SECTION V

4.1.1 PARTICULAR TECHNICAL SPECIFICATIONS

FOR

SWITCHGEARS AND AUXILIARY SUPPLIES

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4.1.1 Particular Technical Specifications for Switchgear and Auxiliary Supplies.

4.1.1.1 General

These Particular Technical Specifications covers the particular technical requirements of the equipment to be procured under this contract.

In order to give the necessary background, equipment not needed in this specific tender may be included. The Scope of Work will in such cases give the limitations in the supply.

The Plant and Equipment is detailed in the section Scope of Works. Where a Turn-Key Delivery is requested, this shall cover engineering, design, manufacture, testing before shipment and packing seaworthy or otherwise as required, delivery CIP site, unloading, storage, civil works, erection and commissioning.

The Turn-Key Stations shall furthermore cover a complete supply for substation including apparatus supports, cable racks and conduits with associated fixing material, insulators, conductors and clamps for busbars and apparatus connections, earthing systems, all cabling and connections, control an protection panels as well as any other equipment and materials not specifically mentioned or quantified, but which are required to make a complete and proper functioning substation.

4.1.1.1.1 General Design Data

Provided no special data are given below, the equipment shall be designed in accordance with the requirements given in “Project Specific Data”

The tentative single-line diagrams, layout plans and sections for the various projects are shown on the drawings enclosed to the Tender Documents. The drawings will be submitted with the bidding documents.

4.1.1.2 Switchgear

4.1.1.2.1 Breakers and Switches

Breakers and switches equipped with motor drive shall be provided for electrical local and remote control. The control voltage for closing and opening commands and for the energy storage of circuit breakers is 110VDC from station battery. The motor drive for switches and breakers shall be controlled with 110VDC or shall be universal motors (110VDC/Single phase -230VAC.)

The complete operating mechanism, including the controls, shall be built-in watertight and dust-proof cubicles fulfilling the requirements for outdoor enclosures as stated in the General Specifications. All parts shall be easily accessible without dismantling other parts. Direct, local push buttons for operating the breaker shall be located not more than 1.7 m above ground. All wiring shall lead to terminals. 10% of the terminals shall be spare.

A local/remote control selector switch shall be provided in the cubicle. With the selector switch set to local control, operation from any remote source apart from the protective relays shall be inhibited. The switch shall have contacts for remote indication.

A sufficient number of auxiliary contacts, with at least 5NO and 5NC contacts as spare, for 110 VDC shall be provided for control and interlock purposes.

Motors shall be designed in accordance with valid IEC publication and shall be effectively protected by miniature circuit breakers, with alarm contacts.

4.1.1.2.2 Circuit Breakers

All circuit breakers rated 33KV and below shall be Vacuum type, whereas those rated 66Kv and above shall be SF_6 gas type.

All circuit breakers shall be provided with means to prevent contact pumping while the closing circuit remains energised should the circuit breaker either fail to latch or be tripped during closing due to the operation of the protective relays.

The opening device of a circuit breaker shall be provided with two independent trip coils, connected to separate terminal blocks in the terminal cubicle, allowing for the connection of two independent opening command circuits.

A local position indicator, visible with the panel door closed, shall be mounted in the front panel of the operating mechanism cubicle.

A crank, lever or other similar suitable device shall be provided to permit charging the operation mechanism by hand in the event of a failure of the auxiliary supplies or in the event of a failure of the energy-storing device.

It shall be possible to determine the available operating energy stored by the mechanism prior to operating the circuit breaker. An alarm shall be given in the event of the stored energy falling below a minimum rated level.

If the stored operating energy is below a minimum rated level in one or more of the mechanisms, closing and auto- reclosing shall be blocked in all phases.

4.1.1.3 Measuring Transformers

If output of measuring transformers are not given the Contractor shall calculate the necessary output based on the instruments and cable length he needs. The output of the measuring transformers for measuring and protection purposes shall be determined according to the technical requirements, but shall not be less than 125% of the overall computed (design) burden of the connected apparatus and conductors. However, the transformer shall not be loaded less than 60% of rated burden.

- Power frequency test voltage on secondary windings, 1min. 2,5 kV
- Overvoltage inter-turn test, 1min. 3.5 kV

4.1.1.3.1 Current transformers

The current transformers shall be designed to carry continuously a current of 120% of the primary rated current.

The rated current of the secondary windings shall be 1A, unless otherwise specified in Scope of Works, the different cores shall have the following characteristics.

The core(s) for measuring:

- Accuracy (if not otherwise specified in scope of work) class 0.2
- Instrument security factor equal to or less than 5

The core(s) for energy metering:

- Accuracy (if not otherwise specified in scope of work) class 0.2
- Instrument security factor equal to or less than 5

The core(s) for protection:

- Accuracy for overcurrent and earth fault Class 5P20
- Transformer Differential protection Class X or SP
- Line differential protection Class X or SP
- Distance protection Class X or SP
- Restricted earth fault Class X or SP
- Busbar protection Class X or SP

The core characteristic shall be optimised to the selected scheme in sections where new busbar protection shall be installed.

The characteristics of the current transformers shall comply with the provisions stipulated in IEC 60044.

The Contractor shall demonstrate that the current transformers selected will ensure correct functioning of the associated protective equipment.

4.1.1.3.2 Voltage Transformers

The windings for measuring purposes shall be designed as follows:
The core(s) for measuring:

- Accuracy (if not otherwise specified in scope of work) class 0.2

The core(s) for energy metering:

- Accuracy (if not otherwise specified in scope of work) class 0.2

The core(s) for protection:

- Accuracy class 3P

The secondaries shall be provided with miniature circuit breakers with alarm contacts.

The characteristics of the voltage transformers shall comply with the provisions stipulated in IEC 60186 (and IEC 60358 for capacitive voltage transformers).

The Contractor shall demonstrate that the voltage transformers selected will ensure correct functioning of the associated protective equipment. The contractor shall also describe the actions taken to avoid ferro-resonance in the circuit.

4.1.1.4 SF6 gas

4.1.1.4.1 Low Density Warning

For all components using SF_6 gas as isolation media a system for visual continuously monitoring of the gas density shall be provided. At a certain low density a signal shall be given to indicate that refilling should take place. At the extreme low density circuit breakers should be automatically blocked against operation.

4.1.1.4.2 Gas Refilling

SF_6 gas refilling equipment mounted on a trolley shall be provided for each substation. The gas handling apparatus to be supplied couplings for all apparatus in the station and shall have sufficient storage facilities for the maximum quantity of gas that could be removed when carrying out maintenance or repair work on the largest section of the switchgear.

4.1.1.5 High and Medium Voltage Outdoor Switchgear

4.1.1.5.1 General

The substation design should be such as to minimise the number of levels of conductors and to ensure that the consequences of a failure of one set of high-level conductors are limited to the loss of that circuit and a single bus bar section. This principle shall also be applied with regard to earth wire conductors.

All apparatus shall be erected on galvanised steel supports dimensioned for the weight of the apparatus as well as short-circuit forces, the climatic forces and the forces arising under operation. Steel lattice landing gantries shall be arranged for incoming lines design for the last slack span.

Vehicle access to permit the transport of major switchgear equipment shall be provided. This shall be achieved without the need to de-energise circuits.

All breakers and switches shall come ready for distribution automation.

This Section covers the technical requirements of the high voltage equipment to be installed at the outdoor switchyards.

4.1.1.5.2 Circuit Breakers

The three-phase circuit breakers shall be of the outdoor, single pressure SF_6 (vacuum type shall be used below 66 kV). The breakers shall be mounted on steel structures.

For 132 kV Voltages and above three-phase rapid auto-reclosing only is required and the mechanism shall be common for all poles (ganged type) for transformer bay and Bus bar, and single poles for Lines.

A spring-operated mechanism is preferred. Hydraulic mechanism can be used. Pneumatic operating mechanism is not accepted.

The breakers shall be capable of handling the following operation cycle, according to the IEC recommendations:

O – t – CO - t' - CO *t = 0.3 sec* *t' = 3 min*
and
CO - t2 - CO *t2 = 15 sec*

The total breaking time (opening time plus duration of the arc) of the breakers shall be as short as possible, but in no case is it to be longer than 50 msec.

The stored energy shall for all types of operating mechanisms be sufficient to allow a complete O-C-O cycle.

4.1.1.5.3 Disconnectors / Isolators and Earthing Switches

Disconnectors and earthing switches shall be manufactured in accordance with IEC 60129. All shall be mounted on steel structures.

All disconnectors and earth witches shall be operated both electrically and manually

The contact surfaces shall be heavily silver-plated. The contact pressure shall be ensured by means of springs.

Each three-phase isolating switch and each three-phase earthing switch shall be equipped with its own independent operating mechanism.

In case of a complete failure of the operating mechanism all switches shall be operable manually by means of a lever or crank or another feature. The manual mechanism shall allow safe switching under energised but no-load conditions and shall be operated from a standing position

The control circuit and the driving mechanism motor shall be 110Vdc operated.

Disconnectors shall have mechanical interlocking to attach earth switches. The interlocking shall prevent closing of earth switch when the disconnector is in closed position, and disconnect the motor and prevent closing of the disconnector when the earth switch is closed.

4.1.1.5.4 Measuring Transformers

The measuring transformers shall be single-phase, oil-immersed, mounted in one insulator. They shall be mounted on steel structures. Each transformer shall be equipped with an oil level gauge to be easily visible from the ground. The transformers shall be supplied including oil filling. The oil of the measuring transformer shall be hermetically sealed against the ambient air. The sealing method shall be described in the Tender, as well as the method of compensation for changes in the oil volume due to temperature changes. Gas cushion shall not be used. The Bidder shall indicate the measures provided for relieving dangerous pressure rises that may develop due to an internal electrical fault.

The primary connections of all measuring transformers shall be silver-plated. All secondary connections shall be connected to a terminal block, which shall be located in a dust-proof and watertight terminal box and shall be clearly labelled. An earth connection to the housing shall be provided.

4.1.1.6 Lightning Arresters

The lightning arresters shall be of the metal oxide gapless type, complying with IEC 60099-1.

For tendering purposes, the lightning arresters shall have the following characteristics (the Contractor shall check the values by calculations to be approved by the Project Manager):

	132kV	**66kV**	**33kV**	**11kV**
(1) Continuous operating voltage (rms) (kV)	84	42	22	7
(2) Rated discharge current (8/20ms) (kA)	10	10	10	10
(3) Rated Voltage (kV)	108	54	27	9
(4) Creepage distance (mm)	4092	1800	900	500

As all other main parts of the switchyard, they shall be mounted on steel structures.

The lightning arresters shall be fitted with a pressure relief device.

Surge counters shall be supplied for each single-phase arrester for voltages above 33 kV.

The earth conductor from the arrester to the counter as well as the in-terminal of the counter shall be suitably insulated or screen protected against accidental touching.

4.1.1.7 Line Traps (where applicable)

The line traps shall comply with IEC 60353. They shall be suitable for mounting directly on the associated coupling capacitors, or separately on post insulators.

The traps shall be secured against birds nesting. The line traps shall have the following characteristics:

1) Minimum Inductance 0.2mH
2) Min. resistive impedance >570Ohm
3) Minimum rated current 1250 A
4) Short time current 31.5kA

The main coil with its spark gap shall have a self-resonant frequency higher than 500 kHz.

The Bidder shall furnish with the Bid a diagram showing the resistive impedance of the traps as a function of the frequency.

The line traps shall be of the band tuned type. Tuning device and surge arrester according to IEC 60353 shall be installed. The tuning device shall be adjustable in the range 260 – 502kHz. Each line trap shall be enclosed by bird barriers

Every line trap shall be supplied with a line matching unit as per specifications in **Clause 4.1.1.7.2** below.

4.1.1.7.1 Coupling Capacitors

The capacitor shall have a rated capacitance of not less than 2000pF and shall meet the insulation level and test voltage equivalents of IEC recommendation for each device (IEC 60358 Coupling capacitors and capacitor dividers)

4.1.1.7.2 Line Matching Units

Phase to phase coupling units complete with coupling filters and protection circuit, including hybrid transformer.

The high frequency coupling units shall be assembled in a sheet steel box or similar and be suitable for mounting on the pedestal support for the coupling capacitor. The filters are to be suitable for outdoor use in a hot dusty/humid climate and are to have weather proof door seals together with breather holes to avoid condensation.

The units are to have an earthing switch which should preferably be interlocked with the box door/lid such that the latter cannot be opened unless the earth switch is closed to earth the device, and clear ON/OFF position of this switch should be indicated.

The terminal of the filter, which shall be connected directly to the substation earth, shall be clearly designated. The device shall meet requirements of IEC 60481.

The device shall be fitted with a rating plate clearly defining but not limited to the following data:

- Manufacturer's Name
- Type
- Serial number
- Peak envelope power
- Available bandwidth or working range

Technical requirements:

Bypass filter:

- Impedance, equip. side unbalanced 75/125 Ohm
- Impedance, line side 240/320 Ohm
- Nominal PEP at < 50kHz < 400 W
- Nominal PEP at > 100kHz < 1000 W
- Coupling capacitance 1.5 to 20nF

Drain Coil:

- Inductance, adjustable 0.2 – 0.7 mH
- Impedance at power frequency < 1.5 Ohm

Earthing Switch:

- Rated current 300 A rms

Lightning Arrester:

- Rated voltage 660 V
- Max. 100% impulse spark over voltage 3,300 V
- Rated discharge current 5 kA

4.1.1.8 Conductors, Insulators, Accessories

4.1.1.8.1 Conductors

Unless otherwise stated in Scope of Works, the conductors shall be concentrically laid, stranded, flexible conductors made of round aluminium, aluminium alloy or copper wires. The alloy shall be aluminium alloy 6201-T81 in accordance with ASTM Standard B 398-67 (equivalent IEC standard) or aluminium alloys of similar approved composition, as known under the trade name "ALDREY".
The same type of conductor may be used for the overhead earth wires, the cross-sections being at least the equivalent of 95mm^2 copper. Other earth wires shall always be of copper.

The cross-sectional area of the conductors shall be chosen according to the electrical and mechanical requirements and shall be proposed in the Tender. Rated currents are given in Scope of Works, for each substation. The minimum factor of safety for busbars or other connections based on elastic limit shall be 2.5.

The number of different cross-sectional areas to be used for the current carrying conductors shall be strictly limited. For overhead earth wires the same cross-sectional area shall be used for all substations.

All wires making up the conductor shall be free from dirt, splints, scratches and all imperfections not consistent with the best commercial practice.

The conductor shall be tightly and uniformly stranded with no loose strands and when subjected to 50% of ultimate strength, it shall show no high wires but shall maintain a true cylindrical form. Any Cu-Al connections shall be made with special junction pieces, outdoor as well as indoor.

Supply and erection of conductors and earth wires from dead end towers to gantries will be provided for under other contracts. It is however, the Contractor's responsibility to supply and erect the clamps and connections to the intake.

4.1.1.8.2 Tubular Conductors

If tubular bus bars are used, they shall be made of aluminium-magnesium-silicon tubes in accordance with IEC 60114. They shall be designed to withstand thermal and dynamic stresses under normal duty and maximal short-circuit current without damage. Fastening shall be so that thermal expansion is accommodated without any undue stresses.

4.1.1.8.3 Insulators

The post and string insulators shall be of the silicon rubber type. The post insulators shall be dimensioned in accordance with IEC 60273. They shall comprise fully interchangeable units of either the pedestal or solid core cylindrical type and shall be designed so that they can be used either upright or inverted.

Substation insulators shall be porcelain type whereas Line insulators shall be polymeric type.

The string insulator units shall comply with the provisions of IEC 60120, IEC 60305 and IEC 60372. The type of insulator and the characteristics of the discs and the number of discs per string shall be chosen according to the electrical and mechanical requirements, which shall be proposed in the Tender.

Minimum factors of safety shall be:

- For complete insulators based on electro-mechanical failing load test (IEC 60383) 2.5
- For insulator metal fittings based on elastic limit 2.5

Each insulator shall be marked with the initials or trademark of the manufacturer and with the guaranteed electromechanical strength. All markings shall be plainly legible and durable.

4.1.1.8.4 Accessories

For all accessories as clamps, connections, etc., care shall be taken to fulfil all conditions required concerning current carrying capacity, mechanical strength, glow discharge characteristics, corrosion resistivity and easy mounting, etc.

All accessories shall comply with VDE Standard 0210 and 0212 and with the corresponding DIN specifications or with other similar and approved specifications and shall be tested according to the same specifications.

4.1.1.9 Cable Ducts

All necessary cable ducts from the switchyard to the control building to be included in the tender. The cable ducts are specified in **Section - Civil Works**.

4.1.1.10 Cable Marshalling Kiosks

For each switch bay, a separate dust and waterproof, cable marshalling kiosk shall be provided, minimum IP54. It shall be possible to securely fix the hinged front door in open position.

All secondary cables coming from the circuit breakers, disconnecting switches, instrument transformers, etc., shall be collected in this cable marshalling kiosk. From here, a minimum amount of multicore or fibre optic cables shall lead to the control room.

The cable marshalling kiosks shall be equipped with rows of terminals for all potential and current circuits, including the necessary test terminals with bushings and lashes.

At least 10% of the terminals shall be spare. For the switch bays, which are not entirely equipped with switchgear, the kiosks shall have all necessary terminals plus 10% spare as if the switch bays were complete.

The kiosks shall be ventilated by means of suitable openings, covered with dust filters and have drainage plugs at its lowest location.

Each kiosk shall be equipped with a thermostat-controlled heater in order to avoid any moisture. The heaters shall be so located that it does not damage any equipment or cables when let on.

An internal AC, single-phase socket outlet for hand lamps and small tools, and an AC three phase socket outlet for heavy tools shall be provided in each and every cable marshalling kiosk. All these outlets to be according to the same standards as for the control building.

Miniature circuit breakers, with alarm contact, shall be provided for the voltage transformer secondaries.

All terminals, socket outlets and other parts of the kiosks shall be easily accessible without dismantling any part.

4.1.1.11 Tests

Tests shall be made in accordance with the applicable standards. Type test shall be carried out on one sample of the equipment or as requested by the employer.

4.1.1.11.1 Conductors, Insulators, Accessories

Tests for physical and electrical properties on conductors shall be made in accordance with ASTM Standard B398 and 399 (IEC Equivalent) or other equivalent and approved standard. These tests on wires shall be made on wires removed from the complete conductor. All wires making up the conductor sample shall be tested.

Sampling, inspection, tests and acceptance of the insulators shall be in accordance with ASA Standards C 29.1 (IEC Equivalent), Test Methods of Electrical Power Insulators and C 29.2, Wet Process Porcelain Insulators (Suspension Type).

4.1.1.11.2 Tests on the Switchyard on Site

All electrical equipment and installations shall be tested for correct connections of the high-voltage circuits as well as of the control and measuring circuits, installation, insulation, and earthing.

All electrical equipment and installations shall be subjected to a complete operational test to check the correct operation thereof in terms of the operational requirements specified in these Specifications.

4.1.1.12 Autoreclosers

4.1.1.12.1 General

Provided below are general requirements for 33/11kv Auto reclosers and where these requirements differ with those provided in the attachment for KPLC Specification for

Auto reclosers, the data in the attachment *KPLC specifications for Auto reclosers* shall prevail.

Auto-reclosers are used on remote/semi urban 33/11 kV substations instead of circuit breakers and control systems. The autorecloser shall be designed for pole mounting with the following features:

(i) Ability to distinguish between permanent and transient/temporary faults
(ii) Ability to interrupt fault currents and thereafter restore every supply.
(iii) Ability to switch normal load currents.
(iv) Ability to coordinate with other protective devices such drop out fuses, Sectionaliser and circuit breakers controlled by normal IDMT protection curves.

4.1.1.12.2 Modes of operation

Autoreclosers shall be equipped to provide three phase tripping and reclosures, then lockout after a pre-selected sequence of three phase unsuccessful reclosures.

If a reclosure is successful the operating mechanism shall re-set to make available the full sequence of operations.

A minimum availability of four opening operations shall be provided with an autoreclose facility on the first three, the fourth opening shall cause lockout. Once the recloser is locked out manual resetting is required in order to restore service.

It shall be possible by a programmable setting device to select the number of operations which the recloser will perform automatically and also the time delay which may be applied to each individual operation independent of the other operations. (this also means to block the recloser function when used as transformer breaker)

4.1.1.12.3 Operating Mechanism

The closing mechanism shall charge a spring during closing which drives the tripping mechanism. Solenoid mechanism shall not be used.

The tripping shall be coil initiated via commands from the control/protection system.

4.1.1.12.4 Power Supply

The recloser shall be completely self-contained deriving all its energy from the feeding side of the HV network. High voltage operated solenoids are preferred. The control and protection facilities may be operated by means of current transformers on the feeding side bushings. If batteries are provided for control, protection and tripping batteries are provided for control, protection and tripping functions detailed capacity calculations are to be provided showing the number of in/out operation the battery can handle in addition to the normal control/protection requirements of the stated ambient temperatures. A minimum of 2000 in/out operations are required with a minimum battery life span of 5 years. A low battery voltage signal shall be provided.

4.1.1.12.5 Control Cabinet

A separate control cabinet shall be provided connected to the recloser by means of a multicore cable. The cabinet shall have a heater for connection to external power supply. The cabinet shall be dust and vermin proof and protected against direct sunshine by means of a shade. Ingress of water shall not be possible.

4.1.1.12.6 Control Requirements

A microprocessor-based control unit for the recloser is required which also integrates the protection relays. The control unit shall have a socket for serial communication and downloading of information to a hand-held external unit from the memory.
The Autorecloser shall have facilities for manual tripping and locking out by means of an external handle or similar.

The following control functions shall be provided on the front panel:
- Local/remote control selection
- Closing/tripping
- Autoreclose in/out (one trip to lockout)
- Protection engaged/disengaged
- Earth fault in/out
- Sensitive earth fault in/out
- Relay status.
- Energy profiles;
- Demand registers

Local status indications shall be included in addition to the above control functions.
The control unit shall also have facilities for remote control/indication.

4.1.1.12.7 Protection Requirements

Relay characteristics settings shall preferably be performed on the front panel as well as selection of the operating sequence.

Dead times and reclaim time shall be selectable in steps.

The protection system shall have facilities for:
- Phase faults
- Earth faults
- Sensitive earth fault.

The phase and earth fault protection shall have standard inverse IDMT characteristics and definite time. The trip setting range for phase faults shall minimum cover 20 to 800 A while for earth faults 10 to 400 A.

The sensitive earth fault relay shall be of the definite time type with instantaneous element, adjustable between 2 and 10A in steps. Time delay should be settable between 0 and 20 secs. in steps.
The relays shall be equipped with in rush restraint facilities. A counter is to be provided to keep record of the number of in/out operations.

4.1.1.12.8 Insulating and Interrupting Medium

The interrupting medium shall be vacuum. The insulating medium shall be SF6 or solid insulation. The SF6 gas used shall comply with IEC publication 60376.

Unless otherwise stated, the insulating oil used with autoreclosers shall be of the standard mineral uninhibited type and shall comply with the requirements of IEC 60269. In addition to the quantity of gas required to fill the supplied equipment, 20% shall be supplied as spare.

Where SF6 gas filled autoreclosers are offered, the supplier shall provide the user with necessary instructions for refilling the gas and maintaining its required quantity and quality. The autorecloser shall have facilities for lockout in case of low pressure

with an associated indicator flag easily seen from the ground. A pressure gauge easily read from the ground shall also be provided.

Reclosers using oil as interrupting medium are not acceptable and will be rejected. Where gas filled reclosers are offered the supplier shall include in the quotation the cost of one set of gas filling equipment. One set of gas filling equipment shall be supplied with the reclosers.

4.1.1.12.9 Ratings

a) The reclosers will be used on networks with nominal operating voltages of 33 kV. The maximum system voltage will be 36 kV. The rated one minute power frequency withstand voltage shall be at least 95 kV when contacts are opened with Basic Insulation Level at least 170 kV.

b) The continuous current rating shall be at least 400 A. The short time 3 seconds current rating shall be at least 12 kA. The interrupting current shall be at least 12 kA. The closing and latching capability shall be at least 20 kA.

4.1.1.12.10 Bushing Current Transformers

The bushing current transformers for protection shall be single core and provided on all phases. They shall be rated as per design requirements if not specified.

If current transformers are used to provide power supply to control, protection and tripping these are to be dimensioned with 30% spare capacity. The cores for this supply shall be separate from the protection core.

4.1.1.13 Alternative Indoor 66 kV Switchgear

For very confined substations in the Nairobi an alternative with indoor 66kV switchgear is to be included in the Bid. The 66 kV breaker shall be mounted on a trolley behind a steel wall together with earthing switches and measuring transformers. In principle the arrangement shall be as for enclosed switchgear below with the exception of the enclosure. The steel wall shall protect operators from any danger followed from live part and possible arching. The motor operated trolley shall act as a disconnector and be retractable from front of steel wall. The earth switch shall also be operated from here.

4.1.1.14 Medium Voltage Indoor Switchgear

4.1.1.14.1 General

This section covers the manufacture and supply of indoor metal enclosed, metal clad type 33kV and 11kV switchboards constructed and tested in accordance with IEC60298 as well as circuit breakers, associated equipment and spares.

All bays shall be clearly labelled in English language with feeder or transformer name.

Tests shall be made in accordance with IEC 60298. Arc tests, as specified in IEC 60298 Annex AA are required. The arch type test shall be performed by an internationally recognised test institution for the full short circuit current in at least 1 sec.

4.1.1.14.2 Switchboard Panels

The boards shall be complete with bus bars, Withdrawable circuit breakers, cable connection points, earthing switches, measuring transformers, cable relays,

instruments and other ancillary equipment, fully wired, but dismantled to individual panels/sections for delivery purposes.

The boards shall be suitable for indoor use and shall be of single bus bar three-phase configuration at a rated frequency of 50 Hz. If so indicated in Scope of Work, the bus bar shall be split by a Withdrawable sectionalizing circuit breaker. In any case shall it be possible to add new boards including such bus coupler at a later stage.

The cubicles shall be short circuit and arch type tested. The switchgear shall consist of cubicles of tropical design. They shall be metal enclosed with separate compartments for bus bars, circuit breakers, cable termination and instruments, and shall be so designed that future extension can easily be made.

The rated short circuit current withstand for 11KV indoor switchgear shall be 31.5KA/1sec, whereas for 33KV shall be 40KA/sec.

The cubicles shall be designed with protection class IP3X for external surfaces and IP2X for internal compartmentalization.

The panels shall also be equipped with arc protection system, capable of sensing internal arcing and initiating trip and alarms through IEDs

The instrumentation compartment shall house all secondary equipment. The compartment shall be accessible from outside without opening any of the doors to the H.V. equipment. In cubicles housing voltage transformers, circuit breakers and switch disconnectors, the instrument compartment shall in addition, contain fuses for secondary circuits and direct-on-line starters for the operating devices.

Internal H.V. connection shall be made of copper or aluminium alloy. The cubicles shall be painted in a colour that will be stated at a later date. Each cubicle shall be labelled and the equipment marked.

The Supplier shall state necessary free spaces behind and above the switchgear for pressure relief purposes. The service side of the switchgear shall be completely screened from shock waves and fume gases.

4.1.1.14.3 Circuit Breakers and Disconnectors

The three phase circuit breakers shall be of the SF_6 for 66kV and above voltages, and vacuum type for 33kV and 11kV Voltages and below. The indoor breakers shall be horizontal withdrawal type

The breakers shall be capable of handling the following operation cycle, according to the IEC recommendations:

O – t – CO - t1 - CO *t = 0.3 sec* *t1 = 15 sec*

The total breaking time (opening time plus duration of the arc) of the breakers shall be as short as possible, but in no case is it to be longer than 60msec.

The circuit breakers shall be designed for switching of capacitor banks and shall be such that restriking during breaking operation cannot occur.

A spring-operated mechanism shall be provided and the mechanism shall be equipped for electrical local (from switchgear) and remote control (from control centre). If not

otherwise stated in Scope of Works, the control voltage for closing and opening commands and for the operating mechanism motor(s) shall be:

110VDC + 10% - 20%, unearthed, from battery

A local position indicator shall be mounted in the front panel of the operating mechanism cubicle.

The circuit breakers shall be mounted on manual operated trucks so that they can be moved into counter contacts of the switchgear (draw-out/jack up down type). All breakers of same rating shall be fully interchangeable.

Each cubicle shall be provided with facilities for local control and position indications. All trucks for circuit breakers and disconnectors shall be incorporated in the interlocking system.

For SF6 circuit breakers, a system for continuously monitoring the gas density shall be provided. At a certain low density signal shall be given to indicate that refilling should take place. At the extreme low density the circuit breaker should automatically trip and be blocked against operation. SF6 gas refilling equipment mounted on a trolley shall be provided.

The stored energy shall for all types of operating mechanisms be sufficient to allow a complete O-C-O cycle.

A sufficient number of auxiliary contacts for 110VDC shall be provided for control and interlock purposes.

Motors shall be designed in accordance with valid IEC publication and shall be effectively protected by miniature circuit breakers, with alarm contacts.

All wiring shall lead to terminals. 10% of the terminals shall be spare.

4.1.1.14.4 Circuit Isolation and Interlocks

The arrangement of the secondary isolating contacts must be such that when the breaker is in the test position, the secondary isolating contacts are still made so that the secondary circuit may be tested without the need for jumper connections. It must be possible to leave the breaker trolley in disconnector open position with closed cabinet door.
Clearly labelled mechanical interlocks shall be provided to prevent:

(a) a closed breaker from being withdrawn from or inserted into the isolating contacts.
(b) the breaker from being withdrawn or replaced except when its mechanism is in the "off" position.
(c) the breaker being closed in the “service” position when the secondary circuits are not properly connected.

4.1.1.14.5 Switch-Disconnectors and Fuses

Cabinets for station transformers for local LV supply to be equipped with switch-disconnectors, fuse holders and earthing switches. Such breakers do not need to be erected on trolley but the arch test requirements prevail and the cubicle must be extensible with standard cubicles on both sides. The disconnector must be so arranged that it is possible to insert an isolating plate between the live and dead contacts when working in the cubicle. Such plate should be part of the supply.

Transformer Cubicles shall be provided with fuse tripping devices via striker pin. The HRC fuses must conform to DIN (IEC equivalent) regulation for 12kV or 36kV.

4.1.1.14.6 Shutter Mechanism

Substantial safety shutters are to be provided to cover the breaker isolating sockets, on both the busbars and circuit connections. These shutters are to be automatically actuated by the breaker.

Each shutter shall be capable of being separately operated and padlocked in the closed position.

4.1.1.14.7 Earthing

All cubicles shall be connected to earth via conductors with min. 95mm^2 cross section.

Neutral terminals of voltage transformers shall be connected via separate, insulated conductors to the main earth conductor.

Cubicle doors shall be separately earthed if live equipment is fixed to the doors.

Permanent earthing facilities shall be installed on all incoming and outgoing feeders and on the busbar in one point (or if split busbars in each section). It shall be possible to connect the earthing devices from outside with closed doors. Earthing devices shall have reliable position indicators and sufficient making capacity shall be proved.
Capacitive voltage indicators shall be arranged to avoid closing of earthing switches against energised components.

4.1.1.14.8 Cable Connection

The cable termination compartment for feeders shall have adequate space for housing of cable terminals up to, 2x3x1 core 300mm^2 Al XLPE (two single core set) and shall be complete with cable terminations, bolts, nuts and cable
The cable termination compartment for the connections to the 66/11kV transformers must allow for cables dimensioned for 23MVA.

For cable test purposes, it must be possible to loosen the connection between cables and the measurement transformers from the front of the switchboard, with energised busbars without removing any apparatus. The Bidder shall demonstrate this in his Bid.

4.1.1.14.9 Measuring Transformers

4.1.1.14.9.1 Current Transformers

All current transformers shall have bar primaries and shall be oil insulated, hermatically sealed type and generally comply with IEC 60044. All current transformers shall have a maximum short-time current rating of 25kA for 3 seconds.

Feeder Bay circuits shall be equipped with a current transformer on three phases with four cores:

For measuring and instruments, not less than 15 VA, Class 0.2

33kV: Ratio	150-300-600/1-1-1Amp
11 kV: Ratio	100-200-400/1-1-1Amp

For overcurrent and earth fault protection, not less than 15 VA, Class 5P20.

33kV: Ratio 150-300-600/1-1-1Amp
11 kV: Ratio 100-200-400/1-1-1Amp

For Distance protection, not less than 15 VA, Class 5P20/PX :
33kV: Ratio 150-300-600/1-1-1Amp
11 kV: Ratio 100-200-400/1-1-1Amp

For overcurrent and earth fault protection, not less than 15 VA, Class 5P20.
33kV: Ratio 150-300-600/1-1-1Amp
11 kV: Ratio 100-200-400/1-1-1Amp

Transformer Incomer Bay circuits shall be equipped with a current transformer on three phases with four cores:

For measuring and instruments, not less than 15 VA, Class 0.2:
33kV: Ratio adapted to transformer rating
11 kV: Ratio: 400-800-1200-1-1-1Amp

For overcurrent and earth fault protection, not less than 15VA, Class 5P20.
33kV: Ratio adapted to transformer rating
11 kV: Ratio: 400-800-1200-1-1-1Amp

For differential protection, not less than 15 VA, Class Px.
33kV: Ratio adapted to transformer rating
11 kV: Ratio: 400-800-1200-1-1-1Amp

For Restricted Earth Fault protection, not less than 15 VA, Class Px.
33kV: Ratio adapted to transformer rating
11 kV: Ratio: 400-800-1200-1-1-1Amp

Loose Neutral Current Transformers (NCT)
Loose single-phase current transformers with three separate secondary cores for connection of Restricted Earth fault Protection and Neutral Overcurrent Protection.. Ratio as per design.

4.1.1.14.9.2 *Voltage Transformers*

Three phase voltage transformers shall have the following characteristics

Ratio $\frac{33000}{\sqrt{3}} / \frac{110}{\sqrt{3}}$ for 33kV switchgears

Ratio $\frac{11000}{\sqrt{3}} / \frac{110}{\sqrt{3}}$ for 11kV switchgears

The accuracy classes shall be 0.2 for the measuring winding and class 3P for protection function. Burden capacity shall be between 100 to 200VA for the protection winding in accordance with IEC 60186.

Each busbar section and each 33kV and 11kV outgoing feeder shall be equipped with a three-phase voltage transformer.

The voltage transformers shall be equipped with both primary H.V. and secondary L.V. fuses, and shall be so arranged that the H.V. fuses are not accessible unless the voltage transformer is withdrawn.

The transformer shall be resin encapsulated of the electromagnetic type.

4.1.1.15 Protection and Control

4.1.1.15.1 General

Each MV panel shall be supplied complete with numeric protection relay and control units. Maximum of two protection functions can be combined in one unit. It shall be possible to block remote control (but not indication) locally. Such blocking shall be indicated remotely. All requirements and facilities described in the Section Control and Protection below shall be incorporated as appropriate.

4.1.1.15.2 Arc Detection

The complete MV switch board shall be fitted with dedicated Ultra-fast detection and clearing arc flash protection system, using a combination of Arc protection relay and unclad fibre optic sensor that can absorb light throughout its length in addition to single sensors for separate compartments. The system shall be capable of detecting arc within 400nm spectrum and above. The arc detection shall be insensitive to sunlight and flashlight.

The system shall ensure arc flash protection in all compartments of the switch gear board (Control compartment, MV Cable connection, Breaker, and Busbar compartments). The arc detection system shall automatically carry out regular self-checking of the sensor's integrity and continuity and generate an alarm if a problem is detected.

In normal operation, both light and over- current shall be present simultaneously for the system to issue tripping command. However, the system shall be capable of being configured to issue tripping command either, by detection of an intense light alone or over current, or both.

Arc flash detection systems shall be standalone protection systems and shall not need to be coordinated with existing protection systems so as to achieve ultra-faster detection and clearing of arc faults.

The arc detection system in the cubicles shall instantaneously trips the incomer circuit breakers in combination with the bus-section breaker, to isolate the faulty part in case of a short circuit on the busbar or in a circuit breaker cubicle.

The arc detection trip indications shall be available on the SCADA.
The arc protection scheme shall be subject to approval of the Project Manager.

4.1.1.15.3 Optional Equipment and Accessories

Bidders shall advise and quote, in detail for accessories and maintenance tools and equipment that they would recommend is provided with such a switchboard installation.

It is emphasised that full information must be provided as to the costs of replacement materials, such as gaskets, seals, 'O' rings, spare contacts and mechanisms, etc.

Bidders shall also specify all equipment, and costs, which will be required to maintain the switchgear in a fully operative condition throughout its service life of at least twenty-five years. This should include gas leakage detection equipment, pressure testing equipment, gas cleaning equipment and gas recharging equipment.

4.1.1.16 MV Cables and Accessories

4.1.1.16.1 General

All cables accessories and materials shall be in accordance with the latest editions (including all amendments) of IEC and ISO recommendations.

All cables shall be suitable for operation:

- on a system with direct earthing of the transformer neutral
- under maximum load (ONAF conditions) plus 10 % specified for respective transformers
- in the climatic conditions prevailing at site

No joints shall be allowed. Only dry vulcanising processes shall be used. Special precautions shall be taken to avoid ingress and spreading of moisture and development of water-treeing. The Tenderers shall document the construction measures used to achieve these requirements.

4.1.1.16.2 Conductors

All conductors shall be stranded copper or aluminium. The conductor shall be clean, uniform in size, shape and quality, smooth and free from scale, splits, sharp edges and other harmful defects. The conductor shall be in accordance with IEC 60228. The conductor shall be filled with swelling powder to stop axial ingress of moisture.

4.1.1.16.3 Cable

The conductor shall be covered with:

- An extruded semi-conducting layer
- A layer of dry vulcanised cross-linked polyethylene (XLPE) insulation
- An extruded strippable semi-conducting layer
- A water tight copper or aluminium seal
- A layer of swelling tape to prevent axial ingress of water along the screen
- A layer of earthing screen of stranded aluminium or copper
- An outer LDPE (low density polyethylene) sheath for water tightness and mechanical protection.

4.1.1.16.4 Cable Laying and Routing

The final routing of HV and LV cables in indoor and outdoor installations shall be determined by the Contractor from the directives given in Particular Specifications, and the principles shown in the layouts on the drawings. All cable routing and arrangement shall be subject to the Project Manager's approval and must adapt to obstacles as tubes and ventilation channels. All penetrations of fire zone separations shall have the same fire classification as the separation itself.

Cables shall be laid on corrosion resistant (aluminium or hot dipped galvanised) cable trays and racks and by raising cables fixed to cable ladders. The trays shall be dimensioned and fixed so that it allows one man to climb on it in addition to the cable load. Each tray shall have at least 15% spare capacity. The distance between each

tray shall at least be 300mm. For exposed outdoor installations cables shall be laid in covered cable trenches, plastic or steel ducts, depending on the available space.

Branch offs to individual equipment shall be fixed and supported all the way to the connection box. Cables and cable supports shall be properly fixed and secured against movement under short-circuit and strain caused by erection work. Particular attention shall be given to termination in confined areas where personnel may climb under erection and maintenance. Flexible tubes of “spiral type” shall not be used whereas tubes of “plica” type can.

Low power cables, i.e. cables for control, metering, etc. shall not be run in close parallel to high power cables or earth wires, but shall be run at the greatest possible separating distance. The minimum distances are:

- High and medium voltage versus control and measuring cables 800 mm
- Low voltage power cables versus control and measuring cables 400 mm

Necessary EMC consideration shall be taken in accordance with EMC standards.

Additionally, cables for extra low power, i.e. mA and mV circuits and cables connected to low power solid state electronic circuits, shall be laid in separate sheet steel trays with covers. The DC trip and AC voltage supplies and wiring to main protective gear shall be segregated from those for back-up protection to the greatest extent possible.

Single-phase power cables shall be run in trefoil configuration; single-phase DC power cables shall be run in parallel. Special care shall be taken so that closed magnetic circuits do not form around single-phase cables.

Cables below 25 mm^2 cross section shall be copper. Larger cross sections may be aluminium. Minimum cross sections shall be as follows:

- Measuring cables for current 2.5 mm^2
- Control and other measuring cables 2.5 mm^2
- Power cables according 120 % max load current

All cross section must be checked against max load current, allowable burden on measuring transformers, short circuit values, voltage drop, protection requirements and selectivity.

The cables shall be marked with item designation in both ends as well as by entrances in enclosures. The cable marking shall be fire proof.

Cables shall be laid in full runs and not spliced unless approved by Project Manager. Termination of multi-stranded conductor ends shall be with a suitable crimped thimble as specified above. All other cable lugs or similar shall be of crimped type adapted to the cable type and cross-section used. The tools used should be special approved for the lugs and cable type used.
The cable supplier’s instructions regarding handling and bending radius shall be followed.

4.1.1.16.5 Laying-up and Fillers of Three Phase Cables

The cores of three-phase cable shall be laid-up together with suitable fillers, wormed circular and binding tapes applied overall.

4.1.1.16.6 Manufacturer’s Identification

The manufacturer's identification shall be provided throughout the length of the cables by means of a tape under the sheath printed with the manufacturer's name. Alternatively, the manufacturer's identifications may be embossed on the outer PVC sheet together with identification and voltage markings

4.1.1.16.7 Armour

All cables shall be steel wire armoured according to IEC and BS standards

4.1.1.16.8 Testing

Notwithstanding that cables are manufactured to approved standards, all cables, accessories and materials shall be subjected to and withstand satisfactorily the test requirements detailed in this specification. All materials shall withstand such routine tests as are customary in the manufacture of the cables and accessories included in the Contract. The manufacturer shall have established a quality control system based on regularly accelerated test of production samples according to CENELEC HD605. This system shall be described in the Bid.

4.1.1.16.9 Sealing and drumming

The cable shall be wound on strong drums arranged to take a round spindle of a section adequate to support the loaded cable drum during installation and handling. The drums shall be lagged with closely fitting battens that shall be securely fixed to prevent damage to the cable. Wooden drums shall be constructed of seasoned timber to prevent shrinkage of drums during shipment and subsequent storage at site. Each drum shall be clearly marked including indication of direction of rolling.

The ends of the cables shall be suitably sealed to prevent ingress of moisture. The end of the cable left projecting from the drum shall be securely protected against damage by mishandling during transport and storage.

4.1.1.16.10 Current carrying Capacity and design Parameters

The maximum continuous current carrying capacity and maximum permissible continuous conductor temperature, and the factors for determining such rating and temperature shall be based on recommendations found in IEC 60287, subsequent amendments and all conditions prevailing on the Site

4.1.1.16.11 Terminations

Detailed drawings showing the types of cable sealing ends, terminal arrangements shall be submitted to the Project Manager for approval. Stress cones or other approved means shall be provided for grading the voltage stress on the core insulation of the cables.

The terminations and joints for the cables shall be of an appropriate heat shrink or cold type jointing kits incorporating a suitable arrangement for stress control, and rain sheds for outdoor use.

Termination kits shall include suitable heat shrink tubing to effectively shroud, seal and insulate the exposed cable conductor and shall include a heat shrink glove to effectively seal the crutch of the cable to prevent ingress of moisture into the interstices of the cable. Suitable arrangements shall be provided to earth the cable screens and armour

Terminations into cable boxes shall include brass compression glands and back nuts of the correct size, which shall secure the cable outer sheath and ensure effective continuity between the cable armouring wires and the metal enclosures on which the

cables are terminated. At all rising terminations the cable inner sheath shall pass through the gland to terminate not less than 6 mm above the gland.

4.1.1.16.12 Joint and termination material

Heat shrinking tubing and moulded parts shall be flexible, flame retardant, polyofin-based material of electrical insulating quality, and shall be obtained from an approved manufacturer. They shall be suitable for use indoors or outdoors in the conditions prevailing on site

The material shall reduce to predetermined size and shape when heated above 120 °C. The components shall also be provided with an internal coating of hot melt adhesive compound that shall not flow or exude at temperature below 85 °C. All parts and materials shall be tested to a program of tests to be agreed with the manufacturer.

Each part shall bear the manufacturer's mark, part number and any other necessary marking to ensure correct identification for use on the correct size and type of cable. Each set of parts shall be packed as one unit with full and complete installation instruction and clearly marked to show the application.

4.1.1.17 Auxiliary Supply and Substation Lighting

4.1.1.17.1 General

This section covers the technical requirements of the low voltage AC and DC supplies, switchyard lighting and other auxiliary equipment.

The station service is to be supplied from the station transformers. If available a back-up supply from the district grid may be brought into the station. No more than one station transformer shall be connected to the bus at any time. If the voltage disappears the supply shall automatically be switched over to an alternative supply if such is available.

From the main low voltage switchboard, (AC and DC) feeders shall supply the sub-distribution boards of the plant.

Domestic installations are part of the Civil Works.

The temperature rise of the conductors above ambient air shall not exceed 40˚C at rated current 1250 A in the three phases.

4.1.1.17.2 Auxiliary Supply Distribution Boards

The Switchboard and AC panels shall be designed, constructed and tested in accordance with IEC 60439: Low-voltage Switchgear and Control gear Assemblies.

The distribution boards shall be vermin proof. The boards and panels shall be self-ventilated. No ventilating fans shall be used.

Permissible temperature rise shall not be exceeded even when the free space available for future feeders is mounted with feeder equipment and loaded with rated current.

The covers (outside covers and doors, including hinges and locks) shall safely withstand the overpressure caused by short circuit currents and shall protect personnel against injury.

The main distribution boards and the larger ones of the sub-distributions shall be of the floor mounted prefabricated metal enclosed type, with separate compartments for each feeder, etc. Small sub-distributions may be of the wall mounted steel sheet or cast metal type.

All boards and panels shall be designed for easy access to the equipment, cable terminals, etc. during erection, maintenance, disassembly and extensions.

In addition to the required number of outgoing circuits, one more of each rating employed shall be fully equipped ready for connection of future circuits. Furthermore, each board and panel shall have at least 20% free space available for future extensions.

The main distribution boards shall be designed so that additional panels can be added in the future (including possibilities for extending the busbars).

Operating handles, operating switches and push buttons, signalling lamps, position indicators, instruments, etc., shall be placed on the fronts. Relays which are not incorporated on the circuit breakers shall be placed in separated compartments, metal shielded from the current carrying parts.

The busbars shall be of copper and shall have three phases and neutral. A grounding bar of copper shall also be provided and a grounding conductor connection shall be brought to each feeder compartment, where the feeder grounding conductor can be connected to it.

4.1.1.17.2.1 Circuit Breakers and Fuses

In general, circuit breakers shall be used for all feeders and distribution circuits. Miniature circuit breakers, MCB's, may be used on small circuits. The breakers shall be rated for full short circuit power. No back up fuses shall be used.

Fuses may be used in exceptional cases such as on very light loaded circuits, or in combination with small contactors and where the use of fuses is justified for the purpose of selectivity.

In the design of the distribution systems and in the selection of circuit breakers, MCB's, fuses and protection relays due attention shall be paid to the selectivity of breaker tripping at overloads and at short circuits. Full selectivity shall be achieved, only the feeder or circuit which has an overload or short circuit shall trip.

Un-delayed MCB's shall be used only as the last breaker of a circuit. Selectivity between MCB's and fuses shall be proved, with ample margin.

The circuit breakers shall be manually operated, except for the breakers in the feeders from the auxiliary transformer which shall be electrically operated.

All circuit breakers and MCB's shall have three-phase overload and short circuit protection to be provided as a part of the breaker assembly or provided separately as for the transformer circuit breaker (in this case separate current transformers shall be included). The ratings of the overload and the short circuit protections shall be selected according to the current rating of the cable or circuit to be protected, and in accordance with the requirements of the selectivity as stated above.

The breakers for DC shall be two-pole, and with thermal overload and magnetic short-circuit protection in both poles. All such circuit breakers, miniature circuit breakers,

switches, contactors, fuses, etc., shall be of a type specifically designated for the use on DC, and the dynamic current and the making and breaking capacities shall be ample for the short-circuit power of the batteries.

All DC circuit breakers, miniature circuit breakers, switches and contactors shall have an alarm contact or an under voltage relay with alarm contact shall be provided.

Circuit breakers on the main DC switchboards which are rated 50A and higher shall be withdrawable

4.1.1.17.2.2 Current Transformers

The current transformers shall have synthetic resin insulation or equivalent dry insulation.

The cores for measuring purposes of current transformers shall have accuracy class1 and instrument security factor less than or equal to 5. The cores for protection shall have accuracy class 5P and accuracy limit factor greater than or equal to 10.

Power frequency test voltages, 1 minute:

- Overvoltage inter-turn test 3.5 kV
- Secondaries 2.5 kV

4.1.1.17.2.3 Instruments and Relays

The instruments shall be 96 x 96 mm square pattern with (at least) 90^{o} pointer deflection.

Instruments shall be of the three-element type, for unbalanced three-phase load and loaded neutral conductor.

The relays shall preferably be of the solid-state type. The instruments and relays shall, as far as applicable, be of the same make and type as those of the other parts of the plant.

4.1.1.17.2.4 Tests

Tests shall be made in accordance with the applicable standards.

4.1.1.18 415/240V Auxiliary Supply

4.1.1.18.1 Auxiliary Transformers

Station transformers are part of the scope of supply.

4.1.1.18.2 Distribution Boards

Current carrying capacity of main transformer circuit breaker and alternative supply shall not be less than 200A. The two sources shall be switched by a changeover system that will select between the sources and shall be arranged within the main board. This changeover system shall incorporate a manual by-pass switch.
For 7.5MVA Substations and above the changeover system shall be Automatic with 240VAC controls circuits with auto and manual operation selection.
Automatic switchover between the sources shall be arranged within the main board. The board shall be equipped with instruments for measuring of current and voltage in

all phases as well as energy meters for recording of energy consumption. Continuous current rating of the phases and neutral from the transformer and of the busbars in the main switchboard shall be at least 200 A. The current rating of the feeders shall be ample for the actual load and have at least 50% reserve capacity compared to the actual load. The figures given in these specifications are indicative only. Only a limited number of different makes, types and ratings shall be used, for the purpose of standardisation and interchangeability.

4.1.1.18.3 Switchyard Lighting

The switchyard lighting shall be by means of floodlights with 400W for bay lighting and 70W for perimeter lighting. The lighting shall be constructed with LED lamps. The housing shall be of high-pressure die-cast aluminium with a non-corrosive finish. Refracting front covers of etched vandal-resistant polycarbonate shall be provided. The enclosure protection shall be min. IP65.

The switch bay and transformer illumination level shall be 50 lux on 0.85m height in the switchyard and for the transformers.

The perimeter illumination level shall be 5lux. The perimeter lighting shall be controlled by photocells. All necessary supports, fixing material and cabling from the distribution board shall be included.

4.1.1.18.4 DC Emergency Lighting

Emergency lighting is provided for 23MVA substations and above as specified under section **Civil Works.**

4.1.1.18.5 Hand Lamps and Portable Hand Sets

The portable battery handsets are for additional DC lighting during maintenance works, etc., in case of AC failure. A locker, with the provisions of housing two handsets, shall be placed in the entrance hall of the substation. AC socket outlets shall be fitted in the locker for continuous charging of the batteries. The charging control shall be automatic and a pilot lamp shall indicate that charging is on. The handsets shall be provided with on/off switch.

The handset shall give flow of approximately 200 lumen, and the battery shall have the capacity of running the lamp for 2 hours. A type with a short fluorescent tube is preferred.

4.1.1.18.6 Clock

A clock shall be installed in the control room. It shall be of the analogue type, having continuously moving hands. For temperature variations between -1 and +40^{o}C with ambient relative humidity of up to 80%, the clock accuracy shall be better than +/-2 seconds deviation in 30 days.

4.1.1.19 DC SUPPLY

4.1.1.19.1 General

This section covers the technical requirements of the batteries and battery chargers, the main DC switchboards and the sub-distribution boards and panels for the DC auxiliary supply of the plants. Where these technical requirements provided in the subsequent clauses are in conflict with those provided in the attachments for KPLC specifications for Battery and chargers, the data in the attachment KPLC specifications for battery and charger shall prevail.

4.1.1.19.2 Distribution Boards

The DC busbars shall have two poles. The bars and the connection conductors to the breakers shall be insulated. All boards shall have instruments for reading of voltage and current (two directions) and be equipped with relays giving alarm by high and low voltage and by earth leakage in all insulted poles.

110VDC shall be used for the main circuits of the control and protection and for DC motors, unless otherwise stated in Scope of Works.

For 132kV Substations and above the 110VDC shall comprise of two independent systems i.e. double battery banks and two chargers allowing one system to carry all loads while the other system is out of services or when boost charging one battery. The two 110V battery banks shall be located in separate rooms. Under normal operational conditions the two systems shall each carry 50% of the load. Trip 1 circuits and trip 2 circuits shall be connected to separate systems.

For 66kV Substations and below the 110VDC shall comprise of single battery bank and charger system to carry all the loads.

Trip circuit shall be connected to the DC system.

All boards and panels shall be supplied with the necessary internal wiring. Battery connections and cabling in the battery rooms shall also be included.

Miniature circuit breakers and DC distributions for control, protection, etc., and which are placed on the control, measuring and protection boards shall be included in those boards.

All instruments and protection relays on the rectifiers and on the boards and panels shall be included.

Starters, contactors and protection for motors shall be included whenever such equipment is not provided as part of the motor supply.

4.1.1.19.3 110VDC battery charger and Batteries

The Contractor shall calculate and determine the battery capacities, the power ratings of the chargers, the number of sub-distribution boards, the number and size of circuits, etc., to suit the requirements of the equipment to be installed, but also considering the future extensions as indicated on the drawings.

The number of cells shall be selected so that the voltage of the battery does not exceed 110% of the rated voltage during float charging.

The capacities of the batteries shall be selected to permit a 10hour service without AC power with DC loads as specified below. At the end of this period the voltage of the DC networks (measured on the busbars of the main distributions) shall be at least 90% of the rated voltage with the batteries being loaded as specified.

The 110 V batteries shall be loaded with the switchyard load.
Alarms shall be provided for battery faults.
The batteries shall be of the Nickel Cadmium type, with a nominal cell voltage of 1.2V.

The polarity of the cells, and of the complete battery, shall be engraved and easily legible. Bolted insulated interconnections between the cells shall be included.

4.1.1.19.4 110VDC Chargers

The rated current of the battery chargers shall be selected to allow for recharging a fully discharged battery in 5 hours, in addition to simultaneously supplying the DC load.
In addition, the chargers shall comply with the following technical data and requirements:

Power supply	415 V AC three-phase or 240 V AC single-phase
Output voltage adjustable between	110 V ±15%
Stability of the output voltage	less than ±1% for the maximum input voltage and frequency variations, and from 1% to 95% of rated output current
Batter type to be charged	Nickel-cadmium, maintenance type
Nominal Voltage of cell	1.2V per cell
Maximum deviation of the current limitation	+/- 2% of rated current
Ripple of output voltage	
without the battery connected	less than 4% peak-peak of the rated output voltage
with battery connected	less than 1% peak-peak of the rated output voltage

Dry type transformers and solid state (thyristor or transistor) rectifiers shall be used throughout. Each charger shall be supplied with reactor to reduce ripples.

The chargers shall be completely equipped for a fully automatic and controlled charging and float charging of the batteries, and shall be of a constant voltage type with current-limiting device.
The charger for the 110V batteries shall be rated to maintain normal charging and float-charging of the batteries.

By means of an automatic change-over switch the charger shall change from normal charging and float-charging to boost charging of the battery. After the boost charging, the charger shall switch back to float charging.

Each charger shall be complete with instruments, breakers and protection, including but not limited to:

- Breakers and protection on AC and DC side, with alarm contacts
- One V-meter for the DC voltage

- One A-meter for the DC current
- One lamp indicating that the charger is charging
- Alarms for "high volts", "low volts", "earth fault" and "fail"

The above devices shall be placed on the front of the charger cubicle and the alarms shall also be transferred to the National Control Centre.

4.1.1.19.5 110VDC Battery Conductors and Fuses

Conductors from the batteries to the fuse boxes shall be mounted short circuit and earth fault proof. That is, the conductors shall be single pole insulated and in addition placed on insulators, separate for each pole. All conductors shall be placed at minimum 5cm distance from each other, even at crossings.

The conductors shall lead through insulating pipes in the wall of the battery room to closed fuse boxes made of insulating material on the wall outside the battery room. For the 110VDC system there shall be one box for pole. The wall-holes shall be tightened against gas intrusion.

4.1.1.19.6 48VDC battery charger and Batteries

The batteries and charger shall be suitable for continuous indoor operation in tropical areas with the following atmospheric conditions.

(a) Altitude: 2200m above mean sea level
(b) Pollution: heavy saline atmosphere
(c) Humidity: up to 90%
(d) Ambient temperatures of +30° C average, (+40° C Max. and -1° C Min).

The battery and charger sets shall be sized to adequately supply the loads to be connected to the battery.

The rectifier output shall be k x S

where *k = 1.5*
S = sum of the following:

- *input power in kVA of the largest tendered RTU*
- *input power to the new telecommunication equipment provided under the contract.*

The battery capacity shall be $C = 1.5 \times C_n$,

where C_n *is the capacity to feed the above total load for eight (8) hours.*

This requirement shall be tested during SAT.

The battery chargers shall provide normal system power and shall be capable of recharging a fully discharged battery in twelve hours while supplying normal system power. The chargers shall have 240VAC, 1phase input power.

The batteries shall be minimal maintenance Vented Nickel cadmium type. As they are vented, there are no special ventilation requirements, and as such the batteries shall be placed in battery room installed with correct rated controlled exhauster fans.

A low voltage disconnect switch shall be provided for protection of the battery. The 48 Volt DC system distribution panel shall be a fused switch distribution panel board. The low voltage disconnect switch and fuse panel shall be provided with local alarms

as well as alarm contacts. The low voltage disconnect switch shall be equipped with external by-pass switch to be used for maintenance purposes.
Detailed drawings and operations manuals shall be provided in duplicate copies and softcopy. Design drawings shall be provided for approval before manufacture.

4.1.1.19.7 48VDC Batteries

The batteries shall be nickel cadmium type. The type and rating shall be in accordance with the prevailing environment and suppliers' standard voltage level.

The batteries shall be mounted on wood or metal stands or racks in a way that all plates of each cell are visible for maintenance purposes. The stands or racks shall have a maximum of two tiers.

The Contractor shall be entirely responsible for carrying out and completing the initial charge, test discharge and subsequent recharge. The final test discharge shall be made at the site.

4.1.1.19.8 48VDC Charger

The battery charger shall operate satisfactorily with input AC supply single phase 240V +- 15%, 50 Hz +-2.5 Hz, harmonic level H4 (less than 20%).

On the input of the rectifier/battery charger there shall be an isolating transformer.

The charger shall be of a modified constant voltage type (constant voltage and current limit) capable of providing a continuous float charge to the batteries with at least C/20 A current when delivering the total inverter rated load.

The charger shall be equipped with a total current limit and a separate battery current limit (10 - 50% of total rectifier current), independently adjustable for each of the charging modes:

Trickle charging and floating operation 1.4V/cell and stand-by parallel operation 1.4 V/cell shall be possible.

Controls shall be provided to vary the DC voltage within the output range. The DC voltage shall remain constant within ± 2% of its pre-set value over the full current range of the rectifier/charger and simultaneous AC mains fluctuations 400V ± 15%, 50 Hz ± 2.5 Hz.

The output ripple shall not exceed 1% peak-to-peak measured across the output of the charger when connected to its associated battery.

In the output of the rectifier there shall be a fuse with alarm contact on the negative terminal only (positive earthed system).

When the battery is connected to the charger the psophometric noise level at the output, for loads between 0% and 100%, shall not exceed the equivalent of 1 mV at a frequency of 800 Hz after weighting as specified by CCIF.

4.1.1.19.9 48VDC Alarms and metering

The following minimum alarms and indications shall be provided:

- rectifier failure: high/low DC voltage, mains failure, rectifier fault
- battery breaker status
- status of the on-load isolating switches.

The following metering instruments (class 1.5) shall be included in each rectifier:

- V-meter for rectifier input
- A-meter for battery current

- V-meter for rectifier output
- A-meter for rectifier output.

4.1.1.19.10 Inspection and Testing

The batteries shall be tested in accordance with the requirements of IEC 60285 and Kenya Bureau of Standards.

KPLC reserves the right to inspect the equipment for acceptance tests, at the manufacturer's place where routine tests and temperature rise shall be performed. Test certificates for Batteries and charger shall be provided.