 metre drain outside the boundary wall is in the scope of Contractor. Outfall points shall be got approved by the Employer before commencement of construction. While designing the drainage system following points shall taken care of:

- i) The surface of the switchyard shall be sloped to prevent accumulation of water.
- ii) Drain shall be constructed on both sides of roads. In the switchyard maximum spacing between two drains shall not be more than 100 meter. It shall be ensured that no area is left undrained.
- iii) Open surface rectangular brick drains having minimum 400mm width and 300mm depth with plaster on inner face and top of brick walls shall be provided.
- iv) Longitudinal slope shall not be less than 1 in 1000.
- v) Open surface drains shall be constructed with 100mm thick plain cement concrete 1:2:4 (1cement: 2 coarse sand: 4 stone aggregate 20mm nominal size). PCC 1:2:4 shall be laid over 40mm thick layer of PCC 1:4:8 (1 cement: 4coarse sand: 8 stone aggregate 20mm nominal size.)
- vi) The side wall of the drains shall be 25 mm above the gravel level to prevent falling of gravel into drain. Groove of 125 mm width shall be provided at 2000 mm spacing with suitable mild steel grating..

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- vii) The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8m/sec respectively. However, minimum non-silting velocity of 0.6m/sec shall be ensured.
- viii) Pipe drains shall be provided in areas of switchyard where movement of crane shall be necessary in operating phase of the substation.
- ix) For pipe drains, concrete pipe of class NP2 shall be used. However, for road crossings etc. higher strength pipe of class NP3 shall be provided. For rail crossings, RCC pipes of class NP4 shall be provided. For design of RCC pipes for drains and culverts, IS:456 and IS:783 shall be followed.
- x) Two Nos. of portable pumps of 5 hp capacity for drainage of water shall be provided by the Contractor.
- xi) Pipe drains shall be connected through manholes at an interval of maximum 30m.
- xii) If the invert level of outfall point is above the last drain point in the substation boundary, sump of suitable size has to be constructed within the substation boundary.
- xiii) The drainage scheme and associated drawings shall be got approved from the Employer before commencement of construction.

8.3.7.2 RAIN WATER HARVESTING

In addition to drainage of rainwater in accordance with, the Contractor shall make arrangement for rainwater harvesting also. Rainwater harvesting shall not be done if the depth of water table is within 8.0m from finished ground level.

Rainwater harvesting shall be done by providing two numbers recharge structures with bore wells. The recharge structures shall be suitably located within the sub-station. Branch drains from the main drain carrying rainwater from entire switchyard, shall be connected to the recharge structures.

The internal diameter of recharge shafts shall be 4.5 meter with 230mm thick lining of brick work upto a depth of 2.0 meter from ground level and 345mm thick brickwork below 2.0 meter depth. The brickwork shall be constructed with cement mortar 1:6 (1 cement: 6 coarse sand). The overall depth of shaft shall be 5.0 meter below invert level of drain. The shaft shall be covered with RCC slab for a live load of 300 kg. per sq.m. Two openings of size

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0.7 x 0.7 meter shall be provided in the RCC cover slab. An iron cover made of 5mm thick chequered plate with hinges shall be provided on the openings. Galvanized M.S. rungs of 20mm diameter at spacing of 300 mm shall be provided in the wall of shaft below the opening in the RCC slab to facilitate cleaning of shaft.

A 300 mm diameter bore well shall be drilled in the centre of the shaft. The depth of bore well shall be 5.0 meter more than the depth of sub soil water.

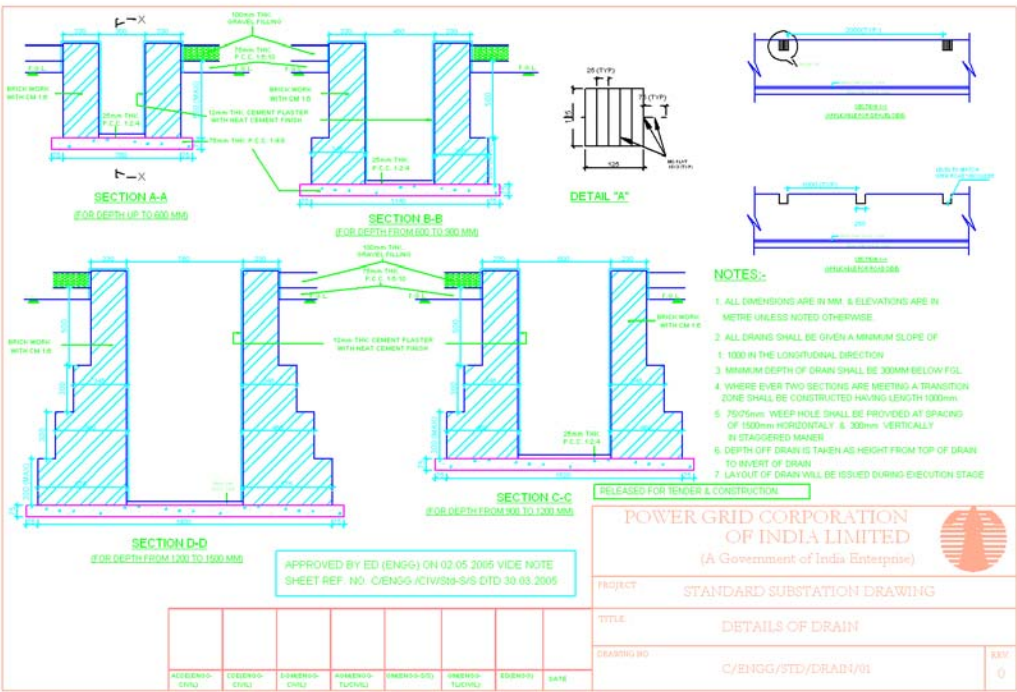
A 100 mm dia medium duty MS pipe conforming to IS 1161 shall be lowered in the bore well keeping bail plug towards bottom of bore well. The pipe shall have 1.58mm holes for 4.0 meter length starting from 1.0 meter from bottom of bore well. Holes of 3.0mm dia shall be provided for a length of 2.0 meter starting from the bottom level of coarse sand and down wards. The overall length of pipe shall be equal to total depth of bore well plus depth of shaft.

Gravel of size 3mm to 6mm shall be filled around 100 dia MS pipe in the bore well. The shaft shall be filled with 500 mm thick layers each from the bottom of shaft with boulders of size 50mm to 150mm, gravel of size 5mm to 10mm, coarse sand having particle size 1.5mm to 2.0mm and boulders of size not less than 200mm respectively.

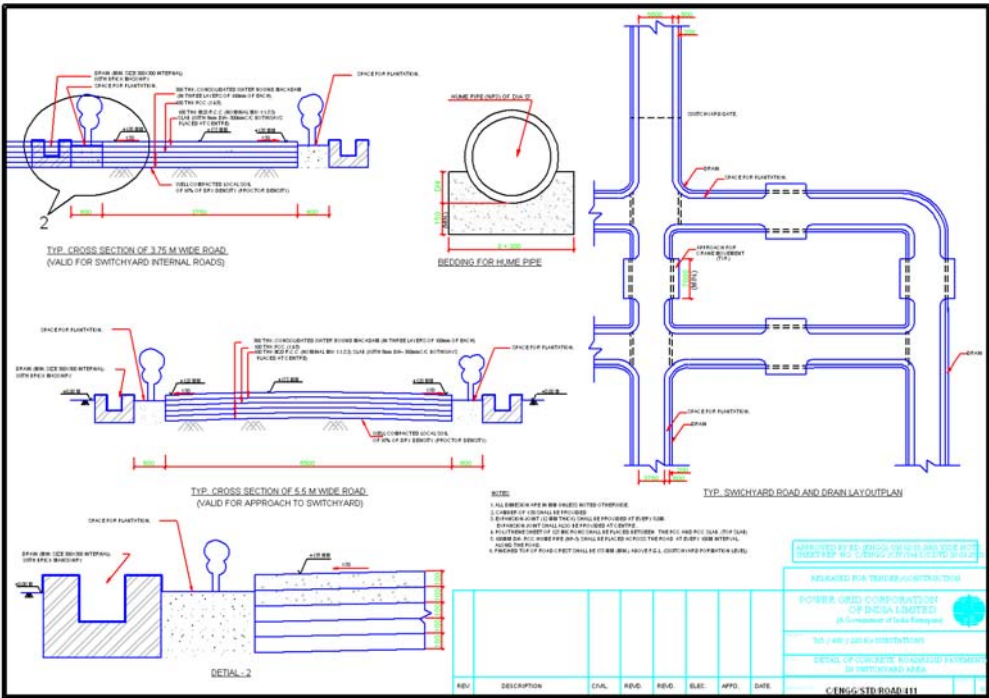
8.3.8 ROADS

- a) All roads shall be concrete road (rigid) pavement.
- b) Adequate turning space for vehicles shall be provided and bend radii shall be set accordingly. Road to the Converter transformer /Reactor shall be as short and straight as possible.
- c) CPWD specification shall be followed for construction of Roads.
- d) Cross section of the road shall be as per drawings C/ENGG/STD/ROAD/410 & 411 enclosed with the tender documents.
- e) All the culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed for class AA loading as per IRC standard / IS code and should be checked for transformer loading.

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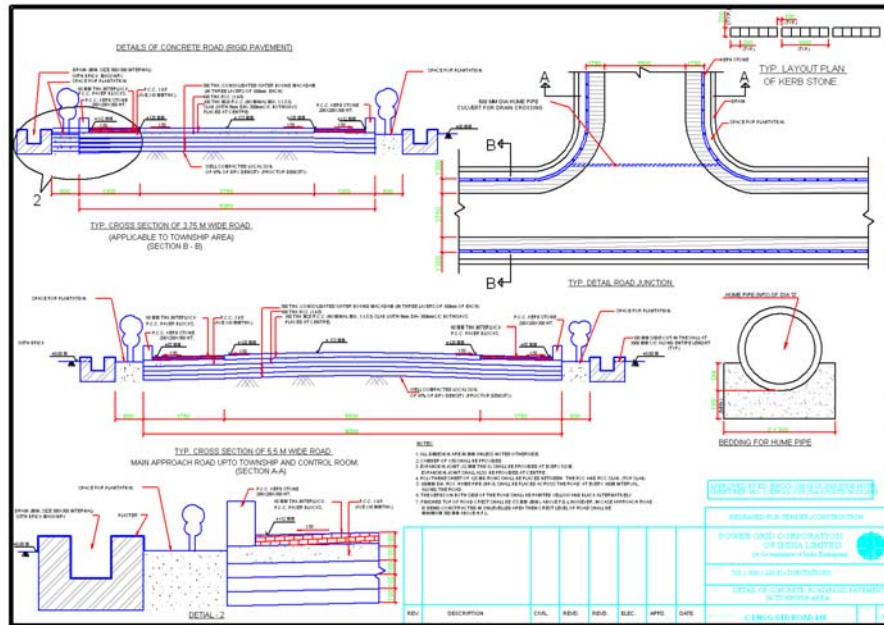


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8.4 FOUNDATIONS AND OTHER RCC CONSTRUCTIONS

8.4.1 GENERAL

- .1 Work covered under this Clause comprises the design, supply and construction of foundations and other RCC constructions for switchyard structures, equipment supports, trenches, drains, jacking pad, pulling block, fencing, boundary wall, control cubicles, bus supports, transformers, reactors, marshalling kiosks, auxiliary equipments & systems, buildings, tanks, rail tracks or for any other equipment or service and any other foundation/RCC construction required to complete the work. This clause is as well applicable to the other RCC constructions.
- .2 Concrete shall conform to the requirements mentioned in CPWD specification and all the tests shall be conducted as mentioned in Standard field quality plan appended with the specification.

A minimum grade of M20 concrete shall be used for all structural/load bearing members. Nominal mix by volume 1:1.5:3 (1cement: 1.5 coarse sand: 3stone aggregate 20mm nominal size) shall be used for all RCC works. Higher grades of concrete can be allowed if Contractor carries out mix design and installs a batching plant or arranges the concrete from a approved ready mix concrete supplier.

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- .3 Where the site is inclined, the foundation height shall be adjusted to maintain the exact level of the top of structures to compensate such slopes.
- .4 The switchyard foundations plinth and building plinth shall be minimum 300 mm and 500 mm above finished ground level respectively.
- .5 Minimum 75 mm thick lean concrete 1:4:8 (1 cement : 4 coarse sand : 8 stone aggregate 40mm nominal size) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.
- .6 Concrete made with ordinary Portland cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering. Portland pozzolone / slag cement can be used, however 53 grade cement shall be used with specific approval of Employer.

8.4.2 DESIGN

- .1 All the foundations shall be of reinforced cement concrete. The design and construction of RCC structures shall be carried out as per IS-456.
- .2 The design and construction of steel-concrete composite beam shall be carried out as per IS-11384.
- .3 For detailing of reinforcement IS-5525 and SP:34 shall be followed. Cold twisted deformed bars ($F_y=415 \text{ N/mm}^2$) conforming to IS-1786 or Thermo – mechanically treated bars of equal grade shall be used as reinforcement. However, in specific areas, mild steel (Grade I) conforming to IS-432 can also be used with specific approval of the Employer. Two layers of reinforcement (on inner and outer face) shall be provided for wall & slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per IS: 456 (latest).
- .4 RCC water retaining structures like storage tanks, cooling water basin etc. shall be designed as un-cracked section in accordance with IS-3370 (Part I to IV) by working stress method. However, water channels and substructure of pump house shall be designed as cracked section with limited steel stresses as per IS-3370 (Part I to IV) by working stress method.
- .5 The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and/or equipment and/or superstructure, and other conditions,

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which produces the maximum stresses in the foundation or the foundation component and as per relevant IS codes.

- .6 The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof. The spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.
- .7 When pile foundations are adopted, the same shall be cast-in-situ/driven/bored or pre-cast type as per relevant IS. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the Contractor showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the Contractor at their entire cost, to establish the piles design capacity. Only after the design capacity of piles has become established, the Contractor shall take up the job of piling. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.
- .8 All foundations shall rest below virgin ground level and the minimum depth of foundation below the virgin ground level shall be at least 1000 mm. For small equipments & minor foundations like marshalling kiosks, pylon supports, cable trenches, drains, etc., this may be reduced to 500 mm with specific approval of the Employer.

All R.C.C. piles (including short piles) shall be suitably anchored into hard virgin strata. The friction resistance of back fill earth shall be neglected for calculation of pile capacity for design purposes, however negative friction due to earth fill, if any, has to be duly considered for deciding pile capacity.

- .9 Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.
- .10 Necessary insulation shall be provided in reinforcement steel to avoid closed loops, wherever required e.g. reactor foundations.
- .11 Necessary protection to the foundation work, if required, shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/ harmful to the concrete foundations.

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- .12 RCC columns shall be provided with rigid connection at the base.
- .13 All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant IS Codes or as stipulated elsewhere in the Specifications.
- .14 Earth pressure for all underground structures shall be calculated using coefficients of earth pressure at rest; co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of substructure of any underground enclosures, earth pressure at rest shall be considered.
- .15 In addition to earth pressure and ground water pressure etc., a surcharge load of minimum 2 T/sq.m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, substructure of any underground hollow enclosure etc., to account for the vehicular traffic in the vicinity of the structure.
- .16 Following conditions shall be considered for the design of substructure of pump house, channels, sumps, tanks, trenches and other underground structures :-
 - a) Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (applicable only to structures which are liable to the filled up with water or any other liquid).
 - b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
 - c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.
- .17 Base slab of the any underground enclosure/tank shall also be designed for its empty condition during construction and maintenance stages with maximum ground water table (GWT). Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.
- .18 Base slab of any underground enclosure like water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with

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maximum GWT. Intermediate dividing piers of such enclosure shall be designed considering water in one pump sump only and the other pump sump being empty e.g. for maintenance.

- .19 The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate. Foundation settlements shall, in no case, exceed the permissible limits specified in relevant Indian Standard Specification.

- .20 All machine foundations shall be designed in accordance with the provisions of the relevant parts of IS-2974, IS-456 and IS-2911. The provisions of DIN-4024 (latest) shall also be followed.

For the foundations of rotating machines, detailed static and dynamic analysis shall be done. A fatigue factor of at least 2.0 shall be considered for dynamic forces. Minimum reinforcement shall be governed by IS-2974 as well as IS-456. RCC design shall be done by working stress method.

For the foundations supporting minor equipments weighing less than one ton or if the mass of the rotating parts is less than one-hundredth of the mass of the foundation, dynamic analysis is not must. However, if such minor equipment is to be supported on building structures, floors etc. suitable vibration isolation shall be provided by means of springs, neoprene pads etc. and such vibration isolation system shall be designed suitably.

- .21 All other foundations shall be designed in accordance with the provisions of the relevant parts IS-2911 and IS-456.
- .22 The gantry/tower foundations shall be designed for factor of safety of 2.2 for normal and broken wire condition and 1.65 for combined short circuit and broken wire condition.
- .23 Minimum two piles shall be provided in any pile group.

8.4.3 ADMIXTURES & ADDITIVES

- .1 Only approved admixtures shall be used in the concrete for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.

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- .2 Admixtures in concrete shall conform to IS-9103. The water proofing cement additives shall conform to IS-2645. Concrete Admixtures/Additives shall be approved by the Employer.
- .3 The Contractor shall use an approved neutralized vinsol resin or air-entraining agent in concrete. The Air-entraining agent shall be supplied and batched as a solution with a solid content not exceeding 15% by weight with suitable, stable and consistent pH. Air- entraining requirements shall be in accordance with CP 100 Part I.
- .4 The Contractor can propose and the Employer, at his discretion, may approve the use of a water-reducing set retarding admixture in some of the concrete. The use of such an admixture shall not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid overcoming unusual circumstances and placing conditions.
- .5 The water-reducing set-retarding admixture shall be an approved brand of ligno-sulphonate type admixture.
- .6 The water proofing cement additives shall be used only after approval of the Employer.

8.4.4 HOT WEATHER REQUIREMENTS

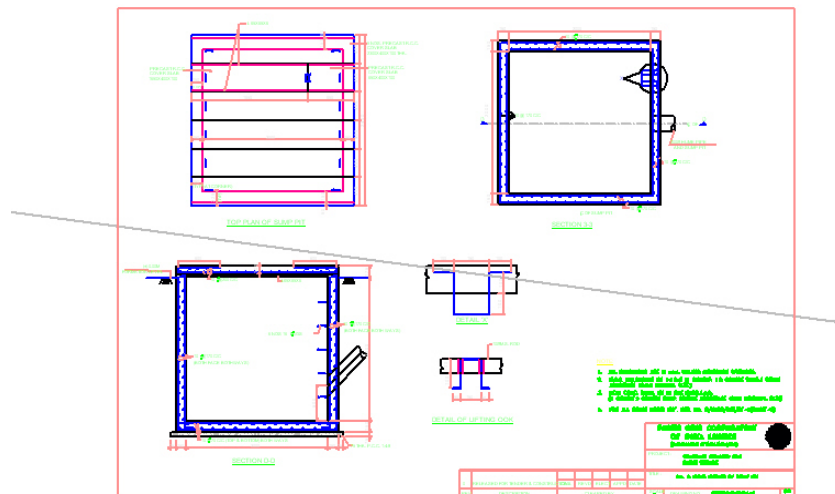
- .1 During hot weather all necessary precautions, as per relevant Codes, shall be taken to avoid premature stiffening of the fresh mix and to reduce water absorption and evaporation losses and when the temperature of the surrounding air is higher than 30°C. The following shall apply unless otherwise approved by the Employer:
 - a) The formwork shall be continuously sprayed with cold water in advance of concreting and excess water shall be removed from inside the forms immediately prior to placement of concrete.
 - b) The reinforcement and the formwork (if metal forms are used), shall be protected from the effects of hot winds and direct sunlight.
 - c) Suitable barriers shall be provided to protect the freshly placed concrete from wind until the concrete is sufficiently hard to allow it to be covered according to (e) below.

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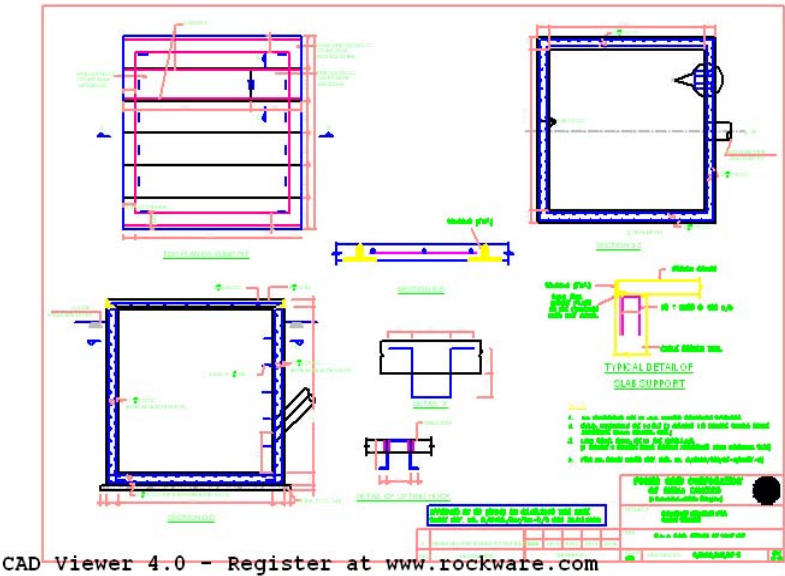
- d) The concrete when placed shall be maintained at a temperature of less than 30 degree C by the use of chilled mixing water or by spraying the aggregate with cold water.
 - e) The concrete shall be mixed, transported, placed and consolidated, as rapidly as possible and shall then be covered with an impervious membrane or wet Hessian until moist curing beings.
- .2 Curing compounds shall not be used as an alternative to the requirements of Clause 8.4.3.
- .3 During hot weather (atmospheric temperature above 40 deg C) or cold weather (atmospheric temperature at & below 5 deg C) the concreting shall be done as per the procedure set out in IS-7861 (Part I & II).

8.5 CABLE & PIPE TRENCHES

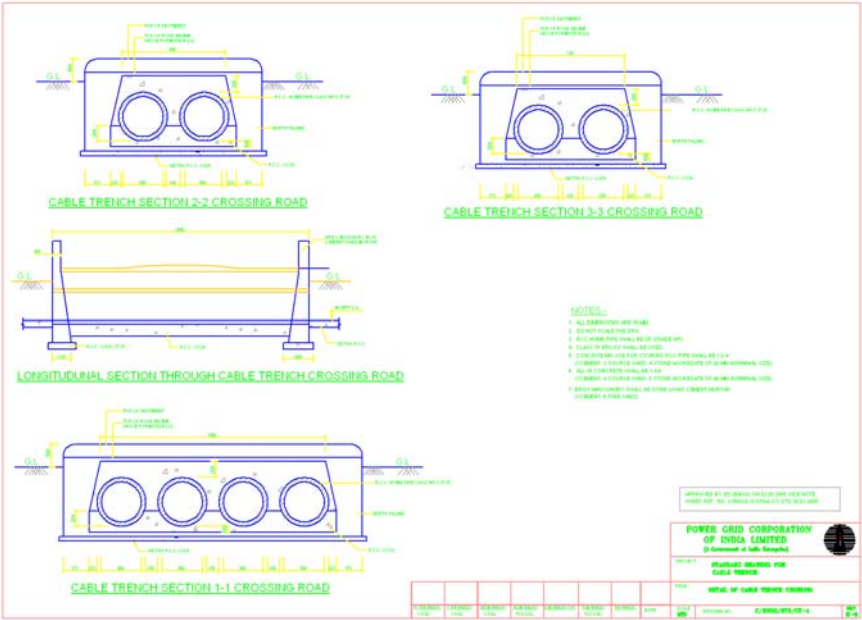
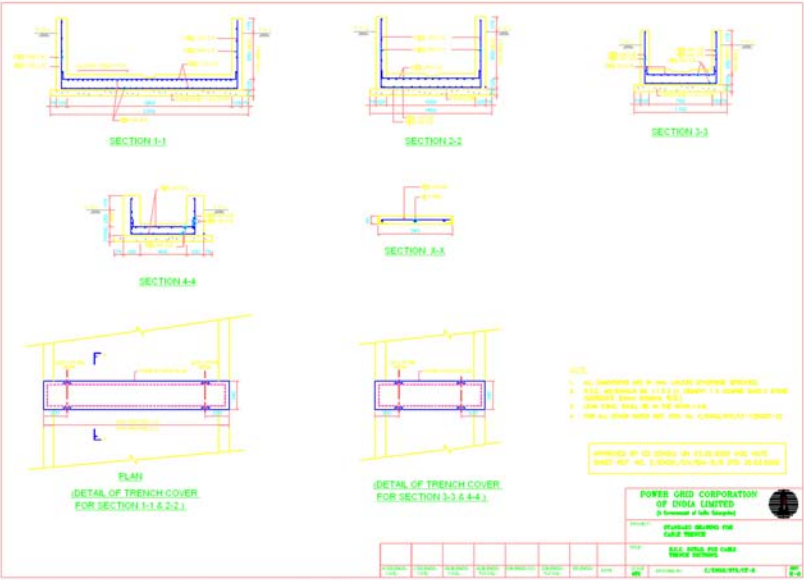
- .1 RCC trenches and pre-cast removable concrete covers (with lifting arrangement) shall be designed to withstand loads of 1000 kg/m² from maintenance trucks and a concentrated load of 200 kg at mid span of cover. Cable trenches shall also be designed with water pressure along with earth pressure.
- .2 Trenches shall be of reinforced cement concrete, having minimum M-20 grade of concrete. The standard / typical trench drawing is indicated below:



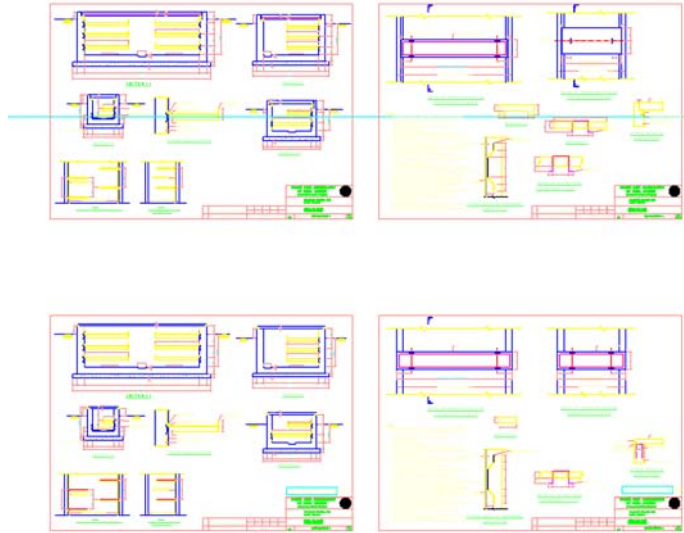
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(Typical drawing of cable trench)

- .3 Trenches shall be drained. Necessary sumps and sump pumps shall be supplied, as required. Cable trenches shall not be used as storm water drains.
- .4 The top of trenches shall be kept at least 150 mm above the final gravel level and be constructed such that the surface rain water do not enter the trench.
- .5 All metal parts inside the trench shall be connected to the grounding system.
- .6 Cables from trench to equipment shall run in hard conduits that are heavy duty PVC or GI pipe.
- .7 Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.
- .8 A clear (vertical) space of at least 300 mm shall be available for each tier in cable trench. From trench bed to lowest tier, a minimum clearance of 200 mm shall be available for one tier trench & 300 mm for trench having tiers more than one.

At least the following tray to opposite wall (and between trays for multi row trench) clear clearance shall be available:

For trenches having	minimum
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depth	clearance
< 500 mm	200 mm
501 - 1000 mm	400 mm
> 1000 mm	500 mm

Instead of cable trays, the Contractor may use steel brackets as per section 6.16 of this specification.

- .9 The trench bed shall have a slope of 1/1000 along the run & 1/250 perpendicular to the run.
- .10 All construction joints of cable trenches i.e. between base slab to base slab and the junction of vertical wall to base slab as well as from vertical wall to wall shall be provided with approved quality PVC water stops of approx. 230 mm x 5 mm size for those cable trenches where the ground water table is expected to be above the junction of base slab and vertical wall of cable trenches.

Suitable expansion joints with PVC water stops and bitumen impregnated board sealing shall be provided at an approximate interval of 30 m for all sections of cable trenches.

8.6 CONVERTER TRANSFORMER / REACTOR FOUNDATION, RAIL TRACK/ ROAD CUM RAIL TRACK

The Contractor shall provide a RCC Rail cum road system integrated with the transformer foundation to enable installation and the removal of any failed unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. The rail cum road track shall be provided all along the length of the transformer area covering both Pole I and Pole II so that any failed unit can be moved from its foundation to the nearest road. If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with I.R.C. standard / relevant IS. The permanent transfer track system shall have RCC raft type foundation integrated with the converter transformer foundations. The road cum rail track shall be of RCC construction and the surface shall be rendered smooth and suitable drainage system shall be provided.

The Contractor shall provide a pylon support system for supporting the fire fighting system.

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Each converter transformer, auto transformer and smoothing reactor (if oil filled) including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the converter transformer shall be 20% of the transformer height or 0.8m whichever is more. The oil collection pit thus formed shall have a void volume equal to minimum 20% volume of total oil in the converter transformer. The oil collection pits below the converter transformers shall be suitably connected through RCC pipes on pole basis. The pipes shall be placed in such a way so that oil can flow from one pit to the main collection sump pit. Only one main collection sump pit per station shall be made.. The volume of main oil collection pit shall be 220 % of the largest transformer oil volume. (for example large transformer oil volume is 100 kL, then the main collection pit oil volume shall be 220 kL). Similarly separate pipe connection shall be made from individual pole to the main collection sump pit. The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside the pit. The bottom of the pit shall have a uniform slope towards a main collection sump pit. While designing the oil collection sump pit, the movement of the transformer must be taken into account.

The pits shall be covered with a grating made of MS flat of minimum size 40mmx 5mm placed at 30mm centre to centre and 25mmx5mm MS flat at spacing of 100mm at right angle to each other. Maximum length of grating shall be 2000mm and width shall not be more than 500mm. The gratings at intermediate location shall be supported on ISMB 150mm, shall be placed at the formation level and shall be covered with 100mm thick layer of broken/crushed/non-crushed stone having size 40mm to 60mm which acts as an extinguisher for flaming oil.

Each oil collection pit shall be drained towards a sump pit within the collection pit whose role is to drain water and oil within the collection pit so that collection pit remains dry.

Complete foundation shall be made of reinforced cement concrete.

A pump of suitable rating with auto start and auto stop features shall be supplied and installed in main collection sump pit by the Contractor to drain out the fire fighting & rain water and oil if any from the sump pit in to the nearest drain.

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8.7 FIRE PROTECTION WALLS

8.7.1 GENERAL

Fire protection walls shall be provided, if required, in accordance with Tariff Advisory Committee (TAC) recommendations.

A fire wall shall be erected between each phase of the converter transformers (in the case of single phase equipment) to protect each one from the effects of fire on another.

Also, if the free distance between the converter building and the converter transformers is less than 10 m, a fire wall shall be erected between the building and the equipment, or otherwise the building walls shall be fire resistant.

8.7.2 FIRE RESISTANCE

The firewall shall have a minimum fire resistance of 3 hours. The partitions, which are made to reduce the noise level, shall have the same fire resistance. The walls of the building, which are used as firewalls, shall also have a minimum fire resistance of 3 hours.

The firewall shall be designed to protect against the effect of radiant heat and flying debris from an adjacent fire.

8.7.3 DIMENSIONS

The firewall shall extend 600 mm on each side of the Converter transformer and 600 mm above the conservator tank or safety vent.

These dimensions might be reduced in special cases, as per the approval of Employer where there is lack of space. A minimum of 2.0 meter clearance shall be provided between the equipments e.g. Converter transformer and firewalls.

The firewall shall be made of reinforced concrete (M-20 grade), as per the system requirements.

8.8 STEEL STRUCTURES

8.8.1 GENERAL

The scope of specification covers design (except design of those tower structures of AC switchyard which are enclosed with the specification), fabrication, proto-assembly, supply and erection of galvanised steel structures for towers, girders, lightning masts and equipment support structures. The scope shall include supply and erection of all types of structures including bolts, nuts, washers,

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hangers, shackles, clamps anti-climbing devices, bird guards, step bolts, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates and any other items as required to complete the job.

The connection of all structures to their foundations shall be by base plates and embedded anchor/foundation bolts. All steel structures and anchor/foundation bolts shall be fully galvanized. The weight of the zinc coating shall be at least 0.610 kg/m² for anchor bolts / foundation bolts and for structural members. One additional nut shall be provided below the base plate which may be used for the purpose of levelling.

For filter equipment and valve cooling towers etc anchor fasteners (e.g. Hilti etc) may be used.

8.8.2 REQUIREMENTS

For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on IS:875, Parts I to V. For materials and permissible stresses IS: 802, Part-I, Section-2 shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.

.1 The minimum thickness of members shall be as follows:

	Open Section	Closed Section
Leg members	6 mm	4 mm
Bracing members	5 mm	4 mm
Redundant members	4 mm	4 mm

.2 The maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per IS-802.

.3 The minimum distance from hole centre to edge shall be 1.5 x bolt diameter and the minimum distance between centre to centre shall be 3.0 x bolt diameter.

.4 The minimum bolt diameter shall be 16 mm.

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- .5 In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices.
- .6 Following design criteria shall be adopted for design of switchyard structures:
 - a) All structures shall be designed for the worst combination of dead loads, live loads, wind loads as per IS-875, seismic forces as per IS-1893, loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including "snatch" in the case of bundled conductors etc. Short circuit forces shall be calculated in accordance of IEC-865 considering a fault level of 40.0 kA.
 - b) Switchyard gantry structures shall be designed for the condition of all the three wires on one side being broken. The design of all structures shall be based on the condition where stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.

A factor of safety of at least 2.0 under normal as well as broken wire conditions and 1.5 under combined short circuit & broken wire conditions shall be considered for the design of switchyard structures.
 - c) For purpose of design, static tension pull & transverse reaction on the gantries as calculated for each individual span shall be considered. Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be considered. Weight of man with tools shall be considered at least 150 kgs for the design of structures.
 - d) Terminal/line take off gantries shall be designed for a minimum conductor tension of 4 MT per phase or as per above requirement, whichever is more for 400 kV switchyard. The design of the terminal gantries shall also be checked considering +/- 30 degrees deviation of conductor in both vertical and horizontal planes.
- .7 The girders shall be connected with lattice columns by bolted joints.
- .8 All equipment supports shall be designed for the worst combination of dead loads, erection load, wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars as per IS- 806.

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.9 The design of steel structures for buildings shall be done by working stress method based on IS: 800.

8.8.3 BOLTING

- i) Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.
- ii) All steel items, bolts, nuts and washers shall be hot dip galvanised.
- iii) 2% extra nuts and bolts shall be supplied for erection.

8.8.4 WELDING

The work shall be done as per approved fabrication drawings which clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld etc. Symbols for welding on erection and shop drawings shall be according to IS:813. Efforts shall be made to reduce site welding so as to avoid improper joints due to constructional difficulties.

8.8.5 FOUNDATION BOLTS

Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate.

The Contractor shall be responsible for the correct alignment and levelling of all steel work on site to ensure that the towers/structures are plumb.

All foundation bolts for lattice structure, pipe structure are to be supplied by the Contractor.

All foundation bolts shall be fully galvanised so as to achieve 0.61 kg. per m² of Zinc Coating as per specifications.

All foundation bolts shall conform to IS:5624 but the material however shall be MS conforming to IS:2062.

8.8.6 STABILITY OF STRUCTURE

The Supplier shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

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8.8.7 GROUTING

The method of grouting the column bases shall be subject to approval of Purchaser and shall be such as to ensure a complete uniformity of contact over the whole area of the steel base. The Contractor shall be fully responsible for the grouting operations.

8.8.8 GALVANISING

All structural steel works and pipe supports shall be galvanised after fabrication. Zinc required for galvanising shall have to be arranged by the manufacturer. Purity of zinc to be used shall be 99.95% as per IS: 209.

The Contractor shall be required to make arrangement for frequent inspection by the Purchaser as well as continuous inspection by a resident representative of the Purchaser, if so desired for fabrication work.

8.8.9 TOUCH-UP PAINTING

The touch up primers and paints shall consist of Red Oxide / Zinc chromate conforming to the requirements of IS: 2074 with a pigment to be specified by the Employer.

8.9 CHAINLINK FENCING AND GATE

8.9.1 AREAS REQUIRING FENCING

Fencing shall be provided for the complete converter stations. Fencing shall also be provided for equipments mounted on ground or at a height lower than 2.5m. Necessary gates shall be provided for each area so fenced.

8.9.2 MATERIALS

The minimum requirements are as follows:

a) Chain link fence fabric (without galvanization) in accordance to IS:2721.

1. Size of mesh: 75mm
2. Nominal wire size: 3.15mm dia meter
3. Width of chain link: 1500mm

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4. Painting: Two or more coats of approved standard make synthetic enamel paint over a coat of standard steel primer.

b) Posts

The posts shall be of medium M.S. tubes of 50mm diameter conforming to grade Yst-22 (Kg/mm²). The tubes shall also conform to IS: 1161/IS 806. The length of tubular post shall be 2600 mm.

An M.S. base plate of size 160 X 160 X 6mm thick shall be welded with the tubular post. The post shall be provided on the top with M S plate.

The tubular post shall be welded with 8 number of M S flat of size 50 x 6mm – 75mm long. Two number of 13.5 mm diameter holes on each cleats shall be provided to bolt the fence fabric panel. The cleats shall be welded at equal spacing in such a way that 4 numbers of cleats are on one side and remaining 4 cleats are on the opposite side of the post. The cleats on the corner posts shall be welded in such a way that it suits the site requirement.

The whole assembly of tubular post shall be hot dip galvanized. The zinc coating shall be minimum 610 gram per sq. meter. The purity of zinc shall be 99.95% as per IS:209.

c) Fence Fabric Panel

Chain link fencing shall be fabricated in the form of panel 1300 X 2928 mm. An M.S. flat of at least 50x6 mm size shall be welded all-round fence fabric to form a panel. Four pairs of 13.5mm diameter holes on the vertical M S flat matching the spacing of holes in cleats fixed with pipe as shown in the drawing shall be provided to fix the fence panel with the tubular posts. A washer shall also be provided below each nut. The Contractor, for fixing the panels, shall supply the 12mm diameter bolts including nuts and washers. All nuts, bolts and washers shall be hot dip galvanized.

The fence panel shall be provided with two or more coats of approved standard synthetic enamel paint over approved standard steel primer.

d) Installation

- i) Fence shall be installed as shown in the approved drawings.
- ii) All posts shall be 3.0m apart measured parallel to ground

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surface.

- iii) Posts shall be set in 1:2:4 Plain Cement Concrete block of minimum 0.40x0.40x1.2m depth. 75mm thick plain cement concrete 1:4:8 shall be provided below concrete blocks. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.
- iv) Fence fabric shall not be installed until concrete has been cured for a minimum of 7 days.
- v) Fence fabric panel shall be fixed to the post by 4 nos. MS flat each of 50x6, 75 long through 2 nos. of bolts (12 diameters) on each flat.
- vi) The painting pattern of fence panels shall be decided by Engineer-in- charge.

e) Gate

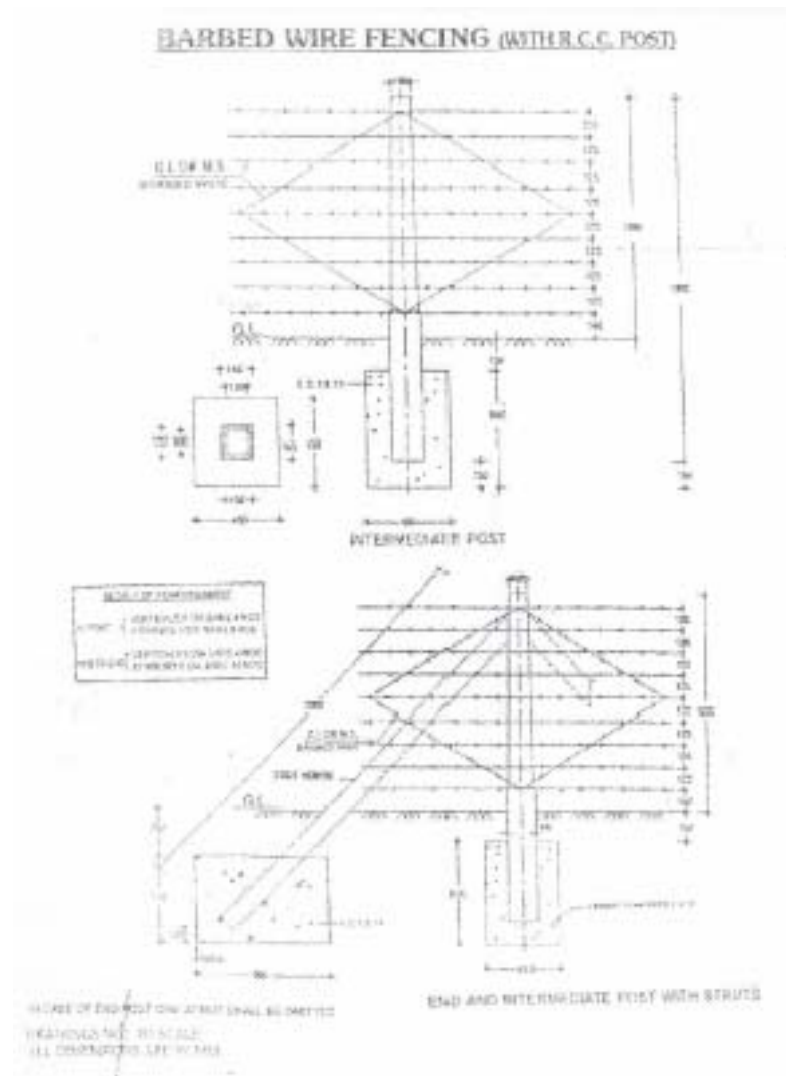
- i) The gate shall be made of medium duty M.S. pipe conforming to relevant I.S. with welded joints. The main frame (outer frame) of the gate shall be made of 40mm dia pipe and vertical pipes of 15mm dia @ 125mm spacing (maximum) shall be welded with the main frame. Other details shall be as shown in the drawing.
- ii) The gates shall be fabricated with welded joints to achieve rigid connections. The gate frames shall be painted with one coat of approved steel primer and two coats of synthetic enamel paint.
- iii) The gates shall be provided with suitable locking arrangement.
- iv) The main gate shall be 5.0m wide and shall be of double leaf type (as shown in the drawing). Next to the main gate, a man gate (1.25m wide single leaf) shall also be provided.
- v) The main gate shall be motorised .
- vi) Gate shall be installed in location as shown in approved G.A. drawing.

f) Electrode station fencing:

The fence shall be 1.2 m high comprising of 1.8 m RCC standard posts, with wooden plugs or 6 mm bar nibs, placed every 3 m apart embedded in cement concrete blocks. Every 15th post, last but one end post and corner post shall be struted on both sides and end post on one side only. There shall be nine parallel

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horizontal lines of barbed wire 9.38 kg per 100 metres (minimum) between the two posts fitted and fixed with GI staples on wooden plugs or GI binding wire tied to 6 mm bar nibs. In addition to horizontal lines, two diagonals shall also be provided between the posts. The RCC posts and fencing shall be provided as per the enclosed drawing.



8.10 BUILDINGS

8.10.1 GENERAL

8.10.1.1 DIMENSIONS

The building design shall take into consideration the layout of the panels, equipments, etc, in order to allow enough area for maintenance.

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An open space as per IE rules shall be provided on the periphery of the rows of panels, and equipment generally, in order to allow easy operator movement and access as well as maintenance.

8.10.1.2 ELECTROSTATIC/RADIO INTERFERENCE SHIELDING

The buildings inside the energized area of the stations shall be electro statically shielded to limit the exposure of the equipment & personnel to specified electric field strengths. The shielding system shall be grounded properly.

The valve halls shall be provided with interference screening. In addition, the control and cable termination rooms shall be suitably screened to minimize radio interference.

8.10.1.3 DESIGN

a) The buildings shall be designed:

- .1 to the requirements of the National Building Code of India, and the standards quoted therein, and as specified in this Specification;
- .2 for the specified climatic & loading conditions;
- .3 to adequately suit the requirements of the equipment and apparatus contained in the buildings and in all respects to be compatible with the intended use and occupancy;
- .4 with a functional and economical space arrangement;
- .5 For a life expectancy of structure, systems and components not less than that of the equipment which is contained in the buildings;
- .6 To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design;
- .7 to allow for easy access to equipment and maintenance of the equipment; wherever access to roof is required, RCC stair case shall be provided.
- .8 With, wherever required, fire retarding materials for walls, ceilings, doors etc., which would prevent supporting or spreading of fire;
- .9 with material preventing dust accumulation.
- .10 all structural steel inside the valve hall shall be provided with suitable epoxy/PU coating.

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- b) Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns.
- c) Individual members of the buildings frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion etc.
- d) Permissible stresses for different load combinations shall be taken as per relevant IS Codes.

8.10.1.4 DESIGN LOADS

Building structures shall be designed for the most critical combinations of dead loads, super-imposed loads, equipment loads, erection loads, crane loads, wind loads, seismic loads, short circuit loads and temperature loads. Dead loads shall include the weight of structures complete with finishes, fixtures and partitions and shall be taken as per IS-1991.

Super-imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/hangers and erection, operation & maintenance loads. Equipment loads shall constitute, if applicable, all load of equipment to be supported on the building frame including those expected during erection.

For crane loads an impact factor of 30% and lateral crane surge of 10% of (lifted weight + trolley weight) shall be considered in the analysis of frame according to provisions of IS-875. The horizontal surge shall be 5% of the static wheel load.

The wind loads and seismic forces shall be computed as specified in section 2 of this specification. Response spectrum method shall be used for the seismic analysis using at least first five modes of vibration.

For temperature loading, the total temperature variation shall be considered as $\frac{2}{3}$ of the average maximum annual variation in temperature. The average maximum annual variation in temperature for the purpose shall be taken as the difference between the mean of the daily minimum temperature during the coldest month of the year and mean of daily maximum temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50% of the total temperature variation.

Wind and Seismic forces shall not be considered to act simultaneously.

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Floors/slabs shall be designed to carry loads imposed by equipment, cables, piping, travel of maintenance trucks (if required) and equipment and other loads associated with the building. In general, floors shall be designed for live loads as per relevant IS and cable and piping loads, if applicable, of not less than 5 kN/sq.m hanging from the underside.

In addition, beams shall be designed for incidental point loads of 20 kN to be applied at any point along the beams. The floor loads shall be subject to the Employer's approval.

For consideration of loads on structures, IS-875, "Code of practice for structural safety of buildings" shall be followed. The following minimum superimposed live loads shall, however, be considered for the design:

- a) 150 kg/m² for accessible roofs
- b) 75 kg/m² for non-accessible roofs
- c) RCC Floors: 500 kg/m² or actual requirement, if higher than 500 kg/m², based on equipment weight and layout plans.
- d) Stairs & balconies 500 kg/m²
- e) Toilet Rooms 200 kg/m²
- f) Chequered plate floor 400 kg/m²
- g) Walkways 300 kg/m²

8.10.1.5 SUBMISSIONS

The following information shall be submitted for review and approval to the Employer:

- .1 Design criteria for structural steel and reinforced concrete design. The criteria shall comprise the codes and standards used, applicable climatic data including wind loads, earthquake factors and maximum and minimum temperatures applicable to the building locations, assumptions of dead and live loads, including equipment loads impact factors, safety factors and other relevant information.
- .2 Structural design calculations and drawings (including construction/fabrication) for all reinforced concrete and structural steel structures.
- .3 Fully dimensioned floor plans, cross sections, longitudinal sections and elevations of each building identifying the major building components.

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- .4 Fully dimensioned drawings showing details and sections drawn to scales of sufficient size to clearly show sizes and configuration of the building components and the relationship between them.
- .5 Product information of building components and materials, including walls, partitions, flooring, ceilings, roofing, doors, wall panelling and windows and building finishes.
- .6 A detailed schedule of building finishes including colour schemes.
- .7 A door & window schedule showing door & window types and locations, lock sets and latch sets and other door hardware.

Approval of the above information shall be obtained before ordering materials or starting fabrication or construction as applicable.

8.10.1.6 FLOORS, WALLS & ROOFS

All walls shall be non-load bearing in filled panel walls.

Design of RCC floor/roof slab shall be carried out either by limit state method or working stress method.

Ground floor slab of buildings shall be of RCC of M20 grade, minimum 150 mm thick. Reinforcement shall consist of minimum 8 mm diameter bars at 200 mm c/c at top in both directions.

Sunken RCC slab shall be provided in false flooring area and toilet area so as to keep the finished floor level of these areas same as that of the surrounding area.

All RCC roofs shall be provided with access through a RCC staircase.

Minimum height of skirting above finished floor level shall be 150 mm.

All up stands and parapet walls on roof shall be of RCC construction for all buildings. Minimum height of parapet walls shall be 750 mm.

All the air-conditioned areas shall be provided with false ceiling.

8.10.2 CONVERTER BUILDING

8.10.2.1 GENERAL

Converter buildings are required at each converter station to house the converter valves and associated equipment, the mechanical and electrical equipment and any other facilities required for other services.

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8.10.2.2 FIRE SEPARATIONS

Each valve hall shall be isolated against the spread of fire by fire wall of three hour rating. These walls shall be of RCC construction or auto clave cellular concrete blocks (e.g. Siporex or equivalent), fire bricks or 3 hours fire rated sandwiched wall panels (e.g. Paroc or equivalent). The wall shall comply to TAC norms.

All openings in between different segregated fire zone areas shall be suitably sealed.

8.10.2.3 BUILDING ENVIRONMENT

The valve hall building shall be pressurized to prevent the ingress of unfiltered air. In addition, the building shall be properly sealed to minimize the flow of outside air into it and vice versa. Openings for equipment and services shall be weatherproof. The Building environment shall be controlled as specified in section 7.

8.10.2.4 BUILDING ARRANGEMENT

The converter building arrangement shall be fit for the valves and associated equipment.

The layout of the converter area buildings comprising the valve halls and the service building shall be submitted to the Employer's for approval. The layout shall be generally in line with the sketch shown below:

Pole (A)	4	(B)	Pole (C)	2	SB (D)	Pole 1(E)	(F)	Pole (G)	3
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A	Valve Hall Pole 4: Bipole 2
B	Valve cooling & valve hall ventilation for pole 2 and 4; LT room, battery room and control & protection room for Pole 4
C	Valve Hall Pole 2: Bipole 1
D	Main service building consisting of main control room with VPS, LT room, battery room and control & protection room for Pole

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	1 and 2
E	Valve Hall Pole 1: Bipole 1
F	Valve cooling & valve hall ventilation for pole 1 and 3; LT room, battery room and control & protection room for Pole 3
G	Valve Hall Pole 3: Bipole 2

The main floor shall be above grade and shall be designed and constructed to ensure that flooding shall not occur. No floor below grade shall be accepted.

Convenient routing of cables from the switchyard into the building shall be considered.

The converter building shall be oriented to offer convenient tie-in to the ac and dc switchyards.

8.10.2.5 VALVE HALLS

The valve halls shall have ample clearances such that the inspection of valves can be possible and allow access of mobile valve servicing equipment without any dismantling. The valve shall also have provision for monorail/rolling bridge suitable for the hoist described in Section 7.

The valve halls shall be arranged so that each valve hall can be fully maintained from the service block with the other valve hall in operation. Necessary key interlocking scheme for restricted area of valve halls shall be employed for safe operation.

Observation windows in the each valve hall shall be provided so that almost whole area of the valve hall is within line of vision when looked from control room floor.

Maintenance of valve auxiliaries which are located at ground potential including valve base electronics, cooling equipment and cabling shall be possible with the valve group energized.

Doors, windows and walls between service block and valve shall be of fireproof type. All trenches leading out shall be sealed with fire proof material. The doors shall be perfectly air tight.

The Valve hall building may consist of either RCC framed or steel framed structure with moment connection in transverse direction

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and with bracings in longitudinal direction to transfer the horizontal forces. Columns can have either hinged or fixed connection at the base. Auxiliary structure shall be of steel consisting of either moment resistant 2-D frames or braced connection may be provided to transfer the horizontal load to the foundation. Design shall be carried out by working stress method.

Structures shall have either complete welded joints shop fabricated part with welded joints. Erection joints can be bolted joints with high strength friction grip bolts.

Either low carbon mild steel or high strength low alloy steel can be used for all steel work.

Aluminium sandwiched metal wall cladding shall be provided on the inside of the valve hall walls for maintenance free construction and speedy execution. The wall cladding shall be suitable to have the air/moisture proof as per the requirement.

The Valve halls and their roofs must be simple and sealed, wind and water tight to avoid ingress of dust and moisture from outside. The valve hall roof shall be given adequate slope to ensure that the rain water does not accumulate on the roof. A parapet with gutter shall be provided around the roof. Special care must be taken to ensure sealing to prevent ingress of dust/moisture from ventilation/air conditioning/smoke ventilation openings, etc.

Roof of valve hall building shall consist of troughed metal sheet decking of minimum 0.8 mm thickness with phosphate coating on both sides to act as a permanent shuttering for cast-in-situ RCC slab. Underside of metal roof decking shall be painted with epoxy paint.

The finished valve hall roofs shall be subjected to a leakage test in which, at the discretion of the Employer, water may be kept stored on top of the roof or sprayed continuously up to 48 hours. The bidder / Contractor may suggest alternative means to test the valve hall roofs against leakages but acceptance of these shall be subject to the approval of the Employer.

Separate fire escape doors shall also be provided in the valve halls.

Faraday cage of approximately 2mtr x 5 meter for each valve hall shall be made in line with floor plan given as fig: 8.10.2.6

Floors shall be epoxy/polyurethane coated and all steel structures in the valve hall shall be coated with maintenance free rust proof paints, like epoxy/PU coatings.

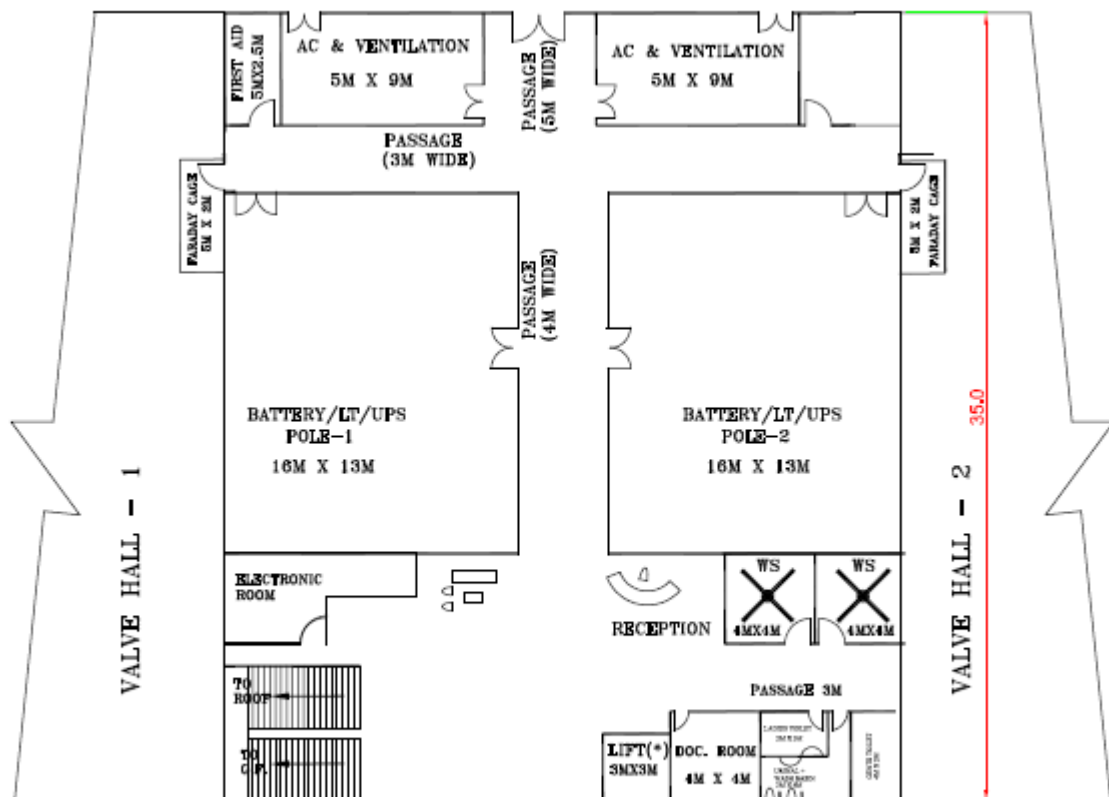
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An attenuation of minimum 60 dB of the radiation emanating from the valve hall equipment shall be achieved by suitably shielding the valve hall.

Facilities shall be provided in each valve hall above the anchoring points of valve structure for regular inspection & maintenance of facilities like ventilation system, lighting fixtures, fire detection etc., as applicable. In case catwalk is provided the same shall be easily approachable from service buildings. The floor of the catwalk shall be of closed type so that nothing can drop accidentally in the valve hall.

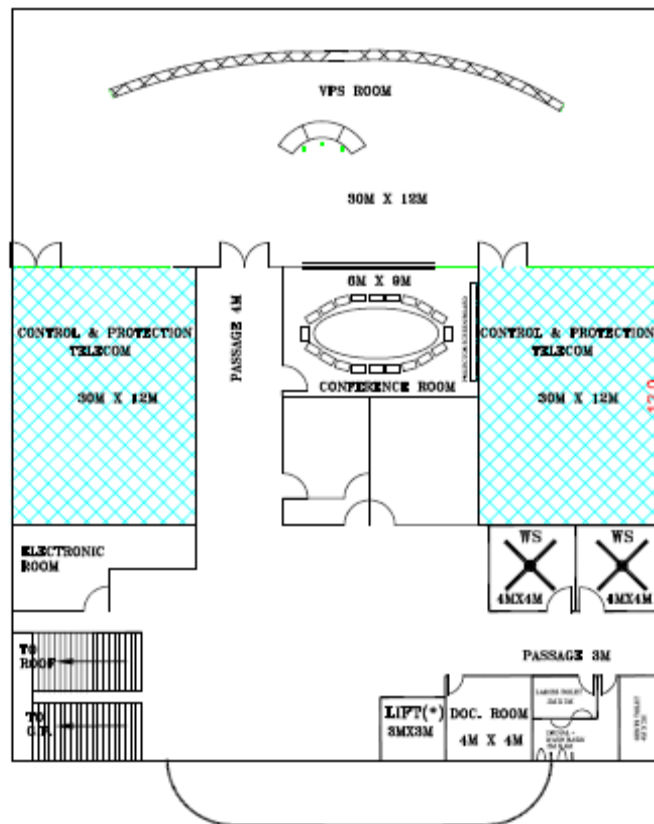
8.10.2.6 SERVICE BLOCK

The conceptual general layout of the service block shall be as shown in the drawings below.



SERVICE BUILDING – GROUND FLOOR PLAN

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SERVICE BUILDING – FIRST FLOOR PLAN

The combined valve cooling, valve hall ventilation and C&P building defined as B & F in clause 8.10.2.4 shall be a two floor building with the LTpanels/battery system, valve cooling and valve platform on the ground floor. The control and protection panels and the ventilation system for valve halls shall be installed on the first floor. The control and protection room shall be air conditioned and comply with the specifications for the main control room.

8.10.2.7 STATION CONTROL ROOM

The station control room shall house the equipment for the control of the HVDC System as well as all other panels like fire alarm panel, BMS etc.

The control room area shall be in three parts as shown on the drawing. The central part shall be the VPS room along with operator consoles. Adequate space shall be provided for the fault recorders, the chronological event recorders and the printers. The nearby rooms (for each pole) on either side shall house the alarm,

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protection and valve control electronics as well as the control and protection panels associated with the valves.

Viewing windows for the valve halls shall be provided in each of the control rooms enabling viewing of the valve halls, while energized.

The arrangement of rooms shall be such that the coming and going of personnel or visitors does not disturb the operators.

8.10.2.8 BATTERY ROOM/ BATTERY CHARGER ROOMS

These rooms house the batteries, chargers and DC distribution boards shall be located as shown on drawing 8.10.2.6 (service building ground floor plan). The room shall be air conditioned. The dimensions shall be as required to suit the equipment.

8.10.2.9 AIR CONDITIONING ROOMS

These rooms shall contain equipment pertaining to ventilation and air conditioning for the service building. The dimensions shall be as required to suit the equipment.

8.10.2.10 MAINTENANCE WORKSHOPS AND STORAGE FACILITIES

The service building shall be provided with the following workshops with necessary equipments and furniture:

.1 Mechanical-Electrical Maintenance Workshops

The workshop shall be used for maintenance of heavy equipment such as pumps, fans, electric motors etc. It shall contain all special tools and spare parts. A lifting system of adequate capacity and a work bench shall also be provided.

.2 Controls and Protection (Electronics) Workshop

8.10.2.11 OFFICES

Each converter building shall be provided with the minimum area required for the offices in line with the drawings in clause 8.10.2.6. The Contractor shall provide suitable furniture (tables and executive chairs) for reception desk, all processor, servers, and workstation consoles. The Contractor shall provide printer / logger trolleys & tables as required. The LAN cable with Ethernet port shall be made available from control room to all work stations, reception, documentation room, workshop and other office rooms inside the service building. The Contractor shall provide conference table with 16 chairs and multimedia projection system in the conference room. The executive chairs shall have caster base, arm rest, swivel, tilt

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and pneumatic seat adjustment features. The specific design, finish and colour of all furniture shall be subject to Employer's approval.

8.10.2.12 MISCELLANEOUS ROOMS

Each converter building shall be provided with at least the following miscellaneous rooms:

- Reception lobby
- Conference room
- One bathroom , washroom & Toilet per floor (with WC, urinal & washbasin)
- One pantry
- Storage of plant documentation
- Work stations
- Loading dock/lifting area - as required
- Maintenance area between the valve halls- This area shall have a lifting beam with monorail fitted with minimum 5MT chain pulley system with all accessories

Normal as well as fire escape staircases shall be located as per TAC requirements.

8.10.2.13 PASSENGER ELEVATORS

Passenger elevators shall be provided in the service building at all the converter stations. A brief specification of the elevator (for 6 persons) is given below:

- | | | | |
|-----|--------------------|---|---------------------------------------------------|
| 1. | Type | : | 1 Nos. Electric Passenger Lift |
| 2. | Load | : | 544 kg. (Approx.) – 6 Passengers |
| 3. | Speed | : | 1.0 Metre/Sec. Two speed |
| 4. | Travel | : | About 8 Metres (Ground to first Floor) |
| 5. | Stops for landings | : | 2 stops 2 landings (All landing on the same side) |
| 6. | Type of drive | : | A.C. Variable drive |
| 7. | Floor Designation | : | Gr., 1 |
| 8. | Control | : | 2 Stop with or without lift attendant. |
| 9. | Operation | : | Simplex Fully collective with/without attendant. |
| 10. | Signals | : | a) Call registers indicators at all landings. |

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- b) Digital car position indicators in car.
 - c) Up/Down (Visual) pre-announcing indicators with single stroke gang at all landings.
 - d) Battery operated alarm bell and emergency light.
 - e) Fireman's switch
 - f) Inter communication system
 - g) Overload warning: In case lift is overload door shall not close & lift will not move till the normal loading is there (Audio Visual indicators).
11. Lift shaft : About 1950 mm wide & 1950 mm deep available
 12. Car size : About 1300 mm wide x 1100 mm deep (inside dimensions)
 13. Door : Automatic Operation
 14. Type of Door : Centre opening sliding door.
 15. Car enclosure : Stainless steel car in hairline finish. The car floor shall have granite flooring. The car will be provided with false ceiling of Perspex sheet with pressure fan and decorative light fittings.
 16. Car entrance : Clear opening about 800 mm wide, 2000 mm stainless steel in hair line finish two panel center opening horizontal Automatic sliding door of . stainless steel
 17. Landing entrance : Clear opening 800 mm wide x 2000 mm stainless steel in hair line finish two panel center opening horizontal Automatic sliding doors
 18. Position of machine room : Directly above the lift shaft.
 19. Power supply : 415 Volts, $\pm 10\%$, 3 phase, 50 Hz $\pm 10\%$.
 20. Emergency rescue device : The Emergency battery Drive Unit: In the event of power failure, the lift shall come to the nearest landing automatically.

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8.10.3 AUXILIARY BUILDINGS

These buildings shall be located at suitable locations but away from converter building.

8.10.3.1 VALVE COOLING EQUIPMENT BUILDING

These buildings shall be provided on per pole basis and shall contain the required cooling equipment for the valves. The dimensions shall be as required to suit the equipment. The cooling towers may be located outside the room. This building shall be located adjacent to respective valve hall. The flooring of the valve cooling building shall be epoxy painted.

8.10.3.2 VALVE HALL VENTILATION BUILDING

This building shall be located adjacent to the valve halls and house all equipment pertaining to valve hall ventilation system. The rooms shall have ample space for maintenance, removal of equipment etc. The Contractor may use a double storied building to house both the valve cooling and valve hall ventilation equipment.

8.10.3.3 PUMP HOUSE

The water pumps for the service/domestic water system as well as for fire protection shall be housed in a pump house. A separate pump house shall be located, if required for station drainage system. The raw water tank(s) also may be located next to this pump house. The pump foundations shall be vibration free and independent of building foundation. Suitable ventilation & exhaust shall be provided.

8.10.3.4 GUARD HUT

A guard hut with lockable door, aluminium windows and attached toilet shall be located near the main entrance to each station. Provision of operating the main gate electrically from the guard hut also shall be provided.

8.10.3.5 INDOOR DC YARD (AT AGRA)

A RCC framed DC yard building shall be built adjacent to the valve halls. The indoor DC yard shall be a ventilated hall containing DC yard equipments, such as smoothing reactors, high speed parallel / de-parallel switch, line isolator, DCCT, Voltage divider, DC filters etc. The ventilated indoor DC yard shall have a pressure at least 5mm of

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water column over the atmospheric pressure. The air shall be suitably filtered before being supplied to the indoor DC yard and shall have a relative humidity less than 60%. The air shall be suitably filtered before being supplied to the indoor DC yard. The size of the building shall be decided by the Contractor based on the requirements of the equipment to be supplied. Suitable lifting and shifting arrangement of smoothing reactor on permanent or portable basis inside the building shall be made available. Provision shall be made in the indoor DC yard building for installation of wall bushing and connection for parallel converter block by Employer. The floor of the indoor DC yard shall have a heavy duty floor slab with ironite flooring suitable for movement of cranes, trailers, etc.

8.10.4 FINISH SCHEDULE

The preliminary indicative finishing schedule is given below. However, at the time of detailed engineering, the Employer reserves the right to alter the finishing schedule and specifications and such changes shall have no additional financial implication whatsoever to the Employer.

8.10.4.1 FLOORING

- .1 The nominal total thickness of floor finish shall be 50 mm.
- .2 Wherever cables are required to be run under the floor (like VPS room) suitable cable raceways shall be provided below the flooring.
- .3 Control room shall be provided with false flooring as specified. The floor of entrance lobby, staircase, control room, VPS room, visitor area and conference room shall have mirror polished 20mm thick granite stone slab flooring over 20mm thick base of cement mortar 1:4 (1 cement : 4 coarse sand). Office areas and electronic workshop shall be provided with vitrified tiles of size 600x 600mm laid over 20mm thick base of cement mortar 1:4 (1 cement : 4 coarse sand).

The floors of rooms having heavy mechanical equipment like Air Conditioning and Valve Cooling shall have Ironite floor finish. The floor shall be further coated with Epoxy/PU.

- .4 The floors of building/room other than those mentioned above shall have vitrified tiles 600 X 600 mm size.

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- .5 Risers and treads of stair-cases shall be provided with 20mm thick mirror polished granite stone slab except external staircases leading to roofs of buildings. Steel staircases shall have grating or chequered plates as per the requirement.
- .6 Entire area around the Converter Buildings (including transformer & reactor area) shall be provided with PCC (1:2:4) paving of minimum 100 mm thick over a sand/moorum suitably consolidated/compacted cushion of minimum 150 mm, starting from the building edge upto 2 m clear distance for the full length of the building. All other buildings shall be provided with 750 mm wide plinth protection all around with plain cement concrete of 1:2:4 over under bed arrangements as specified above.

Minimum 10 m wide strip as approach to the converter building from both sides shall be paved with RCC. The above specified RCC approach shall be with M15 grade concrete over suitable under bed having 100 mm thick PCC (1:4:8) over a sand/moorum suitably consolidated/compacted cushion of minimum 150 mm.

8.10.4.2 ROOF

- .1 The valve hall roofs are described in clause 8.10.2.5.
- .2 Roofs of other buildings shall consist of cast-in-situ RCC slab.
- .3 The roofs of valve hall and service building shall be provided with 30 mm thick polyurethane foam for thermal insulation and 1.5 mm thick layer of isothane elastomeric membrane 'EMA' with polyurethane primer as water proofing treatment. A wearing course of 25 mm thick PCC(1:2:4) laid in panel of 1.2X1.2 metre with 0.56 mm dia galvanised chicken wire mesh interposed shall also be provided over elastomeric membrane.
- .4 For sufficient disposal of rain water, the run off gradient for the roof shall not be less than 1:100. Screed concrete 1:2:4 or cement sand mortar 1:3 shall be used to provide the gradient.
- .5 The water proofing treatment of roof of buildings except service building and valve hall shall consist of the following operations:
 - a) Applying and grouting a slurry coat of neat cement using 2.75 kg/m² of cement admixed with proprietary water proofing compounds conforming to IS: 2645 over the RCC slab including cleaning the surface before treatment.

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- b) Laying cement concrete using broken bricks/brick bats 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to IS: 2645 over 20mm thick layer of cement mortar of min 1:5 (Cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to IS: 2645 to required slope and treating similarly the adjoining walls upto 300mm height including rounding of junctions of walls and slabs.
- c) After two days of proper curing applying a second coat of cement slurry admixed with proprietary water proofing compound conforming to IS: 2645.
- d) Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement : 4 coarse sand) admixed with proprietary water proofing compound conforming to IS: 2645 and finally finishing the surface with trowel with neat cement slurry and making of 300 x 300 mm square.
- e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All above operations to be done in order and as directed and specified by the Engineer-in-charge.

8.10.4.3 WALLS

- .1 All buildings shall have framed super-structure. All walls shall be non-load bearing in filled panel walls.
- .2 External walls of all buildings shall either be with solid concrete block masonry (minimum 200 mm thick) or with brick masonry (minimum 230 mm thick) in cement sand mortar 1:6.
- .3 All internal walls shall be either with solid concrete block masonry (minimum 200 mm thick except the internal partition walls for office area and toilets which shall be 100 mm thick) or with brick masonry
(Minimum 230 mm thick including internal partition walls for office area and toilets) in cement sand mortar 1:6.
- .4 All half brick masonry walls shall be provided with reinforcement consisting of 2 nos. of 6 mm diameter bars every fourth layer.
- .5 A 50 mm thick DPC shall be provided at plinth level before starting the masonry work.

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- .6 For converter building, the external wall upto a height of minimum 6.0m from plant's zero level on the side facing the oil filled equipments e.g. oil filled reactor and transformer to take care of fire accidents and upto a height of 2.5 m on other sides shall be with RCC pre-cast units of minimum M-20 grade as per IS-456.
- .7 The service building entrance lobby, staircase, control room(VPS), visitor area and conference room shall have wall cladding of 1mm laminate over 12mm ply along with 9mm MDF for necessary grooves and pattern.

8.10.4.4 PLASTERING

- .1 External surface of buildings shall have 18mm thick plaster in two layers, with under layer 12mm thick 1:5 cement sand (coarse) plaster and top layer 6mm thick 1:6 cement sand plaster. Inside wall surfaces at all locations shall have 12/15 mm thick cemented sand plaster. Rough surface shall have 15mm and smooth surface shall be provided with 12mm thick cement sand plaster (1:4).
- .2 Inside surface of all walls shall be provided with plaster of Paris punning over the plastered surface except for areas where wall panelling is provided.
- .3 All RCC ceilings shall be provided with 6 mm thick cement sand plaster (1:4) except areas with false ceiling.

8.10.4.5 PAINTING

- .1 Outside face of all buildings and pump houses shall have Novalux exterior paint as per manufacturer's specification.
- .2 Acrylic emulsion paint shall be provided for all rooms except for areas where wall panelling is provided.
- .3 All ceilings shall have oil bound distemper
- .4 Fire resisting transparent paint shall be provided on all wood work over French polish or flat oil paint.
- .5 All fire exits shall be painted in fire red colour shade, which shall not be used anywhere else except to indicate emergency or safety measure.

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8.10.4.6 DOORS & WINDOWS

- .1 All the doors, windows and ventilators of buildings and windows/ventilators provided on the outer face shall be of aluminium. Main entrance shall have aluminium framework with glazing or frameless as required during approval of architectural drawings. Doors shall be of double swing type. Glazed wall panels with aluminium frame shall be provided between control room and adjacent two rooms behind the operator seat to have a clear view. Glazing shall have fire rating of minimum 1 hour.
- .2 WC/toilets shall have wooden panel doors. Doors for office area and in air conditioned areas shall be wooden flush doors.
- .3 All other doors shall be steel doors consisting of double plate flush door shutters, the cavities filled with mineral wool as per specification.
- .4 All windows shall be of aluminium frame.
- .5 Rolling shutters with suitable operating arrangement (manual/mechanical gear operated or electrical according to size shall be provided in buildings to facilitate handling and transportation of equipment.
- .6 All doors/shutters/windows shall be provided with all standard accessories such as handles, tower bolts, locks, stoppers, floor mounted spring type door closure etc. of best quality as approved by the Employer.
- .7 Fire-proof doors shall be provided at all fire exit points as per the recommendations of Tariff Advisory Committee. These shall be as per IS-3614 with minimum 1 hour fire rating.
- .8 Automatic fire proof sliding doors shall be provided wherever required for segregating and preventing the spread of fire.
- .9 Generally no door shall be more than 2.5 m in height. If still a bigger door is required, considering type & size of equipment, then the door shall be made in two parts.

8.10.4.7 GLAZING

- .1 Minimum thickness of glazing shall be 5.5 mm.
- .2 Glazing between air-conditioned (A/C) and non-A/C areas shall be provided with hermetically sealed double glazing having glass of minimum 6.0 mm thickness for thermal insulation & clear view. Doors shall be provided with 6.0mm thick single glazing only.

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- .3 Ground glass of minimum 5.5 mm thickness shall be used in toilets.
- .4 Fire prone area shall be provided with wired glass with minimum 6 mm thickness.

8.10.4.8 FALSE CEILING

The control room and all other air conditioned areas shall have a closed aluminium ceiling system comprising 84mm wide, 12.5mm deep panels of approved colour with a recessed flange of 23.9mm roll formed out of 0.5mm thick aluminium alloy AA 5050 /5052/3003 chromatised and stove enamelled on both sides. The panels shall be fixed on roll formed carriers 32mm wide, 39mm deep made out of minimum 0.9mm thick aluminium alloy strip with cut outs to hold panels in a module of 100mm minimum at 1.6 m c/c maximum. The carrier will be suspended from roof by 4mm diameter galvanised steel wire rod hangers with special height adjustment springs/clips made out of spring steel at maximum spacing of 1.5m c/c hangers. 25mm thick resin bonded mineral wool of approved quality encased in 100 micron black polythene shall be laid over the top of the placed panels.

8.10.4.9 FALSE FLOORING

The false floor system to be installed shall provide a maximum finished floor height of 750mm from the existing floor level. The system shall provide for suitable pedestal and under structure design to withstand various static loads and rolling loads. The entire access floor system shall provide for adequate fire resistance, acoustic barrier and air leakage resistance. The system shall be able to accept an independent floor covering i.e. antistatic PVC/ Laminate with PVC beading. The under structure should be able to withstand a UDL of 1080 Kg/m² and a point load of 360kg. The under structure should be able to accept a pedestal axial load of 2200kg. Panels should be made from steel. The bottom of panel shall be embossed in hemispherical shape to give strength and flexural rigidity. The top sheet shall be plain and resistant welded at various locations after the top and bottom sheets have been degreased and phosphated. The above hollow panel shall have an infill of light weight cementitious material. The entire panel shall be coated with epoxy coating on the exposed surface. The surface shall have factory laminated anti - static PVC/ Laminate with PVC beading on all sides for edge protection. Panel shall provide for impact resistance top surface minimal deflection, corrosion

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resistance properties and shall not be combustible or aid surface spread of flame. Panel shall be free standing on to the under structure with stringers. Pedestal installation to support the panel shall be suitable to achieve a minimum finished floor height of 750mm height of 750mm from the existing floor level. Pedestal shall support an axial load of 3500kg.

8.10.5 PLUMBING & SANITATION

- .1 All plumbing and sanitation shall be executed to comply with the requirements of the appropriate by-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met in regard to inspection, testing, obtaining approval & giving notices etc.
- .2 Galvanized steel pipe of medium class conforming to IS-1239 shall be used for internal piping works for potable water supply.
- .3 C.I. pipes with lead joints conforming to IS-1729 shall be used for sanitary works above ground level.
- .4 Each toilet shall have the following minimum fittings:
 - a) WC (Western type) 390mm high with toilet paper roll holder and all fittings and WC (Indian Type) (580x440 mm) with all fittings to be provided at alternate locations.
 - b) Urinal (430x260x350 mm size) with all fittings and built in sensor for automatic flushing after use.
 - c) Wash basin (550x440 mm) with all fittings
 - d) Bathroom mirror (600x450x5.5mm thick).
 - e) CP brass towel rail (600x20mm)
 - f) Soap holder and liquid soap dispenser.
 - g) Automatic hand dryer.
 - h) Bathing space with shower, geyser etc.
- .5 Provision for installation of water cooler shall be kept adjacent to toilet blocks.
- .6 One no. stainless steel kitchen sink (600x450x250mm) for pantry shall be provided.

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8.10.6 BUILDING STORM WATER DRAINAGE

The building design shall provide for the collection of storm water from the roofs. This water shall be drained to the main drainage system of the station.

Cast Iron rain water down comers conforming to IS-1230 with water tight lead joints or medium class galvanized mild steel pipes conforming to IS-1239/IS-3589 shall be provided to drain off the rain water from the roof. These shall be suitable concealed with masonry work of cement concrete or cladding material. The number and size of down comers shall be governed by IS-1742 and IS-2527.

All drains inside the buildings shall have minimum 40 mm thick grating covers and in areas where heavy equipment loads would be coming, pre-cast RCC covers shall be provided in place of steel grating.

For all buildings, suitable arrangement for draining out water collected from equipment blow downs, leakages, floor washings, fire fighting etc. shall be provided for each floor.

8.11 MISCELLANEOUS GENERAL REQUIREMENTS

1. Dense concrete with controlled water cement ratio preferably 0.45 shall be used for all underground concrete structures such as pump-house, tanks, water retaining structures, cable and pipe trenches etc. for achieving water-tightness.

For all civil works covered under this specification, nominal mix by volume batching as per CPWD specification is intended. The relationship of grade of concrete and ratio of ingredients shall be as below:

S.No.	Mix	Cement	Sand	Coarse Aggregate (As per IS 383)
1.	M10	1	3	6
2.	M15	1	2	4
3.	M20	1	1.5	3

The material specification, workmanship and acceptance criteria shall be as per relevant clauses of CPWD specification and approved Field Quality Plan.

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2. All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 6 mm and minimum width shall be 230 mm.

In case the Contractor can demonstrate for adopting a suitable construction technique to avoid seepage of ground water, then the PVC water stops need not be used as specified above.

3. All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti-corrosive paint to take care of sea worthiness.
4. All mild steel parts used in the water retaining structure shall be hot double dip galvanized. The minimum coating of the zinc shall be 750 gm/sq.m. for galvanized structures and shall comply with IS-2629 and IS-2633. Galvanizing shall be checked and tested in accordance with IS-2629. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen in accordance with BS-3416.
5. A screed of concrete layers not less than 100 mm thick and of grade not weaker than M10 shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.
6. Bricks having minimum 75 kg/m² compressive strength can only be used for masonry work.
7. Monorails, monorail girders and fixtures shall be provided, wherever required.
8. Doors and windows on external walls of buildings (other than areas provided with insulated metal cladding) shall be provided with RCC sun-shade over the openings with 300 mm projection. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.
9. All stairs shall have a maximum riser height of 150 mm and a minimum tread width of 250 mm. Minimum clear width of stairs shall be 1500 mm.

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10. Angles with lugs shall be provided for edge protection all round cut outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of pre-cast covers including cable trench covers and any other place where breakage of corners of concrete is expected.
11. Anti- termite treatment shall be done as per CPWD specification.
12. Hand railing minimum 1200 mm high shall be provided around all floor/roof openings, projections/balconies, walkways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) and shall be galvanized (medium-class as per IS-277). All rungs for ladder shall also be galvanized as per IS-277 medium class.

Stairs within the service building shall be provided with 50mm dia stainless steel hand rail and, 20 mm dia stainless steel balustrades with suitable flats.
13. All shuttering material used shall be of wood only.
14. The proper coordination & execution of all interfacing civil works activities like fixing of conduits in roofs/walls/floors, fixing of foundation bolts, fixing of lighting fixtures, fixing of supports/embedment, provision of cut-outs etc. shall be the sole responsibility of the Contractor. He shall plan all such activities in advance and execute in such a manner that interfacing activities do not become bottlenecks and dismantling, breakage etc. is reduced to minimum.

8.12 STATUTORY RULES

1. The Contractor shall comply with all the applicable statutory rules pertaining to Factories Act, Fire Safety Rules of Tariff Advisory Committee, and Water Act for pollution control etc.
2. Provisions for fire proof doors, number of staircases, fire separation wall, lath plastering on structural members (in fire prone areas) etc. shall be made according to the recommendations of Tariff Advisory Committee.
3. Statutory clearance and norms of State Pollution Control Board shall be followed as per Water Act for effluent quality from plant.
4. Requirement of sulphate resistant cement (SRC) for sub-structural works shall be decided in accordance with the Indian

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Standards based on the findings of the detailed soil investigation to be carried out by the Bidder/ Contractor.

5. Foundation system adopted by the Contractor shall ensure that relative settlement shall be as per provisions in IS-1904 and other Indian Standards.
6. All water retaining structures designed as un-cracked section shall also be tested for water tightness at full water level as per clause no. 10 of IS-3370 (Part-I).
7. Construction joints at the following locations shall be provided
 - a) At the meeting points of the columns and the raft.
 - b) At the points of contra flexure in the columns.

Additional reinforcements and shear keys shall be provided at the construction joints.

8. All underground concrete structures like pump houses, water retaining structures etc. shall have plasticizer cum water proofing cement additive conforming to IS-9103. In addition, limit on permeability as given in IS-2645 shall also be met with. The concrete surface of these structures in contact with earth shall also be provided with two coats of bituminous painting for water/damp proofing.

In case of water leakage in the above structures, Injection grouting shall be applied for repairing the leakage.

SECTION 9: ERECTION, QUALITY & COMMISSIONING

9.1 ERECTION

The Contractor shall unpack, place accurately in position and make ready for service all the equipment required by the Specification. All installations, assembly operations and adjustments shall be done in a neat and professional manner and in accordance with the seismic withstand requirements specified in the Specification, the applicable Indian electrical codes and in accordance with the manufacturer's instructions.

All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer's limits.

The Contractor shall supply and use all lubricants and other consumables as required. Lubricants used for installation purposes shall be drained out, flushed where necessary, and replaced with the lubricant required for operation. All these consumables shall be supplied by the Contractor till completion of successful trial operation.

All cabling interconnections between the HVDC station and the other equipment of the Employer, not falling under the scope of supply of this Contract which are required for purpose of interlocking, alarm, annunciation, control, protection, monitoring or for other purposes shall be in the scope of the Contractor.

All support insulators, bushings, circuit breaker interrupters and other fragile equipment shall be handled with cranes with suitable beams and handling capacity. The slings shall be of sufficient length to avoid any damage to the equipment due to excessive swing, scratching by sling ropes etc. All handling equipment, sling ropes etc. shall be tested before erection and periodically for strength.

Bending of the pipes shall be done with suitable bending machine through cold bending only & in such a manner that inner diameter of pipe is not reduced. Cutting of the pipes shall be done with proper cutting tool.

The Contractor shall arrange all the equipment, instruments, accessories, tools & tackles, auxiliaries, cranes etc. required for the successful erection of Works.

SECTION 9: ERECTION, QUALITY & COMMISSIONING

9.2 FACTORY TESTS

The Contractor shall test in the factory the individual items of equipment in his scope of supply. The routine tests and type tests as specified in the Specifications shall be as per applicable standards and as further specified herein.

All type tests and acceptance tests performed subsequent to the date of award and all routine and other tests, shall be witnessed by the Employer or his Representative(s)/consultants, unless authority to proceed with the tests in his absence is received from the Employer in writing, and all the test reports shall be submitted to the Employer, as specified in Section 10, for approval.

If any equipment fails to pass any test, it may be repaired and the defective parts replaced or redesigned, only with Employer's approval, or the whole equipment replaced or supplier may be changed, as necessary, and the equipment retested without additional cost to the Employer and extension of the delivery time. If the equipment fails to pass the so agreed repeat test(s), the Employer reserves the right to reject the equipment or part thereof in which case the complete equipment shall be replaced and supplied without any additional cost to the Employer and without any time extension.

None of the equipment to be furnished or used in connection with this Contract shall be dispatched until factory tests are satisfactory. Such factory tests on the equipment shall not however relieve the Contractor from full responsibility for furnishing equipment conforming to the requirements of this Contract, nor prejudice any claim, right or privilege which the Employer may have because of the use of defective or unsatisfactory equipment. Should the Employer waive the rights to inspect and test any equipment such a waiver shall not relieve the Contractor, in any way, of his obligations under this Contract.

The Contractor shall provide all instruments and facilities required to perform all the type tests and other factory tests.

The Contractor shall perform comprehensive Factory system tests for Equipment/Systems having complex interfaces within them or with other equipment/systems such as the dc controls & protection including simulation of parallel converter operation, Station monitoring and recording systems, transient fault recorders etc. Control and protection systems shall be set as far as practical in the

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factory during the testing so that only minor adjustments shall be required at the Sites.

9.2.1 FACTORY ROUTINE TESTS

All equipment to be supplied under the Contract shall be subject to acceptance/routine tests as specified in this Specification and/or as required by the relevant Standards, at the factory.

9.2.2 FACTORY TYPE TESTS

9.2.2.1 GENERAL

All equipment being furnished shall meet the type test requirements specified herein and/or those required by the relevant Standards. The certified type test reports shall be submitted for the Employer's approval.

The tests shall be conducted in the Contractor's or his Sub-Contractor's works/laboratory or in independent laboratory after due approval of test procedures, parameters, acceptance criteria and test program by the Employer.

Test data for equipment of different but comparable rating to that proposed to be supplied, may be accepted, if the Contractor can prove to the satisfaction of the Employer's that the equipment proposed shall meet the specified requirements.

9.3 SITE TESTING

9.3.1 GENERAL

After the installation and preliminary adjustments of equipment, the Site tests, shall be performed in the following stages:

- Erection checks
- Commissioning tests
- Subsystem tests
- Subsystem energization tests
- System tests

The site testing has been categorized in above stages for the sake of convenience only. There may be overlapping of two or more stages for particular tests. The Contractor shall perform the site testing with complete responsibility.

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The Contractor shall provide all instruments, equipment and facilities required to perform these site tests. Calibration certificates for the test equipment shall be available at site for review by the Employer prior to the start of the testing

All special & test equipment necessary to simulate devices or switching sequences and required for commissioning shall be provided by the Contractor. Results of the site tests shall be well documented and shall form a part of plant documentation.

9.3.2 ERECTION CHECKS

The checks shall be carried out on all equipment after completion of erection/installation, in accordance with the relevant approved commissioning procedures to be submitted by the Contractor. These checks shall ensure that the equipment has sustained no damage in transit, has been properly erected/installed, is correctly set, and is ready for energization or start-up. These checks shall be carried on all equipment after completion of erection according to the approved field quality plan/installation manual of individual equipment.

The checks shall include, but not be limited to, the following:

- a) Visual examination of
 - Physical damage
 - Paint/zinc coating
 - Corona ring surface
 - Ground connection
 - Electrical connections
 - Cleanliness, specially for insulators & bushings
 - Oil leakage
 - Welded joints/application of Zinc rich paint over them
 - Moving parts for proper lubrication
 - Visit to switch yard area for general observation of any discrepancy
- b) Checking of nameplates
- c) Torque check of electrical connections and mechanical joints
- d) Check of tightness of cable terminations, cable tags and cable glands

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- e) Check of cabling i.e. cable trenches ladders and cable dressing
- f) Electrical clearance measurement.

9.3.3 COMMISSIONING TESTS

After completion of erection finalization checks, equipment tests shall be conducted. These tests shall verify the proper function and healthiness of individual equipment. The tests shall conform to the approved field quality plan/procedures. The Contractor shall, in the quality plans, specify the tests required for each equipment in the station.

The equipment (pre-commissioning) tests shall be in accordance with the standards, practices, codes & Specifications, as applicable, as well as specified below.

9.3.3.1 GENERAL CHECKS

The following general checks/tests shall be carried out on all equipment, wherever applicable:

- a) All checks and tests specified by the manufacturers in their drawings and manuals as well as all tests specified in the relevant field quality plan (FQP).
- b) Pressure test on all pneumatic lines at (minimum) 1.5 times the rated pressure and leakage test as per relevant standards.
- c) Insulation resistance checks on primary equipment consisting of power factor tests and hi-pot tests.
- d) Insulation resistance check of control cables, motor etc.
- e) Resistance measurements of transformers, reactors, filter resistors etc.
- f) Loop resistance measurement of all protection circuits and metering circuits including interface circuits emanating from the Employer's ac yard/control room. Check to confirm short circuiting of unused CT windings.
- g) Wiring continuity and insulation resistance tests, including checks for cables emanating from the Employer's facilities.
- h) Functional tests on control, protection and alarm circuits including relay and control settings, checks on software based equipment and all man - machine interfaces for equipment which have not undergone Factory System Test

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(FST) and for equipment/systems where modifications have been taken place.

- i) Checks of all interlocks including interlocks to interfacing equipment located in the Employer's switchyard.
- j) Checks of all alarms & annunciations.
- k) Single point earthing checks for all equipment including CT secondary circuits. (Including CT secondary in the Employer's ac yard connected to HVDC side protections).
- l) Power abnormality tests for electronic equipment, if not already carried out during FST.
- m) Power supply parameters for electronic equipment, if not already carried out during FST.
- n) Diagnostic demonstration of software functions for control, protection, measuring and applicable telecommunication equipment.
- a) System and redundant equipment switchover function including switchover for transformer cooling bank.
- b) Functional tests on auxiliaries & all auxiliary systems.
- c) Check for air distribution, humidity and temperature on air conditioning system.
- d) Mechanical balancing, alignment, capacity and vibration checks.
- e) Surface treatment, galvanising or painting checks.

Following additional checks & tests for all INSULATING OIL FILLED EQUIPMENT shall be conducted:

- a) Check for oil leakage.
- b) Check for oil level and top up wherever necessary.
- c) Insulating oil tests.
- d) Dissolved gas analysis.
- e) Checks of all protective, alarm and metering functions.

9.3.3.2 BREAKERS, HIGH SPEED & DC SWITCHES

- a) Insulation resistance of each pole.
- b) Breaker closing and tripping time.
- c) Slow (manual) and power closing and opening operation. Simultaneous closing of all three phases.

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- d) Trip free and anti pumping operation.
- e) Minimum pick up voltage of trip & closing coils.
- f) Main Contact resistance and dynamic contact resistance measurement.

Functional checking of compressed air plant and all accessories, if provided.

- g) Checking leakage of gas.
- h) Functional checking of control circuits, interlocks, tripping through protective relays and auto reclose operation (as applicable).
- i) Resistance of closing and tripping coils.
- j) Check on spring charging motor if provided, correct operation of limit switches and time of charging etc.

9.3.3.3 ISOLATORS/DISCONNECTS

- a) Insulation resistance of each pole.
- b) Manual and electrical operation
- c) Mechanical and electrical interlocks.
- d) Contact resistance
- e) Alignment.
- f) Resistance of operating and interlocking coils.

9.3.3.4 MEASURING DEVICES

- a) Insulation resistance test.
- b) Polarity test.
- c) Ratio identification test - checking of all ratios on all cores by primary injection of current.
- d) Dielectric test of oil (wherever applicable).
- e) Magnetizing characteristics test.
- f) Continuity checks on capacitor units of equipment like CVT, CVD etc. including line connection as per connection diagram.
- g) Spare CT cores, if any, to be shorted and grounded.

9.3.3.5 LIGHTNING ARRESTER

- a) Resistance of ground connection.

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- b) Reading of surge counters before and immediately after installation.

9.3.3.6 MOTORS

- a) Insulation resistance
- b) Phase sequence and proper direction of rotation.

9.3.3.7 ELECTRICAL AUXILIARY SYSTEM

The phase sequence and auto changeover of all supplies in the station system shall be carried out.

9.3.3.8 STATION EARTHING

- a) Check continuity of earthing grid interconnections.
- b) Check earth resistance of the entire grid.
- c) Check for weld joint and application of zinc rich paint on galvanized surfaces.

9.3.3.9 CONDUCTOR STRINGING WORK, TUBULAR BUS WORK AND POWER CONNECTORS.

- a) Visual check for finish & welding.
- b) Electrical clearance check; specially at opened disconnector positions.
- c) Torque check on all bus bar power connectors and other accessories.
- d) Sag and tension check on conductors.
- e) Contact resistance check or Mili volt drop test on all joints.
- f) Dye penetration test/radiography test on 10% sample basis on weld joints.
- g) Test check on 5% sample (weld) joints after cutting the weld piece to observe any voids, etc.

9.3.3.10 CUBICLE WIRING (IF NOT ALREADY DONE IN FACTORY SYSTEM TEST)

- a) Each wire shall be traced by continuity tests and it should be made sure that the wiring is as per relevant drawing. All interconnections between panels/equipment shall be similarly checked.

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- b) Functional checking of all control circuits e.g. closing, tripping control, interlock, supervision and alarm circuit.

9.3.3.11 RELAYS

- a) Check all terminals to body.
- b) Megger all terminals to body and AC to DC terminals.
- c) Check operating characteristics by secondary injection.
- d) Check minimum pick up voltage of DC coils.
- e) Check operation of electrical/mechanical parts.
- f) Relay settings.
- g) Check CT and VT connections with particular reference to their polarities for directional relays, wherever required.

9.3.3.12 METERS

- a) Check calibration.
- b) Megger all insulated portions.
- c) Check CT and VT connections with particular reference to their polarities for power type meters.

9.3.3.13 COMMUNICATION

- a) Carrier frequency generation.
- b) Common channel signalling unit test tone and other FSK tones.
- c) System signal frequencies and levels.
- d) Channel frequency response, group delay distortion, signal-to-noise ratio and crosstalk.
- e) Tele control signal functions, response time and bit error rate.
- f) Power supply and alarm checks.
- g) Coupling and transmission line loss and line noise measurements at PLC frequencies at converter stations. Measurement of line impedance and measurement of return loss of complete link.
- h) Telephone and automatic exchange system functions and performance.
- i) Return loss measurements at carrier terminals/coupling devices.
- j) Matching of coupling device and carrier terminal hybrid transformers.

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- k) Proper interfacing with optical fibre based telecommunication system.
- l) Optical fibre terminal equipment tests to establish proper functioning and signal levels.
- m) Change over from main communication channel to back-up channel and vice versa

9.3.3.14 VALVE COOLING SYSTEM

- a) Tests of all alarm and trip functions'
- b) Tests of changeover to backup pumps/coolers
- c) Tests of temperature controls.
- d) Test of level/leakage functions.
- e) Raw water/fine water monitoring functions.
- f) Failure of auxiliary power supplies.

9.3.4 ***SUB-SYSTEM TESTS***

After successful completion of equipment tests on relevant equipment, sub-system tests shall be conducted. In the sub-system tests the joint function of the equipment shall be verified. The test shall be made in accordance with the approved commissioning instructions. The major sub-systems for each station shall be defined as follows:

- 400 kV AC Switchyard
- AC Filters
- Converter Transformer
- HVDC converter (thyristor valves, smoothing reactors etc.)
- DC Switchyard.
- DC filters
- Electrical auxiliary Power system
- Valve cooling systems
- Control, protection, alarm, monitoring, & reporting system
- Communication systems
- Fire detection and protection systems
- A/C & ventilation systems

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- Station service systems

9.3.5 SUBSYSTEM ENERGIZATION TESTS

After successful completion of the relevant sub-system tests, sub-system energization tests shall be performed. All independent sub-systems shall be energized or started up in accordance with the relevant approved commissioning procedures to be submitted by the Contractor. These tests shall demonstrate the electrical and mechanical integrity of these sub-systems. During these tests the Contractor shall make the initial adjustment to the equipment for satisfactory operation.

Prior to commencement of each of the sub-system energization tests, the Contractor, in consultation with the Employer, shall make the following, to ensure the safety of personnel and equipment.

- Review of completeness of tests documentation.
- Review of safety instructions, work permit procedures and tagging procedures
- Review of the operation instructions
- Final inspection of equipment.

9.3.6 SYSTEM TESTS

After the successful completion of the sub-system energization tests, system tests shall be performed in accordance with the relevant approved commissioning procedures.

The program of tests proposed by the Contractor shall include:

- a) Tests within each station and with dc line (other end open) including any tests necessary to confirm insulation, voltage and current capability of high voltage equipment and proper functioning with associated controls and protection including switching sequences, protection sequences, and transfer of control modes & effect of commutation failure.
- b) Tests to check inter-station coordination of controls and alarm circuits with all required telecommunication circuits in operation.
- c) End-to-end HVDC power transmission tests (monopolar metallic and ground return and bipolar modes).
- d) Transient and dynamic control tests
- e) Tests related to parallel converter control and operation.

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The tests to be carried out shall comprise at least, but not be limited to, the tests listed below. It is recognized that some of these tests shall have been carried out as part of the Factory system tests. Repetition of these (successful) tests shall not necessarily be required if there have not been any subsequent modifications and properly documented tests results are available. In case it is not possible to carry out some of the tests at site, proper functioning of protection equipment shall be demonstrated in Factory system tests.

9.3.6.1 TESTS AT AND UP TO NOMINAL CONTINUOUS RATING

- a) Rated voltage
- b) Rated current
- c) Voltage regulation
- d) Current ripple
- e) Power factor of each pole
- f) Radio interference level
- g) Temperature rise of each apparatus, etc. as determined in consultation with the Employer. This test shall however also be done at a power rating corresponding to continuous overload or two hour overload whichever is higher.
- h) DC current/voltage control:
 - maximum
 - minimum
 - current margin
 - high reactive power absorption mode
 - dc filter switching (on load), if applicable
 - inverter current control mode with tap changers in manual mode and current margin compensation.
- i) power control
- j) back up control modes during loss of telecom.,

9.3.6.2 TESTS AT OTHER LOADS

- a) emergency ratings
- b) minimum current

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- c) short time overloads power rating
- d) continuous overload power rating

9.3.6.3 TESTS OF CONTROL FUNCTIONING

a) Switching sequences:

- start/deblock
- stop/block
- dc filter connection/isolation
- ground return to metallic return & vice versa

b) Converter control performance:

- Steady state operation in all possible operating and control modes during operation e.g. reduced voltage mode, back up control at telecom failures, low ambient conditions, etc. The various automatic current limits shall be checked.
- operating mode transfers
- pole current order step setting, step changes
- valve group margin angle setting step changes
- commutation failure recovery
- power order changes
- ac system stabilizing control, transient signal changes
- power limit changes
- coordination of all control system limits
- deblock/block
- current margin compensation on power step increase
- power compensation during inverter current control
- converter control switchover
- ac system disturbances and faults
- dc system disturbances and faults
- converter faults
- dc line faults
- converter transformer and/or filter switching
- ac/dc auxiliary supply changeovers and/or failures

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- telecommunication system transfer and/or failures
 - harmonic measurements (ac and dc)
 - monopolar operation
 - SSO performance if required by studies
 - change of control location
 - frequency control
 - runback and other special controls
- c) Stepping sequences:
- change in power flow
 - tap changer control (auto & manual modes)
 - ac or dc filter
- d) other sequences
- e) reactive power control performance
- dynamic over voltage limiter
 - steady state over voltage limiter
 - voltage control mode
 - reactive power exchange mode
 - filter switching mode changes
 - manual filter switching mode operations
- f) interaction related control performances
- g) any other control verification

9.3.6.4 TESTS OF PROTECTION EQUIPMENT

- a) response of disturbances:
- ac/dc auxiliary supply changeover and/or failures
 - start/stop or deblock/block
 - converter transformer switching
 - sudden changes in sending or receiving end ac system voltage
 - filter switching
- b) fault protection proven by simulation (e.g. by initiation of protection equipment)

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Converter valve faults (including valve short circuits)

- valve group faults including short circuit across dc side, and fault to ground on secondary of converter transformer feeding highest voltage section of the 12 pulse valve group
- ac system faults
- dc switchyard faults
- dc line faults
- converter transformer faults
- ac filter faults
- dc filter protection
- over current protection
- over voltage/under voltage protection
- over frequency / under frequency protection
- capacitor bank protection
- protection for high firing angles/high harmonics

c) fault protection proven by staged tests:

- dc switchyard faults on line side of smoothing reactor
- dc line faults
- electrode line faults
- commutation failures/control pulse failures
- ac system faults

d) overall coordination of protection

e) SSO damping controller testing if provided.

All the tests with the exception of 9.3.6.4 b) shall be conducted with the HVDC system operating in the normal mode, including bipolar operation.

In addition to the above, the Contractor shall also carryout the site tests to establish that the performance/guarantees provided, like audible noise etc. are met.

If any (item of) equipment furnished by the Contractor fails to pass any of the above tests or shows any signs of failure, it shall be rectified and defective parts replaced or redesigned. The Equipment/Works shall then be retested without additional cost to the Employer.

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The retesting shall include the test under which the failure occurred, as well as all of the tests already completed, which might be affected by the repair. All additional items of equipment of the same type and rating furnished shall conform in all respects with the item of equipment which passed the above tests.

During the tests the Contractor shall make final adjustments to the equipment/works for satisfactory operation.

The Contractor in consultation with the Employer shall arrange tests such that the frequency and duration of interruptions to power transmission during tests are minimized. In addition, a ground electrode test programme shall be conducted as part of the system tests. The Contractor shall depute his representative(s) for participating in tests on the ground electrodes. Exact duration and sequence of the test program for the ground electrodes shall be mutually agreed between the Employer and the Contractor prior to start of the system tests. The Contractor shall also provide necessary test instruments for ground electrode tests and assist the Employer based on his previous experience and available expertise.

It is recognized that some of the acceptance tests shall have been carried out as part of the Factory system tests and system tests. Repetition of these (successful) tests shall not necessarily be required if there have not been any subsequent modifications and properly documented tests results are available.

9.3.7 TRIAL OPERATION

After completion of system tests, trial operation shall be conducted for first Bipole for a period of ten days. Subject to Employer agreement, the trial operation could be conducted in stages. However, the final trial operation shall be with the complete multi-terminal systems operation in an uninterrupted continuous period of normal operation of not less than 21 days during which the converter equipment shall be fully operational. Interruptions attributable to dc line and connecting ac system requirements shall be permitted during trial operation.

9.3.8 TESTING OF REPAIRED EQUIPMENT

If any equipment is damaged after factory testing, during transit, commissioning or otherwise, the Contractor shall estimate the extent of damage and shall propose, for consideration of the Employer, whether he wants to repair the same equipment or shall replace the same with new one. In case he proposes to repair, a

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repair procedure, for approval of the Employer shall be submitted along with the proposal. The Employer's decision for repair or replacement shall be final and binding.

The testing requirement shall be discussed and agreed for each such individual equipment. The Employer may decide to carryout all applicable specified tests on the repaired equipment. All costs for such activities shall be borne by the Contractor.

If the damage is of such nature that it is apprehended that it may adversely affect the performance & life of equipment/plant but cannot be quantified by means of testing, then the Contractor shall replace such equipment/plant or alternatively offer an extended guarantee for a period of at least 5 years from the date of completion of successful availability and reliability period.

9.4 COMMISSIONING RESPONSIBILITIES

The test equipment supplied for this contract shall be commissioned at the sites and brought into operation by the Contractor.

The Contractor shall provide a commissioning supervisor and other staff as approved by the Employer. The Contractor shall provide commissioning procedures and details of test equipment required and these procedures shall include, but not be limited to, the tests specified above in this section. These procedures shall be submitted at least six weeks prior to the starting of the tests at site.

The Employer reserves the right, without additional cost to the Employer, to add to the commissioning procedures any tests he may find necessary to prove correct performance of the Equipment/Plant.

During the commissioning the Contractor's commissioning Supervisor shall assume charge and be responsible for the equipment(s) being commissioned. The Employer's clearance and safety procedures shall apply during the commissioning work, with the start of "sub-system Energization Tests" and the Employer shall nominate a representative to coordinate with the Contractor's commissioning Supervisors on matters relating to system operation and control.

The Contractor shall supply the ac and dc testing equipment for the dielectric tests and all measuring devices, including instrument transformers, oscillograph etc., for tests to be performed at the Sites. These instruments and instrument transformers shall be previously calibrated as per accepted standards.

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The Contractor shall bring each stage of Works into operation according to the contract.

No inspection, test or operation which is required to take place or be done in, upon, or about the works which have been energized or existing equipment or facilities of the Employer which are or may be electrically charged or energized from any source, shall be permitted unless and until a written 'Permit to Work' has been issued for this purpose by the Employer. When the inspection, test or operation is sanctioned by the 'Permit to Work' and such inspection, test or operation has been completed, the Contractor shall give written clearance to the Employer of said completion and return the 'Permit to Work' to the issuing authority. The 'Permit to Work' shall specify the date and for what period the said permit shall apply and the permit shall only be valid for such date and such period of time.

The system tests shall be performed after obtaining the permission from the concerned load despatch centres (LDC's). The Employer cannot guarantee that neither the tests shall be performed without interruption nor the tests shall be performed at any particular time period during a particular day. The Contractor shall request the Employer in writing seven days in advance to arrange permission from LDC's, thereafter the Employer shall obtain the permission from the LDCs. The Contractor may be required to perform tests during odd hours.

9.5 TEST EQUIPMENT ON SITE

The test equipment shall be supplied to each site separately and shall be properly adjusted & calibrated.

9.5.1 STATION OPERATION AND MAINTENANCE TEST EQUIPMENT

The Contractor shall supply the test equipment which shall be required by the Employer for the operation & maintenance of the stations. The Bidder/Contractor shall include in the Bid an itemized list of such test equipment for each station. The Contractor shall provide a description of the intended use of each item of test equipment, reasons for the quantity recommended for each unit, major parameters of each unit, and brochures describing each unit together with available features and/or accessories. The Contractor shall supply at least the following test equipments for each terminal alongwith any additional equipment which may be required for the operation and maintenance of the stations.

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Sl.	Description	Qty	Remarks
1.	Clip on meter	2 no.	General Requirements : 2000 A AC, 1000 A DC with a feature of measuring different order harmonics; Accuracy of the instrument shall be 1% of the range. Resolution 100 mA upto 200 A and 1A for higher. Product shall be of LEM AN2060 make, or better .
2	Thermovision Camera: Requirement : The instrument shall be thermal imaging system based on principle of infra-red radiation detection to identify hot spots and loose connections in substations and transmission lines up to 800kV AC and 500kV DC. The instrument shall be portable and battery operated. Functional Requirements :The thermovision camera shall have the facility to measure the following temperatures: Absolute value of Hot spot temperature .Color thermal image of focused object. Isotherm temperature Measured temperatures shall be corrected for effects of solar emittance, atmospheric temperature. Range and Accuracy : Temperature measurement The camera shall be able to measure the hot spot temperatures ranging from 0 to 500°C with an accuracy of + 1 %. Focal range shall be from 0.4m to infinity. The	1 no.	General Requirements: The instruments shall contain all standard accessories including testing lead of 20 meters with suitable clamps/connectors and carrying case. The instrument should have been proven for repeatability of test results in charged switchyard conditions. Documentary evidence for this should be furnished along with the bid. Environmental conditions such as temperature, humidity, vibration, blimp etc. shall be as per IS-9000 and IS-9001 or equivalent standards. Required certificates confirming to above standards shall be furnished along with the offer. Necessary transport packing arrangement shall be supplied along with the equipment. The kit shall be

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	<p>instrument shall be light weight so that Operator can easily scan the Switchyard equipment for hot spots. The instrument shall have storage capacity up to 200 thermal images. The instrument should have been proven for repeatability of test results in charged switchyard conditions. Software for retrieval of data to maintain database and preparation of reports shall be supplied along with the kit. The hot spot focusing shall be motorized. Accessories shall also include FOV wide angle lens of 32° or better, 8°FOV telephoto lens for detailed scanning.</p> <p>Battery and Battery charger</p> <p>Battery shall be re-chargeable Ni-cad battery.</p> <p>Battery charger should be suitable for single phase 230V AC, 50 Hz, with variations of + 15 % and +5 % in Voltage and Frequency respectively. Infrared detectors shall be based on Focal plane array technique.</p> <p>Instrument shall be capable of measuring hot spot temperature from 1m to 1000 meter distance. The specification for laptop PC if required shall be as per requirement of site. The required software for analysis of data measured shall be supplied along with the equipment.</p>		<p>compatible for EMI/EMC environment as per IEC . As per requirement of 1SO-9001, calibration certificate for each testing instrument covering entire range shall be supplied with the test kit at the time of supply. The equipment shall generally comply with the requirement of relevant Indian standard or' equivalent International standards such as IEC, BS, ASTM, ISO, etc. Supplier should have adequate "after sales service facility" in India. Product shall be from AGEMA 3 with model 570 (PAL) / 550 PRO (NTSC) or better.</p>
3.	Capacitance bridge	1 no	General Requirements :

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			Capable of carrying out field measurements. Range from nF to 1000microF. Product shall be of ABB CB10 make Capacitance Bridge or better
4.	Digital Micro Ohm Meter for contact resistance measurement This test kit shall be portable, light weight, robust and tropicalized to suit outdoor applications such as circuit breaker, isolator contact resistance measurement etc. It shall be battery operated, rechargeable and shall include all accessories like probes, test leads, clamps for use of conductor's size up to 35mm dia. The test instrument shall provide contact resistance in digital display. <u>Technical requirements:</u> <u>Range</u> : 1 micro-ohm to 2000 micro-ohm <u>Accuracy</u> : + 2.5 % <u>Resolution</u> : 1 micro-ohm <u>Test Current</u> : 0-1000A(dc)	1 no	General requirements: The instrument shall contain all standard accessories including test leads of 20 meters with suitable clamps / connectors and carrying case. It should offer repeatability of test results in charged switch yard conditions. The test kit shall be compatible for EMI/EMC environment as per IEC 1000. As per requirement of ISO-9001, calibration certificate for each testing instrument covering entire range shall be supplied with the test kit at the time of supply. The testing equipment is generally meant for carrying out testing at site and movement from one place to another is unavoidable. Therefore equipment shall be robust in design so that it gives desired performance even in adverse site conditions. Environmental conditions such as temperature, humidity, vibration, bump etc. shall be as per IS 9000 and IS-9001 or equivalent standards. Required certificates confirming to above

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			<p>standards shall be furnished along with the offer. Necessary transport packing arrangement shall be supplied along with the equipment. The equipment shall generally comply with the requirement of relevant Indian standard or equivalent International standards such as IEC, BS, ASTM, ISO, etc.</p> <p>The Supplier should have adequate "After Sales Service" facility in India. Product shall be from make</p> <p>Programma 1 with Model no. 690. or better.</p>
5.	Digital camera	1 no.	<p>Suitable for taking pictures of equipments along with accessories during O & M stage. It shall have necessary zoom features and shall be capable of operating in 400 kVAC/ 800 kV DC switchyard. It shall have minimum resolution of 7 Mega pixel. Storage capacity shall be minimum 1GB. Suitable accessories and necessary interface for downloading feature to HVDC terminal station PC shall also supplied along with camera. Product shall be Sony Cyber-shot DSC-H5 or better.</p>
6.	Battery Operated 5 KV Insulation Tester: <u>Technical Requirements</u>	1 no	<p>General Requirements: Environmental conditions such as temperature,</p>

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	<p><u>Rated voltage selection :</u> 0.5/1.0/2.5/5 KV (DC volts)</p> <p><u>Rated resistance:</u> 0-10,000 M ohms.</p> <p><u>Accuracy :</u> $\pm 5\%$</p> <p><u>Type:</u> Portable, compact, direct reading (digital) type of multi voltage and multi rated resistance ranges. It shall be suitable for DC battery operation. Battery shall be re-chargeable with 230 V. 50Hz, AC supply. The necessary accessories for this purpose shall be supplied by the supplier.</p>		<p>humidity vibration bump shall be as per IS9000 and IS-9001 or equivalent standards. Required certificates confirming to above standards shall be furnished along with the offer.</p> <p>Necessary transport packing arrangement shall be supplied along with the equipment.</p> <p>The instrument shall be supplied with two meter long mains lead and 20 meters long test leads with carrying case. It shall generally comply with the requirement of IS: 2992-1987 & IS: 11994-1986 or any relevant acceptable international standards. As per requirement for ISO-9001, calibration certificate for each testing instrument covering entire range shall be supplied with the test kit at the time of supply.</p> <p>Test kit shall be compatible for EMI/EMC environment as per IEC-1000. Supplier should have adequate "after sales service" facility in India.</p> <p>Product shall be from AVO1 with model BM-11D or AVO 3 with model MJ-15 or better.</p>
7.	Phase sequence meter	1 no	<p>General Requirements :</p> <p>Equipment should be capable of doing measurements at 415 V 3-phase 50 Hz system .</p>

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			Product shall be make Unitest or better
8.	<p>Test kit for Transformer DC winding resistance measurement :</p> <p>The instrument shall be used for measuring DC winding resistance of the large 400KV class transformer/reactors where high inductance is present. The test kit shall be able to withstand inductive kicks from transformer winding. Variation in test 'current shall not result in loss of accuracy. The display or resistance should be through LED/LCD with out requiring any balancing of decades to obtain stable readings. It should employ four wire method and no lead compensation shall be required for the measurement. Built-in-discharge circuit should be provided to discharge the specimen when test is completed or when current lead accidentally disconnects or when instrument power supply is lost.</p> <p><u>Technical Parameter :</u> Test current Min 25 Amp DC in range of 0-2000 milliohm <u>Resolution</u> :1 milliohm <u>Range</u> : 0 to 10 ohms <u>Accuracy</u> : ± 0.5 % of full scale reading or better</p> <p>Open circuit voltage minimum 30 volts DC. The instrument shall contain all standard accessories including test leads of 20 meters with suit-</p>	1 no	<p>General Requirements :</p> <p>It should offer repeatability of test results in charged switchyard. The test kit shall be compatible for EMI/EMC environment as per IEC 1000.</p> <p>As per requirement of ISO-9001, calibration certificate for each testing instrument covering entire range shall be supplied with the test kit at the time of supply.</p> <p>The testing equipments are generally meant for carrying out testing at site and movement from one place to another is unavoidable. Therefore equipment shall be robust in design so that it gives desired performance even in adverse site conditions. Environmental conditions such as temperature, humidity, vibration, bump etc. shall be as per IS-9000 and IS-9001 or equivalent standards. Required certificates confirming to above standards shall be furnished along with the offer. Necessary transport packing arrangement shall be supplied along with the equipment. The equipment shall generally comply with the requirement of relevant Indian standard or equivalent International</p>

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	able clamps/connectors and carrying case. It shall be suitable for 230V, single phase, AC, 50Hz supply with variations of: $\pm 15\%$ and $\pm 5\%$ in voltage and frequency respectively.		standards such as IEC, BS, ASTM, ISO, etc. The Supplier should have adequate "After Sales Service" facility in India. Product shall be of Tinsley 2 with model 5896B or better.
9.	Digital Oscilloscope with cart	2 no	General Requirements : The device should have four digital/analogue channels, analogue and digital triggering features, data storing facility along with the necessary hardware and software needed for down loading the stored data from the oscilloscope buffer memory to the PC hard disc for storage , printing and analysis. Product shall be of Tektronoix TDS 2014 + TDS 2CMAX + 4 PMS 201 X 1 along with color printer or better.
10.	DC current source	1 no	General Requirements : 600 A for 1 minute continuous, 200 A Continuously. Product shall be T &R DSM600 or better.
11.	Capacitance Inductance and resistance meter	1 no	General Requirements : The equipment should be hand held and should be able to carry out measurement of R.L &C of valve components. Product shall be of Wavetek LCR 55 make or better .
12.	Automatic Relay testing	1 no	General

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	unit		Requirements : The test unit should have Delayed On & OFF features with variable time settings, variable AC & DC voltage and current stabilized supply with over load MCB protection and different ranges of built in resistors and capacitors values. The relay shall be capable of testing all the protective relay installed HVDC terminal. The test unit shall have feature of make Freja 300 or better.
13.	Frequency Counter	1 no	General Requirements : Range 5 Hz to 5 MHz for all kinds of wave forms. It Shall have high sensitivity .Resolution of 0.0001 mHz or better. It shall have feature of THURBLY THANDAR INSTRUMENT , PFM 1300 make or better.
14.	Harmonic analyzer	1 no	General Requirements : Capable of measuring the harmonics upto 60 th order. The equipment should be capable of directly displaying individual and total harmonic distortions. Instrument shall have feature of Fluke 43B or better.
15.	Variable stabilized power supply	1 no	General Requirements : 0 to +/- 50 Volt adjustable stabilized 200 Watt output power supply.
16.	Variac (single phase & three phase) power supply	1 no each	General Requirements : 250 volt single phase, 415

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			volt three phase four wire variable supply. Max output current at three phase version is 25 Amps per phase. There should be a suitable out put over load prevention.
17.	Lifting equipment with slings of various sizes and load capacities.	1 set	General Requirements : The device should be able to lift max 5 Ton load upto the 7 feet height. It shall swivelling hooks with safety catch. It shall have Safe, well covered automatic load reaction break.
18.	Thyristor/valve test unit	1 set	General Requirements : Capable of displaying thyristor firing traces along with the impedance measurement of the damping circuit, grading circuit and indicating healthiness of the other valve components including valve gate electronics.
19.	Digital multimeter	6no.	General Requirements : Capable of measuring Dc and AC voltages (range 200mV to 600 V) and currents (range 2 mA to 10 A), frequency, resistance. It shall also have provision of measuring Current range in mA and voltage range in mV shall be available. Shall have accuracy $\pm 0.2\%$. Digital multimeter shall be Fluke 83 or better. Two of the multimeters shall be

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			compatible for measuring ac/dc current as clamp on meter as an additional feature.
20.	Function generator	1 no.	General Requirements : Capable of generating sine, square, triangular waves for varying magnitude (0 to 50 volt) and varying frequency 0 to 100 kHz shall have high power output and suitable protection. It shall be capable of generating sine, triangle, square, positive and negative pulses, broadband amplifier , DC Input supply 230 V AC. It shall have feature of TCELLNER make TOE 7741 or better.
21.	Primary Injection Kit	1 no.	General Requirements : Out put range 0 to 4000 Amps AC 50 Hz, for three(3) minutes and for currents less than 2000 Amp, the duty should be continuous. Input power supply of the test unit should be single phase 50 Hz AC. The instrument is intended for use in high-voltage substation and industrial environments. It shall have feature of ODEN/2S or better.
22.	CT secondary winding magnetization kit	1 no.	General Requirements : Output 1.0 Amps at 2 kilo volt with overload trip feature. It shall have feature of MAGNUS make

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			or better.
23.	<p>Automatic Capacitance and tan delta kit :</p> <p>The equipment shall be suitable to measure capacitance and tan delta of EHV class transformers (2/3 windings), bushings, windings of shunt reactors, bus & line CVT's and- grading capacitors of CB's at site in a charged switch yard upto 420kV, AC and 500kV Dc. The kit shall be capable of measuring capacitance and tan-delta of each winding of the transformers in suitable mode so that capacitance of other windings does not affect the reading.</p> <p>The equipment shall comply with the requirements laid down in internationally acceptable' standard. The equipment shall be complete with measuring bridge, HV power supply unit of 10 KV, standard capacitor etc. The effects of induced voltage on instrument during testing for getting null point should be compensated. The kit shall be capable of measuring excitation current of transformer winding at 10 KV.</p> <p><u>Technical Requirements :</u></p> <p><u>Output Voltage:</u> Output of the kit shall be from 0 to 10kV in continuously adjustable range.</p> <p><u>Tan delta:</u> The kit shall measure a delta ranging from 1×10^{-4} to 2 with an accuracy of $\pm 1\%$ of the measured value.</p>	1 no.	<p>General Requirements :</p> <p>It should offer repeatability of test results in charged switchyard.</p> <p>The test kit shall be compatible for EMI/EMC environment as per IEC 1000.As per requirement of ISO-9001, calibration certificate for each testing instrument covering entire range shall be supplied with the test kit at the time of delivery.</p> <p>The testing equipment .are generally meant for carrying out testing at site and movement from one place to another is unavoidable. Therefore equipment shall be robust in design so that it gives desired performance even in adverse site conditions. Environmental conditions such as temperature, humidity, vibration bump etc. shall be as per IS-9000 and IS-9001 or 'equivalent standards. Required certificates confirming to above standards The equipment .shall generally comply with the requirement of relevant 'Indian standard or, equivalent international standards such as IEC, BS, ASTM, ISO, etc. The Supplier should have adequate "After Sales Service" facility in India.</p> <p>Product shall be of Dobbie</p>

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	<p>Resolution: $\pm 1 \times 10^{-4}$</p> <p><u>Capacitance</u> :</p> <p>The kit shall measure capacitance ranging from 1.0 Pico-farads to 0.1 micro farads with an accuracy of ± 1 % of the measured value. Resolution : ± 1 Pico-farad.</p> <p>The instrument shall contain all standard accessories including test leads of 20meters with suitable clamps/connectors and carrying case. Input supply of the kit shall be 230volts AC, 50Hz, with variations +15% and 5 % in voltage and frequency respectively. Software shall be supplied along with interfacing accessories with PC for retrieval of test data and analysis.</p>		2 with model M4000 or better.
24.	Impedence Analyser	1 no	<p>This equipment should be able to measure R, L and C of the 400 kV current harmonic filters precisely. It shall be able to measure on different harmonic frequency. Measurement accuracy shall be 0.1% and test frequency upto 10 kHz. It shall have feature of THURLBY THUNDER INSTRUMENT (TTI) make LCR-400 or better.</p>
25.	Phase angle meter	1 no	<p>It should be able to measure the phase difference between all possible combinations of input voltages and currents. It shall have measurement range of 0-359.9deg, input current range 0-10A and can be</p>

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			increased by means of a clamp on meter CT, Input voltage 0-500 V, shall be able to measure phase angle between current-current, voltage -voltage and current -voltage of Sine wave with resolution 0.1 degree. It shall have feature of Programma make PAM 360 or better.
26.	Maintenance equipment for carrier equipment ,protection coupler, modem tester and data channel For PLCC system	1 set	This test equipment (s) Shall be Suitable for supplied PLCC system testing and maintenance
27.	<p>Automatic turns ratio tester :</p> <p>The equipment offered shall be used for measurement of turns ratio of various Power & distribution transformers automatically displaying the, ratio with out requiring any manual balancing of decades.</p> <p><u>Technical requirement :</u></p> <ul style="list-style-type: none"> <u>Input supply Voltage:</u> 230 volts ,50 Hz, single phase a.c. with variation of $\pm 15\%$ in voltage & $\pm 5\%$ in voltage and frequency. <p><u>Measuring principle :</u></p> <p>It should display actual turns ratio of different vector groups in three phase transformers without conversion, <u>Measuring range</u> : 1 to 200</p> <p><u>Accuracy</u> : $\pm 0.5\%$ of FSD</p> <p>The kit should be supplied with 15m of test lead.</p>	1 no.	It shall have feature of TETTEX2 make with model 2793 or better.
28.	<p>Vibration cum noise level meter :</p> <p>The equipment shall be compact, portable and</p>	1 no.	<p>General Requirements :</p> <p>It should offer repeatability of test results in charged switch</p>

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<p>battery operated. It shall conform to IEC, ISO or other international standards. The equipment shall be suitable for measurement of sound, as well as vibration level of EHV class transformers and reactors. The equipment shall have provision for fixing probes for vibration & noise measurements. The equipment shall have suitable arrangement with magnets/studs etc. for mounting. The vibration pick up shall be self-generation type. The sensitive axis shall be the longitudinal axis and shall be perpendicular to the mounting surface. It should be possible to orient the instrument in any mounting position without adjustment and correction.</p> <p><u>Technical Parameters:</u> <u>Vibration Measurement :</u> I. Frequency range : 10 to 1000 Hz</p> <p>II. Amplitude range : 0 to 3000 microns in suitable overlapping range (Displacement)</p> <p>III Velocity : 0 to 200 mm/s true RMS</p> <p>IV. Max. Acceleration : 0 to 300m/sec² true RMS</p> <p>V. Sensitivity : 0.3 micron</p> <p><u>Vibration pick up :</u> i. Amplitude linearity: 15 % over the range of measurement.</p>	<p>yard conditions. The test kit shall be compatible for EMI/EMC environment as per IEC 1000.</p> <p>As per requirement of ISO-9001, calibration certificate for each, testing instrument covering entire range shall be supplied with the test kit at the time of supply. The testing equipment is generally meant for carrying out testing at site and movement from one place to another is unavoidable. Therefore equipment shall be robust in design so that it gives desired performance even in adverse site conditions. Environmental conditions such as temperature, humidity, vibration, bump etc. shall be as per IS-9000 and IS-9001 or equivalent standards. Required certificates confirming to above standards shall be furnished along with the offer. Necessary transport packing arrangement shall be supplied along with the equipment.</p> <p>The equipment shall generally comply with the requirement of relevant Indian standard or equivalent international standards 'such as IEC, BS, ASTM, ISO, etc. The Supplier should have adequate "After Sales Service" facility in India. Special facility and</p>
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	<p>ii. Amplitude Sensitivity: 0.15 mm/s peak velocity. Natural resonant Frequency : < 20 Hz <u>Noise level measurement</u> :</p> <p>i. Range : 10db to 150db ii. Accuracy: +0.7db</p> <p>The equipment offered shall be complete with following: <u>Standard Accessories</u> :</p> <ol style="list-style-type: none"> 1. Vibration pickup :1 no. 2. Straight probe : 1 no. 3. Pick up cable (1.2 mtr) : 1 no. 4. Retractable pick up cable (2 mtrs) : 1 No. 5. Carrying strap : 1 no. 6. Plug recorder output : 1 no. 7. carrying case : 1no. 		<p>software for the Instrument shall be available for downloading the data to station PC /laptop for analysis. Product shall have feature of make Bruel & Kjaer 1 with model no. 2525 or better.</p>
29	PCB repairing work station	1 set	<p>The equipment should have soldering, de-soldering tools. The soldering machine should have variable temperature settings and controlled through microprocessor based system.</p>
30	Portable Earthing kit	3 no.	<p>The kit shall have insulated glass fiber telescopic stick suitable for working in 400KV AC/800KV DC. Self bonding spring loaded jaw type clamps of anticorrosive material suitable for various bus bar conductors/ tubes and earthing cables are to be specially designed to combine low electrical resistance with high mechanical strength suitable for system earth fault current so as to</p>

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			enable the user to achieve an effective connection in order to safely dissipate static electricity (including filter capacitor banks).
31	Fibre optic terminal tool		
(i)	Optical Power Meter 1310/1550 nm	1 No.	Equivalent to Anritsu ML9002A or better
(ii)	Optical Loss test set (including Laser Source and Power Meter)	1 No. 1 No.	Equivalent to Anritsu MS9020D or better
(iii)	Connector Kit	1 No.	Equivalent to FIS FI-0053-FC-INST or better
(iv)	Splice Kit	1 No.	Equivalent to FIS FI-0053FF or better
(v)	Testing accessories kit	1 set	Including all necessary connectors, adapters, cable terminations and other items required for testing
32	Software programming tool		<p>This test equipment (s)/tool Shall be Suitable for supplied Control & Protection system .</p> <p>The programming unit shall be equipped with optimum hardware feature and software for programming, debugging and starting up programmable Controllers in an automation environment. It shall have interface ports for connection to the programmable controllers. The equipment shall be suitable for use in hostile industrial environment.</p>
33	On-Load Purifier machine For Converter	1 no.	Performance Requirement: Purifier

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	transformer Oil		<p>shall be able to remove water, all the dissolved gases which are harmful to transformer operation and solid particle from the transformer oil during on load operation of converter transformer.</p> <p>It shall have suitable accessories for connecting this unit to the converter transformer unit and necessary isolating system. It shall be able to operate with transformer oil temperature below 80° C. It shall be able to operate with electrical power supply with nominal three phase supply 415 V, 50 Hz Product shall be model no. HTP070 of Pall corporation or better.</p>
34.	Earth fault locator for floating dc system.	2 nos	<p>Main Features:</p> <p>It shall able to :</p> <ul style="list-style-type: none"> - locate earth faults on live DC circuits - Traces cable and pin points earth faults - Locates faults up to 68 k Ohm - Operate easily & unaffected by load current , ripple etc. - Operates on live circuits up to 300 Volts . - Locates multiple earth faults & Operates on DC systems <p>Product shall be of Grouser make or better.</p>

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35	Partial discharge detection / monitoring of transformer	1 no	<p>Partial discharge monitoring system shall be portable. It shall be able to detect , analyze and locate the type and nature of partial discharge (PD) activity within the Transformers/Reactors (single / three phase) , converter transformer (± 800 kV HVDC system) equipment.</p> <p>It shall be able to operate outdoor and with equipment to be monitored during energized and environment conditions such as temperature, humidity, vibration bump as per IS9000 &9001.It shall have minimum PD detection level 20 pc .Should include suitable user friendly analysis/diagnostic software and shall be able to transfer data in any Windows base 98/2000/XP operating system PC . The performance should not be affected by the EHV induction (400 KV/800 KV/HVDC 800KV). The test kit shall be compatible for EMI/EMC environment as per IEC 1000. Shall be able to operate with 230 V, 50 Hz single phase or 440 V, 50 Hz three phase power supply. The test kit shall be of Power PD make model TP500A or better.</p>
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9.5.2 **USE OF TEST EQUIPMENT BY THE CONTRACTOR**

The Test equipment shall be delivered to the Employer in as new condition and shall be used' thereafter for maintenance on equipment in operation. Any test equipment which was previously utilised by the Contractor for commissioning shall be refurbished and restored to as new condition or alternately he shall replace it by a new equipment at no additional cost to the Employer.

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9.6 QUALITY ASSURANCE REQUIREMENTS

9.6.1 QUALITY ASSURANCE PROGRAMME

To ensure that the equipment and services under the Scope of Contract whether manufactured or performed at the Contractor's works or at his sub-Contractor's premises or at the Employer's site or at any other place of work are in accordance with the Specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all points, as necessary. Such programmes shall be outlined by the Contractor and shall be finally accepted by the Employer after discussions prior to commencement of manufacturing. A quality assurance programme of the Contractor shall generally cover the following:

- a) His organisation structure for the management and implementation of the proposed quality assurance programme.
- b) Design and Documentation control system.
- c) Qualification data for Contractor's key personnel.
- d) The procedure for purchase of materials, parts, components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.
- e) System for shop manufacturing and site erection control including process controls and fabrication and assembly controls.
- f) Control of non-conforming items and system for corrective actions.
- g) Inspection and test procedure both for manufacture and field activities.
- h) Control of calibration and testing of measuring and testing equipment.
- i) System for quality audits.
- j) System for indication and appraisal of inspection status.
- k) System for authorising release of manufactured product to the Employer.
- l) System for maintenance of records and
- m)Furnishing of quality plans (QP)/inspection and test plan (ITP) for manufacturing and field activities detailing out the specific quality

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control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component.

9.6.2 GENERAL REQUIREMENTS - QUALITY ASSURANCE

- 9.6.2.1 All services, materials, components and equipment covered under this specification shall be engineered, designed, procured, manufactured, erected, commissioned and tested at all the stages, as per a comprehensive Quality Assurance Programme. An indicative programme of quality assurance to be carried out by the Contractor for various items shall be given in the Bid.

It is the Contractor's responsibility to draw up and implement such agreed programme for system as a whole as well as for individual equipment. The detailed Quality Plans for manufacturing and field activities shall be drawn up by the Contractor and shall be submitted to the Employer for approval.

The Contractor shall furnish with his bid a list of approved suppliers for the information of the Employer.

- 9.6.2.2 Engineering and design quality Plan shall detail out the studies, overall detail design documentation and communicating, defining interfaces and controlling changes. To achieve quality, reliability and schedule objectives that project shall be designed so that it meets performance requirements.

Manufacturing Quality Plan shall detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this Specification and standards mentioned therein and quality practices and procedures followed by Contractor's Quality Control Organisation, the relevant reference documents and standards, acceptance norms, inspection documents etc., during all stages of materials procurement, manufacture, assembly, and final testing/performance testing.

- 9.6.2.3 Field Quality Plan shall detail out for all the equipment, the quality practices and procedures etc. to be followed by the Contractor's site Quality Control Organisation, during various stages of site activities from receipt of materials/equipment at site onwards.

- 9.6.2.4 The Bidder/Contractor shall also furnish copies of the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., as referred in Quality Plans along with respective Quality Plan. These Quality Plans and reference documents/standards etc. shall be subject to Employer's approval without which manufacture shall not proceed.

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In these approved QPs, the Employer shall identify customer inspection points (CIP), test/checks which shall be carried out in presence of the Employer's Engineer or his authorised representative and beyond which the work shall not proceed without consent of Employer or his authorised representative in writing. All deviations to specification, approved quality plans and applicable standards must be documented and referred to the Employer for approval and disposition.

- 9.6.2.5 No material shall be dispatched from the manufacturer's works before the same is accepted subsequent to pre-dispatch final inspection including verification of records of all previous tests/inspections by Employer's Engineer and / or his authorised representative, and duly authorised for dispatch issuance of Material Inspection Clearance Certificate (MICC).

Before making request for issuance of MICC, the Contractor shall ensure that approval of type tests, data sheets, drawing etc. had already been obtained from Employer.

All materials used or supplied shall be accompanied by valid materials certificates and tests and inspection reports. These certificates and reports shall indicate the sheet numbers or other such acceptable identification numbers of the material. The material certified shall also have the identification details stamped on it.

- 9.6.2.6 All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME section - IX/BS-4870 or other International equivalent standard acceptable to the Employer.
- 9.6.2.7 All the (sub)-Vendors proposed by the Contractor for procurement of bought out item list of which shall be drawn up by the Contractor and finalised with the Employer shall be subject to the Employer's approval. Quality Plans of the successful vendors shall be discussed, finalised and approved by the Employer and shall form part of the purchase order between the Contractor and the Vendor.
- 9.6.2.8 The Employer reserves the right to carry out quality audit and qualify surveillance of the systems and procedures of the Contractor's of their sub-Contractor's (sub-vendor's) quality management and control activities. The Contractor shall provide all necessary assistance to enable the Employer carry out such audit and surveillance.

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9.6.2.9 As a part of quality assurance of engineering and design, the technical review meetings (TRMs) shall be conducted between the Employer and/or his consultants/representative and the Contractor and/or his subContractor(s). The duration and cycle of such TRMs shall be as frequent and regular as required to meet the time schedules. The meetings shall be held at either at the Employer's office and/or at the office/manufacturing place of the Contractor/sub-Contractor or at any other place as agreed mutually.

9.6.2.10 The Contractor shall agree upon a schedule of submissions of documents concerning the Quality Assurance Program within two months of the effective date of the Contract. This schedule shall indicate the list of mutually agreed items/equipment for which quality Plans shall be submitted by the Contractor and the last dates for the submissions. It shall be ensured by the Contractor that the submissions are so programmed that all relevant approvals are obtained from the Employer for these documents in a timely manner before the material induction and commencement of the manufacture for any equipment.

9.6.2.11 The documents that shall be submitted by the Contractor to the Employer for review and approval as per the agreed schedule include:

- a) QA Manuals
- b) Quality Plans (Inspection & Test Plans) for all equipment/materials manufactured in the Contractor's works and/or in the sub-Contractor's works
- c) Purchase Specifications for equipment procured from sub-Contractors.
- d) Contractor's assessment reports of his sub-Contractors
- e) Field Quality Plans for all activities at site
- f) Reference documents referred to in Quality Plan.
- g) Erection, commissioning, operation and maintenance manuals

9.6.2.12 QA Document Package

The Contractor shall submit the following Quality Assurance Documents to the Employer. These documents shall be as per the approved Quality Plans for the concerned equipment. The documents shall include, but not limited to, the following:

- a) Routine test reports & Acceptance test reports

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- b) Type test reports
- c) Quality records etc. corresponding to items identified Quality Plan
- d) Inspection reports for Customer inspection points
- e) Reports on repair/modification carried out to make the item/equipment acceptable.
- f) Non-destructive examination result reports including radiography interpretation reports, wherever applicable.

The above documents are required to be submitted in required number of copies within three weeks after dispatch of equipment.

9.7 INSPECTION AND TESTING

- 9.7.1** In order to verify that all the manufacturing of equipment by the Contractor as well as materials & equipment being procured and provided by the Contractor are in complete conformance with the requirement of the Contract, the Employer and/or his duly authorized representative shall have access to the Contractor's premises or works at all reasonable times to inspect and examine the material, equipment and workman ship during its manufacture or installation.

In addition to carrying out inspection the Employer and/or his authorized representative/Consultant all carry out quality audit on the Contractor's Quality Assurance System and conduct quality surveillance to check conformance to quality procedure/practice in general. The Contractor shall provide necessary facilities to carry out all the above activities at their works and the works of the sub-Contractors.

- 9.7.2** The Contractor shall provide a detailed inspection schedule for those inspection stages identified as CIP and shall furnish updated schedules once every two months.
- 9.7.3** The Contractor shall give the Employer/Inspector six(6) weeks written notice, by telex or by letter, of the tentative date any material/equipment shall be ready for witness points, corresponding to Customer inspection points (CIP), when the Employer/Inspector is based in India. Final confirmation shall be given at least 15 days in advance.

The Employer/Inspector, unless witnessing of the tests is waived, shall attend such tests, failing which the Contractor may proceed with the test which shall be deemed to have been made in the

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Inspector's presence. The Contractor shall forthwith forward to the Employer copies of duly certified test reports. Test reports of all tests corresponding to CIP performed in the supply shall be reviewed and approved, subject to satisfactory conduction and successful passing of the test, by the Employer or his authorised representative (even if the witnessing of the test was waived).

- 9.7.4** The Employer or his authorized representative shall, within fifteen (15) days from receipt of such reports, give notice in writing to the Contractor of any objection to any aspect of the test reports or any or all equipment and workmanship which in his opinion is not in conformance with the Contract. The Employer or his authorized representative shall advise his reasons for objections on completion and review of the activity. The Contractor shall give due consideration to such objection(s) and shall either make the modifications that may be necessary to overcome the said objection(s) or shall confirm in writing giving reasons therein that no modifications are necessary to comply with the Contract. However, the Contractor may proceed with the works/dispatch even before the receipt of written objection(s), if any, at his own cost & risk.
- 9.7.5** Whenever the Employer's inspection engineer undertakes the inspection, at a particular stage identified as Customer inspection point (CIP) in the Quality Plan, the acceptance of test reports/test results and the MICC where applicable shall be given immediately after the test if the results, including those for previous points identified as per clause 9.6 are found to be in conformity with the Contract. In case of any deviations, the Employer/Inspector at his discretion may refer the matter to the Employer's main office, together with the manufacturer's comments, who in turn shall communicate his final decision regarding the acceptance or otherwise to the Contractor within fifteen (15) days of the receipt of such test reports/results.

In case the presence of the Employer/Inspector is waived, the acceptance of test results and issuance by the Employer of Material Inspection Clearance certificate wherever applicable, shall be given within fifteen (15) days after receipt of test reports/results for the CIP as well as for previous CIP's identified in the approved Quality Plan, provided such test reports/test results are found to be in order.

The Employer/Inspector shall at his discretion and based on the outcome of any inspection and the requirements of the contract, have the right to 'accept', 'accept as noted' or 'reject' any

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equipment/material. The reasons/comments in case of each ruling shall be communicated to the Contractor in writing.

9.7.6 In all cases where the contract provides for tests, whether at the premises of works of the Contractor or of any sub-Contractor, the Contractor, except where otherwise specified, shall provide free of charge such items as labour, materials, electricity, fuel, water, apparatus and instruments as required to fulfil the requirements of the approved Quality Plan.

9.7.7 The inspection by Employer/Inspector or waiver of the presence of the Employer/Inspector, issue of CIP clearance certificate and issue of Material Inspection clearance certificate (MICC) thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed quality plans forming part of the contract.

The Employer shall not be found to accept the material/equipment if on further testing it is found to be not in compliance with the requirements of the contract.

The Contractor shall include in all orders to his sub-Contractors, the requirements for any equipment, being supplied by the sub-Contractor for incorporation in his equipment to be subjected to inspection and testing by the Employer or his authorised representative. Copies of such orders or purchase specifications, blanked for prices, shall be forwarded to the Employer.

9.7.8 The costs of all tests specified in the Contract together with the same for all tests facilities, test samples and such like shall be to the Contractor's account.

9.7.9 The Employer/Inspector shall have complete authority to reject, on behalf of the Employer, any material, equipment or parts thereof considered unsatisfactory and not in accordance with the Contract. Accept, accept as noted or reject materials, equipment or any components thereof shall not relieve the Contractor of any of his obligations under the Contractor, nor impose any liability whatsoever on the Employer.

9.7.10 The Employer shall have the right to have Inspectors on the Sites, on a regular basis or from time to time as required at his sole discretion to monitor the quality and the progress of the work.

Generally the site inspection shall be as per the approved Field Quality Plans (FQPs) and the Installation & Operation Manual(s).

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All quality related documents and test results shall be a part of plant documentation.

SECTION 10: DOCUMENTATION

10.1 GENERAL

- 10.1.1** All technical description, specifications, literature, correspondence, prints, drawings, instruction manuals, test reports(both factory and site), progress photographs, booklets, schedules and all supplementary data or documents furnished in compliance with the requirements of the Contract, shall become the property of the Employer and the costs shall be considered as included in the Contract price.
- 10.1.2** The Contractor shall be responsible for any time delay, misinterpretation, error and conflict during design, manufacturing, testing and erection of the Works resulting from non-compliance with the requirements of this Specification.
- 10.1.3** The Employer shall have the right to make copies of any documents, data, reports, information etc. supplied by the Contractor in connection with the Works. The Employer shall not impart the information of these documents to any other manufacturer or competitor but he shall be free to use these for preparation of technical papers, reports etc.
- 10.1.4** The Contractor shall submit consolidated list of all symbols used in any drawing, data and information under three separate headings namely Civil, Mechanical & Electrical. If symbols other than IS or IEC are used, the Contractor shall submit consolidated list of these symbols and their significance under a separate section.
- 10.1.5** The Contractor is not required to supply detailed drawings whose purpose is manufacture only but in case such information is specifically asked for by the Employer during evaluation of Bid, finalisation of Contract, design review by Employer / his appointed Consultant or during execution of the Contract, the Bidder/Contractor shall comply with the same.
- 10.1.6** All drawings, documents manual etc. as specified in this section shall have to be provided separately for each station.
- 10.1.7** All documentation shall be in English language.

10.2 REQUIREMENTS FOR SUBMISSION OF DOCUMENTS, INFORMATION AND DATA BY THE CONTRACTOR

10.2.1 GENERAL

- 10.2.1.1** The Contractor shall submit to the Employer all documents in accordance with an approved schedule of submissions and shall

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submit any further information (in the form of drawings, documents, manuals, literature, reports etc.) when asked by the Employer while commenting/approving any drawings/documents etc. All applicable documents shall be provided for each converter station separately.

- 10.2.1.2 The documents which are subject to the approval of the Employer shall be identified by the Contractor with the stamp "FOR APPROVAL". All other documents shall be submitted to the Employer for information and shall be identified by the Contractor with the stamp "FOR INFORMATION".
- 10.2.1.3 The sequence of submission of the documents shall be subject to the approval of the Employer. The sequence of submissions of all documents shall be such that the necessary information is available to enable the Employer to approve or comment the document.
- 10.2.1.4 The Contractor shall provide Engineering Documentation Management System (EDMS) at Employers premises in Gurgaon for Electronic receipt, review, and approval of the documents. The Contractor shall supply necessary hardware and software with multi user license with a validity upto the completion of availability and reliability period to be installed on Employers Server room at Gurgaon office. The software shall permit electronic distribution of documents within a user group with sufficient inbuilt security features. The software shall also have features to generate periodic reports on status of Engineering documents submitted for the project. The Employer shall also use EDMS software for managing documentation for other projects.

The Contractor shall supply 4 hard copies of all drawings and documents. The final documentation for the project shall be supplied in six sets of hard copies (two to each site) and six sets of CDs to the Employer.

The entire plant documentation shall include all construction drawings, equipment specifications, design/study reports, O&M documents, factory test reports, etc. All the final/as built drawings shall be submitted in CAD format along with the software package with the complete final documentation. Five latest Laptops of Pentium Centrino M or better from reputed manufacturer one at each site and one each at engineering office and operation services office at corporate centre shall be supplied as part of the Documentation system.

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- 10.2.1.5 In case a "SUBSEQUENT" revision of any document is made due to any reason whatsoever, a revision of the same, highlighting the changes shall be resubmitted for the Employer's specific approval/information.

10.2.2 DOCUMENTS FOR APPROVAL

- 10.2.2.1 The Employer shall be allowed twenty one (21) calendar days to approve the Contractor's submissions. The submissions for approval, shall be returned to the Contractor marked in one of the following ways :

Category I:	Approved
Category II:	Approved with Comments.
Category III:	Returned for correction.
Category IV :	For information

- 10.2.2.2 The first notations "I" or "II" shall be deemed to permit the Contractor to proceed with the work shown on the document, except in the case of notation "II" the work shall be done subject to the corrections indicated thereon and/or described in the letter of transmittal. The Contractor shall bear the full responsibility for proceeding with the Works prior to receipt of the release in notation "I" from the Employer.
- 10.2.2.3 In case of notation "II", the Contractor shall include the alterations required & resubmit the document within twenty one (21) days from date of Employer's letter of transmittal.
- 10.2.2.4 In case of notation "III", the Contractor shall include the alterations required and resubmit the document to the Employer, within twenty-one (21) days, from date of letter of transmittal, so that such document can be returned with the notation "I" or "II".
- 10.2.2.5 It may also be noted that the approval/commenting by the Employer does not relieve the Contractor of any of his contractual obligations and his responsibilities for correctness of dimensions, materials, weights quantities or any other information contained therein, as well as the conformity of designs with Indian Statutory Laws and the Technical Specifications as may be applicable. The

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approval also does not limit the Employer's rights under the Contract.

- 10.2.2.6 All drawings to be used at site shall bear Employer's "APPROVED" stamp.
- 10.2.2.7 When a drawing/document is approved/commented and as such stamped, a marked print shall be sent back to the Contractor. The Contractor shall then include the required alterations and resubmit to the Employer.
- 10.2.2.8 The following is a tentative list of the documents and drawings which shall require the approval of the Employer :
 - 1. Schedule of drawings and data
 - 2. System Engineering studies including studies to finalize design criteria as well as equipment and station design
 - 3. Drawings and details for interfaces
 - 4. Equipment specifications and drawings
 - 5. Nameplates
 - 6. Quality/Inspection plans & Quality control programs
 - 7. Equipment test procedures
 - 8. Control panel's, cubicle's and cabinet's master legend list
 - 9. Panel/cubicle layout
 - 10. Station location plan drawings
 - 11. Station general layout drawings
 - 12. Simplified one-line (electrical & flow) diagrams
 - 13. Detailed one-line diagrams
 - 14. Station service ac and dc one-line diagram
 - 15. Converter building/equipment layout
 - 16. Other building/equipment layout
 - 17. Converter building general arrangement
 - 18. AC/DC schematic drawings
 - 19. Civil work general layouts & other detailed drawings
 - 20. Transient fault recorders input signals
 - 21. Civil works and structural design
 - 22. Outline general arrangement of equipments

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23.. Commissioning Test results of all equipment

24. Sub-system testing, System testing & complete commissioning procedures

10.2.2.9 These approved documents shall be considered as the working documents. However the Technical Specification and connected documents shall prevail over these documents in case a decision is required on interpretation.

10.2.3 DOCUMENTS FOR INFORMATION

The Contractor shall not delay the Works pending the receipt by the Contractor of the comments on documents submitted to the Employer for information. However, the Employer shall have the right to comment on all the documents submitted by the Contractor, when, in the opinion of the Employer the document does not comply with the Contract or otherwise. The Contractor shall satisfactorily demonstrate that the information contained in the aforesaid document does meet the requirements of the Contract or revise the document in order that the information shall comply with the requirements of the Contract.

10.3 ENGINEERING STUDIES REQUIREMENTS

10.3.1 GENERAL

The Contractor shall submit all reports on the system studies, engineering and the design of the Works and shall satisfy the Employer as to the adequacy of the studies to be carried out in accordance with the Contract. The details of the studies to be carried out are given in Section 4.13.

The Contractor shall have his database approved by the Employer prior to commencement of studies during post award detailed engineering. The Contractor shall make available to the Employer all his data files on CDs. He shall also furnish base case data file(s) for the studies carried out and other files as and when requested by the Employer. The Employer shall be able to open these files or files on CDs on their own PC or the documentation laptop supplied by the Contractor as part of this contract.

The results of the preliminary design performed for the preparation of the proposal shall be included in the Contractor's bid. However, all studies would be repeated during the detailed engineering of the project conforming to the technical specification requirements and all equipment would be provided and rated as per final study result.

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Some of the studies to be performed during the progress of the Works shall be performed by the Contractor in consultation and/or with the participation of the Employer and/or his Consultants. Regarding participation of Employer or his representative or his Consultant in various studies, a firm schedule for every such study shall be agreed prior to start of the engineering work.

The study reports shall include, but not be limited to the following:

- a) study objectives
- b) initial conditions, data and assumptions
- c) codes, standards and criteria used in the studies
- d) description of means and methods used in the studies
- e) computer models and data used in the studies to represent the Contractor's HVDC equipment and the Employer's equipment
- f) summary of study results
- g) conclusions

Items a) through e) above shall be submitted to the Employer for review and comment before the studies start.

10.4 DRAWINGS AND DATA

10.4.1 GENERAL

1. The Contractor shall submit to the Employer all assembly and detail drawings of equipment, station design, civil work, building, controls, protection, etc., as well as the corresponding computation where necessary in order to establish to the satisfaction of the Employer the Contractor's compliance with the requirements of the Contract.
2. The Contractor shall submit to the Employer for approval a "Station Design Report" including all the special requirements of the HVDC stations and systems including ground electrode station being supported by technical reports based on the results of the studies carried out by Contractor.
3. Drawings, as set forth below shall be submitted to the Employer and shall be complete with all information necessary for complete interpretation of the drawings by the Employer. All drawings shall show the materials, dimensions, finish, fits, clearances, tolerances, bolting and such other information as is necessary to demonstrate to the Employer that all items covered

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by the drawings are in compliance with the requirements of the Contract.

4. Drawings may consist of several sheets as required in order to provide for the degree of detail required by the Employer, so that he may clearly understand such drawings.
5. Not later than 90 (ninety) days after completion of successful trial operation of the HVDC station, the Contractor shall supply copies of the last revision of all drawings produced for this project, stamped as "AS BUILT".
6. The Contractor shall provide separate sets of drawings for each control cubicle. Typical drawings for similar cubicles shall not be accepted. If there are several cubicles per system, then one common bill of material and one system schematic diagram may be provided. Such system schematic diagram shall show the control scheme for the particular system in its entirety and shall be laid out on the minimum number of drawings sheets consistent with clarity and legibility.
7. The Employer shall not accept typical drawings for control, protection and three-phase schematics, power circuits and single line diagrams. The Contractor shall supply complete set of such drawings for each system, even when drawings are duplicates.
8. The Contractor shall submit to the Employer layout and detailed drawings covering all the items of the Works including the parallel converters to be added by the Employer in the future at the rectifier stations, but not limited to, the following :
 - a) HVAC and HVDC equipment such as circuit breakers, disconnects, surge arresters, transformers, shunt capacitors, filters, smoothing reactors, current transformers, voltage transformers, transducers, valve groups etc.
 - b) Control panels/cubicles and communication equipment and like.
 - c) AC and DC switchyards including layout and sections, grounding, lightning and the like.
 - d) Civil and mechanical works, including earthwork, foundations, buildings, roads, fences, cable trenches, drainage, steel and concrete structures, water supply, oil system, fire protection system, cooling system, hoist, air conditioning, etc.

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- e) Electrical station service equipment including batteries, battery chargers, diesel-generator sets, lighting etc .
- f) Ground Electrode Station

10.4.2 SYMBOLOGY AND DEVICE FUNCTION NUMBER DRAWING

The contractor shall furnish the scheme of numbering and identification of various equipments for the information of the Employer.

10.4.3 REQUIREMENTS FOR EQUIPMENT DRAWING AND DATA

10.4.3.1 ELECTRICAL/MECHANICAL

1. Control Panels, Cubicles and Control Cabinets
 - a) Layout drawing (for approval)
 - b) General arrangement drawings (for approval)
 - c) Floor plan drawing (for approval)
 - d) AC and DC schematics (for information).
 - e) Functional block diagram and logic diagram (for approval)
 - f) Master legend list (for approval)
2. Equipment Outline and Detailed Assembly Drawings (for approval)
3. Wiring Diagram (for information)
4. Final Bills of Material (for information)
5. Nameplates (for approval)

10.4.3.2 STEEL STRUCTURES

1. Steel Structures Calculation Sheet (for approval)
2. Steel Structures Erection Drawings (for information)
3. Steel Structures Details Drawings (for information)
4. Steel Structures Assembly Drawings (for information)

10.4.4 STATION DESIGN DRAWINGS AND DATA

10.4.4.1 ELECTRICAL

1. Electrical equipment Location Plan Drawing (for approval)
2. General Electrical Layout Drawings (for approval)

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3. Simplified One Line Diagrams (for approval)
4. Detailed One Line Diagrams and Three Line Schematics (for approval)
5. Station Service ac and dc One Line and detailed schematic drawings (for approval)
6. Switchyards General Plans and Sections (for approval)
7. Erection Key Diagrams (for information)
8. Cable and Trenches Layout and Sections (for approval)
9. Grounding and Lightning Protection Systems.
10. Station Services Layout (for approval)
11. Buildings - Equipment Layout (for approval)
12. Building Grounding and Lightning Protection Systems (for approval)
13. Building - Lighting and Outlets (for approval)
14. Building - Cable System (for approval)
15. Cable Diagrams (for information)
16. Calculation Sheets (for approval)
17. Bill of Material (for information)

10.4.4.2 CIVIL WORKS

1. General Layout (for approval)
2. Soil Investigation (for approval)
3. Equipment and Structure Foundation (for approval)
4. Concrete Trenches (for approval)
5. Drainage (for approval)
6. Service and Access Rail/Roads (for approval)
7. Buildings (for approval)
8. Reinforcement Steel List (for information)
9. Landscaping (for approval)
10. Fire Protection Walls (for approval)
11. Water Supply Reservoirs or Tanks (for approval)

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12. Oil Tanks (for approval)
13. Design Calculation Sheets (for approval)
14. Wall Cladding (for approval)
15. Finishing schedule (for approval)

10.4.4.3 MECHANICAL WORKS (FOR APPROVAL)

1. Water Storage and Distribution System
2. Fire Protection System
3. Other Fire Protection Systems
4. Sewage and Drainage Oil Systems
5. Air Conditioning, Ventilation and Exhaust system
6. Valve Cooling System

10.4.5 PLANT CIRCUIT DIAGRAM (FOR INFORMATION)

10.4.6 OTHER DOCUMENTS

The following documents, in addition to others, shall be sent to the Employer for his specific approval:

1. Alarm monitoring and reporting systems, Software Computer programs and flow diagrams. Detailed logic diagram/flow diagrams shall be furnished by the Contractor for software implemented functions.
2. Alarm monitoring and reporting systems, Program Copies.
3. Transient fault recorders input signals
4. Internal communication system, detailed system design
5. VPS Layout
6. Colour scheme
7. Testing & Commissioning documentation

10.5 INSPECTIONS PLANS AND DOCUMENTATION (for approval)

10.5.1 The Contractor shall submit for the Employer's approval an inspection plan (quality plan) describing the inspection system, indicating the inspections to be carried out and their sequence in the manufacturing stages.

10.5.2 The inspection plan shall be such that it can be related to the manufacturing program. The plan shall also include a description of

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the inspection methods employed with reference to the Contractor's written inspection procedures.

- 10.5.3** Separate inspection plans describing the inspection systems for equipment supplied by each sub-Contractor, in the same form as that of the Contractor, shall be submitted for the approval of the Employer.
- 10.5.4** In addition to the inspection plans referred to above, the Contractor shall submit complete and satisfactory evidence of possessing a working scheme assuring the control of all critical activities pertinent to the assurance of quality, and objective evidence (by means of quality manuals and appropriate forms, etc.) of this capability to employ and maintain quality control to meet the required quality level of the manufacture and construction of the Works.
- 10.5.5** Contractor's Quality Control Program in the context of this Clause means the implementation of a quality assurance program by means of which full conformance of material and workmanship to best quality standards can be achieved effectively and economically by the Contractor's control and surveillance of all essential inspection operations, and periodic verification of the results of the manufacture of equipment and the assembly, erection and installation of equipment at the sites.
- 10.5.6** Required number of copies of all test reports, including those supplied by Sub-Contractors, shall be submitted to the Employer for approval. The Contractor shall include in the report all additional data required by the Employer to permit a clear understanding of the reports.
- 10.5.7** All test reports shall be certified and shall contain the signature of the Inspector as having witnessed the test, unless such witnessing has been specifically waived by the Employer. A certified test report shall be issued for each test.

10.6 INSTRUCTION MANUALS AND OPERATING MANUALS (for information)

- 10.6.1** The Contractor shall provide Instruction & Maintenance Manuals for each part of the Plant and Equipment included in the Works and Operating Manuals for each Station.
- 10.6.2** The Instruction Manuals and Operating Manuals shall be arranged in an organized library adequately cross referenced to facilitate issuing sections of the manuals as required by the work i.e. erection

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instructions shall be required before operating & maintenance instructions.

10.6.3 All Manuals provided by the Contractor shall be fully detailed and specifically prepared for the Works and equipment provided. General manuals not specifically prepared for the Works shall not be acceptable.

10.6.4 The instruction manuals shall at least contain :

- a) A general description of all components
- b) Storage instruction
- c) Erection instructions
- d) Pre-commissioning Instruction :
- e) Material and part list.
- f) Design clearances and settings
- g) Complete sets of drawings as finally issued
- h) Operating Instructions:
- i) routine and preventive Maintenance instructions with material requirement for each case
- j) Preventive Maintenance Schedule.
- k) Replacement instruction for all equipment

10.6.5 The operation manuals shall at least contain:

- a) Operator oriented functional descriptions of the equipment.
- b) Operator oriented description of the protection and control systems
- c) Description of the equipment auxiliary systems
- d) Fault findings and diagnostic tools
- e) User Software interface tools for modification/augmentation etc.

SECTION 11: PERFORMANCE GUARANTEES & LOSSES

11.1 INTRODUCTION

This section defines the Performance Guarantees provided by the Contractor, the methods of test to determine the fulfilment of these guarantees, the time(s) of establishing these parameters, and the calculation of liquidated damages in case of non- fulfilment of the guarantees.

11.2 GUARANTEES

The guaranteed parameters as stated above to be established by the Contractor are

- Availability
- Reliability
- Station Efficiency
- Station Power Rating
- Thyristor Failure Rate
- Capacitor Failure Rate
- Flashover guarantee

The above guarantees shall be given by the Contractor on Bipole basis, i.e., for Biswanath Chariali – Agra and Siliguri (New)-Agra separately. The penalties specified shall also be on the basis of each Bipole separately.

11.3 TECHNICAL PERFORMANCE REQUIREMENTS

Clause 11.2 above lists specific Performance Guarantees. The other sections of the Technical Specifications give further requirements on the equipment and on the Station. These requirements must be fulfilled by the Contractor prior to the Employer accepting the Equipment and the Station.

11.4 RELIABILITY AND AVAILABILITY OF HVDC SYSTEM

11.4.1 DEFINITIONS

11.4.1.1 OUTAGE TERMS

.1 Outage

The state in which equipment or a unit of equipment is unavailable for normal operation due to an event directly related to the same equipment or some unit of equipment.

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.2 Scheduled Outage

Scheduled outage is an outage which can be scheduled at least one week in advance. This includes planned maintenance, normally conducted on annual basis, and also unplanned maintenance or repair which can be deferred at least one week subsequent to discovery of the need for maintenance or repair. If the outage is extended due to additional work which would have otherwise caused a forced outage, the excess period is counted as a forced outage.

.3 Forced Outage

The state in which equipment is unavailable for normal operation, but is not in the scheduled outage state, i.e., an outage which is not a scheduled outage.

.4 Pole Outages

An outage which causes a reduction in the Bipole dc power system transfer capacity equal to or less than the power rating of one pole as defined at Clause 4.1.

.5 Bipole Outages

An outage which causes a reduction in the bipolar dc system power transfer capacity greater than the power rating of one pole as defined at Clause 4.1.

11.4.1.2 CAPACITY TERMS

.1 Maximum Continuous Capacity (P_m)

The maximum bipolar HVDC system capacity (MW) for which continuous operation under normal conditions is possible referred on to the rectifier DC bus as defined in Clause 4.1, i.e., 3000 MW.

.2 Outage Capacity (P_o)

The capacity reduction in MW which the outage would have caused if the HVDC system were operating at its maximum continuous capacity (P_m) at the time of the outage.

.3 Outage Derating Factor (ODF)

The ratio of outage capacity (P_o) to maximum continuous

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capacity (P_m).

$$ODF = P_o / P_m$$

11.4.1.3 OUTAGE DURATION TERMS

.1 Actual Outage Duration (AOD)

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest 1/10th of an hour. Time less than 1/10 of an hour shall be counted as having duration of 1/10 of an hour.

.2 Equivalent Outage Duration (EOD)

The actual outage duration (AOD) in hours, multiplied by the outage derating factor (ODF), so as to take account of partial loss of capacity.

$$EOD = AOD \times ODF$$

Each equivalent outage duration may be classified according to the type of outage involved, i.e., equivalent forced outage duration (EFOD) and equivalent scheduled outage duration (ESOD).

11.4.1.4 TIME CATEGORIES

.1 Period Hours (PH)

The number of hours in the reporting period.

In a full year the Period Hours are 8760 h (8784 h for a leap year). If the equipment is commissioned part way through a year the period hours shall be proportionately less than 8760 h. (This shall not be applicable for verification of guarantees).

.2 Actual Outage Hours (AOH)

The sum of actual outage durations within the reporting period

$$AOH = \sum AOD$$

The actual outage hours (AOH) may be classified according to

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the type of outage involved, i.e., AFOH and ASOH.

.3 Equivalent Outage Hours (EOH)

The sum of all equivalent outage durations within the reporting period.

$$EOH = \sum EOD$$

The equivalent outage hours may be classified according to the type of outage involved, i.e., equivalent forced outage hours (EFOH) and equivalent scheduled outage hours (ESOH).

If outage duration overlaps the beginning or end of a reporting period, only the EOD which lie within the reporting period shall be included in EOH.

11.4.1.5 AVAILABILITY AND RELIABILITY TERMS

.1 Energy Unavailability (EU)

Energy unavailability is a measure of the energy which could not have been transmitted due to (scheduled & forced) outages. The impact of overload capability of the individual poles shall not be considered for calculating the Energy unavailability.

$$\text{Energy Unavailability \% (EU)} = EOH/PH \times 100$$

$$\text{Forced Energy Unavailability \% (FEU)} = EFOH/PH \times 100$$

$$\text{Scheduled Energy Unavailability \% (SEU)} = ESOH/PH \times 100$$

.2 Energy Availability (EA)

A measure of the energy which could have been transmitted except for limitations of capacity due to outages, arising from any cause, either forced or scheduled.

$$\text{Energy Availability \% (EA)} = (100 - EU)$$

.3 Energy Utilisation (U)

A factor giving a measure of energy actually transmitted over the system.

$$\text{Energy Utilisation \% (U)} = [\text{Total energy transmitted} / (P_m \times$$

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PH)] x 100]

.4 Reliability

Reliability is expressed in terms of the number of forced outages of curtailment occurrences of poles and Bipole per unit of time, usually one year.

EOF is the equivalent outage frequency which shall be calculated as follows:

$$\text{EOF} = \text{number of one pole outages} \times 1 + \text{number of other pole outages} \times 1 + \text{number of bipole outages} \times 2$$

11.5 SCOPE OF REQUIREMENTS

11.5.1 GENERAL

The converter stations shall be engineered to meet "design target" values of availability and reliability, as outlined herein. The Contractor shall also guarantee the availability and reliability at least to the levels of performance as specified herein.

Availability and reliability requirements shall apply to that part of the HVDC system within the Contractor's Scope of Work and shall exclude HVDC transmission lines, electrode lines and all other equipment outside his Scope of Work. However, the failure of auxiliary power supply shall be considered when calculating "design target" values.

Except as specifically noted, availability and reliability requirements shall be applied on a complete bipole basis for all converter stations and associated interface stations together.

The terms availability and reliability, as used in these Specifications exclude the effect of certain outages and curtailment events described below which are, in general, beyond the Contractor's control. Hence these effects shall be excluded from the analysis. The outage and curtailment of HVDC system capacity events to be excluded are as follows:

- (a) Misuse, operator error or other human causes which contravenes the Contractor's operating and maintenance

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instructions.

- (b) Environmental conditions or ac system conditions outside the design criteria given in these Specifications or as modified during detailed engineering.
- (c) External causes beyond the control of the Contractor and Employer i.e. land slides, earthquake shock beyond the seismic criteria of these Specifications, and fire arising from causes outside the Contractor's equipment and Scope of Work.

Circumstances causing curtailment of HVDC system capacity that shall be included in the availability and reliability assessment and which can lead to a forced outage include, but are not limited to:

- a) Failures of equipment.
- b) Mal-operation of control and protection system due to electrical interference, incorrect settings or inadequate interlocks & provisions.
- c) Failure to, or delay in, start of a pole/bipole.
- d) Failure to complete switching sequences such as metallic-return switching.
- e) Failure to recover within the times specified following ac/dc system faults.
- f) Reduction of dc power transmission capacity.

Although outages and curtailment of HVDC system capacity caused by failures in equipment outside the Contractor's Scope of work are not included in the availability and reliability assessment, the Contractor shall design the HVDC system to function as set forth in these Specifications during known faults and failures in the HVDC line, electrode lines and equipment which interfaces with the equipment within the Contractor's Scope of Work.

If the transfer capacity of the HVDC system is reduced due to equipment not within the scope of the HVDC Contractor, then it shall be considered as if the HVDC system had been operating at rated power for such period. But if any maintenance is carried out during such period then the same shall be counted as an outage for the duration of the maintenance operation.

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11.5.2 GUARANTEES REQUIRED

The reliability and availability of the complete bipole shall be guaranteed by the Contractor. The operation of the bipole shall be monitored during the guarantee period of minimum 36 months by a data base software developed by the Contractor incorporating details as specified under clause 11.4 to determine whether it meets the guarantees.

The HVDC power transmission capacities of the bipole to be used in the reliability and availability assessment are stated in Clause 4.1.5. The overload and low ambient capabilities of the HVDC equipment shall not be considered in the analysis made to confirm the design target values.

11.6 DESIGN PRINCIPLES

The objective for the design of the HVDC system shall be to achieve high levels of availability and reliability. Except where greater reliability requirements are specified in these Specifications, the design basis for the HVDC system shall be such that no single contingency shall cause a multi terminal outage. In case of outage of one pole, the other poles shall carry the overload as per the design. The design of controls and protection, directly associated with the transmission of power over the HVDC system, shall be such that the normal failure modes of components shall not result in a reduction in HVDC system capacity nor in a hazardous operating condition for the equipment or the operator.

The Contractor shall design the control & protection equipment, to cause no more than 5 transient disturbances (with a duration exceeding 20 ms) per pole per year. Transient disturbances in connection with events resulting in forced outages shall be excluded from the above. When more than one transient disturbance occurs within a time period of (max.) 10 sec in connection with the same failure or mis-operation, this shall be counted as single transient disturbance.

- a) The design of the auxiliary system and associated controls & protection shall be such that a single contingency shall not cause a reduction in converter station capability.

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11.7 AVAILABILITY AND RELIABILITY CALCULATIONS

11.7.1 GENERAL

Definitions of availability and outage state conditions are given in Clause 11.4.1. The period basis for availability and reliability calculations shall be 12 consecutive months (one year). The period over which the guarantees are to be in effect shall be thirty six (36) months (i.e. three years), or any valid extension thereof, commencing six months after successful completion of trial operation of complete multi-terminal HVDC systems. Annual Planned schedule maintenance (generally once in a year), outages shall not be included in the evaluation of availability. The Contractor shall provide calculations to demonstrate that the design shall meet the specified guaranteed and design target values of availability and reliability for the HVDC system during the first stage bid. The Contractor shall indicate the maintenance duration for annual planned maintenance activities.

The calculations shall show the expected availability & reliability of installation based on the Contractor's recommended provision of mandatory spare parts/equipment.

The calculations of reliability / availability of the station shall also include the effect of outages on the communication system.

Outage times for repair, maintenance and replacement of components, shall be based on the premise that all items in the Contractor's lists of recommended spare parts are on hand, that all Contractor's schedules of recommended maintenance are adhered to and that maintenance personnel (a maximum of 20 men for the down time of 40 hours at either station) shall be on hand to effect repairs immediately on a normal 6 day, 48 hour week basis. It shall be assumed that outside of normal working hours the maintenance personnel shall be available in 2 hours at converter station. The effect of already consumed spares shall also be considered assuming reasonable spare reorder and delivery time.

Reliability calculations shall be made and shall be presented as the expected frequency of occurrence of unscheduled loss of HVDC power transfer capacity in amounts corresponding to the capacity of a pole and a bipole.

For simultaneous occurrence of events, for either of which a loss of capacity would result, the longer repair time shall be counted.

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The HVDC terminal equipment and all associated facilities shall be assumed to be utilized 100% of the time at 100% load, regardless of the actual power and energy transmitted by the system. Hence the reliability and availability assessment shall be based on the capability of the facility to transmit power and energy and provide service, regardless of whether it is actually in service or not and regardless of whether the dc line pole or electrode or other system(s) outside Contractor's scope are available or not. The circuit elements which are not used at 100% load but provided to be used at less than 100% load shall be considered that as if these were used continuously. For purpose of design calculations only, it shall be assumed that the system shall be required to operate at reduced voltage for 5% time in a year. Similarly, for design calculations only, it shall be assumed that HVDC system shall be operating in monopolar mode for 10% time in a year.

The Contractor shall submit a detailed report to the Employer substantiating the system design within six months of award of Contract. The report shall document the Contractor's reliability and availability calculation procedures and state his data on component failure rates along with their sources/basis.

The Contractor shall provide details of calculations to substantiate the design of the equipment insofar as reliability and availability are concerned, prior to the commencement of manufacture of the equipment.

These calculations shall clearly show the component failure rates assumed and the subsystem availability calculations and forced outage rates.

The Contractor shall submit his detailed calculations in readily assimilated formats suitable for engineering use in verifying applications in the design. The data shall include both Contractor's preliminary design calculations and the final calculations based on the finalized equipment design. Revisions shall be submitted to the Employer whenever required by modifications that may affect the calculations prior to the acceptance of the equipment and system.

11.7.2 SCHEDULED MAINTENANCE OUTAGES

Scheduled preventative maintenance by the Employer shall be in accordance with the following:

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- a) Performed sequentially to the two poles in the bipole at a converter station and concurrently on the same pole in both stations, and with the interval between maintenance as prescribed in Contractor's proposal. The Contractor shall submit a comprehensive maintenance plan, listing the activities to be carried out by the Employer's maintenance staff.
- b) Executed according to the Contractor's instructions and following a schedule to be mutually agreed upon. The Contractor shall be informed at least 10 days in advance regarding schedule maintenance of the terminals and have the right to witness and advise during the availability guarantee period. The Contractor shall bear the costs for any such witnessing.
- c) Executed with a qualified working crew of the size prescribed, properly trained according to the Contractor's prescribed training program. The maintenance shall be executed during consecutive days with a shift time per day of 8 hours (plus a maximum of 4 hours overtime) to fulfil the maintenance program. For intervals between the two consecutive working shifts the HVDC system may be put into service (and then shall be regarded as available during this time) provided that the prescribed maintenance schedule would allow the part of the HVDC system on which maintenance is being carried out to be brought back into operation after the working shift.

11.7.3 OUTAGE AND CURTAILMENT TIME

When determining the duration of an outage or curtailment covered by the availability guarantee, the following time elements shall be excluded:

- a) Unreasonable lengths of time required to obtain access to a piece of equipment for repair or maintenance including time for permits to de-energize or disconnect equipment, time to get physical access to equipment location, delivery, transport and erection of ladders or lifting facilities (however for calculation purposes, 1 hour for obtaining access shall be assumed). Reasonable times shall be established during the Contractor's operator and maintenance training program and during initial operation. These times shall be deemed included in the unavailability calculations.
- b) Time of unavailability of operating, maintenance or repair staff during the normal 6 day 48 hour week and in excess of 2 hours

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if outside of normal working hours.

- c) Time of unavailability of specified tools/repair equipment/repair facilities.
- d) Unreasonable waiting time to locate spares in Employer's stock.

The following shall be included in outage duration:

- a) Time required to determine the cause of an outage and to determine which equipment/unit must be repaired/replaced.
- b) Time required for disconnection, grounding of equipment, preparation of repair and reconnection after repair.
- c) Time required for movement of spare.
- d) Time required for repair.
- e) Time required for acquiring spare parts, tools or test equipment whose acquisition was not recommended by the Contractor in his Bid.

Non-availability of the control for multi-terminal operation shall be treated as outage of both the bipoles for calculation of availability.

The times when replacements have to be ordered shall be specified, for each type of spare, by the Contractor during the guaranteed period of operation of the system to ensure that sufficient spares are on hand when required.

The Employer shall keep and make available to the Contractor, during the availability guarantee period, operation records so as to make a determination of the cause of any curtailment or outage as well as the sub-division of the total outage time into specified time elements. The basic data and general format of the above operation records are to be mutually agreed upon prior to commencement of the guarantee period or acceptance test for operation of the Bipole HVDC system.

The time required for measurement "to verify" capacitor unit failure rates, shall not be included in the outage time accumulated for availability guarantee verification only provided that this was not part of activities required for regular maintenance of capacitor bank.

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11.8 AVAILABILITY REQUIREMENT

11.8.1 REQUIREMENTS

The calculated energy availability (EA) of the complete bipole, considered on a 12 (consecutive) months basis and based on the Contractor's recommended list of spare parts/equipment shall be equal to or shall exceed the specified value given below. Also, subject to the terms and conditions specified, the availability per year, considering forced outages, shall be equal to or exceed the guaranteed value.

The Guaranteed Minimum Energy Availability Requirement (EA) of each Bipole system shall not be less than 98.00%.

The Guaranteed forced Energy unavailability Requirement (FEU) of each Bipole system shall not be more than 0.5%.

11.8.2 FULFILLMENT OF AVAILABILITY GUARANTEE(FOR BIPOLES)

The availability of each complete bipole shall be monitored during the availability guarantee period. A preventative maintenance check shall be carried out immediately before the start of the said period.

The Employer shall maintain records of the number and duration of forced and scheduled outages, and the amount of HVDC system capacity reduction resulting from each outage. The effect of overload capability of the HVDC system shall not be considered.

Classification of outages into transient, forced and scheduled outages shall be in accordance with definitions given in Clause 11.4.1.

The availability of dc power transfer capability shall be calculated as per clause 11.8.1 annually. If availability levels achieved are below the target/guaranteed levels, the Contractor shall make a thorough analysis of the cause and take appropriate remedial action to improve the performance. Implementation of corrective actions shall be subjected to the approval of the Employer. All costs towards such implementation of corrective actions shall be borne by the Contractor. All scheduled outages thereby required

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shall be included in the calculation of the scheduled outage times for the affected pole or poles.

For fulfilment of the guaranteed energy availability, the following shall apply:

- a) Annual energy availability shall be calculated for each year for three years continuously and if energy availability is $\geq 99.5\%$ for each year, then the availability guarantee shall be considered as fulfilled.
- b) If the annual energy availability is below the guaranteed value for any year(s), the guarantee period shall be extended for the year(s) (Maximum three years) in which annual energy availability is less than 99.5%. If at the end of the extended year(s), the energy availability in the best three years (out of total period including extended year(s)) is $\geq 99.5\%$, then the availability guarantee shall be considered as fulfilled.
- c) If the annual energy availability as referred under 11.8.2(b) is not fulfilled, the Contractor shall correct all design deficiencies and equipment defects at no cost to the Employer.
- d) After correction of such deficiencies and defects,
 - i) If the average annual energy availability calculated over a further two year period (excluding the previous years and the period for correcting the deficiencies) is $\geq 99.5\%$, then the availability guarantee shall be considered as fulfilled.
 - ii) If the average annual energy availability calculated over the two year period for each bipole (excluding the previous years and the period for correcting deficiencies) is $\geq 98.5\%$, then the availability guarantee shall be considered as fulfilled. However the Contractor shall pay to Employer liquidated damages calculated as given below:

Liquidated damages = Rs. 90 Million for each 0.1 % or part thereof for average availability below 99.5%. Compensation shall be paid up to maximum Rs. 900 Million.

- e) In case average annual energy availability for each bipole as described in Para (d) above, is found to be below 98.5% the Contractor shall replace the plant/equipment as identified by

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the Employer at no cost to the Employer. In case of default, the Employer may reject the plant and recover the amount paid to the Contractor as per relevant clauses of GCC.

11.8.3 AVAILABILITY GUARANTEE FOR CONTINUOUS OVERLOAD CAPABILITY(FOR MULTI TERMINAL)

The Contractor shall provide separate guarantee for availability based on specified continuous overload of the HVDC terminal.

Availability calculation shall be based on rated power being available for transmission of maximum of 6000 MW using, if required the continuous overload capability of the converters. In calculating this availability, all conditions excluding planned maintenance of one rectifier and / or one inverter of the same pole shall be considered. The overload capability shall be monitored during the availability and reliability period during normal operation and during both forced and scheduled pole outage condition. The availability of overload capacity and capability shall be 99.9%. The Contractor shall provide adequate availability spares to ensure the guaranteed availability. The availability shall be calculated for the total time the overload capability was actually available against the total time for which it was required by the system on an annual basis.

The penalty for not meeting the specified availability shall be Rs. 90 Million for each 0.1 % or part thereof for average availability below 99.9%.

11.9 RELIABILITY REQUIREMENT

11.9.1 REQUIREMENTS

In the assessment of reliability, the following events, in addition to those listed in Clause 11.4, shall be considered to constitute a bipole forced outage:

- a) A bipole shutdown.
- b) A reduction of HVDC system capacity in excess of the normal capacity of one pole, for any reason.

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The calculated reliability of the HVDC system shall be equal to or shall exceed the following design target values. Also, subject to the terms and conditions specified, the reliability per year (12 months) shall be equal to or exceed the guaranteed values stated in the Contractor's Bid.

The average number of forced outage and curtailment occurrences per year (12 months) for the multi-terminal HVDC system, shall not exceed the following values :

Curtailment in HVDC system	Number of occurrences/year(for each bipole)	
Capacity corresponding to	Design Target Value	Acceptable Value
a pole	4	--
the bipole	0.1	--
EOF	8.2	10

In addition, the Contractor shall use a design target of 5 occurrences of transient disturbances (TD) (with duration between 20 ms & 100 ms) per pole per year against a maximum guaranteed value of 10 per pole per year.

11.9.2 FULFILLMENT OF RELIABILITY GUARANTEE

The Employer shall monitor the operation of the HVDC system during the three year availability/reliability guarantee period.

An annual appraisal of reliability performance shall be jointly made by the Employer and the Contractor to determine whether correction of design deficiencies, if any, is warranted. Evaluation of EOF and transient disturbance shall be made separately.

With respect to the guaranteed reliability values for curtailment in HVDC system capacity, the following shall apply:

- Reliability shall be monitored on yearly basis for three years. If the number of occurrences (EOF/TD) in each year of the three year guarantee period is less than or equal to the guaranteed value, the reliability guarantee shall be considered as fulfilled.
- If the number of occurrences (EOF/TD) in any year(s) of the three year guarantee period exceeds the guaranteed value, the guarantee period shall be extended for the year(s) (maximum three years) the number of occurrences (EOF/TD) exceeds the

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guaranteed value. If at the end of the extended years, the number of occurrences (EOF/TD) in the best three years (total period including extended year(s)) is less than or equal to the guaranteed value, the reliability guarantee shall be considered as fulfilled.

- c) If the reliability guarantee is not fulfilled as per 11.9.2 (b) above, the Contractor shall correct all design deficiencies and equipment defects at no cost to the Employer.
- d) After correction of such deficiencies and defects, if the number of occurrences/year averaged over a further two year period (excluding the previous years and the period for correcting such deficiencies) is still above the guaranteed value, compensation calculated as per the formula below shall be paid by the Contractor to the Employer:
 - Rs. 1.4 Million for each EOF or part thereof above the guaranteed value.
 - Rs. 0.7 Million for each transient disturbance or part thereof above the guaranteed value.

11.10 STATION LOSSES AND LOSS EVALUATION

The losses for the converter stations shall be determined in accordance with IEC Standard 61803 "Determination of power losses in high voltage direct current (HVDC) converter stations". The Contractor shall calculate the equivalent station load losses assuming, for the purposes of this calculation only, that each Bipole of the multi terminal HVDC system shall operate at the following load levels for the percentages of time listed. The losses shall be given separately for each rectifier and inverter of the multi terminal system.

Bipole Power	Biswanath Chariali-Agra	Siliguri (New)-Agra
1000 MW	40% of time	40% of time
1500 MW	16% of time	16% of time
2500 MW	16% of time	16% of time
3000 MW	28% of time	28% of time

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Auxiliary power requirements shall be calculated from the rated kW and efficiency of all motors necessary to provide the required cooling, but excluding redundant motors. The auxiliary power requirements of the cooling towers shall be included as well as any air-conditioning and ventilation load of the valve halls and indoor DC yard.

Losses for the dynamic compensation systems, if provided, shall also be included.

For auxiliary power transformers (33/0.433kV), the no-load, load and auxiliary power losses shall be included as if the transformers, in the Contractor's scope of work were fully loaded to meet the auxiliary power requirement for rated station load.

The oil treatment plant and fire fighting load shall be excluded from the loss calculations.

The losses for the 400/220/33kV and 400/132/33kV auto transformers shall be considered separately.

11.10.1 GUARANTEED STATION & EQUIPMENT LOSSES

The Contractor shall guarantee the standby (no-load) losses and equivalent load losses of each station. No tolerance shall be considered on the submitted figures. The guaranteed losses shall not be greater than the losses quoted by the Contractor in his bid.

The Contractor shall submit to the Employer comprehensive loss calculation study report giving losses as measured for the HVDC equipments during type test/Routine tests as per actual design values of per item losses for the converter transformer, smoothing reactor, and thyristor valve. For Other equipment the values of calculated losses (where measurements are not possible) shall be indicated in the equipment specification and shall indicate tolerance limits for individual items. The total station standby and load losses individually shall not be more than 10% above the respective guaranteed values.

If the losses, for the stations considered individually as determined in accordance with Specification, exceed the guaranteed values then the Employer shall reduce the value of the contract as stipulated in the table below as liquidated damages :

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For converter stations

	Per converter station in INR/KW
Standby(No-Load) Losses	400,000
Equivalent Load Losses	2,00,000

FOR 400/220/33kV and 400/132/33kV ICT's

No Load Loss	INR 400,000 per KW
Load Losses	INR 300,000 per KW

11.10.2 EVALUATION OF LOSSES

The Employer undertakes to make an evaluation of standby and equivalent load losses stated by the Bidder in his bid. No tolerance shall be considered on the submitted figures. Evaluation of losses shall be done as follows:

FOR EACH HVDC BIPOLE:

Evaluated Losses in (INR) = No load loss in KW * 400000 + (Load Loss at 1000 MW in KW * 0.4 + Load loss at 1500 MW in KW*0.16+ Load loss at 2500 MW in KW * 0.16 + Load loss at 3000MW in KW*0.28) X200000

FOR 400/220/33kV and 400/132/33kV ICT's

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No Load Loss	INR 400,000 per KW
Load Losses	INR 300,000 per KW

11.11 STATION POWER RATING GUARANTEE

The Contractor shall guarantee that the rated capacity of the system is in conformance with the requirements specified in section 4.1 of this specification.

The necessary field tests shall be performed after the trial operation period to demonstrate that the performance of the HVDC System with respect to basic operating modes and continuous ratings are in conformance with the Specification and are not less than the levels quoted by the Contractor in his bid.

Each bipole system shall be run at the nominal maximum power transfer limit for at least 12 hours continuously. If any interruption occurs, the test shall be repeated until such time that uninterrupted operation is achieved. In the event that system conditions do not permit the full Bipole power transmission at any point of time during testing, power blocks may be connected back-to-back circulating the active power for the purpose of this test.

Following the above, the maximum multi terminal operation capacity of 6000MW shall also be field tested by running the multi terminal system for 12 hours at 6000 MW with any three rectifier groups and/or any three inverter groups.

The power transfer capabilities of the system shall be measured on the dc bus of the rectifiers using metering accuracy instrumentation.

Measurement shall also be made simultaneously at the ac bus of the Rectifier(s) using metering accuracy instrumentation for purpose of Employer's information.

The penalties for not meeting the required power transfers shall be as follows:

Shortfall in the total power transfer capability (3000 MW)	Rs. 200,000 for each kW, or part thereof
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of any bipole	
Shortfall in the total power transfer capability, of multi terminal capacity of 6000 MW.	Rs. 400,000 for each kW, or part thereof

11.12 GUARANTEED FAILURE RATE OF THYRISTORS

- .1 The maximum annual guaranteed thyristor failure rate shall not exceed 0.2%. The failure rate shall not include failures directly attributable to operating and maintenance errors.
- .2 Just before the start of guarantee period, the faulty thyristors shall be replaced and thereafter faulty thyristors may be replaced after each 12 month period only. In case, it is desired by the Contractor that thyristor be replaced in between the 12 month period, the guarantee period shall be counted a fresh again from that time. Till the expiry of guarantee period, all replacement for failed thyristors shall be supplied by the Contractor free of cost.
- .3 The thyristor failure rate shall be monitored over a period of three years starting at the end of six months following trial operation of the HVDC Bipole system. If the average failure rate of thyristors, of single bipole individually, over a period of these three years proves to be within the guaranteed value the guarantee shall be considered as fulfilled otherwise the guarantee period shall be extended by one more year. If the average thyristor failure rate calculated, individually for bipole, for three out of the four years, disregarding the year (any consecutive 12 months) with the highest thyristor failure rate is equal to or lower than the guaranteed value then the thyristor failure rate guarantee is considered to be fulfilled.

If the annual thyristor failure rate averaged over the best three years is still above the guaranteed value the Contractor shall supply, without any additional cost to the Employer, additional spare thyristors equal to twenty (20) times the difference between the actual annual failure rate averaged over the best three years and the guaranteed annual failure rate. The performance calculations shall be done for a complete

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bipole.

11.13 CAPACITOR FAILURE RATE GUARANTEES

HIGH VOLTAGE CAPACITORS

The failure rate guarantee as specified below shall apply only for high voltage capacitors.

- .1 The maximum guaranteed annual capacitor failure rate shall not exceed 0.15%. The capacitor shall be considered as failed if its capacitance value varies more than $\pm 5\%$ of the nameplate value. Leakage of oil from the capacitor and deformation of the capacitor unit shall be considered as a failure even if the capacitance value is within the tolerance limits.
- .2 Capacitor units failing during the first six consecutive months of operation after successful trial operation shall not be included in the calculation of failure rate, although these shall be replaced under the provisions of the equipment guarantee. Just before the start of guarantee period, all the failed units shall be replaced. Till the expire of guarantee period, all replacement for failed units shall be supplied by the Contractor free of cost.
- .3 In case the Contractor uses capacitors from other filter sub-bank(s) to replace failed capacitor units in another sub bank, the station availability period shall be extended even if guaranteed availability is met. The extension will be till the failed capacitors are replaced. This period shall be apart from any extension required to meet station availability guarantee.
- .4 The failure rate shall be monitored over a period of three years starting at the end of six months following trial operation of the HVDC system. If the average failure rate of each type of unit during these three years proves to be within the guaranteed value the guarantee shall be considered as fulfilled otherwise the guarantee period shall be extended by one more year. If the average unit failure rate calculated, individually for each type, for three out of the four years, disregarding the year (any consecutive 12 months) with the highest failure rate is equal to or lower than the guaranteed value then the failure rate guarantee is considered to be fulfilled.
- .5 If the annual failure rate averaged over the best three years is still above the guaranteed value for any type of unit the

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Contractor shall supply, without any additional cost to the Employer, additional spare units equal to twenty times the difference between the actual annual failure rate averaged over the best three years and the guaranteed annual failure rate.

- .6 The above shall apply to high voltage capacitors of each "type" of capacitor unit supplied individually where "type" refers to the unit capacitance and voltage, current, and kVAr rating. The calculations shall be made separately for each manufacturer in case the capacitors are supplied from different sources. In case, 0.15% of any particular type of capacitor units is less than one, the annual failure rate shall be calculated without taking the first unit.

LOW VOLTAGE CAPACITORS

For low voltage capacitors, for every failure of capacitor upto the availability reliability period, double the number of failed capacitors shall be provided.

11.14 FLASHOVER GUARANTEE

The Contractor shall guarantee that there shall be not more than three flashovers in a year in the outdoor DC yard and zero flashovers in the indoor DC yard. The number of flashovers shall be monitored over a period of three years starting at the end of six months following trial operation of the HVDC system. If the number of flashovers during these three years is within the guaranteed value, the guarantee shall be considered as fulfilled otherwise the guarantee period shall be extended by one more year. If the number of flashovers for three out of the four years, disregarding the year (any consecutive 12 months) with the highest number of flashovers is equal to or lower than the guaranteed value then flashover guarantee is considered to be fulfilled. If the number of flashovers averaged over the best three years is still above the guaranteed value, the Contractor shall pay Rs. 15 Million for each flashover above the guaranteed value and shall provide the required mitigation measures to reduce the number of flashover within guaranteed value.